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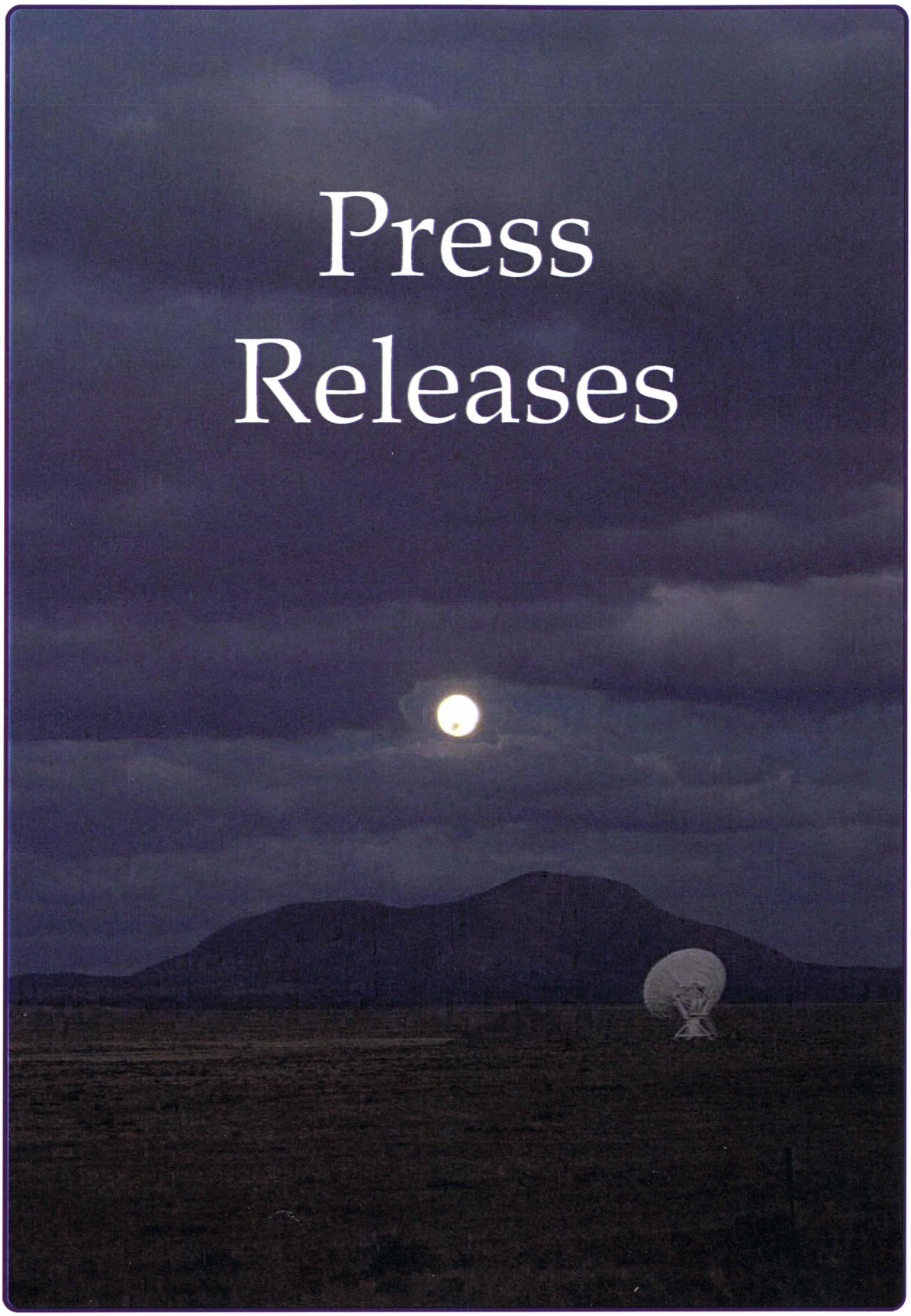
Kristal Armendariz, Photographer

January 2004 — January 2005


Press
Releases

January 25, 2005

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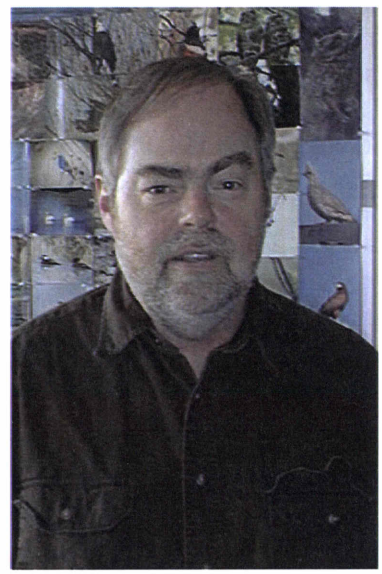
American Astronomical Society Honors NRAO Scientist

The American Astronomical Society (AAS) has awarded its prestigious George Van Biesbroeck Prize to Dr. Eric Greisen of the National Radio Astronomy Observatory (NRAO) in Socorro, New Mexico. The society cited Greisen's quarter-century as "principal architect and tireless custodian" of the Astronomical Image Processing System (AIPS), a massive software package used by astronomers around the world, as "an invaluable service to astronomy."



Dr. Eric Greisen
CREDIT: NRAO/AUI/NSF

The Van Biesbroeck Prize "honors a living individual for long-term extraordinary or unselfish service to astronomy, often beyond the requirements of his or her paid position." The AAS, with about 7,000 members, is the major organization of professional astronomers in North America.

"The Very Large Array (VLA) is the most productive ground-based telescope in the history of astronomy, and most of the more than 10,000 observing projects on the VLA have depended upon the AIPS software to produce their scientific results," said Dr. James Ulvestad, NRAO's Director of New Mexico Operations. "This same software package also has been the principal tool for scientists using the Very Long Baseline Array and numerous other radio telescopes around the world," Ulvestad added.

Greisen, who received a Ph.D in astronomy from the California Institute of Technology, joined the NRAO in 1972. He moved from the observatory's headquarters in Charlottesville, Virginia, to its Array Operations Center in Socorro in 2000.

Greisen, who learned of the award in a telephone call from the AAS President, Dr. Robert Kirschner of Harvard University, said, "I'm pleased for the recognition of AIPS and also for the recognition of the contributions of radio astronomy to astronomy as a whole." He added that "it wasn't just me who did AIPS. There were many others."

The AIPS software package grew out of the need for an efficient tool for producing images with the VLA, which was being built in the late 1970s. Work on the package began in 1978 in Charlottesville. Now including nearly a million lines of program code and almost a half-million lines of documentation, AIPS is used at more than 500 sites around the world. The package is a mainstay and a daily tool for most of the world's radio astronomers, and also has been used by scientists in such other fields as fluid-dynamics simulation and medical imaging.

Over the years, Greisen and his colleagues at NRAO have revised the AIPS package numerous times and expanded its capabilities as new astronomical and computing hardware was developed. The software has been kept independent of specific computing hardware and operating systems, and so has been successfully used on a wide variety of computing equipment.

"We are extremely proud of Eric's work and congratulate him on receiving this award," said NRAO Director Dr. Fred K.Y. Lo. "He has shown extraordinary dedication to making AIPS a valuable and effective tool for the world astronomical community, and this award is well-deserved recognition."

The AAS citation reads, "The 2005 Van Biesbroeck Prize is awarded to Dr. Eric Greisen of NRAO for the initiation, development, and maintenance for twenty-five years of the Astronomical Image Processing System (AIPS). Virtually every VLA and VLBA program relies on AIPS for calibration and image reconstruction, and it has been exported to more than 500 sites worldwide. Greisen, as its principal architect and tireless custodian, has provided an invaluable service to astronomy. Moreover, AIPS represented a new paradigm for the processing of massive astronomical datasets, i.e., a comprehensive software package that was rigorously independent of particular operating systems, which supported portability and adaptability to evolving hardware designs. Beyond the call of duty, Greisen has generously responded to individual queries about the code from users at all levels, sometimes in real time at odd hours to support observations in progress."

Greisen is the second NRAO scientist to receive the Van Biesbroeck Prize. Dr. Barry Clark, one of the early architects of the VLA who has scheduled that telescope's observations for nearly three decades, received the award in 1991.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

EMBARGOED For Release: 9:30 a.m., PST, Wednesday, **January 12, 2005**

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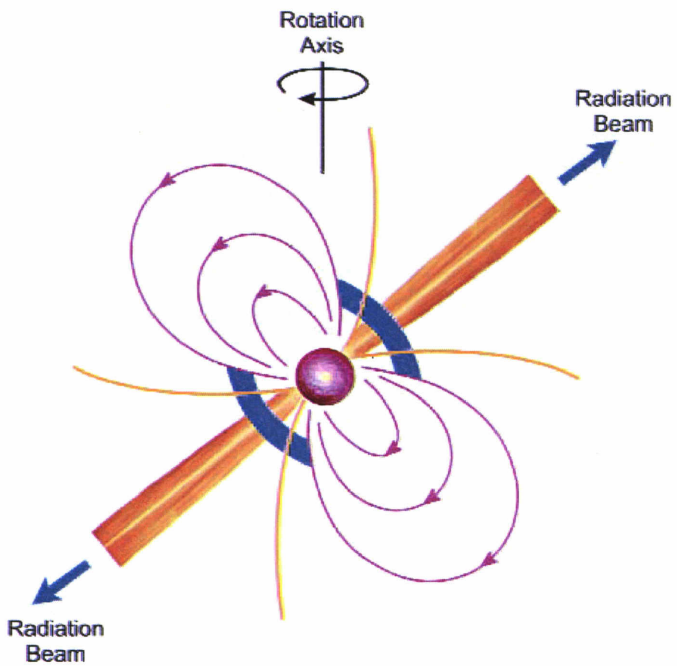
Star Cluster Buzzing With Pulsars

A dense globular star cluster near the center of our Milky Way Galaxy holds a buzzing beehive of rapidly-spinning millisecond pulsars, according to astronomers who discovered 21 new pulsars in the cluster using the National Science Foundation's 100-meter Robert C. Byrd Green Bank Telescope (GBT) in West Virginia. The cluster, called Terzan 5, now holds the record for pulsars, with 24, including three known before the GBT observations.

"We hit the jackpot when we looked at this cluster," said Scott Ransom, an astronomer at the National Radio Astronomy Observatory in Charlottesville, VA. "Not only does this cluster have a lot of pulsars -- and we still expect to find more in it -- but the pulsars in it are very interesting. They include at least 13 in binary systems, two of which are eclipsing, and the four fastest-rotating pulsars known in any globular cluster, with the fastest two rotating nearly 600 times per second, roughly as fast as a household blender," Ransom added. Ransom and his colleagues reported their findings to the American Astronomical Society's meeting in San Diego, CA, and in the online journal Science Express.



Pulsar Diagram
CREDIT: NRAO/AUI/NSF

The star cluster's numerous pulsars are expected to yield a bonanza of new information about not only the pulsars themselves, but also about the dense stellar environment in which they reside and probably even about nuclear physics, according to the scientists. For example, preliminary measurements indicate that two of the pulsars are more massive than some theoretical models would allow. "All these exotic pulsars will keep us busy for years to come," said Jason Hessels, a Ph.D student at McGill University in Montreal.

Globular clusters are dense agglomerations of up to millions of stars, all of which formed at about the same time. Pulsars are spinning, superdense neutron stars that whirl "lighthouse beams" of radio waves or light around as they spin. A neutron star is what is left after a massive star explodes as a supernova at the end of its life.

The pulsars in Terzan 5 are the product of a complex history. The stars in the cluster formed about 10 billion years ago, the astronomers say. Some of the most massive stars in the cluster exploded and left the neutron stars as their remnants after only a few million years. Normally, these neutron stars would no longer be seen as swiftly-rotating pulsars: their spin would have slowed because of the "drag" of their intense magnetic fields until the "lighthouse" effect is no longer observable.
The Green Bank Telescope

The Robert C. Byrd Green Bank Telescope
CREDIT: NRAO/AUI/NSF

However, the dense concentration of stars in the cluster gave new life to the pulsars. In the core of a globular cluster, as many as a million stars may be packed into a volume that would fit easily between the Sun and our nearest neighbor star. In such close quarters, stars can pass near enough to form new binary pairs, split apart such pairs, and binary systems even can trade partners, like an elaborate cosmic square dance. When a neutron star pairs up with a "normal" companion star, its strong gravitational pull can draw material off the companion onto the neutron star. This also transfers some of the companion's spin, or angular momentum, to the neutron star, thereby "recycling" the neutron star into a rapidly-rotating millisecond pulsar. In Terzan 5, all the pulsars discovered are rotating rapidly as a result of this process.

Astronomers previously had discovered three pulsars in Terzan 5, some 28,000 light-years distant in the constellation Sagittarius, but suspected there were more. On July 17, 2004, Ransom and his colleagues used the GBT, and, in a 6-hour observation, found 14 new pulsars, the most ever found in a single observation.

"This was possible because of the great sensitivity of the GBT and the new capabilities of our back-end processor," said Ingrid Stairs, a professor at the University of British Columbia in Vancouver. The processor, named, appropriately, the Pulsar Spigot, was built in a collaboration between the NRAO and the California Institute of Technology. The processor, which generates almost 100 GigaBytes of data per hour, allowed the astronomers to gather and analyze radio waves over a wide range of frequencies (1650-2250 MegaHertz), adding to the sensitivity of their system.

Eight more observations between July and November of 2004 discovered seven additional pulsars in Terzan 5. In addition, the astronomers' data show evidence for several more pulsars that still need to be confirmed.

Future studies of the pulsars in Terzan 5 will help scientists understand the nature of the cluster and the complex interactions of the stars at its dense core. Also, several of the pulsars offer a rich yield of new scientific information. The scientists suspect that one pulsar, which shows strange eclipses of its radio emission, has recently traded its original binary companion for another, and two others have white-dwarf companions that they believe may have been produced by the collision of a neutron star and a red-giant star. Subtle effects seen in these two systems can be explained by Einstein's general relativistic theory of gravity, and indicate that the neutron stars are more massive than some theories allow. The material in a neutron star is as dense as that in an atomic nucleus, so that fact has implications for nuclear physics as well as astrophysics.

"Finding all these pulsars has been extremely exciting, but the excitement really has just begun," Ransom said. "Now we can start to use them as a rich and valuable cosmic laboratory," he added.

In addition to Ransom, Hessels and Stairs, the research team included Paulo Freire of Arecibo Observatory in Puerto Rico, Fernando Camilo of Columbia University, Victoria Kaspi of McGill University, and David Kaplan of the Massachusetts Institute of Technology.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc. The pulsar research also was supported by the Canada Foundation for Innovation, Science and Engineering Research Canada, the Quebec Foundation for Research on Nature and Technology, the Canadian Institute for Advanced Research, Canada Research Chairs Program, and the National Science Foundation.

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Blazar Jets Push Closer to Cosmic Speed Limit

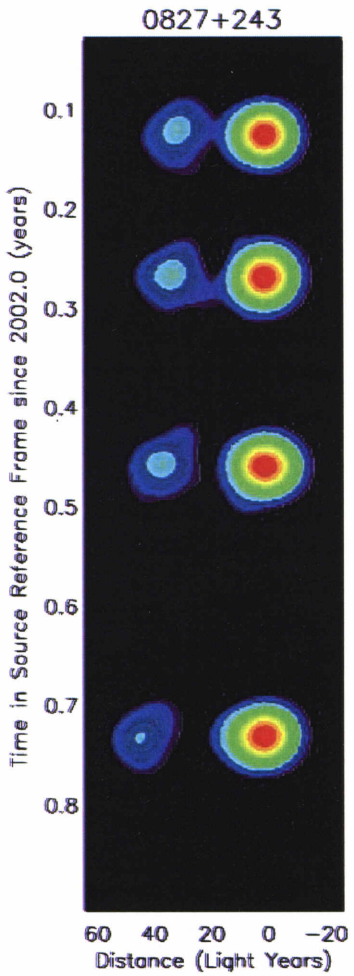
Astronomers using the National Science Foundation's Very Long Baseline Array (VLBA) have discovered jets of plasma blasted from the cores of distant galaxies at speeds within one-tenth of one percent of the speed of light, placing these plasma jets among the fastest objects yet seen in the Universe.

"This tells us that the physical processes at the cores of these galaxies, called blazars, are extremely energetic and are capable of propelling matter very close to the absolute cosmic speed limit," said Glenn Piner of Whittier College in Whittier, California. Piner, who worked on the project with student Dipesh Bhattari, also of Whittier College, Philip Edwards of the Japan Aerospace Exploration Agency, and Dayton Jones of NASA's Jet Propulsion Laboratory, presented their findings to the American Astronomical Society's meeting in San Diego, California.

According to Einstein's Special Theory of Relativity, no object with mass can be accelerated to the speed of light. To get even close to the speed of light requires enormous amounts of energy. "For example, to accelerate a bowling ball to the speed newly measured in these blazars would require all the energy produced in the world for an entire week," Piner said, "and the blobs of plasma in these jets are at least as massive as a large planet".

Blazars are active galactic nuclei -- energetic regions surrounding massive black holes at the centers of galaxies. Material being drawn into the black hole forms a spinning disk called an accretion disk. Powerful jets of charged particles are ejected at high speeds along the poles of accretion disks. When these jets happen to be aimed nearly toward the Earth, the objects are called blazars.

Taking advantage of the extremely sharp radio "vision" of the continent-wide VLBA, the scientists tracked individual features in the jets of three blazars at distances from Earth ranging from 7.3 to 9 billion light-years. A Boston University team led by Svetlana Jorstad earlier had identified the three blazars as having potentially very high jet speeds based on VLBA observations in the mid-1990s. Piner and his colleagues observed the blazars again in 2002 and 2003 with much longer observations, and were able to confirm the high-speed motions in the faint blazar jets.



VLBA sequence of blazar 0827+243. This sequence shows plasma moving away from the blazar's core. The core is the bright red dot at right; the plasma is the blue object to the left. The VLBA images show the plasma's motion over about 8.4 months.

CREDIT: Piner et al., NRAO/AUI/NSF

Their measurements showed that features in the blazar jets were moving at apparent speeds more than 25 times greater than that of light. This phenomenon, called superluminal motion, is not real, but rather is an illusion caused by the fact that the material in the jet is moving at nearly the speed of light almost directly toward the observer. Because the jet features are moving toward Earth at almost the same speed as the radio waves they emit, they can appear to move across the sky at faster-than-light speeds. Scientists can correct for this geometrical effect to calculate a lower limit to the true speed of the features.

"We typically see apparent speeds in blazar jets that are about five times the speed of light, and that corresponds to a true speed of more than 98 percent of light speed," Piner said. "Now, based on independent confirmation by two groups of astronomers, we see these three blazars with apparent speeds greater than 25 times that of light," Piner added. That apparent speed, the scientists said, corresponds to a true speed of greater than 99.9 percent of light speed, which is 186,282 miles per second.

Based on other properties of blazars, the scientists believe that their interpretation of the data is accurate and that they have measured the extremely fast speeds in the three blazar jets. However, "we do have to be somewhat careful in interpreting these results, because it is possible that the observed motions represent the motion of some propagating disturbance in the plasma rather than the plasma itself, in the same way that a water wave can move across the surface of the ocean without physically transporting the water," Piner said.

The VLBA is a system of ten radio-telescope antennas, each with a dish 25 meters (82 feet) in diameter and weighing 240 tons. From Mauna Kea on the Big Island of Hawaii to St. Croix in the U.S. Virgin Islands, the VLBA spans more than 5,000 miles, providing astronomers with the sharpest vision of any telescope on Earth or in space. Dedicated in 1993, the VLBA has an ability to see fine detail equivalent to being able to stand in New York and read a newspaper in Los Angeles. The VLBA is operated from the National Radio Astronomy Observatory's Array Operations Center in Socorro, NM.

The research was supported by the National Science Foundation and the Research Corporation. Part of the research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration. The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

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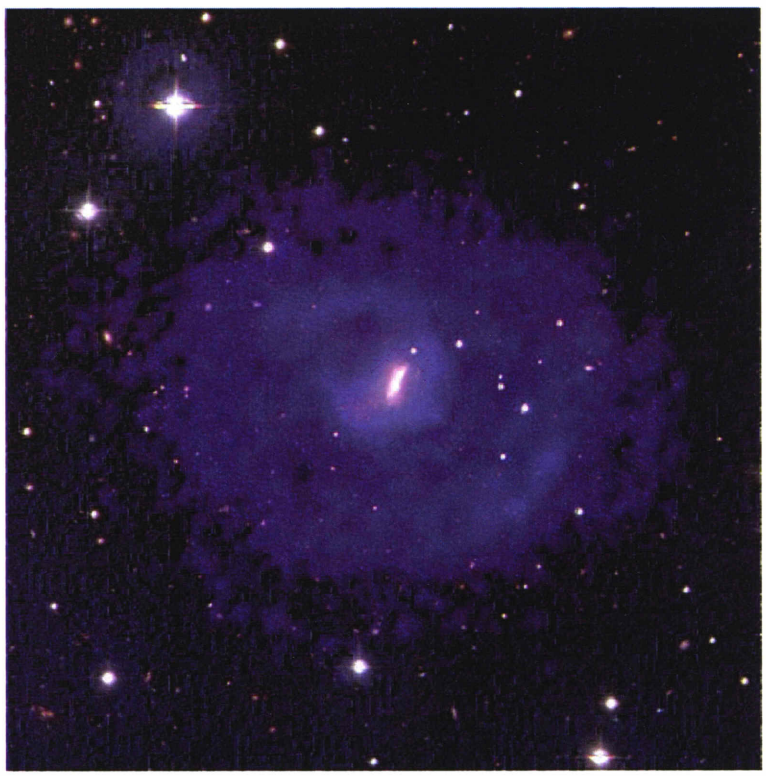
Dwarf Galaxy Gives Giant Surprise

An astronomer studying small irregular galaxies discovered a remarkable feature in one galaxy that may provide key clues to understanding how galaxies form and the relationship between the gas and the stars within galaxies. Liese van Zee of Indiana University, using the National Science Foundation's Very Large Array (VLA) radio telescope, found that a small galaxy 16 million light-years from Earth is surrounded by a huge disk of hydrogen gas that has not been involved in the galaxy's star-formation processes and may be primordial material left over from the galaxy's formation.

"The lack of interaction between the large gas disk and the inner, star-forming region of this galaxy is a perplexing situation. When we figure out how this has happened, we'll undoubtedly learn more about how galaxies form," van Zee said. She presented her findings to the American Astronomical Society's meeting in San Diego, CA.

The galaxy van Zee studied, called UGC 5288, had been regarded as just one ordinary example of a very numerous type of galaxy called dwarf irregular galaxies. As part of a study of such galaxies, she had earlier made a visible-light image of it at Kitt Peak National Observatory. When she observed it later using the VLA, she found that the small galaxy is embedded in a huge disk of atomic hydrogen gas. In visible light, the elongated galaxy is about 6000 by 4000 light-years, but the hydrogen-gas disk, seen with the VLA, is about 41,000 by 28,000 light-years.

The hydrogen disk can be seen by radio telescopes because hydrogen atoms emit and absorb radio waves at a frequency of 1420 MHz, a wavelength of about 21 centimeters.



Radio/Optical Image of UGC 5288
Bright white center object is visible-light image;
Purple is giant hydrogen-gas disk seen with VLA

CREDIT: Van Zee, NOAO, NRAO/AUI/NSF

A few other dwarf galaxies have large gas disks, but unlike these, UGC 5288's disk shows no signs that the gas was either blown out of the galaxy by furious star formation or pulled out by a close encounter

with another galaxy. "This gas disk is rotating quite peacefully around the galaxy," van Zee explained. That means, she said, that the gas around UGC 5288 most likely is pristine material that never has been "polluted" by the heavier elements produced in stars.

What's surprising, said Martha Haynes, an astronomer at Cornell University in Ithaca, NY, is that the huge gas disk seems to be completely uninvolved in the small galaxy's star-formation processes. "You need the gas to make the stars, so we might have thought the two would be better correlated," Haynes said. "This means we really don't understand how the star-forming gas and the stars themselves are related," she added.

In addition, Haynes said, it is exciting to find such a large reservoir of apparently unprocessed matter. "This object and others like it could be the targets for studying pristine material in the Universe," she said.

Haynes also was amused to point out that a galaxy that looked "boring" to some in visible-light images showed such a remarkable feature when viewed with a radio telescope. "This shows that you can't judge an object by its appearance at only one wavelength -- what seems boring at one wavelength may be very exciting at another."

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

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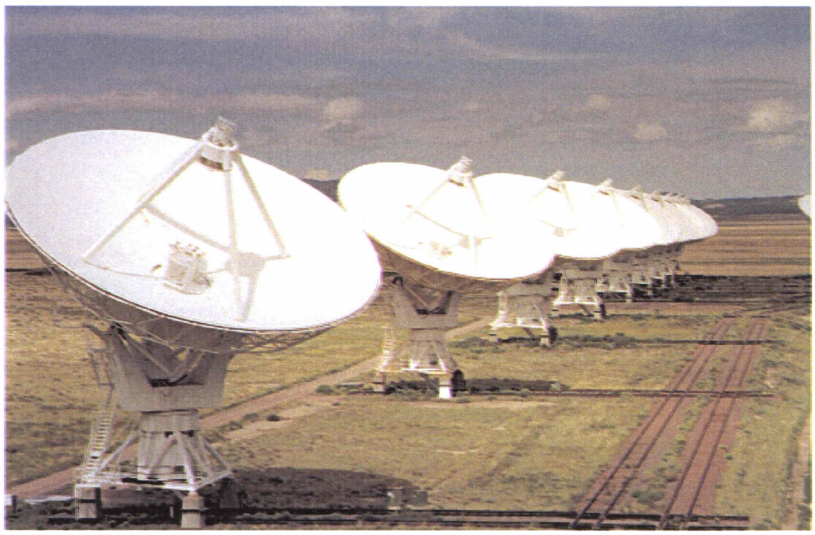
VLA Detects Unexplained Radio Emission From Three Brown Dwarfs



The Very Large Array
Credit: NRAO/AUI/NSF

Astronomers have discovered three brown dwarfs -- enigmatic objects that are neither stars nor planets -- emitting radio waves that scientists cannot explain. The three newly-discovered radio-emitting brown dwarfs were found as part of a systematic study of nearby brown dwarfs using the National Science Foundation's Very Large Array (VLA) radio telescope.

Until 2001, scientists believed that brown dwarfs, which are intermediate in mass between stars and planets, could not emit detectable amounts of radio waves. That year, summer students at the VLA made the first discovery of radio emission from a brown dwarf.

Subsequently, as many as a half- dozen more radio-emitting brown dwarfs were discovered.

"It clearly had become time to make a systematic study and try to find out just what percentage of brown dwarfs are emitting radio waves," said Rachel Osten, an astronomer at the National Radio Astronomy Observatory (NRAO) in Charlottesville, Virginia. Osten was assisted in the project in the summer of 2004 by Lynnae Quick, a student at North Carolina Agricultural and Technical State University; Tim Bastian, also an astronomer at NRAO; and Suzanne Hawley, an astronomer at the University of Washington. The research team presented their results to the American Astronomical Society's meeting in San Diego, CA.

The three new detections of radio-emitting brown dwarfs are just the first results from the systematic study, which aims to observe all the known brown dwarfs within about 45 light-years of Earth. "We want to be able to say definitively just how common radio emission is among brown dwarfs," Osten explained. The study involves observing 65 individual brown dwarfs, so these new detections represent just the beginning of the results expected from the study.

Brown dwarfs are too big to be planets but too small to be true stars, as they have too little mass to trigger hydrogen fusion reactions at their cores, the source of the energy output in larger stars. With roughly 15 to 80 times the mass of Jupiter, the largest planet in our Solar System, brown dwarfs had long been thought to exist, but proved difficult to find. Astronomers found the first brown dwarf in 1995, and a few hundred now are known.

The type of radio emission seen in the brown dwarfs arises in more-massive stars as a result of plasma interacting with the star's magnetic field. However, astronomers have noted that this type of activity

declines in less-massive stars. This is why they expected brown dwarfs, with masses less than that of any star, to lack radio emission.

Surprisingly, based on discoveries since 2001, it now appears that radio-emitting magnetic activity may actually become more common in these very low-mass objects. "We don't have an explanation for this," Osten said.

The scientists hope that brown-dwarf radio emission may give them a new tool for analysis. "Since both stars and the planets in our Solar System produce radio emission, detailed study of the radio emission properties of these brown dwarfs may enable us to distinguish where the boundary between stellar and planetary behavior occurs in these not-quite-stars, not-quite-planets," Osten explained.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

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Radio Telescopes Will Add to Cassini-Huygens Discoveries

When the European Space Agency's Huygens spacecraft makes its plunge into the atmosphere of Saturn's moon Titan on January 14, radio telescopes of the National Science Foundation's National Radio Astronomy Observatory (NRAO) will help international teams of scientists extract the maximum possible amount of irreplaceable information from an experiment unique in human history. Huygens is the 700-pound probe that has accompanied the larger Cassini spacecraft on a mission to thoroughly explore Saturn, its rings and its numerous moons.

The Robert C. Byrd Green Bank Telescope
Credit: NRAO/AUI/NSF

The Robert C. Byrd Green Bank Telescope (GBT) in West Virginia and eight of the ten telescopes of the continent-wide Very Long Baseline Array (VLBA), located at Pie Town and Los Alamos, NM, Fort Davis, TX, North Liberty, IA, Kitt Peak, AZ, Brewster, WA, Owens Valley, CA, and Mauna Kea, HI, will directly receive the faint signal from Huygens during its descent.

Along with other radio telescopes in Australia, Japan, and China, the NRAO facilities will add significantly to the information about Titan and its atmosphere that will be gained from the Huygens mission. A European-led team will use the radio telescopes to make extremely precise measurements of the probe's position during its descent, while a U.S.-led team will concentrate on gathering measurements of the probe's descent speed and the direction of its motion. The radio-telescope measurements will provide data vital to gaining a full understanding of the winds that Huygens encounters in Titan's atmosphere.

Currently, scientists know little about Titan's winds. Data from the Voyager I spacecraft's 1980 flyby indicated that east-west winds may reach 225 mph or more. North-south winds and possible vertical winds, while probably much weaker, may still be significant. There are competing theoretical models of Titan's winds, and the overall picture is best summarized as poorly understood. Predictions of where the Huygens probe will land range from nearly 250 miles east to nearly 125 miles west of the point where its parachute first deploys, depending on which wind model is used. What actually happens to the probe as it makes its parachute descent through Titan's atmosphere will give scientists their best-ever opportunity to learn about Titan's winds.

During its descent, Huygens will transmit data from its onboard sensors to Cassini, the "mother ship" that brought it to Titan. Cassini will then relay the data back to Earth. However, the large radio telescopes will be able to receive the faint (10-watt) signal from Huygens directly, even at a distance of nearly 750 million miles. This will not be done to duplicate the data collection, but to generate new data about Huygens' position and motions through direct measurement.

Measurements of the Doppler shift in the frequency of Huygens' radio signal made from the Cassini spacecraft, in an experiment led by Mike Bird of the University of Bonn, will largely give information about

The VLBA CREDIT: NRAO/AUI/NSF

the speed of Titan's east-west winds. A team led by scientists at NASA's Jet Propulsion Laboratory in Pasadena, CA, will measure the Doppler shift in the probe's signal relative to Earth. These additional Doppler measurements from the Earth-based radio telescopes will provide important data needed to learn about the north-south winds.

"Adding the ground-based telescopes to the experiment will not only help confirm the data we get from the Cassini orbiter but also will allow us to get a much more complete picture of the winds on Titan," said William Folkner, a JPL scientist.

Another team, led by scientists from the Joint Institute for Very Long Baseline Interferometry in Europe (JIVE), in Dwingeloo, The Netherlands, will use a world-wide network of radio telescopes, including the NRAO telescopes, to track the probe's trajectory with unprecedented accuracy. They expect to measure the probe's position within two-thirds of a mile (1 kilometer) at a distance of nearly 750 million miles.

"That's like being able to sit in your back yard and watch the ball in a ping-pong game being played on the Moon," said Leonid Gurvits of JIVE.

Both the JPL and JIVE teams will record the data collected by the radio telescopes and process it later. In the case of the Doppler measurements, some real-time information may be available, depending on the strength of the signal, but the scientists on this team also plan to do their detailed analysis on recorded data.

The JPL team is utilizing special instrumentation from the Deep Space Network called Radio Science Receivers. One will be loaned to the GBT and another to the Parkes radio observatory. "This is the same instrument that allowed us to support the challenging communications during the landing of the Spirit and Opportunity Mars rovers as well as the Cassini Saturn Orbit Insertion when the received radio signal was very weak," said Sami Asmar, the JPL scientist responsible for the data recording.

When the Galileo spacecraft's probe entered Jupiter's atmosphere in 1995, a JPL team used the NSF's Very Large Array (VLA) radio telescope in New Mexico to directly track the probe's signal. Adding the data from the VLA to that experiment dramatically improved the accuracy of the wind-speed measurements.

"The Galileo probe gave us a surprise. Contrary to some predictions, we learned that Jupiter's winds got stronger as we went deeper into its atmosphere. That tells us that those deeper winds are not driven entirely by sunlight, but also by heat coming up from the planet's core. If we get lucky at Titan, we'll get surprises there, too," said Robert Preston, another JPL scientist.

The Huygens probe is a spacecraft built by the European Space Agency (ESA). In addition to the NRAO telescopes, the JPL Doppler Wind Experiment will use the Australia Telescope National Facility and other radio telescopes in Parkes, Mopra, and Ceduna, Australia; Hobart, Tasmania; Urumqi and Shanghai, China; and Kashima, Japan. The positional measurements are a project led by JIVE and involving ESA, the Netherlands Foundation for Research in Astronomy, the University of Bonn, Helsinki University of Technology, JPL, the Australia Telescope National Facility, the National Astronomical Observatories of China, the Shanghai Astronomical Observatory, and the National Institute for Communication Technologies in Kashima, Japan.

The Joint Institute for VLBI in Europe is funded by the national research councils, national facilities and institutes of The Netherlands (NWO and ASTRON), the United Kingdom (PPARC), Italy (CNR), Sweden (Onsala Space Observatory, National Facility), Spain (IGN) and Germany (MPIfR). The European VLBI Network is a joint facility of European, Chinese, South African and other radio astronomy institutes funded

by their national research councils. The Australia Telescope is funded by the Commonwealth of Australia for operation as a National Facility managed by CSIRO.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

November 8, 2004

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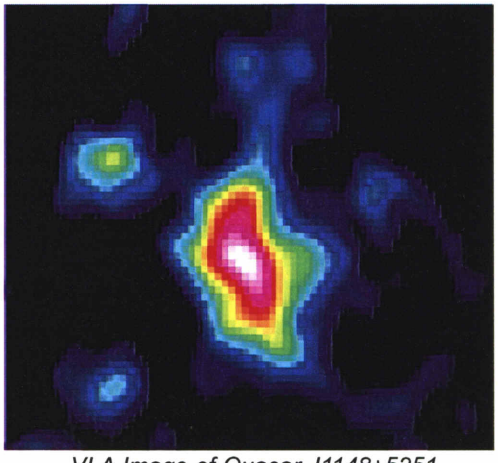
VLA Study Offers Clue to Galaxy Formation

Astronomers using the National Science Foundation's Very Large Array (VLA) radio telescope to study the most distant known quasar have found a tantalizing clue that may answer a long-standing cosmic chicken-and-egg question: which came first, supermassive black holes or giant galaxies?



VLA Image of Quasar J1148+5251
CREDIT: Walter et al., NRAO/AUI/NSF

For years, astronomers have noted a direct relationship between the mass of a galaxy's central, supermassive black hole and the total mass of the "bulge" of stars at its core. The more massive the black hole, the more massive the bulge. Scientists have speculated extensively about whether the black hole or the stellar bulge formed first. Recently, some theories have suggested that the two may form simultaneously.

However, the new VLA observations of a quasar and its host galaxy seen as they were when the Universe was less than a billion years old indicate that the young galaxy has a supermassive black hole but no massive bulge of stars.

"We found a large amount of gas in this young galaxy, and, when we add the mass of this gas to that of the black hole, they add up to nearly the total mass of the entire system. The dynamics of the galaxy imply that there isn't much mass left to make up the size of stellar bulge predicted by current models," said Chris Carilli, of the National Radio Astronomy Observatory (NRAO), in Socorro, NM.

The scientists studied a quasar dubbed J1148+5251, that, at more than 12.8 billion light-years, is the most distant quasar yet found. Discovered in 2003 by the Sloan Digital Sky Survey, J1148+5251 is a young galaxy with a bright quasar core seen as it was when the Universe was only 870 million years old. The Universe now is 13.7 billion years old.

Aiming the VLA at J1148+4241 for about 60 hours, the researchers were able to determine the amount of molecular gas in the system. In addition, they were able to measure the motions of that gas, and thus estimate the total mass of the galactic system. Earlier studies of the system had produced estimates that the black hole was 1 to 5 billion times the mass of our Sun.

The new VLA observations indicate that there are about 10 billion solar masses of molecular gas in the system, and that the system's total mass is 40-50 billion solar masses. The gas and black hole combined thus account for 11-15 billion solar masses out of that total.

"The accepted ratio indicates that a black hole of this mass should be surrounded by a stellar bulge of several trillion solar masses. Our dynamical measurement shows there's not much mass left over, excluding the black hole and the gas, to form a stellar bulge. This provides evidence that the black hole forms before the stellar bulge," said Fabian Walter, of the Max Planck Institute for Radioastronomy in

Heidelberg, Germany, who was a Jansky Postdoctoral Fellow at NRAO in Socorro when the observations were made.

"One example certainly doesn't make the case, but in this object we we apparently have an example of a black hole without much of a stellar bulge. Now we need to make detailed studies of more such objects in the far-distant, early Universe," Carilli said. "With the vastly improved sensitivity of the Expanded VLA and the Atacama Large Millimeter Array (ALMA), which will come on line in a few years, we will have the tools we need to resolve this question definitively," Carilli added.

"Studies like this are the key to understanding how galaxies first formed," Walter said.

Walter and Carilli worked with Frank Bertoldi and Karl Menten of the Max Planck Institute in Bonn; Pierre Cox of the Institute of Space Astrophysics of the University of Paris-South; Fred K.Y. Lo of the NRAO in Charlottesville, VA; Xiahui Fan of the University of Arizona's Steward Observatory; and Michael Strauss of Princeton University, on the project. Their research results are being published in the Astrophysical Journal Letters.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

October 26, 2004

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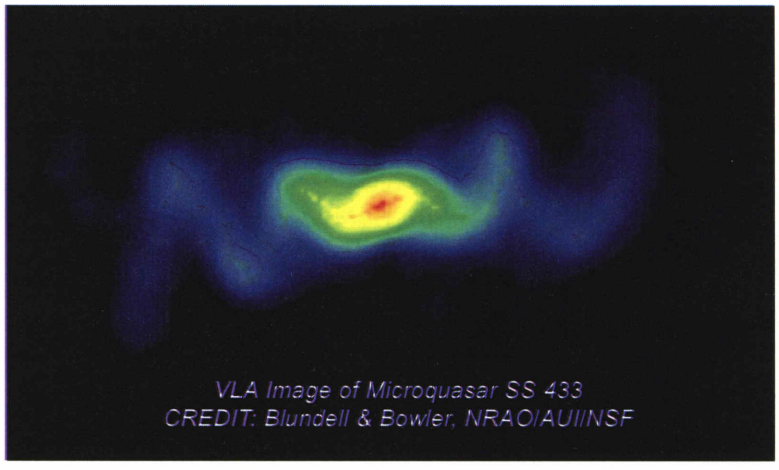
GIGANTIC COSMIC CORKSCREW REVEALS NEW DETAILS ABOUT MYSTERIOUS MICROQUASAR

Making an extra effort to image a faint, gigantic corkscrew traced by fast protons and electrons shot out from a mysterious microquasar paid off for a pair of astrophysicists who gained new insights into the beast's inner workings and also resolved a longstanding dispute over the object's distance.



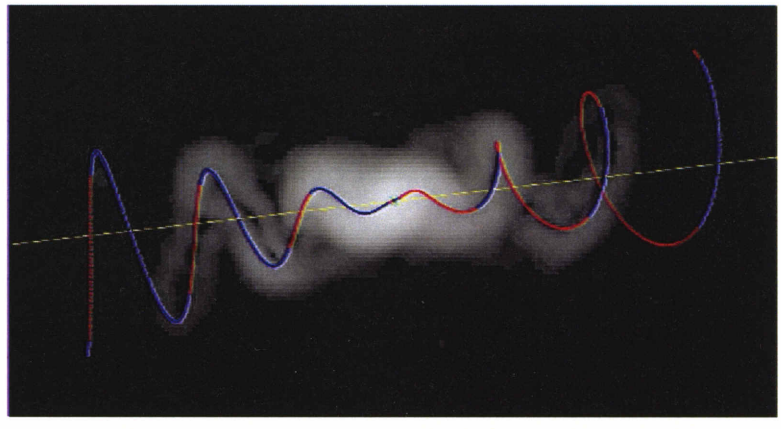
VLA Image of Microquasar SS 433
CREDIT: Blundell & Bowler, NRAO/AUI/NSF

The astrophysicists used the National Science Foundation's Very Large Array (VLA) radio telescope to capture the faintest details yet seen in the plasma jets emerging from the microquasar SS 433, an object once dubbed the "enigma of the century." As a result, they have changed scientists' understanding of the jets and settled the controversy over its distance "beyond all reasonable doubt," they said.

SS 433 is a neutron star or black hole orbited by a "normal" companion star. The powerful gravity of the neutron star or black hole draws material from the stellar wind of its companion into an accretion disk of material tightly circling the dense central object prior to being pulled onto it. This disk propels jets of fast protons and electrons outward from its poles at about a quarter of the speed of light. The disk in SS 433 wobbles like a child's top, causing its jets to trace a corkscrew in the sky every 162 days.

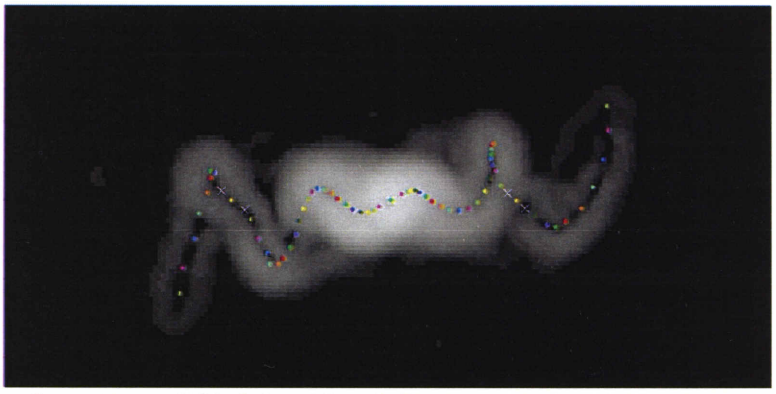
The new VLA study indicates that the speed of the ejected particles varies over time, contrary to the traditional model for SS 433.

"We found that the actual speed varies between 24 percent to 28 percent of light speed, as opposed to staying constant," said Katherine Blundell, of the University of Oxford in the United Kingdom. "Amazingly, the jets going in both directions change their speeds simultaneously, producing identical speeds in both directions at any given time," Blundell added. Blundell worked with Michael Bowler, also of Oxford. The scientists' findings have been accepted by the Astrophysical Journal Letters.



New VLA Image of SS 433: Red-and-Blue Line Shows Path of Constant-Speed Jets. Note Poor Match of Path to Image.
CREDIT: Blundell & Bowler, NRAO/AUI/NSF

The new VLA image shows two full turns of the jets' corkscrew on both sides of the core. Analyzing the image showed that if material came from the core at a constant speed, the jet paths would not accurately match the details of the image.



Same Image, With Colored Beads Representing Particle Ejections at Different Speeds. Particle Path Now Matches. CREDIT: Blundell & Bowler, NRAO/AUI/NSF

"By simulating ejections at varying speeds, we were able to produce an exact match to the observed structure," Blundell explained. The scientists first did their match to one of the jets. "We then were stunned to see that the varying speeds that matched the structure of one jet also exactly reproduced the other jet's path," Blundell said. Matching the speeds in the two jets reproduced the observed structure even allowing for the fact that, because one jet is moving more nearly away from us than the other, it takes light longer to reach us from it, she added.

The astrophysicists speculate that the changes in ejection speed may be caused by changes in the rate at which material is transferred from the companion star onto the accretion disk.

The detailed new VLA image also allowed the astrophysicists to determine that SS 433 is nearly 18,000 light-years distant from Earth. Earlier estimates had the object, in the constellation Aquila, as near as 10,000 light-years. An accurate distance, the scientists said, now allows them to better determine the age of the shell of debris blown out by the supernova explosion that created the dense, compact object in the microquasar. Knowing the distance accurately also allows them to measure the actual brightness of the microquasar's components, and this, they said, improves their understanding of the physical processes at work in the system.

The breakthrough image was made using 10 hours of observing time with the VLA in a configuration that maximizes the VLA's ability to see fine detail. It represents the longest "time exposure" of SS 433 at radio wavelengths, and thus shows the faintest details. It also represents the best such image that can be done with current technology. Because the jets in SS 433 are moving, their image would be "smeared" in a longer observation. In order to see even fainter details in the jets, the astrophysicists must await the greater sensitivity of the Expanded VLA, set to become available in a few years.

SS 433 was the first example of what now are termed microquasars, binary systems with either a neutron star or black hole orbited by another star, and emitting jets of material at high speeds. The strange stellar system received a wealth of media coverage in the late 1970s and early 1980s. A 1981 Sky & Telescope article was entitled, "SS 433 -- Enigma of the Century."

Because microquasars in our own Milky Way Galaxy are thought to produce their high-speed jets of material through processes similar to those that produce jets from the cores of galaxies, the nearby microquasars serve as a convenient "laboratory" for studying the physics of jets. The microquasars are closer and show changes more quickly than their larger cousins.

Katherine Blundell is a University Research Fellow funded by the UK's Royal Society.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

October 20, 2004

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SKY SURVEY PROVIDES NEW RADIO VIEW OF UNIVERSE

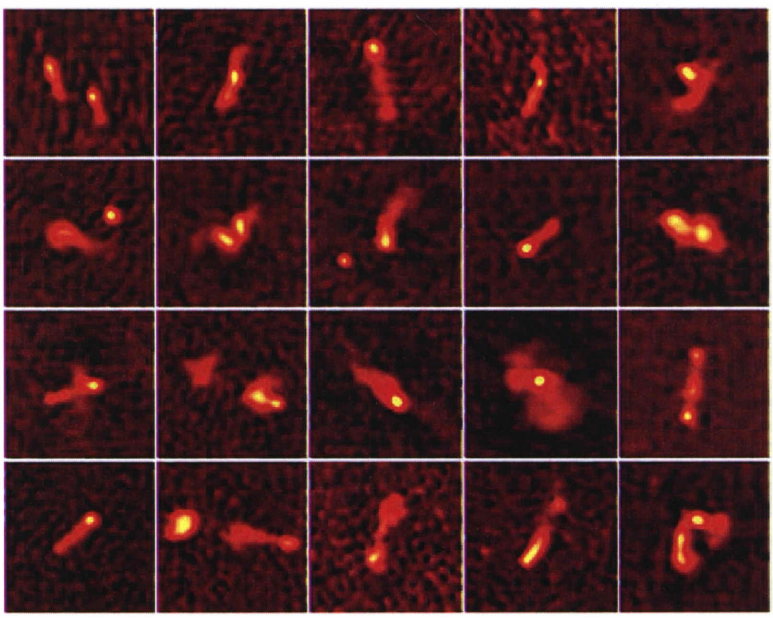
Astronomers using the National Science Foundation's Very Large Array (VLA) have overcome longstanding technical hurdles to map the sky at little-explored radio frequencies that may provide a tantalizing look deep into the early Universe. The scientists have released images and data covering half of the sky visible from the VLA, and hope to complete their survey within a year.
Radio Galaxies

The VLA Low-frequency Sky Survey (VLSS) is producing sky images made at an observing frequency of 74 MHz, a far lower frequency than used for most current radio-astronomy research.

"Because of the Earth's ionosphere, such a low frequency has proven very difficult for high-quality imaging, and it is only in the past few years that we have developed the techniques that make a project like the VLSS possible," said Rick Perley, of the National Radio Astronomy Observatory (NRAO) in Socorro, NM.

Because the high-quality VLSS images will give astronomers a look at the Universe through what essentially is a new "window," they expect the images to reveal some rare and important objects.

"We expect to find very distant radio galaxies -- galaxies spewing jets of material at nearly light speed and powered by supermassive black holes," said Joseph Lazio of the Naval Research Laboratory in Washington, DC. "By determining just how distant these radio galaxies are, we will learn how early the black holes formed in the history of the Universe," he added.



A "rogues' gallery" of radio galaxy types seen in the VLSS. White regions indicate radio-bright emitting regions in the galaxies, while deep red/black indicate regions of little or no radio emission. In all cases, the radio galaxies are thought to shine because of jets of highly relativistic material being shot from the environment of a supermassive black hole in the center of the radio galaxy. The diversity of shapes probably reflects the environment of the radio galaxy itself as well as the history of the supermassive black hole and how much material has fallen into it. A "rogues' gallery" of radio galaxy types seen in the VLSS. CREDIT: NRAO/AUI/NSF

Another tantalizing possibility is that the low-frequency images may reveal "halos" and "relics" produced by collisions of galaxies in clusters. If the halos and relics are found in the distant, and thus early, Universe, it will give scientists important clues about the timetable for formation of large-scale structure. In addition, the astronomers hope that the VLSS images may show previously-undiscovered pulsars -- superdense, spinning neutron stars.

Massive planets -- "super Jupiters" circling stars beyond the Sun -- also might reveal themselves through bursts of radio emission at the frequency of this survey, the astronomers speculated.

Images from the survey are being made available to other scientists as soon as they are completed. The survey will use some 800 hours of VLA observing time. The newly-released images and data are available via the NRAO Web site.

"By doing this survey and making the results available, we are bringing low-frequency radio data, previously quite difficult to produce, to all astronomers in a simple and easy manner," Perley said.

"We also expect that this survey will spur additional research into objects that scientists find puzzling or interesting," Perley saidd. "We really will have to wait for years to know the full scientific benefit of this survey," he said.

In addition to Perley and Lazio, the VLSS team includes James Condon and William Cotton of NRAO; Aaron Cohen and Wendy Lane of the National Research Council and the Naval Research Laboratory; Namir Kassim of the Naval Research Laboratory; and William Erickson of the University of Maryland and University of Tasmania.

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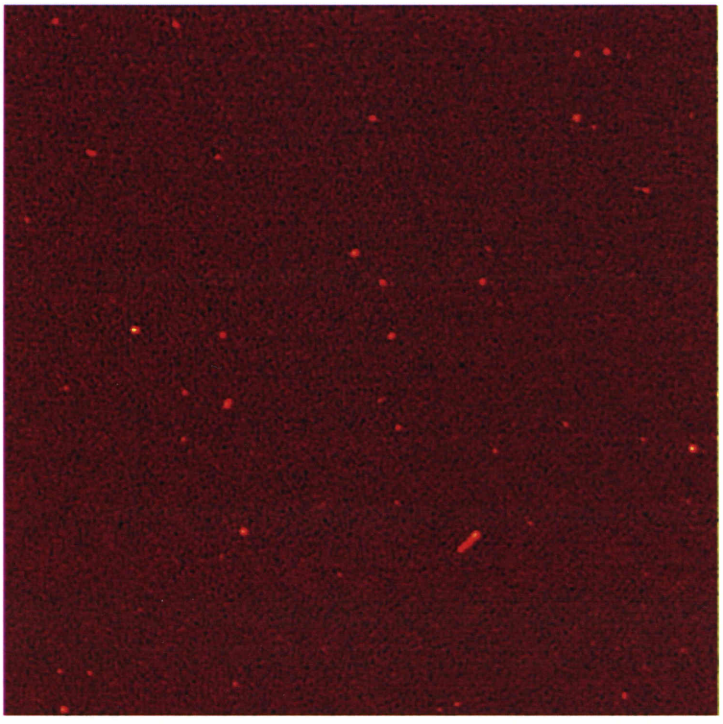

This false color image shows a small portion of the radio sky as seen by the VLA in the VLSS. White regions indicate radio-bright emitting galaxies, while deep red/black indicate regions of little or no radio emission. All of the "spots" in the image are radio-bright galaxies. The extended object in the lower right is a nearby radio galaxy. Its elongated shape results from jets of highly relativistic (moving at nearly the speed of light) material being shot in opposing directions from the environment of a supermassive black hole located near the center of the source. (The supermassive black hole and its environment are not visible in this image.) The typical radio-bright galaxy in this image is only about half-way across the observable Universe, but astronomers are trying to determine if there might be an extremely distant one among the more typical ones. CREDIT: NRAO/AUI/NSF

September 20, 2004

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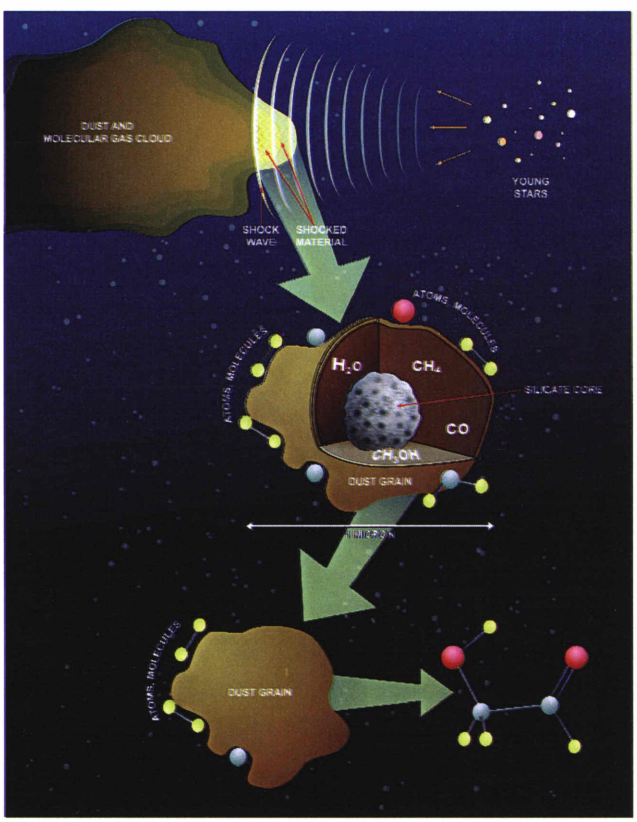
Cold Sugar in Space Provides Clue to the Molecular Origin of Life

Astronomers using the National Science Foundation's giant Robert C. Byrd Green Bank Telescope (GBT) have discovered a frigid reservoir of simple sugar molecules in a cloud of gas and dust some 26,000 light-years away, near the center of our Milky Way Galaxy. The discovery suggests how the molecular building blocks necessary for the creation of life could first form in interstellar space.

The astronomers detected the 8-atom sugar molecule glycolaldehyde in a gas-and-dust cloud called Sagittarius B2. Such clouds, often many light-years across, are the raw material from which new stars and planets are formed. The astronomers detected the same molecule in a warmer part of that cloud in 2000, but the new detection shows that the sugar exists at an extremely low temperature -- only 8 degrees above absolute zero, the temperature at which all molecular motion stops. The cold glycolaldehyde detections were surprisingly strong when compared to the original detections and indicate that a considerable quantity of this simple interstellar sugar exists at extremely low temperatures.

Glycoaldehyde is composed of 2 carbon atoms, 2 oxygen atoms and 4 hydrogen atoms and is called a 2-carbon sugar. Glycolaldehyde can react with a 3-carbon sugar to produce a 5-carbon sugar called ribose. Ribose molecules form the backbone structure of the molecules DNA and RNA, which carry the genetic code of living organisms.

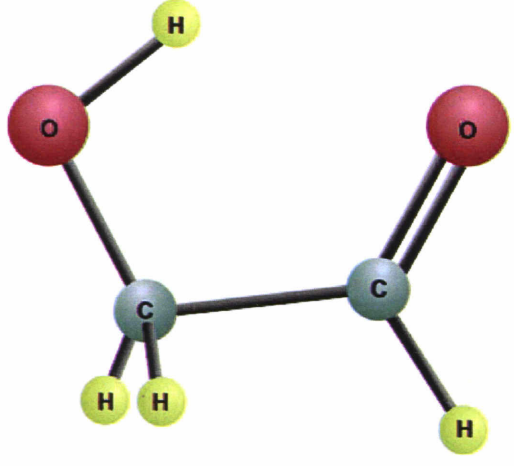
On Earth, most chemical reactions occur in liquid water. Conditions are quite different in interstellar space, and most of the complex molecules appear to form on or under the surfaces of tiny dust grains. In this scenario, smaller molecules such as water, formaldehyde, methane, ammonia, carbon dioxide, or methanol, coat the surfaces and interiors of dust grains in the clouds. When a shock wave, caused by the infall or outflow of material in the star-formation process, hits the dust grains, it provides the energy to assemble more-complex molecules from the simpler ones, and also to free the newly-formed molecules from the dust grains. Once the shock has passed, the molecules cool into a cold, thin gas.



Section of graphic illustrating processes that may produce complex molecules in cold interstellar space. CREDIT: Bill Saxton, NRAO/AUI/NSF

Although the chemistry on Earth and in interstellar clouds is much different, the results can be very similar. This and other recent studies show that prebiotic chemistry -- the formation of the molecular building blocks necessary for the creation of life -- occurs in interstellar clouds long before that cloud collapses to form a new solar system with planets. "Many of the interstellar molecules discovered to date are the same kinds detected in laboratory experiments specifically designed to synthesize prebiotic molecules. This fact suggests a universal prebiotic chemistry," said Jan M. Hollis of NASA's Goddard Space Flight Center in Greenbelt, MD. This suggests that the molecular building blocks for the creation of life on a new planet might get a head start in the dust of interstellar clouds.

The actual formation of a planetary system is such a hot process that any prebiotic molecules would likely be destroyed. However, this study has shown that such molecules may form in very cold regions following the passage of a shock wave. Such conditions might be typical of the outer regions of a young solar system following the star-formation process. A repository of prebiotic molecules might exist in these outer regions, which is also where comets are formed, the scientists said. It has long been suggested that a collision with a comet or an encounter with the passing tail of a comet might "seed" a young planet with prebiotic material.



GLYCOLADEHYDE

CREDIT: Bill Saxton, NRAO/AUI/NSF

Hollis worked with Philip Jewell of the National Radio Astronomy Observatory in Green Bank, WV, Frank Lovas of the National Institute of Standards and Technology in Gaithersburg, MD, and Anthony Remijan of NASA's Goddard Space Flight Center. The scientists reported their findings in the September 20 issue of the Astrophysical Journal Letters.

The discovery of the cold glycolaldehyde was made by detecting faint radio emission from the molecules. Molecules rotate end-for-end. When they change from a higher rotational energy level to a lower energy level, they emit radio waves at precise frequencies. Conversely, they can absorb radio waves at specific frequencies and change from a lower rotational energy level to a higher one. A set of frequencies emitted or absorbed by a particular molecule forms a unique "fingerprint" identifying that molecule. The cold glycolaldehyde was identified both by emission from the molecules and by absorption of radio waves emitted by a background source, all between 13 GHz and 22 GHz in frequency.

"The large diameter and great precision of the GBT made this discovery possible, and also holds the promise of discovering additional new complex interstellar molecules," Jewell said. The GBT, dedicated in 2000, is the world's largest fully- steerable radio-telescope antenna. Its dish reflector has more than 2 acres of signal-collecting area.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

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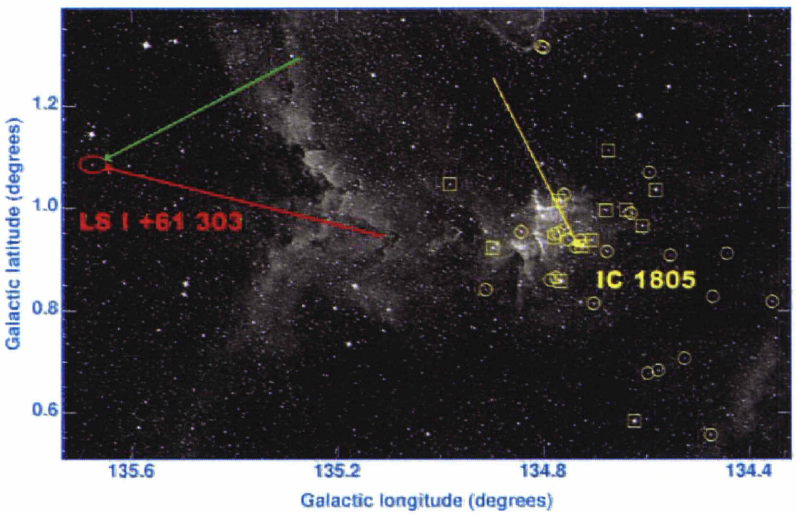
STELLAR PAIR SHOT OUT FROM ITS BIRTHPLACE: ASTRONOMERS LINK MOVING MICROQUASAR TO STAR CLUSTER

Astronomers studying data from the National Science Foundation's Very Long Baseline Array (VLBA) and other telescopes have concluded that a binary pair of stars forming an energetic microquasar was blasted out of the cluster in which it was born by a supernova explosion some 1.7 million years ago. This is the first time that a fast-moving stellar pair has been tracked back to a specific star cluster.



The microquasar, circled in red, and stars of the cluster (yellow) in visible-light image. Green arrow indicates microquasar's motion in sky and yellow arrow indicates star cluster's motion. Red arrow indicates micro-quasar's motion relative to (away from) star cluster. CREDIT: NRAO/AUI/NSF

The scientists analyzed numerous observations of a microquasar called LSI +61 303, and concluded that it is moving away from a star cluster named IC 1805 at nearly 17 miles per second.

A microquasar is a pair of stars, one of which is either a dense neutron star or a black hole, in which material sucked from a "normal" star forms a rapidly-rotating disk around the denser object. The disk becomes so hot it emits X-rays, and also spits out "jets" of subatomic particles at nearly the speed of light.

"In this case, both the microquasar and the star cluster are about 7,500 light-years from Earth and the characteristics of the 'normal' star in the microquasar match those of the other stars in the cluster, so we feel confident that the microquasar was shot out from a birthplace in this cluster," said Felix Mirabel, an astrophysicist at the Institute for Astronomy and Space Physics of Argentina and French Atomic Energy Commission. Mirabel worked with Irapuan Rodrigues, of the Federal University of Rio Grande do Sul, Brazil, and Qingzhong Liu of the Purple Mountain Observatory in Nanjing, China. The astronomers reported their results in the August 1 issue of the scientific journal Astronomy & Astrophysics.

Many neutron stars have been found to be moving rapidly through the sky, leading scientists to conclude that the supernova explosions that produced them were asymmetric, giving a "kick" to the star. LSI +61 303's motion has carried it about 130 light-years from the cluster IC 1805. The cluster is in the constellation Cassiopeia.

LSI +61 303 contains, the astronomers say, either a black hole or a neutron star with twice the mass of the Sun, orbiting a normal star 14 times more massive than the Sun every 26.5 days. The supernova explosion that produced the black hole or neutron star blew away about twice the mass of the Sun.

The black hole or neutron star originally was much more massive than its companion. The scientists still are unsure about how massive it was. Some evidence, they say, indicates that it was formed only four or five million years ago and exploded a million or so years ago. In that case, the star would have been 60 or more times more massive than the Sun, and would have expelled some 90 percent of its initial mass before the supernova explosion.

On the other hand, they say, the star may have formed some 10 million years ago, in which case it would have been 15-20 times more massive than the Sun.

"Studying this system and hopefully others like it that may be found will help us to understand both the evolution of stars before they explode as supernovae and the physics of the supernova explosions themselves," Mirabel said.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

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Fo For Release: Monday, June 21, 2004

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Scientists Discover Two New Interstellar Molecules: Point to Probable Pathways for Chemical Evolution in Space

A team of scientists using the National Science Foundation's Robert C. Byrd Green Bank Telescope (GBT) has discovered two new molecules in an interstellar cloud near the center of the Milky Way Galaxy. This discovery is the GBT's first detection of new molecules, and is already helping astronomers better understand the complex processes by which large molecules form in space.

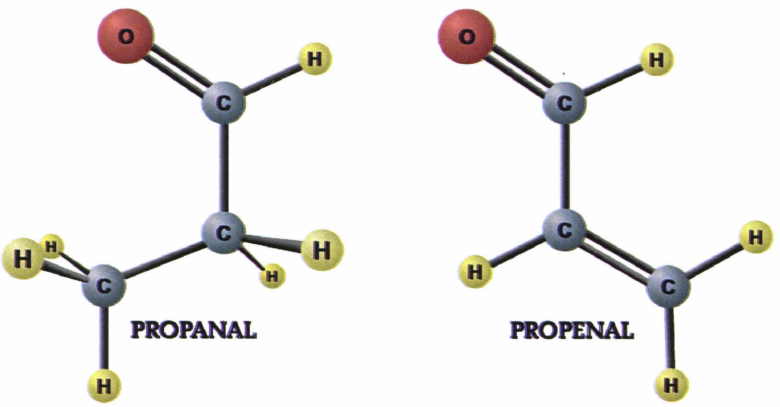

Diagram of the 10-atom molecule propanal and the 8-atom molecule propenal. CREDIT: NRAO/AUI/NSF

The 8-atom molecule propenal and the 10-atom molecule propanal were detected in a large cloud of gas and dust some 26,000 light-years away in an area known as Sagittarius B2. Such clouds, often many light-years across, are the raw material from which new stars are formed.

"Though very rarefied by Earth standards, these interstellar clouds are the sites of complex chemical reactions that occur over hundreds-of-thousands or millions of years," said Jan M. Hollis of the NASA Goddard Space Flight Center in Greenbelt, Md. "Over time, more and more complex molecules can be formed in these clouds. At present, however, there is no accepted theory addressing how interstellar molecules containing more than 5 atoms are formed."

So far, about 130 different molecules have been discovered in interstellar clouds. Most of these molecules contain a small number of atoms, and only a few molecules with eight or more atoms have been found in interstellar clouds. Each time a new molecule is discovered, it helps to

constrain the formation chemistry and the nature of interstellar dust grains, which are believed to be the formation sites of most complex interstellar molecules.

Hollis collaborated with Anthony Remijan, also of NASA Goddard; Frank J. Lovas of the National Institute of Standards and Technology in Gaithersburg, Md.; Harald Mollendal of the University of Oslo, Norway; and Philip R. Jewell of the National Radio Astronomy Observatory (NRAO) in Green Bank, W.Va. Their results were accepted for publication in the Astrophysical Journal Letters.

In the GBT experiment, three aldehyde molecules were observed and appear to be related by simple hydrogen addition reactions, which probably occur on the surface of interstellar grains. An aldehyde is a molecule that contains the aldehyde group (CHO): a carbon atom singly bonded to a hydrogen atom and double-bonded to an oxygen atom; the remaining bond on that same carbon atom bonds to the rest of the molecule.

Starting with previously reported propynal (HC2CHO), propenal (CH2CHCHO) is formed by adding two hydrogen atoms. By the same process propanal (CH3CH2CHO) is formed from propenal.

After these molecules are formed on interstellar dust grains, they may be ejected as a diffuse gas. If enough molecules accumulate in the gas, they can be detected with a radio telescope. As the molecules rotate end-for-end, they change from one rotational energy state to another, emitting radio waves at precise frequencies. The "family" of radio frequencies emitted by a particular molecule forms a unique "fingerprint" that scientists can use to identify that molecule. The scientists identified the two new aldehydes by detecting a number of frequencies of radio emission in what is termed the K-band region (18 to 26 GHz) of the electromagnetic spectrum.

"Interstellar molecules are identified by means of the frequencies that are unique to the rotational spectrum of each molecule," said Lovas. "These are either directly measured in the laboratory or calculated from the measured data. In this case we used the calculated spectral frequencies based on an analysis of the literature data."

Complex molecules in space are of interest for many reasons, including their possible connection to the formation of biologically significant molecules on the early Earth. Complex molecules might have formed on the early Earth, or they might have first formed in interstellar clouds and been transported to the surface of the Earth.

Molecules with the aldehyde group are particularly interesting since several biologically significant molecules, including a family of sugar molecules, are aldehydes.

"The GBT can be used to fully explore the possibility that a significant amount of prebiotic chemistry may occur in space long before it occurs on a newly formed planet," said Remijan. "Comets form from interstellar clouds and incessantly bombard a newly formed planet early in its history. Craters on our Moon attest to this. Thus, comets may be the delivery vehicles for organic molecules necessary for life to begin on a new planet."

Laboratory experiments also demonstrate that atomic addition reactions -- similar to those assumed to occur in interstellar clouds -- play a role in synthesizing complex molecules by subjecting ices containing simpler molecules such as water, carbon dioxide, and methanol to ionizing radiation dosages. Thus, laboratory experiments can now be devised with various ice components to attempt production of the aldehydes observed with the GBT.

“The detection of the two new aldehydes, which are related by a common chemical pathway called hydrogen addition, demonstrates that evolution to more complex species occurs routinely in interstellar clouds and that a relatively simple mechanism may build large molecules out of smaller ones. The GBT is now a key instrument in exploring chemical evolution in space," said Hollis.

The GBT is the world's largest fully steerable radio telescope; it is operated by the NRAO.

"The large diameter and high precision of the GBT allowed us to study small interstellar clouds that can absorb the radiation from a bright, background source. The sensitivity and flexibility of the telescope gave us an important new tool for the study of complex interstellar molecules," said Jewell.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

June 10, 2004

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RADIO TELESCOPES REVEAL YOUNGEST STELLAR CORPSE

Astronomers using a global combination of radio telescopes to study a stellar explosion some 30 million light-years from Earth have likely discovered either the youngest black hole or the youngest neutron star known in the Universe. Their discovery also marks the first time that a black hole or neutron star has been found associated with a supernova that has been seen to explode since the invention of the telescope nearly 400 years ago.

An artist's impression of Supernova 1986J. The newly discovered nebula around the black hole or neutron star in the center is shown in blue, and is in the center of the expanding, fragmented shell of material thrown off in the supernova explosion, which is shown in red. CREDIT: Norbert Bartel and Michael F. Bietenholz, York University; Artist: G. Arguner

A supernova is the explosion of a massive star after it exhausts its supply of nuclear fuel and collapses violently, rebounding in a cataclysmic blast that spews most of its material into interstellar space. What remains is either a neutron star, with its material compressed to the density of an atomic nucleus, or a black hole, with its matter compressed so tightly that its gravitational pull is so strong that not even light can escape it.

A team of scientists studied a supernova called SN 1986J in a galaxy known as NGC 891. The supernova was discovered in 1986, but astronomers believe the explosion actually occurred about three years before. Using the National Science Foundation's Very Long Baseline Array (VLBA), Robert C. Byrd Green Bank Telescope (GBT), and Very Large Array (VLA), along with radio telescopes from the European VLBI Network, they made images that showed fine details of how the explosion evolves over time.

"SN 1986J has shown a brightly-emitting object at its center that only became visible recently. This is the first time such a thing has been seen in any supernova," said Michael Bietenholz, of York University in Toronto, Ontario. Bietenholz worked with Norbert Bartel, also of York University, and Michael Rupen of the National Radio Astronomy Observatory (NRAO) in Socorro, New Mexico, on the project. The scientists reported their findings in the June 10 edition of Science Express.

"A supernova is likely the most energetic single event in the Universe after the Big Bang. It is just fascinating to see how the smoke from the explosion is blown away and how now after all these years the fiery center is unveiled. It is a textbook story, now witnessed for the first time," Bartel said.

Analysis of the bright central object shows that its characteristics are different from the outer shell of explosion debris in the supernova.

"We can't yet tell if this bright object at the center is caused by material being sucked into a black hole or if it results from the action of a young pulsar, or neutron star," said Rupen.

"It's very exciting because it's either the youngest black hole or the youngest neutron star anybody has ever seen," Rupen said. The youngest pulsar found to date is 822 years old.

Finding the young object is only the beginning of the scientific excitement, the astronomers say.

"We'll be watching it over the coming years. First, we hope to find out whether it's a black hole or a neutron star. Next, whichever it is, it's going to give us a whole new view of how these things start and develop over time," Rupen said.

For example, Rupen explained, if the object is a young pulsar, learning the rate at which it is spinning and the strength of its magnetic field would be extremely important for understanding the physics of pulsars.

The scientists point out that it will be important to observe SN 1986J at many wavelengths, not just radio, but also in visible light, infrared and others.

In addition, the astronomers also now want to look for simiilar objects elsewhere in the Universe.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

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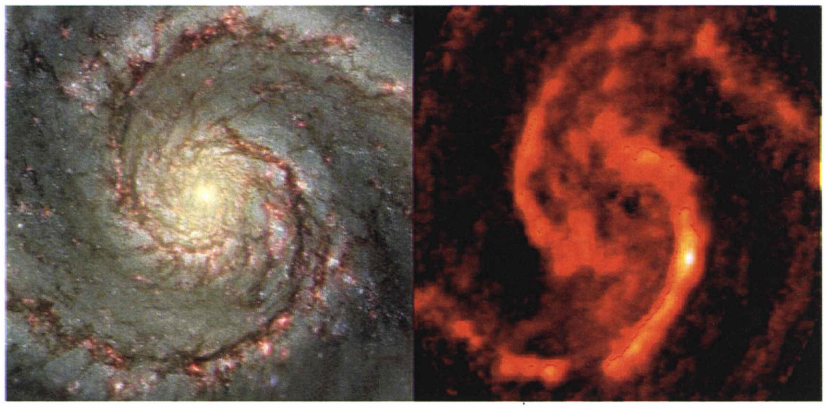
GAS CLOUDS IN WHIRLPOOL GALAXY YIELD IMPORTANT CLUES SUPPORTING THEORY ON SPIRAL ARMS

Astronomers studying gas clouds in the famous Whirlpool Galaxy have found important clues supporting a theory that seeks to explain how the spectacular spiral arms of galaxies can persist for billions of years. The astronomers applied techniques used to study similar gas clouds in our own Milky Way to those in the spiral arms of a neighbor galaxy for the first time, and their results bolster a theory first proposed in 1964.



The spiral galaxy M51: Left, as seen with the Hubble Space Telescope; Right, radio image showing location of Carbon Monoxide gas.
CREDIT: STScI, OVRO, IRAM

The Whirlpool Galaxy, about 31 million light-years distant, is a beautiful spiral in the constellation Canes Venatici. Also known as M51, it is seen nearly face-on from Earth and is familiar to amateur astronomers and has been featured in countless posters, books and magazine articles.

"This galaxy made a great target for our study of spiral arms and how star formation works along them," said Eva Schinnerer, of the National Radio Astronomy Observatory in Socorro, NM. "It was ideal for us because it's one of the closest face-on spirals in the sky," she added.

Schinnerer worked with Axel Weiss of the Institute for Millimeter Radio Astronomy (IRAM) in Spain, Susanne Aalto of the Onsala Space Observatory in Sweden, and Nick Scoville of Caltech. The astronomers presented their findings to the American Astronomical Society's meeting in Denver, Colorado.

The scientists analyzed radio emission from Carbon Monoxide (CO) molecules in giant gas clouds along M51's spiral arms. Using telescopes at Caltech's Owens Valley Radio Observatory and the 30-meter radio telescope of IRAM, they were able to determine the temperatures and amounts of turbulence within the clouds. Their results provide strong support for a theory that "density waves" explain how spiral arms can persist in a galaxy without winding themselves so tightly that, in effect, they disappear.

The density-wave theory, proposed by Frank Shu and C.C. Lin in 1964, says that a galaxy's spiral pattern is a wave of higher density, or compression, that revolves around the galaxy at a speed different from that of the galaxy's gas and stars. Schinnerer and her colleagues studied a region in one of M51's spiral arms that presumably has just overtaken and passed through the density wave.

Their data indicate that gas on the trailing edge of the spiral arm, which has most recently passed through the density wave, is both warmer and more turbulent than gas in the forward edge of the arm, which would have passed through the density wave longer ago.

"This is what we would expect from the density-wave theory," Schinnerer said. "The gas that passed through the density wave earlier has had time to cool and lose the turbulence caused by the passage," she added.

"Our results show, for the first time, how the density wave operates on a cloud-cloud scale, and how it promotes and prevents star formation in spiral arms," Aalto said.

The next step, the scientists say, is to look at other spiral galaxies to see if a similar pattern is present. That will have to wait, Schinnerer said, because the radio emission from CO molecules that provides the information on temperature and turbulence is very faint.

"When the Atacama Large Millimeter Array (ALMA) comes on line, it will have the ability to extend this type of study to other galaxies. We look forward to using ALMA to test the density-wave model more thoroughly," Schinnerer said. ALMA is a millimeter-wave observatory that will use 64, 12-meter-diameter dish antennas on the Atacama Desert of northern Chile. Now under construction, ALMA will provide astronomers with an unprecedented capability to study the Universe at millimeter wavelengths.

The Whirlpool Galaxy was discovered by the French comet-hunter Charles Messier on October 13, 1773. He included it as object number 51 in his now-famous catalog of astronomical objects that, in a small telescope, might be mistaken for a comet. In 1845, the British astronomer Lord Rosse discovered the spiral structure in the galaxy. For amateur astronomers using telescopes in dark-sky locations, M51 is a showpiece object.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

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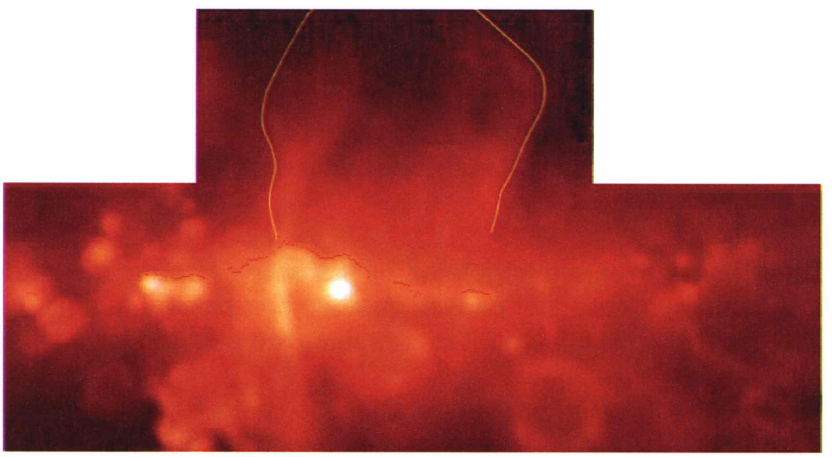
STARBURST-DRIVEN WINDS MAY HAVE CREATED GIANT "LOBE" IN GALACTIC CENTER

An astronomer using the National Science Foundation's Robert C. Byrd Green Bank Telescope (GBT) has discovered that two prominent features rising out of the center of the Milky Way Galaxy are actually the distant edges of the same superstructure. This object, which has the appearance of a "lobe," may have been formed during an epoch of furious star formation.



This is an image of radio emission from the central two hundred light years of the Galaxy. The two added lines highlight the brightest parts of the Galactic center "lobe", a 100-light-year loop-like structure that spans the very center of the Galaxy. Star-forming regions, supernovae, and other objects are distributed horizontally along the center of the image; the massive black hole, Sgr A, is the brightest point near the center of the image. (NRAO/AUI/NSF, Cotton, Law, Maddalena, Yusef-Zadeh, Roberts, Hewitt)*

Astronomer Casey Law of Northwestern University presented his results at the Denver, Colorado, meeting of the American Astronomical Society (AAS).

"The center of our Galaxy is an incredibly dynamic place and morphologically very difficult to untangle" said Law. "Among the many features we see there, including supernova remnants, hot star-forming regions, and massive molecular clouds, are two very prominent columns of radio-emitting material that seem to erupt out of the plane of the Galaxy. The nature and origin of these features have been the subjects of much speculation, but with the new data from the Green Bank Telescope we're finally able to discern that they are in fact part of the same superstructure."

Much of what we know about the center of our Galaxy has come from studies conducted on radio telescopes. The center of the Milky Way is, in fact, hidden from view to optical telescopes due to intervening clouds of dust and gas. Radio waves, however, are able to pass through the obscuring material and reveal details about the core of our Galaxy.

Astronomers now know that this area of the Milky Way — approximately 26,000 light-years from Earth — is a densely packed region brimming with hot, young stars, supernova remnants, and more esoteric features — like long radio-emitting filaments. At the center of it all is a remarkably radio-bright region known as Sagittarius A* (pronounced A-star), which is known to contain a supermassive black hole. Deciphering what all these features are and how they are formed are particularly difficult tasks.

To help better understand the nature and possible connection of the columns in this study, Law studied data taken by a team of astronomers who used the GBT to create what is being called "the best single-dish survey of the Galactic center." The team made several maps of the Galactic center at multiple wavelengths, from as short as 3.6 centimeters to as long as 90 centimeters.

By comparing an object at multiple radio frequencies (known as the spectral index), astronomers can produce a more complete picture of that object and also determine how the radio waves were produced.

Hot bodies, such as stellar nurseries and even our Sun, generate radio waves across the radio spectrum. This is known as thermal emission, and it is characterized by stronger emission at shorter wavelengths.

Other radio waves are generated by the acceleration of electrons within a magnetic field, which is the same process that causes quasars and pulsars to emit radio waves. This is known as non- thermal emission and it is characterized by stronger emission at longer wavelengths.

"By looking at the features in the Galactic center at multiple frequencies," said Farhad Yusef-Zadeh of Northwestern University and a member of the observation team, "we can not only distinguish between thermal and non-thermal processes, but we can also compare and contrast different features to see if they are related."

In looking at the lobe, which rises approximately 450 light-years above the Galactic center, Law determined that the spectral index of both sides of the lobe matched almost identically.

"Early radio surveys of the galactic center suggested that the two columns eventually connected above the plane of the galaxy," said Law. "But the clear correlation we now see between these two distant features strongly suggests that they are part of the same structure and produced by the same process."

One of the leading explanations of how these features were produced is by a wind of energetic particles driven by an epoch of starburst near the Galactic center.

Law speculates that approximately 10 million years ago, there was a furious period of star formation, with many stars being born and quickly dying in a series of supernovae.

"At that time, something caused an acceleration of star formation near the very center of our Galaxy that thrust this material out of the plane of the Galaxy. The hot, young stars would have generated a lot of wind, and the supernovae would have contributed more energy," added Law. "This collective energy would have blown a lot of gas out of the disk for an extended period, eventually producing the features we see today."

As the hot gas and particles shot out of the plane they would have "shocked" or energized the gas in the interstellar medium, which would have concentrated and amplified the ambient magnetic fields. The magnetic fields would then have accelerated electrons in the interstellar medium, producing the non-thermal radio profiles of the lobe.

Earlier work done by other researchers estimates that this feature could contain approximately 5,000,000 solar masses of material, and that — in the starburst model — it would take the energy of possibly 10,000 supernovae to eject that amount of material out of the plane of the Galaxy and produce the feature seen in the lobe.

In addition to Law and Yusef-Zadeh, the team that conducted the multiwavelength GBT survey included Douglas Roberts and Jack Hewitt of Northwestern University, and William Cotton and Ron Maddalena of the National Radio Astronomy Observatory.

The GBT is the world's largest fully steerable radio telescope.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under a cooperative agreement with Associated Universities, Inc.

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EDITORS: An electronic version of this release, with images of the Galactic center with and without outlines, is located at: http://www.nrao.edu/pr/2004/GBTlobe/

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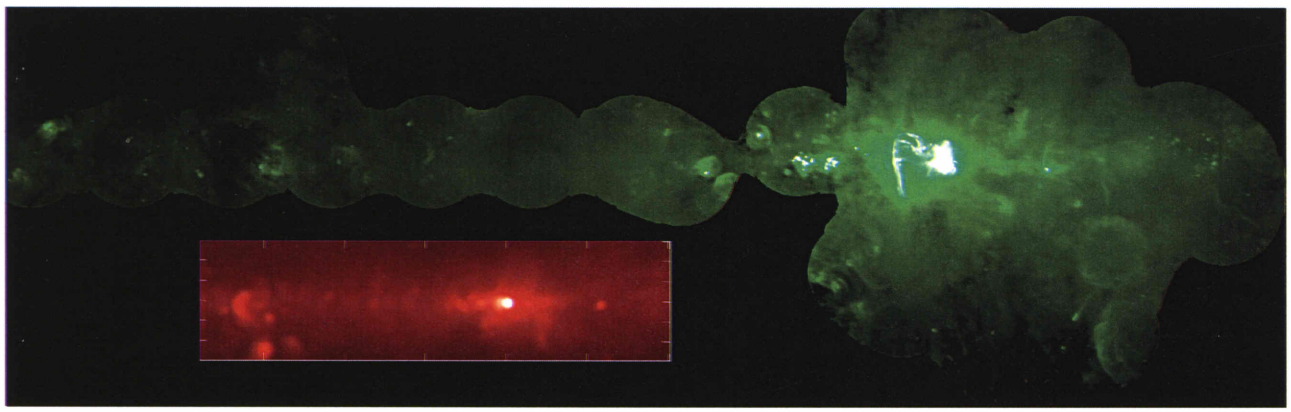
ORIGIN OF ENIGMATIC GALACTIC-CENTER FILAMENTS REVEALED

Twenty years ago, astronomers discovered a number of enigmatic radio-emitting filaments concentrated near the center of the Milky Way Galaxy. These features initially defied explanation, but a new study of radio images of the Galactic center may point to their possible source.

By combining data from the National Science Foundation's Very Large Array (VLA) and Robert C. Byrd Green Bank Telescope (GBT) astronomer Farhad Yusef-Zadeh of Northwestern University has found evidence that at least some of the filaments spring from the concentrated star-formation regions that populate the Galactic center.

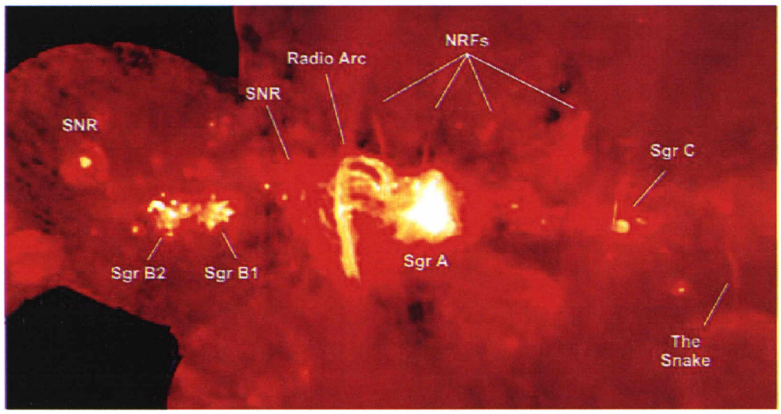


Combined VLA and GBT image (green) of the Galactic center, with red inset of GBT data only (red). Bright region on right is location of supermassive black hole. Linear filaments are visible above this area. (NRAO/AUI/NSF Yusef-Zadeh, et. al.)

Yusef-Zadeh presented his findings at the Denver, Colorado, meeting of the American Astronomical Society (AAS). William Cotton of the National Radio Astronomy Observatory (NRAO) in Charlottesville, Virginia, and William Hewitt of Northwestern University also contributed to this research.

"Astronomers have long puzzled over the cause of these striking features," said Yusef-Zadeh, "and the turbulent nature of the Galactic center has made detailed analysis difficult. With new

multi-wavelength radio images of the Galactic center, however, we can finally see a link between areas of starburst activity and these long-linear filaments."



Combined radio image from the Very Large Array and Green Bank Telescope. The linear features near the top are some of the nonthermal radio filaments (NRFs) studied by the researchers. Other features, such as supernova remnants (SNR) and the area surrounding our Galaxy's supermassive black hole (Sgr A) are shown. (NRAO/AUI/NSF Yusef-Zadeh, et al.)

The filaments, which range from 10 to 100 light-years in length and are perhaps little more than 1 to 3 light-years across, occur only in a very narrow area, within approximately two degrees of the Galactic center (which translates to approximately 900 light-years across).

Early theories about the origin of these filaments suggest that they were somehow related to the Milky Way's own magnetic field. This was due to the fact that the first filaments detected were oriented perpendicular to the plane of the Galaxy, which would have aligned them with the Galaxy's own magnetic field.

"The problem with this hypothesis is that more recent images have revealed a population of weaker filaments oriented randomly in relation to the plane of the Galaxy," said Yusef-Zadeh. "This makes it difficult to explain the origin of the filaments by an organized Galactic magnetic field."

In March and June of 2004, a team of astronomers using the GBT made images of the Galactic center at various wavelengths. The purpose of these surveys was to help identify radio featured produced by hot gas (thermal emission) and those produced in magnetic fields (non-thermal emission). In general, thermal features radiate more strongly at shorter wavelengths and non-thermal at longer wavelengths.

By comparing the GBT images with earlier VLA data taken of the same region, Yusef-Zadeh determined that a number of the non-thermal filaments seemed to connect to concentrated areas of thermal emission, which identify pockets of star formation.

"What this showed us is that two seemingly disparate processes, thermal and non-thermal radio emission, can be created by the very same phenomenon," said Yusef-Zadeh. "In this case, that phenomenon is pockets of starburst activity."

Yusef-Zadeh notes that the exact mechanism for how the areas of starburst generate the magnetic fields is still being investigated. "There are many ideas about the mechanism that generates these filaments," added Yusef-Zadeh, "but one possibility is that they are produced by the collision of winds blown off from individual stars."

The star-forming regions associated with the filaments may contain about 100 massive stars each.

The center of the Milky Way Galaxy is shrouded from optical telescopes by dense clouds of dust and gas. Radio telescopes, however, are able to pierce through the optical veil and see the features within. Concealed at the very heart of our Galaxy is a supermassive black hole. Known as Sagittarius A* (pronounced A-star), this area is a very powerful source of radio waves and was first detected by Karl Jansky in 1932.

While the VLA can image fine scale structures with great precision, it can not always detect extended radio emission. The GBT, however, can help fill in the gaps. Together, they create a more complete image than either instrument could produce separately. "The ability to combine the data from the two telescopes," said Cotton, "gives us a very powerful tool for understanding how the smallest features relate to the overall structure. This is particularly important when you want to study an area like the center of our Galaxy."

In addition to Yusef-Zadeh, Hewitt, and Cotton, the GBT survey was conducted by Casey Law and Douglas Roberts of Northwestern University; and Ron Maddalena of the National Radio Astronomy Observatory.

The VLA is a single radio telescope made up of 27 separate antennas located on the Plains of San Agustin near Socorro, New Mexico. The GBT is the world's largest fully steerable radio telescope, and it is located in Green Bank, West Virginia. Both telescopes are operated by the NRAO.

The NRAO is a facility of the National Science Foundation, and operated under a cooperative agreement by Associated Universities, Inc.

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Editors: An electronic version of this release and images are located at:
www.nrao.edu/pr/2004/filaments/

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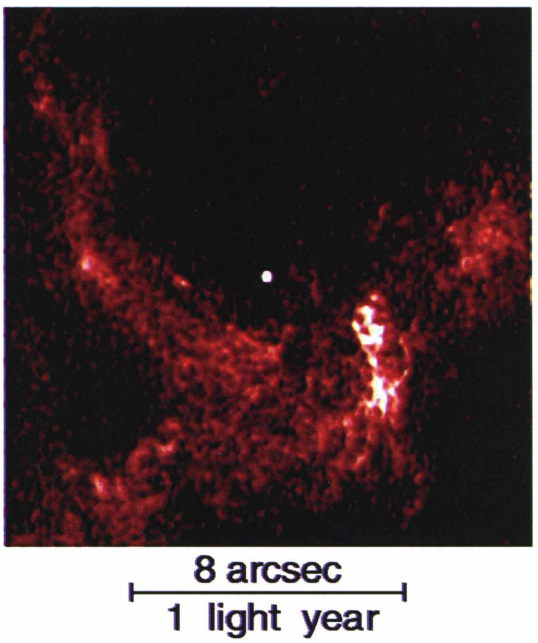
RADIO ASTRONOMERS LIFT "FOG" ON MILKY WAY'S DARK HEART: BLACK HOLE FITS INSIDE EARTH'S ORBIT

Thirty years after astronomers discovered the mysterious object at the exact center of our Milky Way Galaxy, an international team of scientists has finally succeeded in directly measuring the size of that object, which surrounds a black hole nearly four million times more massive than the Sun. This is the closest telescopic approach to a black hole so far and puts a major frontier of astrophysics within reach of future observations. The scientists used the National Science Foundation's Very Long Baseline Array (VLBA) radio telescope to make the breakthrough.

"This is a big step forward," said Geoffrey Bower, of the University of California-Berkeley. "This is something that people have wanted to do for 30 years," since the Galactic center object, called Sagittarius A* (pronounced "A-star"), was discovered in 1974. The astronomers reported their research in the April 1 edition of Science Express.

"Now we have a size for the object, but the mystery about its exact nature still remains," Bower added. The next step, he explained, is to learn its shape, "so we can tell if it is jets, a thin disk, or a spherical cloud."



The Milky Way's nucleus,as seen with the VLA. Sagittarius A is the bright white dot at center. CREDIT: NRAO/AUI/NSF, Jun-Hui Zhao, W.M. Goss*

The Milky Way's center, 26,000 light-years from Earth, is obscured by dust, so visible-light telescopes cannot study the object. While radio waves from the Galaxy's central region can penetrate the dust, they are scattered by turbulent charged plasma in the space along the line of sight to Earth. This scattering had frustrated earlier attempts to measure the size of the central object, just as fog blurs the glare of distant lighthouses.

"After 30 years, radio telescopes finally have lifted the fog and we can see what is going on," said Heino Falcke, of the Westerbork Radio Observatory in the Netherlands, another member of the research team.

The bright, radio-emitting object would fit neatly just inside the path of the Earth's orbit around the Sun, the astronomers said. The black hole itself, they calculate, is about 14 million miles across, and would fit easily inside the orbit of Mercury. Black holes are concentrations of matter so dense that not even light can escape their powerful gravity.

The new VLBA observations provided astronomers their best look yet at a black hole system. "We are much closer to seeing the effects of a black hole on its environment here than anywhere else," Bower said.

The Milky Way's central black hole, like its more-massive cousins in more-active galactic nuclei, is believed to be drawing in material from its surroundings, and in the process powering the emission of the radio waves. While the new VLBA observations have not provided a final answer on the nature of this process, they have helped rule out some theories, Bower said. Based on the latest work, he explained, the top remaining theories for the nature of the radio- emitting object are jets of subatomic particles, similar to those seen in radio galaxies; and some theories involving matter being accelerated near the edge of the black hole.

As the astronomers studied Sagittarius A* at higher and higher radio frequencies, the apparent size of the object became smaller. This fact, too, Bower said, helped rule out some ideas of the object's nature. The decrease in observed size with increasing frequency, or shorter wavelength, also gives the astronomers a tantalizing target.

"We think we can eventually observe at short enough wavelengths that we will see a cutoff when we reach the size of the black hole itself," Bower said. In addition, he said, "in future observations, we hope to see a 'shadow' cast by a gravitational lensing effect of the very strong gravity of the black hole."

In 2000, Falcke and his colleagues proposed such an observation on theoretical grounds, and it now seems feasible. "Imaging the shadow of the black hole's event horizon is now within our reach, if we work hard enough in the coming years," Falcke added.

Another conclusion the scientists reached is that "the total mass of the black hole is very concentrated," according to Bower. The new VLBA observations provide, he said, the "most precise localization of the mass of a supermassive black hole ever." The precision of these observations allows the scientists to say that a mass of at least 40,000 Suns has to reside in a space corresponding to the size of the Earth's orbit. However, that figure represents only a lower limit on the mass. Most likely, the scientists believe, all the black hole's mass -- equal to four million Suns -- is concentrated well inside the area engulfed by the radio-emitting object.

To make their measurement, the astronomers had to go to painstaking lengths to circumvent the scattering effect of the plasma "fog" between Sagittarius A* and Earth. "We had to push our technique really hard," Bower said.

Bower likened the task to "trying to see your yellow rubber duckie through the frosted glass of the shower stall." By making many observations, only keeping the highest-quality data, and mathematically removing the scattering effect of the plasma, the scientists succeeded in making the first-ever measurement of Sagittarius A*'s size.

The VLBA
CREDIT: NRAO/AUI/NSF

In addition to Bower and Falcke, the research team includes Robin Herrnstein of Columbia University, Jun-Hui Zhao of the Harvard-Smithsonian Center for Astrophysics, Miller Goss of the National Radio Astronomy Observatory, and Donald Backer of the University of California-Berkeley. Falcke also is an adjunct professor at the University of Nijmegen and a visiting scientist at the Max-Planck Institute for Radioastronomy in Bonn, Germany.

Sagittarius A* was discovered in February of 1974 by Bruce Balick, now at the University of Washington, and Robert Brown, now director of the National Astronomy and Ionospheric Center at Cornell University. It has been shown conclusively to be the center of the Milky Way, around which the rest of the Galaxy rotates. In 1999, Mark Reid of the

Harvard-Smithsonian Center for Astrophysics and his colleagues used VLBA observations of Sagittarius A* to detect the Earth's motion in orbit around the Galaxy's center and determined that our Solar System takes 226 million years to make one circuit around the Galaxy.

In March 2004, 55 astronomers gathered at the National Radio Astronomy Observatory facility in Green Bank, West Virginia, for a scientific conference celebrating the discovery of Sagittarius A* at Green Bank 30 years ago. At this conference, the scientists unveiled a commemorative plaque on one of the discovery telescopes.

The Very Long Baseline Array, part of the National Radio Astronomy Observatory, is a continent-wide radio-telescope system, with 10, 240-ton dish antennas ranging from Hawaii to the Caribbean. It provides the greatest resolving power, or ability to see fine detail, of any telescope in astronomy, on Earth or in space.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

February 3, 2004

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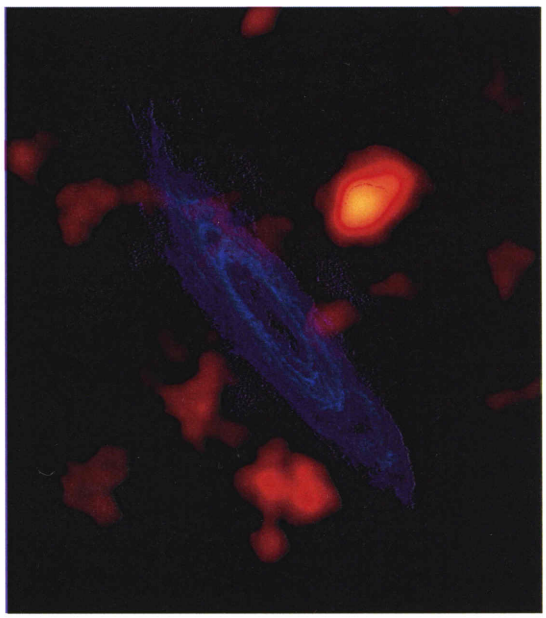
GALACTIC BUILDING BLOCKS SEEN SWARMING AROUND ANDROMEDA

Green Bank, WV - A team of astronomers using the National Science Foundation's Robert C. Byrd Green Bank Telescope (GBT) has made the first conclusive detection of what appear to be the leftover building blocks of galaxy formation -- neutral hydrogen clouds -- swarming around the Andromeda Galaxy, the nearest large spiral galaxy to the Milky Way.



This image depicts several long-sought galactic "building blocks" in orbit of the Andromeda Galaxy (M31). The newfound hydrogen clouds are depicted in a shade of orange (GBT), while gas that comprises the massive hydrogen disk of Andromeda is shown at high-resolution in blue (Westerbork Sythesis Radio Telescope). CREDIT: NRAO/AUI/NSF, WSRT

This discovery may help scientists understand the structure and evolution of the Milky Way and all spiral galaxies. It also may help explain why certain young stars in mature galaxies are surprisingly bereft of the heavy elements that their contemporaries contain.

"Giant galaxies, like Andromeda and our own Milky Way, are thought to form through repeated mergers with smaller galaxies and through the accretion of vast numbers of even lower mass 'clouds' -- dark objects that lack stars and even are too small to call galaxies," said David A. Thilker of the Johns Hopkins University in Baltimore, Maryland. "Theoretical studies predict that this process of galactic growth continues today, but astronomers have been unable to detect the expected low mass 'building blocks' falling into nearby galaxies, until now."

Thilker's research is published in the Astrophysical Journal Letters. Other contributors include: Robert Braun of the Netherlands Foundation for Research in Astronomy; Rene A.M. Walterbos of New Mexico State University; Edvige Corbelli of the Osservatorio Astrofisico di Arcetri in Italy; Felix J. Lockman and Ronald Maddalena of the National Radio Astronomy Observatory (NRAO) in Green Bank, West Virginia; and Edward Murphy of the University of Virginia.

The Milky Way and Andromeda were formed many billions of years ago in a cosmic neighborhood brimming with galactic raw materials -- among which hydrogen, helium, and cold dark matter were primary constituents. By now, most of this raw material has probably been gobbled up by the two galaxies, but astronomers suspect that some primitive clouds are still floating free.

Previous studies have revealed a number of clouds of neutral atomic hydrogen that are near the Milky Way but not part of its disk. These were initially referred to as high-velocity clouds (HVCs) when they were first discovered because they appeared to move at velocities difficult to reconcile with Galactic rotation.

Scientists were uncertain if HVCs comprised building blocks of the Milky Way that had so far escaped capture, or if they traced gas accelerated to unexpected velocities by energetic processes (multiple

supernovae) within the Milky Way. The discovery of similar clouds bound to the Andromeda Galaxy strengthens the case that at least some of these HVCs are indeed galactic building blocks.

Astronomers are able to use radio telescopes to detect the characteristic 21-centimeter radiation emitted naturally by neutral atomic hydrogen. The great difficulty in analyzing these low-mass galactic building blocks has been that their natural radio emission is extremely faint. Even those nearest to us, clouds orbiting our Galaxy, are hard to study because of serious distance uncertainties. "We know the Milky Way HVCs are relatively nearby, but precisely how close is maddeningly tough to determine," said Thilker.

Past attempts to find missing satellites around external galaxies at well-known distances have been unsuccessful because of the need for a very sensitive instrument capable of producing high-fidelity images, even in the vicinity of a bright source such as the Andromeda Galaxy.

One might consider this task similar to visually distinguishing a candle placed adjacent to a spotlight. The novel design of the recently commissioned GBT met these challenges brilliantly, and gave astronomers their first look at the cluttered neighborhood around Andromeda.

The Andromeda Galaxy was targeted because it is the nearest massive spiral galaxy. "In some sense, the rich get richer, even in space," said Thilker. "All else being equal, one would expect to find more primordial clouds in the vicinity of a large spiral galaxy than near a small dwarf galaxy, for instance. This makes Andromeda a good place to look, especially considering its relative proximity -- a mere 2.5 million light-years from Earth."

What the GBT was able to pin down was a population of 20 discrete neutral hydrogen clouds, together with an extended filamentary component, which, the astronomers believe, are both associated with Andromeda. These objects, seemingly under the gravitational influence of Andromeda's halo, are thought to be the gaseous clouds of the "missing" (perhaps dark-matter dominated) satellites and their merger remnants. They were found within 163,000 light-years of Andromeda.

Favored cosmological models have predicted the existence of these satellites, and their discovery could account for some of the missing "cold dark matter" in the Universe. Also, confirmation that these low-mass objects are ubiquitous around larger galaxies could help solve the mystery of why certain young stars, known as G-dwarf stars, are chemically similar to ones that evolved billions of years ago.

As galaxies age, they develop greater concentrations of heavy elements formed by the nuclear reactions in the cores of stars and in the cataclysmic explosions of supernovae. These explosions spew heavy elements out into the galaxy, which then become planets and get taken up in the next generation of stars.

Spectral and photometric analysis of young stars in the Milky Way and other galaxies, however, show that there are a certain number of young stars that are surprisingly bereft of heavy elements, making them resemble stars that should have formed in the early stages of galactic evolution.

"One way to account for this strange anomaly is to have a fresh source of raw galactic material from which to form new stars," said Murphy. "Since high-velocity clouds may be the leftover building blocks of galaxy formation, they contain nearly pristine concentrations of hydrogen, mostly free from the heavy metals that seed older galaxies." Their merger into large galaxies, therefore, could explain how fresh material is available for the formation of G-dwarf stars.

The Andromeda Galaxy, also known as M31, is one of only a few galaxies that are visible from Earth with the unaided eye, and is seen as a faint smudge in the constellation Andromeda. When viewed through a modest telescope, Andromeda also reveals that it has two prominent satellite dwarf galaxies, known as M32 and M110. These dwarfs, along with the clouds studied by Thilker and collaborators, are doomed to eventually merge with Andromeda. The Milky Way, M33, and the Andromeda Galaxy plus about 40 dwarf companions, comprise what is known as the "Local Group."

Today, Andromeda is perhaps the most studied galaxy other than the Milky Way. In fact, many of the things we know about the nature of galaxies like the Milky Way were learned by studying Andromeda, since the overall features of our own galaxy are disguised by our internal vantage point. "In this case, Andromeda is a good analogue for the Milky Way," said Murphy. "It clarifies the picture. Living inside the Milky Way is like trying to determine what your house looks like from the inside, without stepping outdoors. However, if you look at neighbors' houses, you can get a feeling for what your own home might look like."

The GBT is the world's largest fully steerable radio telescope.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

Embargoed For Release: 11:00 a.m., EST, Monday, January 5, 2004

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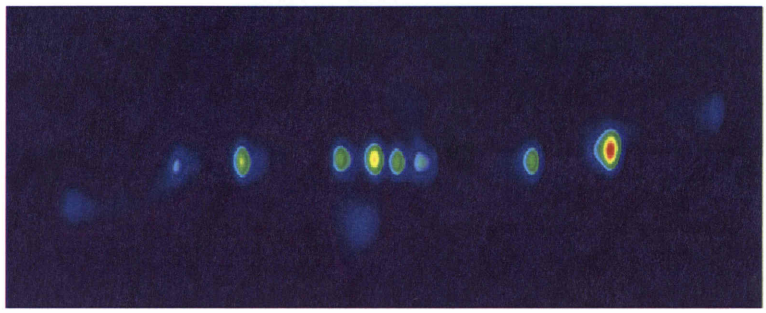
VLBA "Movie" Gives Scientists New Insights On Workings of Mysterious Microquasars

Astronomers have made a 42-day movie showing unprecedented detail of the inner workings of a strange star system that has puzzled scientists for more than two decades. Their work is providing new insights that are changing scientists' understanding of the enigmatic stellar pairs known as microquasars.



Frame from SS 433 Movie:
End to end is some 200 billion miles.
CREDIT: Mioduszewski et al., NRAO/AUI/NSF

"This once-a-day series of exquisitely-detailed images is the best look anyone has ever had at a microquasar, and already has made us change our thinking about how these things work," said Amy Mioduszewski, of the National Radio Astronomy Observatory (NRAO), in Socorro, New Mexico.

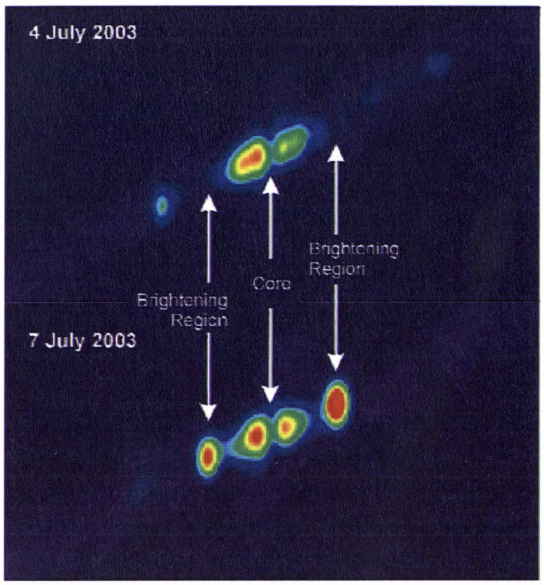
The astronomers used the National Science Foundation's Very Long Baseline Array (VLBA), a system of radio telescopes stretching from Hawaii to the Caribbean, to follow daily changes in a binary-star system called SS 433, some 15,000 light-years from Earth in the constellation Aquila. Mioduszewski worked with Michael Rupen, Greg Taylor and Craig Walker, all of NRAO. They reported their findings to the American Astronomical Society's meeting in Atlanta, Georgia.

SS 433 consists of a neutron star or black hole orbited by a "normal" companion star. The powerful gravity of the neutron star or black hole is drawing material from the stellar wind of its companion into an accretion disk of material tightly circling the dense, central object prior to being pulled onto that object. This disk propels jets of subatomic particles outward from its poles. In SS 433, the particles in the jets move at 26 percent of the speed of light; in other microquasars, the jet material moves at 90-95 percent of light speed. The disk in SS 433 wobbles like a child's top, causing its jets to move in a circle every 164 days.

By imaging SS 433 daily, the astronomers were able to trace individual ejections of material in these jets as they moved outward from the center. In addition, they could track the jets' precession, the movement caused by the disk's wobble.

In other microquasars, blobs of material shot from the core become fainter, as seen with radio telescopes, as they move outward. However, in SS 433, blobs routinely brighten at specific distances from the core. From earlier studies, researchers had concluded that such brightening always occurs at one specific distance. The VLBA movie shows, instead, that there are multiple brightening regions and not all blobs brighten at all the regions.

"We think the ejected material brightens because it's slamming into something," Rupen said. "However, whatever it's hitting has to be replenished somehow so that the brightening can occur again when the jet sweeps through that area the next time," he added.



Mioduszewski et al., NRAO/AUI/NSF

"It also appears that it isn't always replenished, because the brightening doesn't always happen," Mioduszewski pointed out.

The VLBA movie revealed vital new information about another part of SS 433 -- material moving outward from the core, but not part of the superfast jets. This material moves outward in a direction not quite perpendicular to the direction of the jets. Discovered with the VLBA in 2000, this material had been seen only in one-time snapshots before, but the movie shows the steady evolution of its movement for the first time.

That motion was the key to a possible answer to two riddles -- the source of the slower-moving material itself and the source of whatever the jet blobs are hitting when they brighten.

"What seems most plausible to us is that the accretion disk is putting out a broad wind," Rupen explained.

That broad wind from the disk hits a denser wind coming from the "normal" companion star to generate the radio waves seen coming from the nonjet region. The same disk-generated wind could be the source of the material that replenishes the regions where the jet blobs brighten, the researchers say.

"The motion we measure for this slower-moving material is fast enough -- about 10,000 kilometers per second -- to put new material in a brightening region before the jet circles around to that spot again," Mioduszewski said.

Because accretion disks like that around the dense central star of SS 433 are known to be unstable, any wind put out by such a disk could vary, putting out symmetric chunks in opposite directions. This, the scientists think, may explain why the jet brightening regions don't always get replenished with the material needed to cause brightening.

"We still have more questions than answers about this microquasar, but the VLBA movie shows us that following the system on a daily basis with such greatly-detailed images is the most powerful tool available so far to understand these phenomena," Rupen said.

The astronomers now hope to follow SS 433 with the VLBA for an entire, 164-day cycle of the jet wobble. At the same time, they would like to observe the object with visible-light telescopes, then follow up with larger- scale images using the NSF's Very Large Array (VLA) radio telescope. The VLA images would trace blob motions in the jets beyond the distances traced with the VLBA.

SS 433 and Microquasars

SS 433 was first noted in the 1960s by astronomers Bruce Stephenson and Nicholas Sanduleak, who included it in a catalog they published of stars with unusual features in their spectra. As the 433rd object in Stephenson and Sanduleak's catalog, it became known as SS 433.

In 1978, David Clark and Paul Murdin identified SS 433 as the visible-light counterpart of a small object that had been found to be emitting both radio waves and X-rays. The small object also sat within a large supernova remnant called W50. Clark and Murdin, using the Anglo-Australian Telescope in Australia, also produced a spectrum of SS 433 that showed strange features. In addition, the object not only varied in its brightness, but features within the spectrum changed.

By 1979, further research, including work by Bruce Margon and George Abell, had shown that SS 433

was producing jets of material moving in opposite directions. The strange stellar system received a wealth of media coverage, dubbed "the star that is both coming and going" in one story. A 1981 Sky & Telescope article was entitled, "SS433 -- Enigma of the Century."

The late Robert Hjellming of NRAO spearheaded studies of motions within the radio-emitting jets of SS 433 in the early 1980s.

SS 433 was the first example of what are now termed microquasars, binary systems with either a neutron star or black hole orbited by another star, and emitting jets of material at high speeds. With the VLA's discovery of jets moving at 92 percent of the speed of light in an object called GRS 1915+105 in 1994, such systems became known as microquasars. Several others have since been discovered and studied.

Because microquasars in our own Milky Way Galaxy are thought to produce their high-speed jets of material through processes similar to those that produce jets from the cores of galaxies, the nearby microquasars serve as a convenient "laboratory" for studying the physics of jets. The microquasars are closer and show changes more quickly than their larger cousins.

The Very Long Baseline Array

The VLBA
CREDIT: NRAO/AUI/NSF

The VLBA is a system of ten radio-telescope antennas, each with a dish 25 meters (82 feet) in diameter and weighing 240 tons. From Mauna Kea on the Big Island of Hawaii to St. Croix in the U.S. Virgin Islands, the VLBA spans more than 5,000 miles, providing astronomers with the sharpest vision of any telescope on Earth or in space. Dedicated in 1993, the VLBA has an ability to see fine detail equivalent to being able to stand in New York and read a newspaper in Los Angeles.

The VLBA's scientific achievements include making the most accurate distance measurement ever made of an object beyond the Milky Way Galaxy; the first mapping of the magnetic field of a star other than the Sun; movies of motions in powerful cosmic jets and of distant supernova explosions; the first measurement of the propagation speed of gravity; and long-term measurements that have improved the reference frame used to map the Universe and detect tectonic motions of Earth's continents.

The VLBA is operated from the NRAO's Array Operations Center in Socorro, NM.

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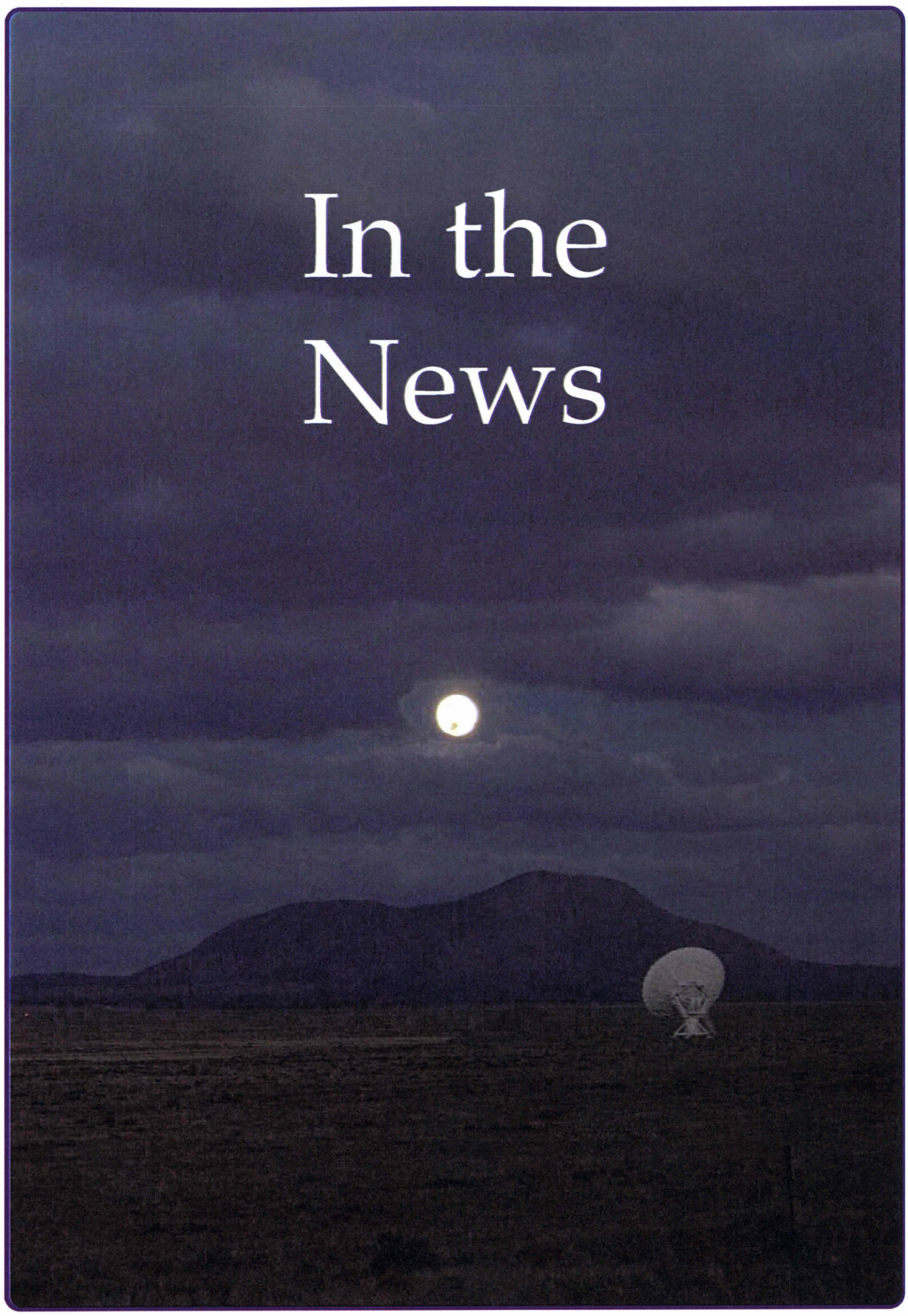
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Wednesday, Jan. 26, 2005

Wednesday, January 26, 2005

NRAO scientist awarded major astronomy prize

Dave Finley

National Radio Astronomy Observatory

The American Astronomical Society has awarded its prestigious George Van Biesbroeck Prize to Dr. Eric Greisen of the National Radio Astronomy Observatory in Socorro. The society cited Greisen's quarter-century as "principal architect and tireless custodian" of the Astronomical Image Processing System, a massive software package used by astronomers around the world, as "an invaluable service to astronomy."

The Van Biesbroeck Prize "honors a living individual for long-term extraordinary or unselfish service to astronomy, often beyond the requirements of his or her paid position." The AAS, with about 7,000 members, is the major organization of professional astronomers in North America.

"The Very Large Array is the most productive ground-based telescope in the history of astronomy, and most of the more than 10,000 observing projects on the VLA have depended upon the AIPS software to produce their scientific results," said Dr. James Ulvestad, NRAO's Director of New Mexico Operations.

"This same software package also has been the principal tool for scientists using the Very Long Baseline Array and numerous other radio telescopes around the world," Ulvestad added.

Greisen, who received a PhD in astronomy from the California Institute of Technology, joined the NRAO in 1972. He moved from the observatory's headquarters in Charlottesville, Va., to its Array Operations Center in Socorro in 2000.

Greisen, who learned of the award in a telephone call from the AAS President, Dr. Robert Kirschner of Harvard University, said, "I'm pleased for the recognition of AIPS and also for the recognition of the contributions of radio astronomy to astronomy as a whole."

He added that "it wasn't just me who did AIPS. There were many others."

The AIPS software package grew out of the need for an

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efficient tool for producing images with the VLA, which was being built in the late 1970s. Work on the package began in 1978 in Charlottesville.

Now including nearly a million lines of program code and almost a half-million lines of documentation, AIPS is used at more than 500 sites around the world. The package is a mainstay and a daily tool for most of the world's radio astronomers, and also has been used by scientists in such other fields as fluid-dynamics simulation and medical imaging.

Over the years, Greisen and his colleagues at NRAO have revised the AIPS package numerous times and expanded its capabilities as new astronomical and computing hardware was developed. The software has been kept independent of specific computing hardware and operating systems, and so has been successfully used on a wide variety of computing equipment.

"We are extremely proud of Eric's work and congratulate him on receiving this award," said NRAO Director Dr. Fred K.Y. Lo. "He has shown extraordinary dedication to making AIPS a valuable and effective tool for the world astronomical community, and this award is well-deserved recognition."

The AAS citation reads, "The 2005 Van Biesbroeck Prize is awarded to Dr. Eric Greisen of NRAO for the initiation, development, and maintenance for twenty-five years of the Astronomical Image Processing System.

Virtually every VLA and VLBA program relies on AIPS for calibration and image reconstruction, and it has been exported to more than 500 sites worldwide. Greisen, as its principal architect and tireless custodian, has provided an invaluable service to astronomy. Moreover, AIPS represented a new paradigm for the processing of massive astronomical datasets, i.e., a comprehensive software package that was rigorously independent of particular operating systems, which supported portability and adaptability to evolving hardware designs. Beyond the call of duty, Greisen has generously responded to individual queries about the code from users at all levels, sometimes in real time at odd hours to support observations in progress."

Greisen is a native New Mexican, born in Los Alamos when the existence of that city still was a secret during World War II. His father was a physicist working on the conventional explosives used to trigger the first atomic bomb.

Greisen is the second NRAO scientist to receive the Van Biesbroeck Prize. Dr. Barry Clark, one of the early architects of the VLA who has scheduled that telescope's observations for nearly three decades, received the award in 1991.

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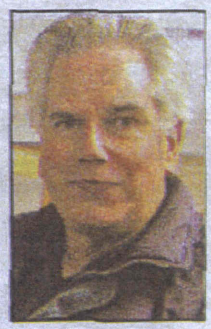
Mountain Mail

Thursday, January 20, 2005
Serving Socorro & Catron Counties Since 1980

Scientists Gather At Pie Town

By John Larson
Mountain Mail
johnl@socorroisp.com

PIE TOWN – Last Friday the focus for many scientists tracking the Cassini-Huygens mission to Saturn was the VLBA dish at Pie Town. While the world's scientific community was waiting for word that the Huygens probe reached the surface, Datil's Kelly Gatlin was making sure the data from the transmissions were received and recorded.


Kelly Gatlin

Gatlin is operator of the Pie Town radio telescope, which received the first transmissions from the European Space Agency probe as it was launched from the Cassini spacecraft and descended to the surface of

See VLBA, Page 4

VLBA: Gets Data From Saturn Probe

Continued from front page

surface of Saturn's moon Titan Friday morning at 3 a.m.

The Pie Town installation is one of 10 radio telescopes that comprise the Very Long Baseline Array, or VLBA, a system of radio telescopes around the globe. The VLBA telescopes are controlled remotely from the Array Operations Center in Socorro that work together as the world's largest dedicated, full-time astronomical instrument.

The normally quiet station was the center of attention for several scientists from around the world and at NASA's Jet Propulsion Laboratory in Pasadena, who were linked up through a conference call from the station's control room. JPL scientist Bill Folkner and NRAO's Donald Haenichen of Socorro oversaw the recording of the signals from Saturn.

Folkner made the trip to Pie Town from Pasadena, Calif., specifically for the 3 a.m. transmission.

"To receive signals from a moon of another planet with an atmosphere is remarkable," he said. "We began getting readings as the probe parachuted to the surface. Cameras, spectrometers, samplers and other instruments were all working perfectly."

According to Folkner, the 800-pound Huygens probe, about the size of a Volkswagen Beetle, landed safely on the surface, which was described by one scientist on the conference call as not unlike creme brulle.

"Like a muddy surface," said Folkner.

During the all-night conference call from Pie Town, Folkner discussed the readings with scientists at the Very Long Base Interferometer in Germany, the Green Bank Telescope in West Virginia, and a radio-telescope at Parks, Australia.

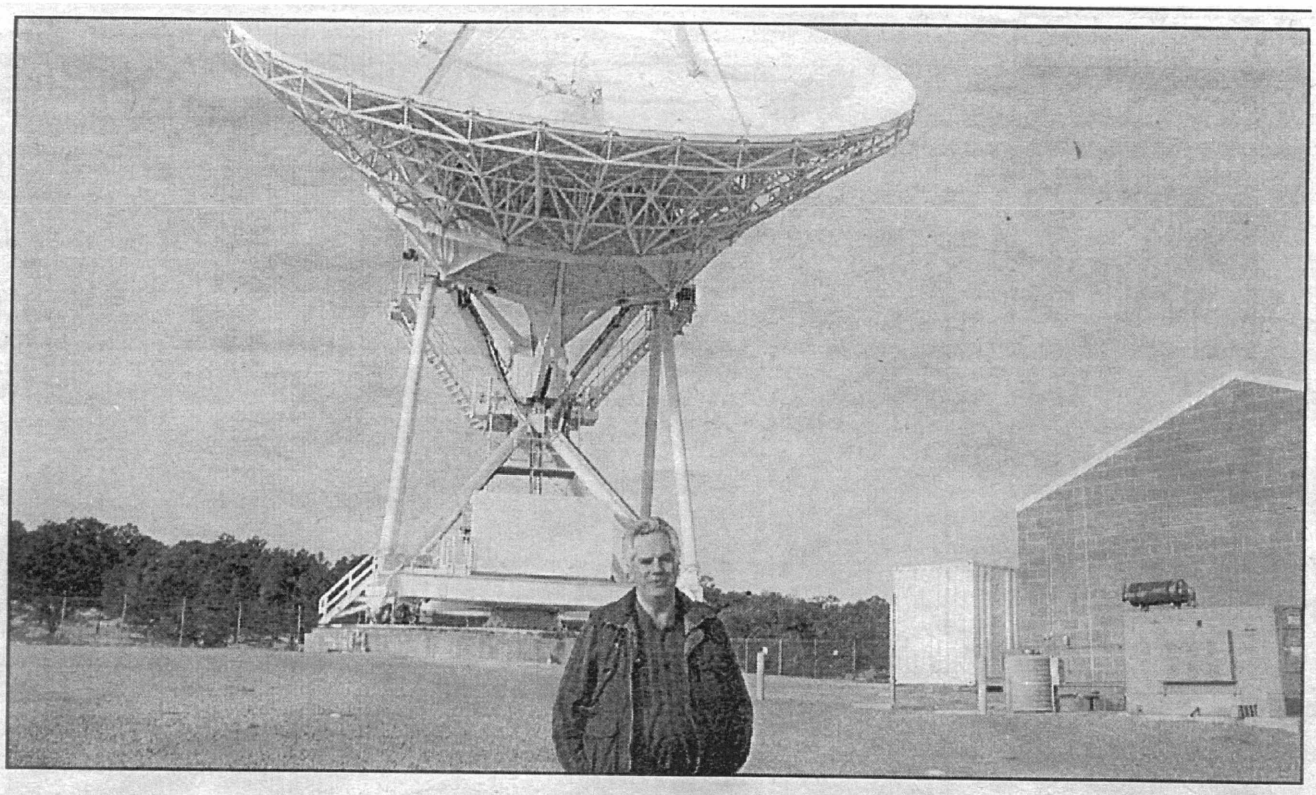
Haenichen, NRAO's electronics technician, said he was assigned as Base Band Converter technician to assist in setting up the JPL equipment.

"I had to make sure everything was working OK, and if there was any problem to address I could take care of it then and there," he said. "We began recording approximately at 2 a.m."

According to Haenichen, they were recording an experiment that was thought up after launch.

"It wind Doppler experiment," he said. "To map the wind currents and get atmospheric information about Titan. It turned out to be a very fruitful mission. The supplementary data gathered will be studied for months, even years."

The presence of the out-of-town scientists did not go unnoticed by Kathy Knapp, owner of the Pie-O-Neer restaurant. She made a late-night delivery of slices of her most popular pies, Oatmeal Raisin and Almond Joy, to the scientists at the dish. "I couldn't let them get away without a piece of pie," Knapp said.



John Larson/Mountain Mail

Kelly Gatlin and the dish of the Very Long Baseline Array radio-telescope he oversees. The installation is located just off Highway 60 in Pie Town -- not too far from the Gatlin Ranch.

Kelly Gatlin: Dish Operator, Photographer, Ranch Kid

By John Larson
Mountain Mail
mtnmail@socorroisp.com

Kelly Gatlin is one of two operators of the radio-telescope at Pie Town. This out-of-the-way dish is part of the Very Large Base Array, or VLBA, ten radio telescopes stretching from Hawaii to New Hampshire to St. Croix in the Caribbean.

Each VLBA station consists of an 82-foot diameter dish antenna and an adjacent control building that houses the station computer, tape recorders and other equipment associated with collecting the radio signals gathered by the antenna. Each antenna weighs 240 tons and is nearly as tall as a 10-story building when pointed straight up.

When he's not making sure the giant radio telescope is pointing the right direction, Gatlin is taking photographs.

"I like to go out and take shots of the antenna at night, with up to a 30 minute exposure, showing star trails behind it," Gatlin said. "Several of my shots can be seen in the gift shop at the VLA."

After graduating from Magdalena High School, Gatlin said he wanted to pursue a career in, not astrophysics or astronomy, but criminology.

"I was interested in a career in law enforcement, until I had to take crime scene photographs," he said. "After that experience, I decided criminology wasn't for me."

Taking pictures of dead people didn't deter him from photography, however, and he began concentrating on artistic and scenic pictures.

"I've been interested in photography since the early 70's while I was going to college in Portales. It was a picture I took of a wheat harvest with my first SLR 35mm camera that got me hooked," Gatlin said. "But it wasn't until about 1993 that New Mexico Magazine first began publishing my photos. Over the years Anne Sullivan and I have collaborated on several articles on places in New Mexico."

In fact, Gatlin and Sullivan collaborated on an illustrated article in the most recent edition of New Mexico Magazine. Gatlin's photos have also been published in the Mountain Mail.

He said he's partial to two types of pictures.

"The first is nature in general, from landscapes to wildlife," Gatlin said. "The second is science and technical, like the VLA. And since I switched to mostly all digital four years ago, I've gotten to like to do close-ups too."

Gatlin has been working for NRAO for almost 20 years.

"I started at the VLA in 1985 and worked there for five years," he said. "Then they moved me up here to Pie Town when they were building the VLBA."

The VLBA is a national research facility, funded by the National Science Foundation. It is open for use by all scientists in the United States and abroad. Scientists who wish to use the VLBA send proposals to the National Radio Astronomy Observatory, describing what they want to observe and the scientific benefits they expect to gain from the observation.

The first observation using all 10 sites occurred May 29, 1993. Total construction cost was $85 million.

Coincidently, the former Gatlin Ranch is not far from the Pie Town installation. "It's nice to be back home, so to speak," Gatlin said.

Editorial: Bouquets & brickbats

January 19, 2005

Bouquet: dark skies

Dark skies are the key to a brighter future for Albuquerque.

City Hall is proposing a new light pollution ordinance that would stop backyard floodlights from shining into neighboring bedrooms, annoying folks struggling to get a decent night's sleep. The ordinance, drafted by Assistant City Attorney Josh Skarsgard, would also remove energy-guzzling mercury vapor lights from residential property, make businesses turn off outdoor lights after 11 p.m., and require the city to replace mercury vapor streetlights within three years and shield high-pressure sodium streetlights.

The changes promise more comfort for weary citizens, savings in energy costs and the aesthetic of a better view of the vast night skies. But the greatest benefit - if the measure is sufficiently enforced - may be to improve declining visibility for New Mexico's huge community of astronomers. New Mexico's clear, dry air and dark skies have made the state a mecca for astronomical observatories, which bring money and worldwide prestige to the Land of Enchantment. But the darkness is dwindling as the state grows.

Dark sky laws such as this one can preserve and enhance the darkness and save energy, while actually enhancing security. Laws such as these have long been touted but rarely passed. Let's put this one on the books.

Bouquet: VLA

Speaking of the prestige that astronomy brings New Mexico (see above), New Mexico's famed National Radio Astronomy Observatory is being cited internationally for its role in the European Space Agency's Huygens space probe, which has been sending spectacular images of Saturn's moon, Titan, to Earth.

The NRAO's Very Long Baseline Array, based in Socorro, was being used to download hours of data that will be studied to learn more about Titan and Huygens' descent and landing.

The Very Long Baseline Array, a radiotelescope, isn't affected by light pollution the way optical telescopes are. But it is an indication of the attention showered on New Mexico-based observatories when they help make exciting discoveries.

Brickbat: DWI omission

Make no mistake: The latest crusade by Gov. Bill Richardson and the Legislature to fight DWI even more fiercely deserves public support. New Mexico, despite recent successes, is still among the worst states in the nation for alcohol-related traffic deaths.

But something's missing from Richardson's otherwise creditable legislative wish list: Better support for state and local law enforcement, so they can deploy more DWI units to catch drunken drivers.

One big reason DWI stats are improving here is that folks know they're more likely to get caught by police when breaking the law. Albuquerque Mayor Martin Chavez recognized this recently when he insisted on beefing up Albuquerque anti-DWI efforts with newly graduated Albuquerque police officers.

After drunken drivers are caught, they need to be assured of swift trial and punishment - an issue the governor is addressing - and adequate access to effective treatment.

Richardson's wish list has a lot of virtue, but don't forget more cops and treatment

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Thursday, Feb. 17, 2005

Wednesday, January 19, 2005

Blazar jets push closer to cosmic speed limit

Dave Finley

National Radio Astronomy Observatory

Astronomers using the National Science Foundation's Very Long Baseline Array have discovered jets of plasma blasted from the cores of distant galaxies at speeds within 1/10 of 1 percent of the speed of light, placing these plasma jets among the fastest objects yet seen in the Universe.

"This tells us that the physical processes at the cores of these galaxies, called blazars, are extremely energetic and are capable of propelling matter very close to the absolute cosmic speed limit," said Glenn Piner, of Whittier College in Whittier, Calif.

Piner, who worked on the project with student Dipesh Bhattari, also of Whittier College, Philip Edwards of the Japan Aerospace Exploration Agency, and Dayton Jones of NASA's Jet Propulsion Laboratory, presented their findings to the American Astronomical Society's meeting in San Diego.

According to Einstein's Special Theory of Relativity, no object with mass can be accelerated to the speed of light. To get even close to the speed of light requires enormous amounts of energy.

"For example, to accelerate a bowling ball to the speed newly measured in these blazars would require all the energy produced in the world for an entire week," Piner said, "and the blobs of plasma in these jets are at least as massive as a large planet."

Blazars are active galactic nuclei — energetic regions surrounding massive black holes at the centers of galaxies. Material being drawn into the black hole forms a spinning disk called an accretion disk. Powerful jets of charged particles are ejected at high speeds along the poles of accretion disks. When these jets happen to be aimed nearly toward the Earth, the objects are called blazars.

Taking advantage of the extremely sharp radio "vision" of the continent-wide VLBA, the scientists tracked individual features in the jets of three blazars at distances from Earth ranging from 7.3 to 9 billion light-years. A Boston University team led by

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Svetlana Jorstad earlier had identified the three blazars as having potentially very high jet speeds based on VLBA observations in the mid-1990s. Piner and his colleagues observed the blazars again in 2002 and 2003 with much longer observations, and were able to confirm the high-speed motions in the faint blazar jets.

Their measurements showed that features in the blazar jets were moving at apparent speeds more than 25 times greater than that of light. This phenomenon, called superluminal motion, is not real, but rather is an illusion caused by the fact that the material in the jet is moving at nearly the speed of light almost directly toward the observer. Because the jet features are moving toward Earth at almost the same speed as the radio waves they emit, they can appear to move across the sky at faster-than-light speeds. Scientists can correct for this geometrical effect to calculate a lower limit to the true speed of the features.

"We typically see apparent speeds in blazar jets that are about five times the speed of light, and that corresponds to a true speed of more than 98 percent of light speed," Piner said.

"Now, based on independent confirmation by two groups of astronomers, we see these three blazars with apparent speeds greater than 25 times that of light," Piner added.

"That apparent speed, the scientists said, corresponds to a true speed of greater than 99.9 percent of light speed, which is 186,282 miles per second.

Based on other properties of blazars, the scientists believe that their interpretation of the data is accurate and that they have measured the extremely fast speeds in the three blazar jets. However, "we do have to be somewhat careful in interpreting these results, because it is possible that the observed motions represent the motion of some propagating disturbance in the plasma rather than the plasma itself, in the same way that a water wave can move across the surface of the ocean without physically transporting the water," Piner said.

The VLBA is a system of 10 radio-telescope antennas, each with a dish 25 meters (82 feet) in diameter and weighing 240 tons. From Mauna Kea on the Big Island of Hawaii to St. Croix in the U.S. Virgin Islands, the VLBA spans more than 5,000 miles, providing astronomers with the sharpest vision of any telescope on Earth or in space. Dedicated in 1993, the VLBA has an ability to see fine detail equivalent to being able to stand in New York and read a newspaper in Los Angeles. The VLBA is operated from the National Radio Astronomy Observatory's Array Operations Center in Socorro.

The research was supported by the National Science Foundation and the Research Corporation. Part of the research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

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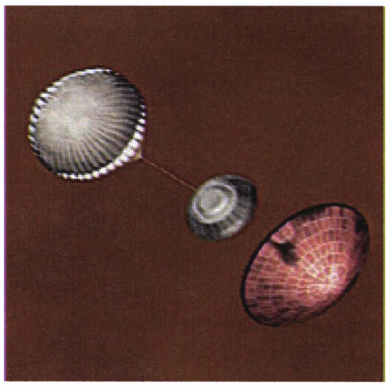

Radio astronomers confirm Huygens entry in the atmosphere of Titan

14 January 2005

At 11:25 CET the Robert C. Byrd Green Bank Telescope (GBT) of the National Radio-astronomy Observatory in West Virginia, USA, a part of the global network of radio telescopes involved in tracking the Huygens Titan probe, has detected the probe's 'carrier' (tone) signal.

The detection occurred between 11:20 and 11:25 CET, shortly after the probe began its parachute descent through Titan's atmosphere. The extremely feeble signal was first picked up by the Radio Science Receiver supplied by the NASA Jet Propulsion Laboratory. This signal is an important indication that the Huygens probe is 'alive'. However, it does not contain yet any substance; the latter is expected to come a few hours later via the Cassini spacecraft.

What the Green Bank radio telescope has detected is only a 'carrier' signal. It indicates that the back cover of Huygens must have been ejected, the main parachute must have been deployed and that the probe has begun to transmit, in other words, the probe is 'alive'. This, however, still does not mean that any data have been acquired, nor that they have been received by Cassini. The carrier signal is sent continuously throughout the descent and as such does not contain any scientific data. It is similar to the tone signal heard in a telephone handset once the latter is picked up.

Only after having received the data packets at ESOC will it be possible to say with certainty whether data were properly acquired. The first data set from Cassini will reach ESOC in the afternoon. Additional downlinks will follow throughout the evening and night for redundancy.

Further analysis of the signals will be conducted using other three independent data acquisition systems at the Green Bank Telescope. In addition to the GBT, sixteen other radio telescopes in Australia, China, Japan and the USA are involved in tracking the Huygens probe.

The ultimate goal of the tracking experiment is to reconstruct the probe's descent trajectory with an unprecedented accuracy of the order of one kilometre. The measurements will be conducted using Very Long Baseline Interferometry (VLBI) and Doppler tracking techniques. This would enable studies of the dynamics of Titan's atmosphere, which is considered to be a 'frozen' copy of that of the early Earth.

The VLBI component of the tracking experiment is coordinated by the Joint Institute for VLBI in Europe (JIVE) and ESA; the Doppler measurements are conducted by the Jet Propulsion Laboratory.

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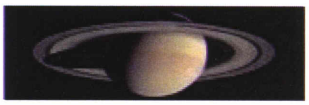

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SCIENCE & SPACE

Blazing speed: The fastest stuff in the universe

By Robert Roy Britt
SPACE.com
Tuesday, January 18, 2005 Posted: 1605 GMT (0005 HKT)

(SPACE.com) -- If you're light, it's fairly easy to travel at your own speed -- that is to say 186,282 miles per second or 299,800 kilometers per second.

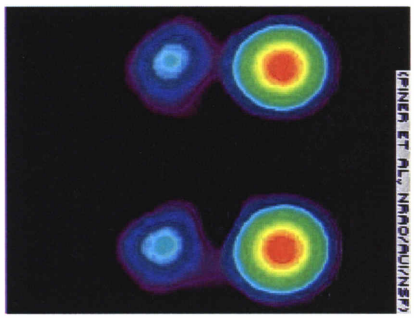
But if you are matter, then it's another matter altogether.

Nothing we know of zips along more quickly than light. Einstein, nearly 100 years ago, said it's not possible. For us, the speed limit makes strange sense: Go faster than light, and you could return before you've left, become your own grandpa, or other perform other leaps of cosmic logic.

Fast forward a century. Astronomers are now measuring stuff -- material, matter, things -- that moves at so close to the speed of light you might think it'd make Einstein a bit nervous. His theory of relativity appears not to be endangered by the blazing speeds, though.

Among thee speed demons of the universe are Jupiter-sized blobs of hot gas embedded in streams of material ejected from hyperactive galaxies known as blazars. Last week at a meeting here of the American Astronomical Society, scientists announced they had measured blobs in blazar jets screaming through space at 99.9 percent of light-speed.

"This tells us that the physical processes at the cores of these galaxies ... are extremely energetic and are capable of propelling matter very close to the absolute cosmic speed limit," said Glenn Piner of Whittier College in Whittier, California.



A sequence of radio observations shows a plasma blob moving away from a blazar's core, right, over about 8.4 months.

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Ponder the power of the fast moving superheated gas, known as plasma:

"To accelerate a bowling ball to the speed newly measured in these blazars would require all the energy produced in the world for an entire week," Piner said. "And the blobs of plasma in these jets are at least as massive as a large planet."

The blazar jets are running around the universe in some fast company. Slightly faster, in fact.

In another study presented at the meeting, ultra high-energy cosmic rays thought to originate in a collision of galaxy clusters are slamming into Earth's atmosphere at more than 99.9 percent of the speed of light. Measurements put the number at 99.9 followed by 19 more nines -- about as close to light-speed as you can get without splitting hairs.

The particles are not light, but actual matter. They are tiny, thought to be mostly protons, but the energy that motivates them is similarly fantastic, and the mechanisms may be intertwined.

Scientists still don't know the exact mechanisms involved in accelerating matter to such high speeds, however. In the case of a blazars, it appears a black hole is involved. Anchoring an active galaxy, a supermassive black hole draws gas inward. Some is swallowed, yet some is simply accelerated and then ejected in high-speed jets along the galaxy's axis of rotation. Intense, twisted magnetic fields may play a role.

Some ultra high-energy cosmic rays might originate in blazar jets, Piner told SPACE.com. But other phenomena may serve as particle accelerators in space, such as merging galaxies or colliding black holes.

Piner and his colleagues observed three blazars, known from previous observations to be super speedy, using the National Science Foundation's Very Long Baseline Array radio observatory.

The results confirm the previous work and pin down the speeds with greater accuracy. The phenomenal pace of the plasma blobs looks to have reached a limit.

"All the results from blazar jet observations are in agreement with Einstein's Theory of Special Relativity," Piner said. "The jets are accelerated right up to the edge of the speed-of-light barrier but not beyond, even though these are some of the most efficient accelerators in the universe."

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Detached Meaning

January 18, 2005

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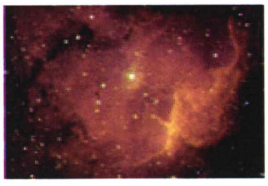

Where Stars Are Born

14 January 2005

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Detached Meaning

In a strange case of cosmic detachment, astronomers have discovered a huge disk of hydrogen gas that surrounds a galaxy but does not appear to be involved in the galaxy's star-formation processes. The gas may be primordial material left over from the galaxy's formation, and that would provide an interesting natural laboratory for further study.

The dwarf galaxy, called UGC 5288, is much smaller than our Milky Way. In this combined radio and visible-light image, the bright white center object is the main galaxy, seen in visible light. The purple region is a giant hydrogen-gas disk detected by the National Science Foundation's Very Large Array (VLA) radio telescope.

In visible light, the elongated galaxy is about 6000 by 4000 light-years, but the hydrogen-gas disk is about 41,000 by 28,000 light-years. A

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light-year is the distance light travels in a year, about 6 trillion miles (10 trillion kilometers).

Astronomers wonder how the gas came to be in its present configuration. The disk shows no signs that the gas was either blown out of the galaxy by star formation or pulled out by a close encounter with another galaxy.

"You need the gas to make the stars, so we might have thought the two would be better correlated," said Martha Haynes, an astronomer at Cornell University. "This means we really don't understand how the star-forming gas and the stars themselves are related."

"This gas disk is rotating quite peacefully around the galaxy," said Liese van Zee of Indiana University. That means, she said, that the gas around UGC 5288 most likely is pristine material that never has been "polluted" by the heavier elements produced in stars.

"The lack of interaction between the large gas disk and the inner, star-forming region of this galaxy is a perplexing situation," van Zee said. "When we figure out how this has happened, we'll undoubtedly learn more about how galaxies form."

The galaxy is relatively nearby, at about 16 million light-years from Earth.

The observations were presented last week at a meeting of the American Astronomical Society. The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

-- SPACE.com Staff

Credit: Van Zee, NOAO, NRAO/AUI/NSF

TimesDispatch.com
Richmond Times-Dispatch
Tuesday, Jan. 18, 2005

NEWS

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A huge thanks to Mother Nature

Scientists tracking Titan probe relieved weather cooperated

BY A.J. HOSTETLER Jan 15, 2005
TIMES-DISPATCH STAFF WRITER

The wind died down and the snow held off, allowing the Green Bank Telescope to be the first to catch the Huygens probe's weak signal home as it parachuted toward Titan.

Despite forecasts of nasty weather that could have scuttled its role, the West Virginia radio telescope facility was first to hear from the European probe yesterday morning as it neared the Saturn moon.

The long-distance call from 750 million miles away came in at 5:19 a.m. EST, said Sami Asmar, the NASA Jet Propulsion Laboratory scientist who first spotted the signal oscillating across his computer screen.

In real time

As the Huygens probe began its harrowing descent, a network of 18 radio telescopes around the world strained to hear its feeble 10-watt signal -- just slightly stronger than a Christmas tree light bulb, Asmar said.

The Green Bank site was the only one to hear it in real time. The predawn signal indicated that the probe had completed its entry maneuvers, ejected its back cover, deployed its

parachutes and turned on its on-board instruments.

With his boss on one phone and the European Space Agency on another, Asmar spread the word that the probe was alive and transmitting.

"I was very awake, the adrenaline was running, the pressure was on," Asmar said. "They were relieved."

Later in the morning, Asmar stepped outside into light snow, which had it fallen earlier could have obscured the probe's signal. High wind also could have prevented Green Bank from tuning in.

'Only one shot'

"Nature . . . cooperated tremendously with us," he said.

The probe's arrival was a model of cooperation. A JPL receiver installed just a few days earlier at Green Bank, part of the Charlottesville-based National Radio Astronomy Observatory, picked up the probe's weak signal. With its 360-foot-wide dish, Green Bank hears more of the universe from more of the radio spectrum than any other telescope.

The European scientists were depending on it for first word that their baby was OK, Asmar said.

"This is the kind of project where you get only one shot," said Phil Jewell, director of the Green Bank Telescope. "We were thrilled to be able to participate."

European scientists used the signal to track the probe through its 2½-hour descent, while a U.S.-led team gathered information on the speed and direction of descent.

Contact A.J. Hostetler at (804) 649-6355 or
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News

January 15, 2005

Green Bank delivered Huygens landing news to ESA

■ Signal from probe picked up exactly where expected, scientist says

By **Rick Steelhammer**
Staff writer

As the European Space Agency's Huygens landing craft descended through the dense atmosphere of Saturn's largest moon and approached its never-seen, ice-strewn surface early Friday, the Green Bank Telescope traced its faint radio signal, letting scientists know the probe was "alive."

"As the time approached when we expected to detect its signal, our group was very tense," said Sami Asmar, a radio scientist with the Jet Propulsion Laboratory in Pasadena, Calif., which designed and built the Cassini orbiter that took Huygens on its seven-year journey to Saturn's moon, Titan.

Asmar, another JPL scientist, and three observers from the European Space Agency joined National Radio Astronomy Observatory personnel in the control room of the Pocahontas County facility to monitor the probe's descent.

"We assumed the chances of detecting a signal from Huygens very early in its descent wouldn't be high," said Asmar. "So those in our group were a little anxious and spent our time running every possible test with the special instrumentation we brought with us — including the same receiver used to track the Mars Rover.

"But when the time came to expect the signal, it turned up at the exact time and the exact frequency that it was supposed to. We were elated, but before we could celebrate, we had to relay the information that Huygens was alive to the European Space Agency's operations center in Germany.

"When the project manager picked up the line, I thought he was going to cry out of happiness. You could hear people clapping and cheering in the background, and from the tone of voice, you could tell the people were just beside themselves."

The Robert C. Byrd Green Bank Telescope, the world's largest steerable radio telescope, detected Huygens' descent through Titan's atmosphere at about 5:25 a.m.,

Photos

Blocks of ice are strewn across the surface of the Saturn moon Titan in this raw photograph taken Friday by the Huygens space probe after the European Space Agency craft beamed its first data back to Earth through its Cassini mothership, which remains in orbit. The size and distance of the blocks will be determined by scientists later.

The Huygens space probe took this photo during its descent to Titan's surface

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shortly after a parachute was deployed to slow its fall to the moon's surface.

"We kept receiving its signal much longer than predicted," said Asmar. "We thought it would transmit for maybe one or two hours, but it continued for close to five. ...It would make a good commercial for whoever made its batteries."

After the Earth's rotation broke contact between Green Bank and Huygens, the Parkes Radio Telescope in Australia promptly picked up the landing probe's signal.

The orbiting Cassini picked up telemetry from the probe as it approached the surface, and began sending the data back to Earth.

Continue 1 | 2

Friday. It was taken from an altitude of about 10

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San Francisco Chronicle

Huygens' landing on Titan an achievement for the ages
Scientists celebrate successful mission, await hard data

David Perlman, Chronicle Science Editor
Saturday, January 15, 2005

Darmstadt, Germany -- A bold and perilous space adventure into a far-off unknown world achieved an extraordinary success Friday as Europe's Huygens probe descended to a safe landing through the dense atmosphere of Titan, Saturn's largest moon, its camera snapping hundreds of images of a fantastic surface never seen before.

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It was a triumph for the hundreds of scientists and technicians in 19 countries who have been laboring on the probe for nearly 25 years -- but an even larger triumph for human knowledge. Titan's organic chemicals are thought by many to be the very array of constituents that marked early Earth 4 billion years ago and that combined here into complex forms to launch the long journey toward life itself.

"This is a grand descent into the unknown," said an ecstatic David Southwood, the European Space Agency's science director. "The atmosphere we're about to analyze is a cooking pot for life, and all the ingredients for life are there -- except perhaps for water."

The probe's instruments all worked superbly.

Guy Israel of France's National Center for Scientific Research, whose instrument was to collect and heat the atmospheric particles for chemical analysis by Hasso Niemann of NASA's Goddard Space Flight Center, was overjoyed.

"Now, we can examine materials that have been strange for billions of years," Israel said. "At last we can really examine prebiotic molecules, seeking the bricks of life."

The science teams here at ESA's control center were jubilant at the word from Jean-Pierre Lebreton, the Huygens probe's chief scientist and project manager, that the craft had not only touched down safely after the roughly 2 hour and 10 minute descent but was still functioning after five full hours on the surface -- far longer than the short post-landing lifetime that mission engineers had expected when they designed the complex but rugged craft.

"We really have a good mission," Lebreton told reporters with his usual Gallic grin. "We're all unbelievably happy, elated, and not at all worried even though we haven't seen the real science data that's there yet."

And one thing was clear, Lebreton said: Huygens had landed intact, most probably on a solid surface, with no danger of sinking or vanishing into a thick smog of hydrocarbons. Later in the night, Lebreton's speculation about the surface was confirmed by Martin Tomasko of the University of Arizona, whose descent imaging camera snapped the first three of 350 pictures that revealed Titan's surface in startling and surely historic detail.

Earlier speculation about the perils of the landing was only that. Huygens was not floating or sunken in a sea of methane; it was not impaled on a spire of frozen methane ice, or showered by an erupting methane volcano.

The pictures are more fantastic than anyone could have imagined. Amid the cheers and applause of hundreds at Mission Control as the first image filled the screen, Southwood exclaimed, "This shows a world of completely new science, and this one image alone will provide endless scientific reports. It's only the beginning."

The black and white images, taken during the descent at 95 miles above the surface, then 10 miles above, and a final one at the surface itself, revealed solid, rough-sided hills with deeply shadowed drainage channels, most likely carved by liquid hydrocarbons flowing down from above; clusters of rough boulders, and what appeared to be a shoreline, possibly fronting a dark lake or perhaps a hydrocarbon sea.

"This is all hot off the computer," Tomasko said in an interview, "and we've had eight minutes to look at them, but to me the large white hills seem spectacularly like water ice." To Tomasko, the dark regions "suggest they were flooded -- or may be flooded now -- from the photochemical haze that's falling out of the atmosphere and flowing into what looks like dark lakes or seas. Some of it may be liquefied natural gas, or some form of tar, or complex organic chemicals no one on Earth has ever known. ...

"This is kind of instant science," Tomasko said, with the enthusiasm of a man discovering a new world, "and it will need lots and lots of interpretation. "

The detailed data from Titan began arriving in bursts soon after the landing and was relayed through the Cassini spacecraft in orbit around Saturn, more than 40,000 miles from the landing site. But as of late Friday night, the scientists

had not begun to analyze the thousands of bytes that had come down into their control room computers.

The first word that the 700-pound, wok-shaped probe was alive came early Friday in a faint "carrier signal" -- a sound like a high-pitched European telephone dial tone -- from the craft's onboard radio. The steady signal was picked up and transmitted first by the United States' 110-meter radio telescope observatory in Green Bank, W.Va. That huge antenna was the focus of the worldwide Very Large Baseline Array of 17 other radio telescopes -- in New Mexico, Australia, China and Japan -- all trying to pick up that same signal that Huygens was alive.

The network, directed by Leonid Gurvitz, a Soviet-born physicist now headquartered for the European Space Agency in Holland, scooped the more roundabout signal transmission system that Huygens was sending up to Cassini.

As the 2 1/2-hour descent to Titan's surface began, one of Huygens' six instruments reported instantly that it was working, and Green Bank heard it. That instrument was the Doppler Wind Experiment, led by Michael K. Bird of Germany's University of Bonn, and from the varying frequency of the carrier signal, it confirmed that Titan's atmosphere is stormy indeed.

Images of Titan's moving clouds taken Oct. 28, when Cassini's orbit around Saturn carried it within 750 miles of the mystery moon, showed clearly that the winds are strong. Precisely how hard the winds blow, however, remains for Bird's detailed analysis in the coming days.

Excited almost beyond words at the initial success of the descent, Bird said: "This is my salute to the Titanians -- if they exist!"

The $3.2 billion Cassini-Huygens mission was planned and executed jointly by NASA and the European Space Agency -- but Huygens' success is the European agency's proudest achievement ever.

The Green Bank signal confirmed that all three of the Huygens' parachutes had opened successfully, slowing the spacecraft down from 11,200 mph at the top of Titan's atmosphere to a mere 15 mph when it landed on the unknown surface.

The Green Bank signal also confirmed that the Huygens heat shield had been jettisoned safely after protecting the precious spacecraft against atmospheric entry temperatures of more than 3,000 degrees Fahrenheit. Although the shield must have been flaming fiercely, astronomers atop Mauna Kea in Hawaii reported that they spotted no glow at all in their powerful cluster of optical telescopes.

Lebreton said that even on the surface, the Huygens battery pack kept the instruments inside their foam cocoons at a comfortable 76.5 degrees Fahrenheit, even though the outside temperature was a bitter 225 degrees below zero Fahrenheit.

With the landing on Titan completed, Cassini, which carried Huygens piggyback from Earth across 2 billion miles of space, will transmit the data again and again, lest any be lost. The mother ship's direct contact with Huygens ended within hours -- when the orbiter swung beyond the moon's horizon, the radio signal ceased.

*E-mail David Perlman at **dperlman@sfchronicle.com**.*

Page A - 1

Health/Science

Tuesday, January 18, 2005

LASSOING A MOON

Space probe lands on Saturn's Titan and sends back photos; thrilled scientists call it once-in-a-lifetime feat

BY BRYN NELSON
STAFF WRITER

January 15, 2005

Touchdown!

After a seven-year trip through outer space, the Huygens space probe successfully completed the last leg of its epic voyage to Titan on Friday, releasing initial black-and-white images that brought tears to the eyes of the mission's scientists.

Taken from 10 miles above Saturn's mysterious moon, one picture shows what appear to be short drainage channels heading to a coastline, perhaps carved by liquids such as methane. Another image, from five miles above Titan, portrays what researchers said might be flooded plains and shorelines. A third depicts a surface strewn with blocks of frozen liquid.

Scientists said they were "astonished" by the images. Hundreds more are expected.

"My initial reaction on seeing these pictures was 'Wow! Look at that, it worked,'" said NASA's Robert Mitchell, program manager for the international Cassini program that delivered the probe to Titan.

The scientific feat, 25 years in the making, represents the farthest from Earth that a spacecraft has ever landed, about 890 million miles away. Researchers believe Saturn's hazy moon may mirror conditions of an early Earth "in deep freeze," with some scientists speculating on the existence of everything from icy methane lakes and an organic compound-rich smog to "continents" of rock and ice and fierce lightning and thunderstorms. A slew of photo and sensor data sent back to Earth may now begin answering those questions.

Three weeks after detaching from NASA's Cassini spacecraft and hurtling toward the gargantuan moon, Huygens completed its journey through Titan's thick atmosphere in slightly less than 2 1/2 hours, said the agency's researchers. In comments to the media, Mitchell said all of the probe's photo and sensor data had been relayed to Cassini within minutes of its landing.

Crowded into the European Space Agency's control center in Darmstadt, Germany, scientists joined journalists in peering at computer monitors throughout the day. At 11:19 a.m. Friday, with confirmation that the first data had arrived from the probe via Cassini, the control room burst into cheers, with researchers hugging one another and smiling broadly.

"So we are the very first visitors of Titan and that scientific data that we are collecting now shall unveil the secrets of this new world," said Jean-Jacques Dordain, ESA's director general, in a briefing broadcast on NASA TV. The Cassini-Huygens mission, jointly sponsored by ESA, NASA, and the Italian Space Agency, will live on through the Cassini mothership, slated to explore Saturn's planetary system for four more years.

The first sighs of relief arrived at 5:25 a.m., when a telescope at the National Radio Astronomy Observatory in Green Bank, W.Va., detected a faint signal from the probe during its descent. This "carrier" signal, similar to the dial tone of a phone, indicated the heat shield covering the back of Huygens had been ejected, the main parachute had been deployed, the batteries had switched on, and the probe had begun transmitting data.

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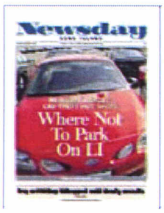

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The 705-pound probe, elated researchers said, was "alive."

His voice choked with emotion, NASA Associate Administrator of Science Alphonso Diaz saluted the "tremendous success" of the effort. "There will only be one first successful landing on Titan and this was it," Diaz said. David Southwood, director of ESA's scientific program, said he doubted a repeat landing on Titan would occur within the lifetime of anyone at the briefing. "It's for posterity and it's for mankind."

It is also, he concluded, only the beginning.

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January 15, 2005

The Daily Progress

European probe scans Saturn moon

Associated Press

DARMSTADT, Germany - A European space probe Friday sent back the first detailed pictures of the frozen surface of Saturn's moon Titan, showing stunning black and white images of what appeared to be hilly terrain riddled with channels or riverbeds carved by a liquid.

One picture, taken about 10 miles above the surface as the Huygens spacecraft descended by parachute to a safe landing after a seven-year voyage from Earth, showed snaking, dark lines cut into the light-colored surface.

"Clearly there is liquid matter flowing on the surface of Titan," said scientist Marty Tomasko of the Lunar and Planetary Labora-tory at the University of Arizona, in Tucson, which made the probe's camera.

He said the liquid appeared to be flowing into a dark area at the right side of the image.

"It almost looks like a river delta," he said. "It could be liquid methane, or hydrocarbons that settled out of the haze" that envel-ops Titan.

The Robert C. Byrd Green Bank Telescope
CREDIT: NRAO/AUI/NSF

The mission was made possible, in part, because of the efforts of the National Radio Astronomy Observatory, headquartered in Charlottesville.

The NRAO's Green Bank Tele-scope in West Virginia and eight of the 10 telescopes of its Very Long Baseline Array in Iowa and points west were to pinpoint where the Huygens spacecraft was during its descent to Titan.

The huge radio telescopes were being used because NASA's scope in California cannot pick up the spacecraft's signal, said Frank Ghigo, an NRAO scientist in West Virginia.

Another of Friday's images, taken about five miles above the surface, showed light and dark masses, which Tomasko said seemed to be shadows, indicating a varied terrain. The dark areas appeared to be flooded or to have been so at an earlier time.

A third image taken at the sur-face showed several large white chunks - boulders or blocks of water ice - in the foreground and a stretch of gray surface behind them.

"There aren't too many planets with liquid," Tomasko said. "There's Earth, and now there's Titan."

Titan is the first moon other than the Earth's to be explored. Scientists believe its atmosphere is similar to that of the young Earth, and studying it could provide clues to how life arose here.

"I think all of us continue to be amazed as we watch our solar system unveil," NASA science administrator Alphonso Diaz said as the extraordinary images were displayed on screens at mission control in Darmstadt.

"It challenges all our preconcep-tions that all these planets are static places. Seeing a planet emerge that has dynamics and complexity to it is just amazing."

Huygens was spun off from the Cassini mother ship on Dec. 24 before its descent to the surface of Titan. The mission is a joint effort among NASA, the European Space Agency and the Italian space agency.

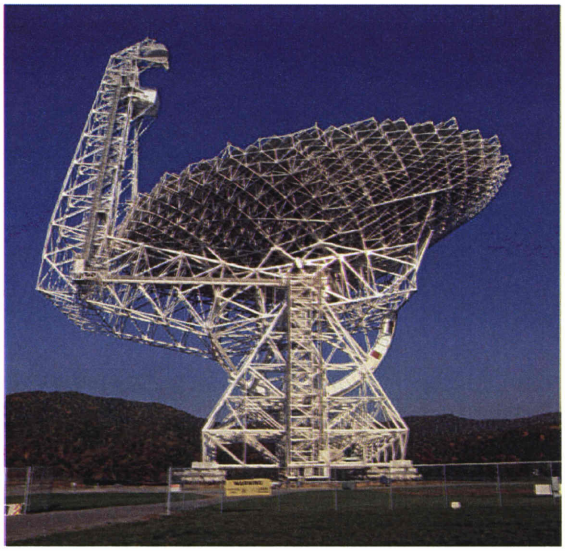
The Daily Progress contributed to this story.

January 15, 2005

The Daily Progress

Green Bank Telescope finds pulsar cluster

RICHMOND - Astronomers using the Green Bank Telescope have observed a star cluster teeming with pulsars, rotating stars whose beams of radio waves periodically pass over Earth like a searchlight.



The Robert C. Byrd Green Bank Telescope
CREDIT: NRAO/AUI/NSF

Further studies of these pulsars should provide insights into pulsar physics, general relativity and how such stellar clusters evolve.

A U.S.-Canadian team of scientists, led by the National Radio Astronomy Observatory in Charlottesville, looked at the cluster called Terzan 5 some 28,000 light-years away in the constellation Sagittarius. Using the West Virginia-based telescope, they discovered 21 new pulsars in the cluster, bringing its total to a record 24.

Prior to the new findings, there were 80 known pulsars strewn through two-dozen clusters. Astronomers had long predicted that Terzan 5 had more pulsars, but some of the largest telescopes failed to find anything.

The recently rebuilt 360-foot-wide Green Bank Telescope, along with new data-processing techniques, offered a chance to spot the missing pulsars with five to 20 times greater sensitivity than previous attempts.

A single, six-hour observation with the telescope last July 17, and two days of number crunching, revealed 14 new pulsars. Over the next four months the astronomers turned up the rest; a few suspected pulsars await confirmation.

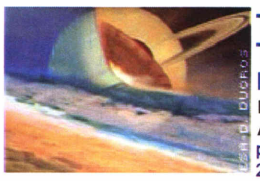
"It's truly astonishing," said NRAO astronomer Scott Ransom, who presented the findings Wednesday to the American Astronomical Society. The findings also are online in the journal Science Express.

Globular clusters are crammed with millions of stars, which form at about the same time. Pulsars are whirling versions of super-dense neutron stars that died early in the cluster's history. As they spin, the pulsars regularly shoot out beams of radio waves, like a rotating searchlight.

Terzan 5's stars formed about 10 billion years ago. Normally, their magnetic fields would have halted any observable twirling. But like kids in a small neighborhood, some of the Terzan 5 stars eventually had to play together. In Terzan 5, they play together a lot and find buddies to hang out with. Those friendships don't always last, and some pulsars seem to have gone off in a huff with new pals. Over time, these playground politics start spinning the neutron stars, turning them into pulsars.

At least 13 of Terzan 5's pulsars are paired off in these binary systems.

A.J. Hostetler is a staff writer at the Richmond Times-Dispatch.



Touchdown on Titan: Huygens Probe Hits its Mark

By Tariq Malik
And Peter de Selding
posted: 14 January 2005
2:30 a.m. ET

This story was last updated at 11:40 a.m. EST.

A European probe has landed on Saturn's moon Titan a mysterious satellite that has perplexed astronomers for decades.

Built by the European Space Agency (ESA), the 705-pound (320-kilogram) Huygens probe landed on Titan between 7:45-7:46 a.m. EST (1245-1246 GMT) and apparently began beaming at least some data to NASA's Cassini orbiter for later transmission to Earth.

SPACE.com's preview of today's Huygens landing is available here . Refresh this page for live updates of Huygen's status as they become available.

Click Here For NASA TV

Live Huygens descent and landing commentary provided by ESA is being webcast on NASA TV.

LIVE Coverage of Huygens' Titan Descent

11:40: Huygens worked "beautifully" according to ESA Director-General Jean-Jacque Dordain.

"The morning was good, the afternoon is better," Dordain said. "We have a scientific success."

11:35 a.m. EST: It's confirmed! Huygens has successfully returned science data from Titan's surface. The probe's landing is the farthest touchdown for any human-built object to set land on another world.

A news briefing on Huygens' apparent success is underway and its thumbs-up all around for mission scientists and managers.

11:19 a.m. EST: Shouts and applause erupted from Huygens mission control, and presumably some data from the probe has apparently arrived.

"We have it? We have it!" said one mission team member before the shouts.

Stand by for confirmation.

11:15 a.m. EST: ESA officials had said earlier today that they anticipated the first science from Huygens at this time. So far, no word on the status of science data from the Titan probe.

11:12 a.m. EST: There is some discussion, from talk broadcast from ESOC's main control room, that it may be another seven minutes for the first Huygens data.

11:00 a.m. EST: ESA and NASA Huygens team members are still waiting to see the first data sent by the probe from Saturn's hazy moon Titan. At ESA's ESOC spacecraft operations center in Darmstadt, Germany, personnel are steadily gathering around computer consoles in anticipation.

10:35 a.m. EST: It's confirmed. Cassini has turned back to the Earth and is sending data. No Huygens probe data has been downloaded yet, but researchers are waiting expectantly.

"We have 40 more minutes of suspense, then we'll know if everything worked properly," said John Dodsworth, Huygens ground manager at ESOC.

10:30 a.m. EST: Applause broke out briefly at ESA's ESOC spacecraft operations center in Darmstadt, Germany. Apparently, mission controllers have detected the first data from Cassini's Huygens receivers, spacecraft engineers said.

That doesn't mean that any Huygens science has arrived, just that the receivers aboard Cassini designed to record that data were functioning at the start of the descent, they added.

10:15 a.m. EST: Huygens is still pounding out a signal to the surprise of ESA engineers, but any science data it is currently transmitting is falling on deaf ears.

The Cassini orbiter, Huygens' only connection to Earth, has turned away from the probe and is preparing to relay the probe's data home, mission controllers said.

"The probe has been living for more than five hours," said Huygens mission manager Jean-Pierre Lebreton. "But we knew at a certain time Cassini would have to stop recording."

Lebreton said the Huygens science team is eager to see any science data, but can wait. After all, they've waited more than seven years -Cassini-Huygens launched in 1997 - just to reach this point in the mission, he added.

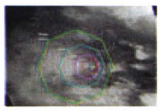
10:00 a.m. EST: Engineers at JPL said that although Huygens' data will first be received at JPL, it will be forwarded straight to ESA's ESOC spacecraft operations center in Germany where hundreds of scientists and engineers are eagerly awaiting news from the Titan probe.

9:50 a.m. EST: As ESA commentators take a break in Darmstadt, Germany, researchers and engineers at NASA's Jet Propulsion Laboratory in Pasadena, California are lauding Huygens' apparently successful landing on Titan.

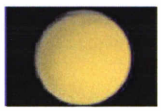
"There are a lot of excited people in Darmstadt and here too," said ESA Huygens system engineer Shaun Standley at JPL.

9:45 a.m. EST: By 10 a.m. EST, mission managers expect Cassini to have begun to swing back to point toward Earth and deliver the first packets of information from the Huygens probe on Titan.

Images



This map illustrates the planned imaging coverage for the NASA Descent Imager/Spectral Radiometer aboard ESA's Huygens probe during its descent toward Titan's surface on Jan. 14, 2005.



Titan as Orange Globe: Titan as we might see it with our eyes from the Cassini UV camera (colorized). Credit: NASA/JPL. Click to enlarge.

This schematic illustrates the different stages of Huygen's 2.5-hour descent to Titan's surface. Credit: NASA/ESA. Click to enlarge.

More Stories

- **Click here for a live look inside ESA's ESOC mission control room.**
- **SPACE.com Special Report: Cassini-Huygens at Saturn and Titan**
- **Image Gallery: Cassini Explores Saturn's Moons**

9:20 a.m. EST: NASA's Cassini orbiter has a quadruple redundant data recording capability, meaning the spacecraft is collecting Huygens data with four redundant systems in hopes of ensuring that no information is lost, ESA officials said.

"We really don't want to lose any bit of this precious data," ESA mission operations manager Claudio Solazzo said earlier today.

9:10 a.m. EST: "The probe is still alive and sending a signal," said Claudio Solazzo, ESA Huygens mission operations manager.

Now that Huygens is apparently on Titan, researchers hope a pair of electronic levels will register any movement of the probe. If it landed on a hydrocarbon lake, the levels would detect any bobbing motion, researchers have said.

A penetrating instrument on Huygens' bottom should make a very simple measurement upon landing to determine if the landing zone is firm, clay, sand or other type of surface, Huygens mission scientists said.

8:35 a.m. EST: Huygens mission controllers report that the probe landed somewhere between 1:45 p.m. and 1:46 p.m. local time in Darmstadt, Germany (CET), that's somewhere between 7:45 a.m. and 7:46 a.m. EST.

The probe is apparently on Titan's surface and still going strong, mission managers said.

8:00 a.m. EST: The first Huygens news briefing post-Titan descent has concluded.

ESA mission managers said Huygens' carrier signal, the only signal researchers expected to detect from Earth, has also been detected by the Parkes radio telescope in Australia. The signal has been blaring strong for two hours now, researchers said.

Mission manager Jean-Pierre Lebreton said that four optical telescopes around the world were trained on Titan during Huygens' descent. One telescope was unable to observe the event due to poor weather, while the other three failed to detect any sign of a entry fireball, he added.

The first real telemetry from Huygens should reach Earth around 10:21 a.m. EST (1521 GMT), though it will be 4:21 p.m. local time at ESOC in Darmstadt, Germany. The first science data is anticipated to arrive by 11:15 a.m. EST (1615 GMT), mission controllers said.

7:45 a.m. EST: At least one instrument aboard Huygens is taking data. A Doppler instrument designed to track wind patterns on Titan is apparently working, Jean-Pierre Lebreton, Huygens mission manager, said during the press conference.

7:20 a.m. EST: The first news briefing on today's Huygens descent to Titan should begin in about 10 minutes at ESA's ESOC spacecraft operations center. Huygens reached Titan successfully about two hours ago, and should have touching down on the moon's surface at 7:34 a.m. EST according to a NASA mission timeline.

6:45 a.m. EST: ESA officials say the mood at ESOC has eased with the Huygens signal detection by West Virginia's Green Bank Telescope. Nail-biting tension has been replaced with some relief, though Huygens mission scientists are still eager to learn if their science instruments are taking measurements as designed.

"We're now just waiting for Cassini," John Dodsworth said earlier.

6:15 a.m. EST: With the confirmation signal from Huygens in hand, ESA officials know the probe is currently floating down toward Titan under its main parachute. It will jettison the parachute as it descends and deploy a smaller, three-meter parachute in order to reach the surface before onboard batteries run out, mission managers said today.

6:05 a.m. EST:

Space News Staff Writer Peter de Selding reports live from Huygens mission control:

DARMSTADT, Germany-- A network of powerful ground telescopes has picked up the signal of Europe's Huygens descent probe 1.2 billion kilometers away, confirming that the probe is alive as it begins its descent into the thick atmosphere of Saturn's largest moon, Titan.

European Space Agency officials at Huygens mission control here said the signal -- no more than the equivalent of a telephone dial tone -- was detected by a network of 18 telescopes deployed to listen for a signal coming directly from Huygens.

The biggest of these antennas is the 100-meter-diameter Robert C.

Byrd Green Bank Telescope, operated by the National Radio Astronomy Observatory in Green Bank, West Virginia.

The signal did not confirm anything beyond the fact that Huygens is alive. But it was enough to cause a burst

of applause here when announced at 5:35 a.m. EST (10:35 a.m. GMT) today. 'There is a lot of emotion in this room," said Jean-Pierre Lebreton, Huygens program manager at ESA. "It's great news."

Leonid Gurvitz, mission manager for Huygens' communications with the ground telescope network, said 18 telescopes including Green Bank had been trained to pick up a signal and that it is the network itself, more than any single telescope, that received the Huygens signal.

NASA's Cassini satellite, which carried Huygens to Saturn orbit, has been moved into position to receive Huygens mission data during the probe's 2.5-hour descent into Huygens' thick atmosphere.

A more-complete assessment of whether Huygens' parachutes have deployed and its heat shield jettisoned to permit the start of observations is expected to be received by science teams from Cassini around 11:20 a.m. EST (1620 GMT) today.

6:00 a.m. EST: If it switched on as planned, a microphone instrument aboard Huygens may allow researchers to recreate the sound of the probe's descent as it plunged through Titan's atmosphere, ESA mission scientists said. The instrument may also record thunder, and Huygens scientists hope to have at least initial data to present within 24 hours.

5:50 a.m. EST: Cautious ESA commentators stress the Huygens signal is just a carrier tone. There is no confirmation that the six science instruments aboard the probe are working as planned.

"It looks like we heard the baby crying," said Huygens mission manager Jean-Pierre Lebreton from the floor of ESOC mission control. "But clearly it tells us the probe is alive, the entry has been successful and we are under parachutes."

5:35 a.m. EST: Huygens speaks from Titan! ESA has confirmed that the Green Bank Telescope successfully detected a Huygens signal tone. The signal, a confirmation that Huygen's transmitter is at least functioning, and activated on time at about 5:18 a.m. EST.

About 600 people are at ESOC mission control for Huygens Titan descent and some engineers crowded around computer monitors when the signal confirmation was announced.

"It's a tremendously exciting moment," said John Dodsworth, Huygens ground manager at ESOC.

5:30 a.m. EST: If everything is going well, researchers may be able to assemble Huygens first pictures of Titan within 24 hours, U.S. astronomer Martin Tomakso, the international lead of the probe's only optical instrument, has said.

"The first images may be pretty murky," Tomasko said from Darmstadt, adding that Titan's nitrogen-rich atmosphere is quite hazy. "But we think the haze has a bottom, and that once we get through it we'll have a clear view of the surface."

Tomasko said that during its slow descent, Huygens will most likely be swinging and rocking while taking numerous images that will later have to be assembled into mosaics. The Sun should appear 10 times smaller from Titan than it does from Earth, so researchers expect a sort of twilight environment, he added.

5:15 a.m. EST: According to its timeline, Huygens should now be transmitting data to its Cassini mothership, after deploying a series of parachutes to slow its descent. The first few measurements could already be in Cassini's data file, researchers say. But they will not know for sure whether Huygens transmitter is working unless Green Bank is successful in picking up the tone, or from Cassini once it turns back toward Earth.

5:00 a.m. EST: ESA's Huygens probe is scheduled to reach Titan in the next few minutes. While all Huygens data will be recorded by Cassini for later playback to Earth, astronomers are hoping that the powerful 100 by 110-meter Green Bank radio telescope in West Virginia will pick up a simple tone from the probe.

4:15 a.m. EST: Al Diaz, NASA's associate administrator of the Science Mission Directorate, is monitoring the joint Cassini-Huygens operations at ESA's ESOC mission control center in Darmstadt.

"It's a mission unlike anything we've tried before," he said today of Cassini-Huygens.

4:00 a.m. EST: ESA is providing a real time tracking of Cassini and Huygens. You can see find it here. At last report, Huygens was set to reach Titan at about 5:05 a.m. EST, then deploy parachutes a few minutes later. The Cassini orbiter was last reported about 72,000 kilometers from Titan. It has turned away from Earth to record any data Huygens is able to broadcast.

3:30 a.m. EST: ESA mission controllers are playing a waiting game now with Huygens' mothership Cassini. The NASA orbiter has apparently turned away from Earth and is oriented toward Titan to receive data fromthe Huygens probe.

European commentators have their fingers crossed that Huygens' descent goes better than a recent - but fictional - probe to Titan in the BBC science fiction series *Space Odyssey*. In that series, which follows a crew of astronauts exploring the solar system, an automated Titan probe fails after deployement.

3:25 a.m. EST: Huygens mission controllers report the probe is hurtling toward Titan at about 22,000 kilometers an hour.

3:20 a.m. EST: John Dodsworth, of ESA's ESOC mission control center at Darmstadt, said Huygens is about two hours from reaching Titan interface - about 1,270 kilometers above the surface. The probe is right on target and will land well within its target, he added.

3 a.m. EST: ESA officials are counting down to the Huygens probe's arrival at Titan. The probe is still a few hours off from encountering the moon's atmosphere.

"I certainly am jumping all over in anticipation," said Claudio Solazzo, ESA Huygens Mission operations manager, from Darmstadt, Germany. "Today is a great day."

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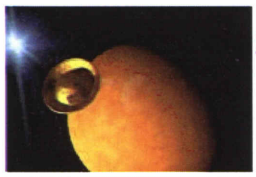
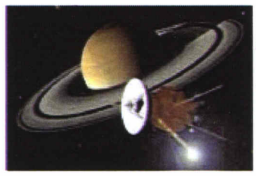


Cassini Releases Huygens Probe
Dec. 25, 2004: PASADENA, Calif. (AP) -- A probe once attached to the international Cassini spacecraft was on its own Saturday for the first time, headed on a slow, tumbling course into the hazy atmosphere of Saturn's planet-size moon Titan.



ARRIVAL! Cassini Enters Orbit Around Saturn
June 30, 2004: BOULDER, COLORADO --After a nearly seven year journey, the spacecraft swung into an orbit around the giant gas globe tonight, ready to spend the next four years performing scientific investigations of the Saturnian system.

The Cassini Quest
Learn more about the Cassini-Huygens project with these video journey behind the mission.

January 14, 2005

The Daily Progress

Local scientists aid Saturn trip

By Kurt Loft
and Kate Andrews
Media General News Service

The Robert C. Byrd Green Bank Telescope
CREDIT: NRAO/AUI/NSF

Earthlings are used to pictures from space, but what about sounds?

This weekend, the cosmic noise from a mysterious world more than a billion miles away can be heard on the Internet, thanks to a historic mission unfolding on one of the icy moons of Saturn. The mission was made possible, in part, because of the efforts of the National Radio Astronomy Observatory, headquartered in Charlottesville

If all goes well today, a probe called Huygens will parachute onto Titan, the only moon in the solar system with an Earth-like atmosphere. As Huygens (pronounced HOY-genz) descends over 2 1/2 hours, it will snap pictures and record sounds of whatever Titan has to offer: thunderstorms, lightning or swirling winds of methane.

"Hearing the sounds of Titan promises to be amazing,"v said Bruce Betts, a spokesman with the Planetary Society, which is working with the European Space Agency to make the sounds available over the Internet.

"And there is definitely science to be gleaned from the sounds," he said.

The National Radio Astronomy Observatory's Green Bank Telescope in West Virginia and eight of the 10 telescopes of its Very Long Baseline Array in Iowa and points west will pinpoint where the Huygens spacecraft is during its descent to Titan.

The Huygens probe will broadcast a signal, which will be picked up by the larger Cassini spacecraft and received on Earth with the NRAO telescopes, as well as others in Australia and Japan.

The huge radio telescopes are being used because NASA's scope in California cannot pick up the spacecraft's signal, said Frank Ghigo, an NRAO scientist in West Virginia.

It is expected to be very weak, Ghigo warned. "We may not be able to tell if we have detected it right away."

The scientists have little time, though, to find the signal, given that the entire experiment is ex-pected to last five or six hours, from the time the spacecraft enters Titan's atmosphere to its landing, aided by a parachute.

The probe will take a few pictures during its descent.

Ghigo will be joined by other scientists, programmers and engineers, "standing by to fix problems" such as computer crashes. The experiment was expected to start at 4 a.m. today.

"It"s kind of a unique thing," he said, while acknowledging, "If we screw up, we don't get another shot."

Last month, the 700-pound, saucer-shaped craft detached itself from its mother ship, Cassini, and began a three-week journey to Titan. While Huygens won't last long after touching down, Cassini will orbit Saturn for four more years, studying its giant rings, atmosphere and magnetic field.

Scientist don't know if Huygens will settle on land or splash into the oceans on Titan. Either way, people on Earth may hear those final moments.

"We hope to give the impression of being there," Huygens scientist Marcello Fulchignoni said.

If all goes according to plan, audio from Titan can be heard beginning at 2 a.m. Saturday on the Web at http://planetary.org/sounds/

Contact Kate Andrews at (434) 978-7261 or kandrews@dailyprogress.com. Kurt Loft is a staff writer at the Tampa Trib-une.

January 14, 2005

N.M.-Based Radiotelescope Listens To Saturn Probe's Signal

By Matt Mygatt
The Associated Press

A New Mexico-based radiotelescope eavesdropped Friday on the faint signal of a European space probe as the craft parachuted through the atmosphere of Saturn's moon Titan.

"I've been running on adrenaline for a while," said Jonathan Romney, an astronomer with the National Radio Astronomy Observatory's Very Long Baseline Array radiotelescope, which is operated from Socorro, south of Albuquerque.

The VLBA collected about 7 1/2 hours of data on magnetic discs beginning at about 2 a.m. Friday from the European Space Agency's Huygens probe, said Romney, who was on the job for about 24 consecutive hours.

The discs will be sent to the Joint Institute for Very Long Baseline Interferometry in Europe in Dwingeloo, Netherlands, Romney said in a telephone interview.

The data collected by the 12-person team at Socorro will help scientists learn about Huygens' descent and landing, he said.

The data also tracked the craft's motions as it drifted downward for 2 1/2 hours to a successful landing on Titan's surface, Romney said. The motions will provide information about Titan's wind, he said.

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The VLBA used eight of its 10 dishes to listen to the 10-watt transmissions from Huygens during the probe's descent, he said.

The dishes — at Pie Town and Los Alamos, N.M.; Fort Davis, Texas; North Liberty, Iowa; Kitt Peak, Ariz.; Brewster, Wash.; Owens Valley, Calif.; and Mauna Kea, Hawaii — were the first to detect the signals 762 million miles away, Romney said.

Titan, Huygens and Cassini — the probe's mother ship, orbiting Saturn — "were all above the mid-Pacific Ocean at the time the probe went in," he said.

"So the European radiotelescopes could not observe this because they were on the other side of the Earth, but we could," Romney said.

The VLBA also tapped into data from the NRAO's Robert C. Byrd Green Bank Telescope in West Virginia, which, he said.

"What we are doing is eavesdropping on the data link from the Huygens probe to the Cassini orbiter," Romney said.

The VLBA was detecting Huygens' carrier signal, he said. "The carrier is just like one note and all the information is in the many, many notes that accompany it," he said.

"We're just measuring where did the spacecraft go," Romney said.

With the real-time data from the West Virginia telescope, "we got the fist signal, the first knowledge that it (Huygens) had survived its fall through the atmosphere and that the heat shield had been properly jettisoned," he said.

Scientists originally predicted Huygens' batteries might last only a few minutes after the craft landed, Romney said.

"But they lasted for so long that it may well be possible to make some useful measurements of the rotation of Titan at the surface," he said.

The Cassini-Huygens mission is a project of the National Aeronautics and Space Administration, the European Space Agency and the Italian space agency. It was launched Oct. 15, 1997, from Cape Canaveral, Fla., to study Saturn along with the planet's rings and moons.

Cassini ejected the 705-pound Huygens on Dec. 24 to begin the probe's fall toward Titan.

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4 National News

14 January 2005

European joy as Huygens probe lands on Titan

The European-built Huygens probe has successfully landed on Titan, penetrating the thick, orange-coloured clouds that have until now prevented scientists observing details of the moon's surface.

The first scientific data to reach Earth arrived at the European Space Operations Centre (ESOC) in Germany at around 16:30 GMT today.

Descending by parachute over a period of two-and-a-half hours, Huygens has gathered invaluable atmospheric readings and taken some 750 images of Saturn's largest and most mysterious moon along the way.

"Titan was always the target in the Saturn system where the need for 'ground truth' from a probe was critical. It is a fascinating world and we are now eagerly awaiting the scientific results," said Professor David Southwood, Director of ESA's scientific programme.

Huygens is mankind's first successful attempt to deliver a probe onto to a target so far out in the solar system, and is being hailed a great achievement for Europe and its US partners in this ambitious international endeavour.

The probe started its descent through Titan's hazy cloud layers from an altitude of about 1270 kilometres at around 10:15 GMT, and during the next three minutes Huygens had to decelerate from 18,000 to 1400 kilometres per hour.

A sequence of parachutes then slowed down the probe to less than 300kph. At a height of about 160 kilometres the probe's scientific instruments were exposed to Titan's atmosphere, and at about 120 kilometres the main parachute was replaced by a smaller one to complete the descent, with touchdown at around 12:34 GMT.

The earliest indication that the mission was a success came this morning when the Robert C. Byrd Green Bank Telescope (GBT) of the National Radio-astronomy Observatory in West Virginia, a part of the global network of radio telescopes involved in tracking the probe, detected a 'carrier' signal to NASA's Cassini spacecraft, currently in orbit above Saturn. The presence of the carrier signal indicated that Huygens had survived the trip intact and had begun to transmit.

Cassini then began to relay the signal back to Earth at around 15:30 GMT. Scientists are as yet uncertain what kind of surface the probe encountered when it 'landed', but speculate a richly diverse topography. A splash down in an ocean would probably mean better data from Huygens, as even if the probe lasted only a few minutes before sinking it would have at least stayed in an upright position, essential for sending the data back to Cassini and to the scientists on Earth. Moreover, some of Huygens's instruments are better prepared to analyse liquids.

One of the main reasons of sending Huygens to Titan is that its methane-rich nitrogen atmosphere and its surface may contain many chemicals of the kind that existed on a young Earth.

Huygen's journey began on Christmas Day 2004 when Cassini, which spent

seven years travelling to the ringed planet, deployed the European Space Agency's 2.7m-wide, 319kg probe, sending the craft on its 22-day trip to Titan.
(GB)

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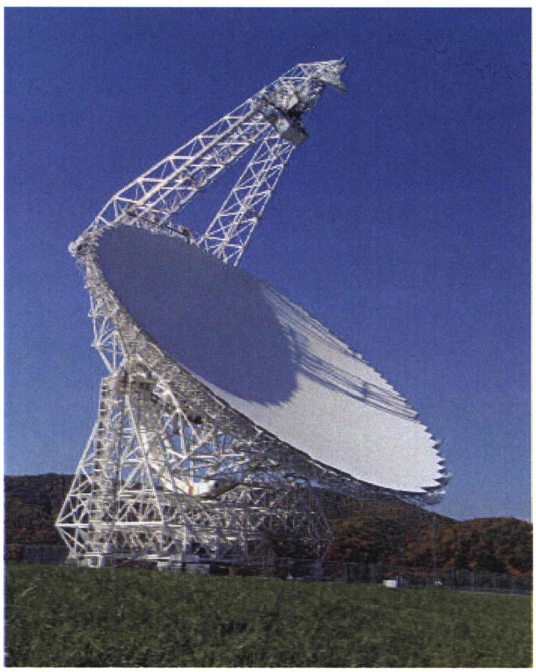
TUNING IN TO PULSARS

RADIO ASTRONOMERS SAY "ASTONISHING" NUMBER OF WHIRLING STARS FOUND

BY A.J. HOSTETLER
TIMES-DISPATCH STAFF WRITER

Jan 13, 2005

Astronomers using the Green Bank Telescope have observed a star cluster teeming with pulsars, rotating stars whose beams of radio waves periodically pass over Earth like a searchlight.
Parker Orleans



The Robert C. Byrd Green Bank Telescope
CREDIT: NRAO/AUI/NSF

Further studies of these pulsars should provide insights into pulsar physics, general relativity and how such stellar clusters evolve.

A U.S.-Canadian team of scientists, led by the National Radio Astronomy Observatory in Charlottesville, looked at the cluster called Terzan 5 some 28,000 light-years away in the constellation Sagittarius. Using the West Virginia-based telescope, they discovered 21 new pulsars in the cluster, bringing its total to a record 24.

Prior to the new findings, there were 80 known pulsars strewn through two-dozen clusters. Astronomers had long predicted that Terzan 5 had more pulsars, but some of the largest telescopes failed to find anything.

The recently rebuilt 360-foot-wide Green Bank Telescope, along with new data-processing techniques, offered a chance to spot the missing pulsars with five to 20 times greater sensitivity than previous attempts.

A single, six-hour observation with the telescope last July 17, and two days of number crunching, revealed 14 new pulsars. Over the next four months the astronomers turned up the rest; a few suspected pulsars await confirmation.

"It's truly astonishing," said NRAO astronomer Scott Ransom, who presented the findings yesterday to the American Astronomical Society. The findings also are online in the journal Science Express.

Globular clusters are crammed with millions of stars, which form at about the same time. Pulsars are whirling versions of super-dense neutron stars that died early in the cluster's history. As they spin, the pulsars regularly shoot out beams of radio waves, like a rotating searchlight.

Terzan 5's stars formed about 10 billion years ago. Normally, their magnetic fields would have halted any observable twirling. But like kids in a small neighborhood, some of the Terzan 5 stars eventually had to play together. In Terzan 5, they play together a lot and find buddies to hang out with. Those friendships don't always last, and some pulsars seem to have gone off in a huff with new pals. Over time, these playground politics start spinning the neutron stars, turning them into pulsars.

At least 13 of Terzan 5's pulsars are paired off in these binary systems.

Four of the pulsars are the fastest-rotating known, with two spinning at nearly 600 times per second, "roughly as fast as a household blender," Ransom said.

A lot of the science can now begin, with long-term monitoring of the pulsars and their beams planned, Ransom said.

Ransom hopes to expand his census of Terzan 5, sizing up the binary systems, watching the stellar dynamics unfold over time and determining whether a black hole sits in the middle of the neighborhood.

The pulsar findings are also helping astronomers discard theories on neutron star formation and nuclear physics, according to the scientists. For example, preliminary measurements indicate that two of the pulsars are more massive than some theoretical models would allow.

Contact A.J. Hostetler at (804) 649-6355 or ahostetler@timesdispatch.com

El Defensor Chieftain

January 12, 2005

VLA detects unexplained radio emissions from three brown dwarfs

By Dave Finley
National Radio Astronomy Observatory

Astronomers have discovered three brown dwarfs — enigmatic objects that are neither stars nor planets — emitting radio waves that scientists cannot explain. The three newly-discovered radio-emitting brown dwarfs were found as part of a systematic study of nearby brown dwarfs using the National Science Foundation's Very Large Array radio telescope.

Until 2001, scientists believed that brown dwarfs, which are intermediate in mass between stars and planets, could not emit detectable amounts of radio waves. That year,

summer students at the VLA made the first discovery of radio emission from a brown dwarf. Subsequently, as many as a half-dozen more radio-emitting brown dwarfs were discovered.

"It clearly had become time to make a systematic study and try to find out just what percentage of brown dwarfs are emitting radio waves," said Rachel Osten, an astronomer at the National Radio Astronomy Observatory in Charlottesville, Virginia.

Osten was assisted in the project in the summer of 2004 by Lynnae Quick, a student at North Carolina Agricultural and Technical State University; Tim Bastian, also an astronomer at NRAO; and Suzanne Hawley, an astronomer at the University of

Washington. The research team presented their results to the American Astronomical Society's meeting in San Diego, Calif.

The three new detections of radio-emitting brown dwarfs are just the first results from the systematic study, which aims to observe all the known brown dwarfs within about 45 light-years of Earth.

"We want to be able to say definitively just how common radio emission is among brown dwarfs," Osten explained.

The study involves observing 65 individual brown dwarfs, so these new detections represent just the beginning of the results expected from the study.

Brown dwarfs are too big to be planets but too small to be true stars, as they have too little mass to trigger hydrogen fusion reactions at their cores, the source of the energy output in larger stars. With roughly 15 to 80 times the mass of Jupiter, the largest planet in our Solar System, brown dwarfs had long been thought to exist, but proved difficult to find. Astronomers found the first brown dwarf in 1995, and a few hundred now are known.

The type of radio emission seen in the brown dwarfs arises in more-massive stars as a result of plasma interacting with the star's magnetic field. However, astronomers have noted that this type of activity declines in less-massive stars. This is why they

expected brown dwarfs, with masses less that that of any star, to lack radio emission.

Surprisingly, based on discoveries since 2001, it now appears that radio-emitting magnetic actvity may actually become more common in these very low-mass objects. "We don't have an explanation for this," Osten said.

The scientists hope that brown-dwarf radio emission may give them a new tool for analysis. "Since both stars and the planets in our Solar System produce radio emission, detailed study of the radio emission properties of these brown dwarfs may enable us to distinguish where the boundary between stellar and planetary behavior occurs in these not-quite-stars, not-quite-planets," Osten explained.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities Inc.

local news
IOWA CITY PRESS-CITIZEN

Monday, January 10, 2005

Local telescope to collect data from Saturn probe

By the Press-Citizen
More...
• Cassini grabs a close-up look at Saturn's moon Titan
• Next stop: Saturn

From University of Iowa News Services:

Eastern Iowa, by way of the North Liberty radio telescope, will participate in the exploration of Titan, Saturn's largest moon, on Jan. 14.

That's when the European Space Agency's 700-pound Huygens spacecraft -- part of NASA's Cassini spacecraft probe of Saturn, its rings and moons -- is scheduled to dive into Titan's atmosphere and begin collecting data on the atmosphere and the rest of the planet.

The information will be gathered by the National Science Foundation's National Radio Astronomy Observatory (NRAO), one of the world's premier research facilities for radio astronomy. The NRAO includes the 10 radio antennas of the Very Long Baseline Array (VLBA), stretching from Mauna Kea, Hawaii across the United States to St. Croix, the Virgin Islands and including the North Liberty, Iowa, instrument. The VLBA is operated from the NRAO's Array Operations Center in Socorro, New Mexico.

Robert Mutel, professor in the University of Iowa College of Liberal Arts and Sciences (CLAS) Department of Physics and Astronomy, says that the North Liberty radio telescope was built about 15 years ago to match its nine sister instruments and to replace a less powerful telescope. Today, it plays an important role in the VLBA network as the only telescope located between Los Alamos, N.M., and Hancock, N.H. Mutel, whose research interests include using the VLBA to study active galaxies, active stars and interstellar turbulence, is one of several UI researchers who use the facility for teaching and research.

The position and condition of the probe as it parachutes through the atmosphere will reveal information about Titan's winds, which were measured in excess of 200 miles an hour during the Voyager 1 spacecraft 1980 flyby. A European-led team will track the probe's position during its descent, while a U.S.-led team will measure the probe's descent speed and the direction of its motion.

The Robert C. Byrd Green Bank Telescope (GBT) in West Virginia and eight of the 10 VLBA telescopes (those located at Pie Town and Los Alamos, N.M., Fort Davis, Tex., North Liberty, Iowa, Kitt Peak, Ariz., Brewster, Wash., Owens Valley, Calif., and Mauna Kea, Hawaii) will directly receive the faint signal from Huygens during its descent. Radio telescopes in Australia, Japan and China will also gather data.

Cassini, carrying 12 scientific instruments, on June 30, 2004 became the first spacecraft to orbit Saturn and begin a four-year study of the planet, its rings and its 31 known moons. The $1.4 billion spacecraft is part of the $3.3 billion Cassini-Huygens Mission that includes the Huygens probe, a six-instrument European Space Agency probe, scheduled to land on Titan Jan. 14.

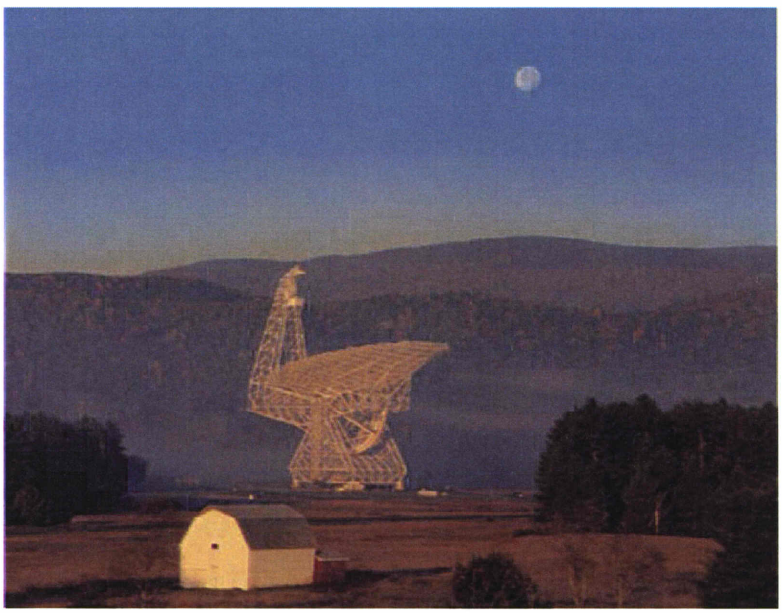
The Cassini-Huygens mission is a cooperative project of NASA, the European Space Agency and the Italian Space Agency. JPL, a division of the California Institute of Technology, Pasadena, Calif. manages the Cassini-Huygens mission for NASA's Office of Space Science, Washington, D.C. JPL designed, developed and assembled the Cassini orbiter. For the latest images and information about the Cassini-Huygens mission, visit: http://www.nasa.gov/cassini.

ABC News: Telescope to Study Winds of Saturn's Moon

Green Bank Telescope to Study the Winds of Saturn's Largest Moon

The Associated Press

CHARLESTON, W.Va. Jan 4, 2005 — The Green Bank Telescope will be used to study the winds of Saturn's largest moon as the European Space Agency's Huygens spacecraft plunges into Titan's atmosphere later this month.



The Robert C. Byrd Green Bank Telescope
CREDIT: NRAO/AUI/NSF

The car-sized spacecraft is scheduled to parachute to the moon's surface on Jan. 14.

During its expected two-hour descent through Titan's thick orange clouds, Huygens will sample the atmosphere, measure wind and precipitation, record sounds and take photographs.

A team of scientists from the Joint Institute of Very Long Baseline Interferometry in Europe will use a worldwide network of radio telescopes, including those operated by the National Radio Astronomy Observatory, to track Huygens' trajectory and record its position on Titan to within one kilometer.

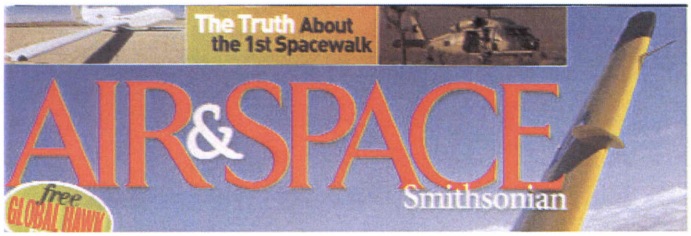
"That's like being able to sit in your back yard and watch the ball in a pingpong game being played on the Moon," said the Joint Institute's Leonid Gurvits.

The Green Bank Telescope and other radio telescopes in the United States, Japan, China and Australia will be able to receive the spacecraft's faint, 10-watt signal from a distance of 750 million miles. The radio telescopes will provide new data on Titan's poorly understood winds.

Titan has been a target of astronomers for centuries. But in 1980, when NASA's Voyager spacecraft flew by the moon, astronomers realized it had a number of unique characteristics, including an atmosphere three times taller than Earth's and choked with organic compounds similar to smog.

Methane is known to be one element of Titan's atmosphere, but scientists have no idea where it comes from.

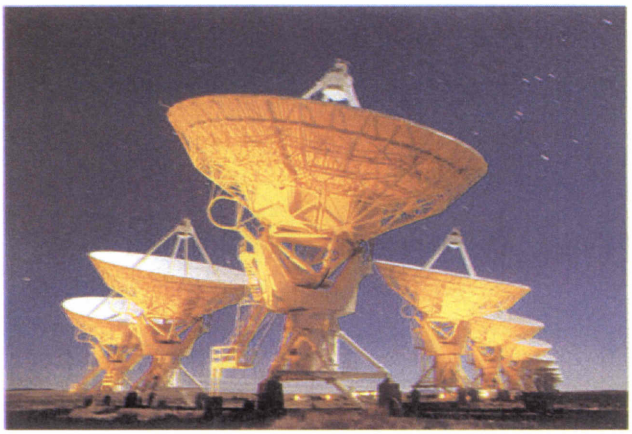
SIGHTINGS



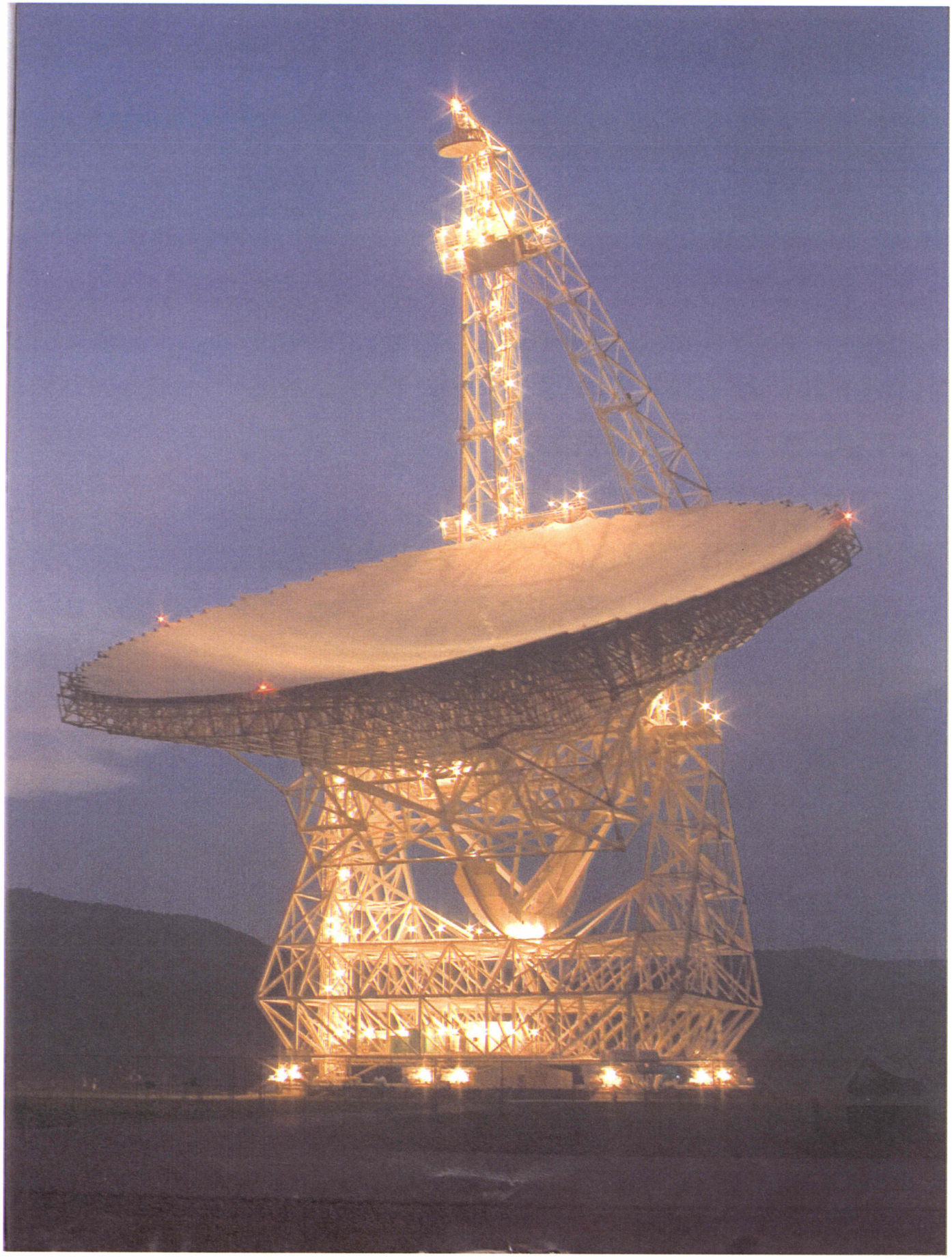
January 2005

In straining to hear ever-fainter radio emissions from distant galaxies, astronomers have built some of the most graceful machines on the planet. The 20-acre collecting dish of the Arecibo Radio Telescope lets enough rain and sunshine through to allow ferns and orchids to grow beneath it (below). Sitting in a natural hollow in the mountains of Puerto Rico, Arecibo remains the world's largest radio telescope more than 40 years after it was built.

New Mexico's Very Large Array (right) took a different approach, combining the signals from 27 dishes to simulate the resolving power of an antenna 22 miles in diameter. The Green Bank Telescope in West Virginia (opposite) went for sheer bulk. The 100-meter telescope is the largest fully steerable dish in use today. Virginia-based photographer Tim Wright notes: "The telescope seems like a marble sculpture until the silence is pierced by a steady, industrial buzzer warning of impending movement. The motor hum builds to a crescendo and climaxes with a clang as metal strains metal. Then the massive structure spins and the dish bows with a speed that belies its enormous girth. After a while, it seems almost alive, moving with free will as it searches the sky."

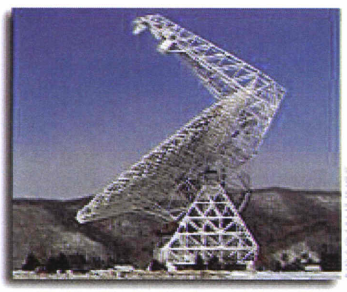


ROGER RESSMEYER/CORBIS (2); OPPOSITE: TIM WRIGHT



PRESS RELEASE
Date Released: Wednesday, December 22, 2004
Source: National Radio Astronomy Observatory

Radio Telescopes Will Add to Cassini-Huygens Discoveries



When the European Space Agency's Huygens spacecraft makes its plunge into the atmosphere of Saturn's moon Titan on January 14, radio telescopes of the National Science Foundation's National Radio Astronomy Observatory (NRAO) will help international teams of scientists extract the maximum possible amount of irreplaceable information from an experiment unique in human history. Huygens is the 700-pound probe that has accompanied the larger Cassini spacecraft on a mission to thoroughly explore Saturn, its rings and its numerous moons.

The Robert C. Byrd Green Bank Telescope (GBT) in West Virginia and eight of the ten telescopes of the continent-wide Very Long Baseline Array (VLBA), located at Pie Town and Los Alamos, NM, Fort Davis, TX, North Liberty, IA, Kitt Peak, AZ, Brewster, WA, Owens Valley, CA, and Mauna Kea, HI, will directly receive the faint signal from Huygens during its descent.

Along with other radio telescopes in Australia, Japan, and China, the NRAO facilities will add significantly to the information about Titan and its atmosphere that will be gained from the Huygens mission. A European-led team will use the radio telescopes to make extremely precise measurements of the probe's position during its descent, while a U.S.-led team will concentrate on gathering measurements of the probe's descent speed and the direction of its motion. The radio-telescope measurements will provide data vital to gaining a full understanding of the winds that Huygens encounters in Titan's atmosphere.

Currently, scientists know little about Titan's winds. Data from the Voyager I spacecraft's 1980 flyby indicated that east-west winds may reach 225 mph or more. North-south winds and possible vertical winds, while probably much weaker, may still be significant. There are competing theoretical models of Titan's winds, and the overall picture is best summarized as poorly understood. Predictions of where the Huygens probe will land range from nearly 250 miles east to nearly 125 miles west of the point where its parachute first deploys, depending on which wind model is used. What actually happens to the probe as it makes its parachute descent through Titan's atmosphere will give scientists their best-ever opportunity to learn about Titan's winds.

During its descent, Huygens will transmit data from its onboard sensors to Cassini, the "mother ship" that brought it to Titan. Cassini will then relay the data back to Earth. However, the large radio telescopes will be able to receive the faint (10-watt) signal from Huygens directly, even at a distance of nearly 750 million miles. This will not be done to duplicate the data collection, but

to generate new data about Huygens' position and motions through direct measurement.

Measurements of the Doppler shift in the frequency of Huygens' radio signal made from the Cassini spacecraft, in an experiment led by Mike Bird of the University of Bonn, will largely give information about the speed of Titan's east-west winds. A team led by scientists at NASA's Jet Propulsion Laboratory in Pasadena, CA, will measure the Doppler shift in the probe's signal relative to Earth. These additional Doppler measurements from the Earth-based radio telescopes will provide important data needed to learn about the north-south winds.

"Adding the ground-based telescopes to the experiment will not only help confirm the data we get from the Cassini orbiter but also will allow us to get a much more complete picture of the winds on Titan," said William Folkner, a JPL scientist.

Another team, led by scientists from the Joint Institute for Very Long Baseline Interferometry in Europe (JIVE), in Dwingeloo, The Netherlands, will use a world-wide network of radio telescopes, including the NRAO telescopes, to track the probe's trajectory with unprecedented accuracy. They expect to measure the probe's position within two-thirds of a mile (1 kilometer) at a distance of nearly 750 million miles.

"That's like being able to sit in your back yard and watch the ball in a ping-pong game being played on the Moon," said Leonid Gurvits of JIVE.

Both the JPL and JIVE teams will record the data collected by the radio telescopes and process it later. In the case of the Doppler measurements, some real-time information may be available, depending on the strength of the signal, but the scientists on this team also plan to do their detailed analysis on recorded data.

The JPL team is utilizing special instrumentation from the Deep Space Network called Radio Science Receivers. One will be loaned to the GBT and another to the Parkes radio observatory. "This is the same instrument that allowed us to support the challenging communications during the landing of the Spirit and Opportunity Mars rovers as well as the Cassini Saturn Orbit Insertion when the received radio signal was very weak," said Sami Asmar, the JPL scientist responsible for the data recording.

When the Galileo spacecraft's probe entered Jupiter's atmosphere in 1995, a JPL team used the NSF's Very Large Array (VLA) radio telescope in New Mexico to directly track the probe's signal. Adding the data from the VLA to that experiment dramatically improved the accuracy of the wind-speed measurements.

"The Galileo probe gave us a surprise. Contrary to some predictions, we learned that Jupiter's winds got stronger as we went deeper into its atmosphere. That tells us that those deeper winds are not driven entirely by sunlight, but also by heat coming up from the planet's core. If we get lucky at Titan, we'll get surprises there, too," said Robert Preston, another JPL scientist.

The Huygens probe is a spacecraft built by the European Space Agency (ESA). In addition to the NRAO telescopes, the JPL Doppler Wind Experiment will use the Australia Telescope National Facility and other radio telescopes in Parkes, Mopra, and Ceduna, Australia; Hobart, Tasmania; Urumqi and Shanghai, China; and Kashima, Japan. The positional measurements are a project led by JIVE and involving ESA, the Netherlands Foundation for Research in Astronomy, the University of Bonn, Helsinki University of Technology, JPL, the Australia Telescope National Facility, the National Astronomical Observatories of China, the Shanghai Astronomical Observatory, and the National Institute for Communication Technologies in Kashima, Japan.

The Joint Institute for VLBI in Europe is funded by the national research councils, national facilities and institutes of The Netherlands (NWO and ASTRON), the United Kingdom (PPARC), Italy (CNR), Sweden (Onsala Space Observatory, National Facility), Spain (IGN) and Germany (MPIfR). The European VLBI Network is a joint facility of European, Chinese, South African and other radio astronomy institutes funded by their national research councils. The Australia Telescope is funded by the Commonwealth of Australia for operation as a National Facility managed by CSIRO.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

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December 27, 2004

NRAO Gathers Data On Saturn, Its Moons

By Dave Finley
NRAO

When the European Space Agency's Huygens spacecraft makes its plunge into the atmosphere of Saturn's moon Titan on January 14, radio telescopes of the National Science Foundation's National Radio Astronomy Observatory (NRAO) will help international teams of scientists extract the maximum possible amount of irreplaceable information from an experiment unique in human history. Huygens is the 700-pound probe that has accompanied the larger Cassini spacecraft on a mission to thoroughly explore Saturn, its rings and its numerous moons.

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Along with other radio telescopes in Australia, Japan and China, the NRAO facilities will add significantly to the information about Titan and its atmosphere that will be gained from the Huygens mission. A European-led team will use the radio telescopes to make extremely precise measurements of the probe's position during its descent, while a U.S.-led team will concentrate on gathering measurements of the probe's descent speed and the direction of its motion. The radio-telescope measurements will provide data vital to gaining a full understanding of the winds that Huygens encounters in Titan's atmosphere.

See SATURN on page 4

Saturn: NRAO Helping Global Effort

Continued from front page

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El Defensor Chieftain December 25, 2004

VLBA plays big role in Cassini-Huygens mission

By Dave Finley
National Radio Astronomy Observatory

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THE WALL STREET JOURNAL.
Monday, November 15, 2004

THE RULES

Be Quiet. We're Listening.

Scientists in West Virginia are trying to hear what the universe has to say. But wireless devices are making it increasingly difficult.

By MARCELO PRINCE

NESTLED IN A valley amid the mountains of West Virginia, surrounded by farmland and national forests, sits a giant white dish that scientists use to study the darkest corners of the universe.

The dish, more than two acres in size, serves as the antenna for a powerful telescope used by astronomers to collect faint radio waves emitted by distant stars and galaxies. It's part of an observatory set up in Green Bank, W.Va., nearly 50 years ago and financed by the federal government for university research.

But it's an endangered species. Scientists at the observatory are fighting an endless battle to save their highly sensitive telescope from man-made interference. Nearly every day, engineers must hunt down an unknown radio source, such as a faulty power line or home appliance, that's spoiling their readings. And more and more the astronomers find themselves fighting decisions in Washington that could threaten their ability to continue their research.

On the Quiet

To protect the observatory, the Federal Communications Commission created a National Radio Quiet Zone in 1958. The zone, which covers 13,000 square miles in Virginia, West Virginia and Maryland, restricts radio transmissions in the area and gives scientists at the observatory a say in where radio transmitters or cellphone towers can be placed in the zone. A West Virginia state law gives the observatory even more authority to restrict signals within 10 miles of the telescope. Deep within the zone, there can be no cellphone coverage or radio stations. On the observatory's grounds, cable-TV lines are buried, computer rooms are shielded with sheets of copper and staffers drive diesel cars, which don't create harmful sparks upon ignition.

MR. PRINCE IS THE DEPUTY TECHNOLOGY EDITOR IN NEW YORK FOR THE WALL STREET JOURNAL ONLINE. HE CAN BE REACHED AT MARCELO.PRINCE@WSJ.COM.

But keeping the Quiet Zone silent has become increasingly difficult amid the spread of such wireless technologies as cellphones and Wi-Fi computer networks, and a push by the FCC for ever more flexible use of the electromagnetic spectrum. Of particular concern to radio astronomers is the rollout of new services, like broadband service delivered through power lines, or cars with radar collision-avoidance systems.

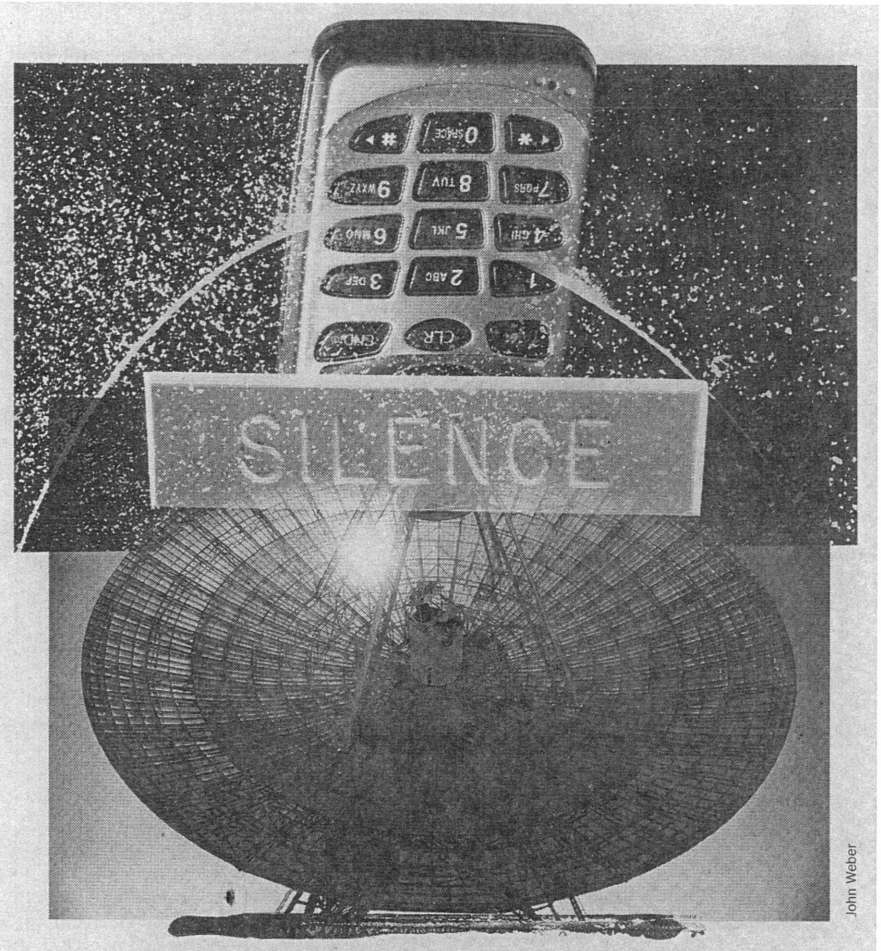
"We are struggling with the mushrooming growth" in wireless services, says Christopher Reynolds, a Prince Frederick, Md., lawyer who has fought to protect the Quiet Zone since the 1960s. Says Mr. Reynolds, "It is a classic struggle between the government trying to find a way to facilitate rapid deployment of new advanced communications services" and trying to protect the radio astronomers whose work cannot be done elsewhere.

"To some extent, I'm sometimes surprised [a relatively small group of scientists] have been as successful as we have been" protecting the Quiet Zone, says Tomas Gergely, electromagnetic spectrum manager at the National Science Foundation in Arlington, Va., which funds the observatory. The big fear is that "once you lose it, you cannot recover it," Mr. Gergely says.

Great Listeners

The science of radio astronomy dates back to the early 1930s and the work of Bell Labs physicist Karl Jansky. While investigating disturbances in trans-Atlantic telephone service, he discovered that radio waves were emanating from the center of the Milky Way galaxy. Over the decades, radio astronomers have won a number of Nobel Prizes for their discoveries, including the first quasar, an extremely bright object in distant galaxies, and remnants of the Big Bang—a cosmic explosion that many scientists believe was responsible for the creation of the universe.

Many astronomical bodies emit radio waves that travel millions of light years before reaching Earth. Since they have a much longer wavelength than visible light, radio waves are able to penetrate much of the gas and dust in



John Weber

space as well as planetary atmospheres. Radio telescopes can therefore obtain a much clearer picture of stars and galaxies than is possible by means of optical observation—if there is no signal interference.

The task of preserving the Quiet Zone largely falls to Mr. Reynolds and a team of scientists at Green Bank. The radio frequency interference team spends hours every week driving around in a vehicle equipped with sensitive antennas and special gear to pinpoint local sources of interference, like a broken knot in an electric fence. They must also monitor thousands of cellphone towers and broadcast antennas in the zone to ensure they don't disrupt the telescope—an increasingly time-consuming and difficult task.

"We're putting out fires that are about three feet high," says Wesley Sizemore, a technical specialist on the team that has been tracking down sources of interference around Green Bank for 20 years. "It is a constant battle....We don't have the luxury of adding additional staff to fight new problems, while still fighting the old battles which are not lessening."

The FCC has largely upheld the Quiet Zone and has set up a similar radio-coordination zone in Puerto Rico to protect a telescope in Arecibo. The FCC says the public benefit of the research conducted at the observatories justifies the extra burdens of the regulations. Earlier this year, the agency streamlined the process for applying for licenses within the Green Bank zone, but said its "rules have been largely successful" in protecting the observatories and facilitating the roll-out of new technology.

"I don't think people are happy when they are driving through West Vir-

ginia someplace and can't get [cell-phone] reception and don't understand where that's coming from," says Linda Chang, associate director of the FCC's mobility division, which reviewed the Quiet Zone rules. But "it's very important to us as an agency that Arecibo, Green Bank and other quiet zones are able to function. It's important to the public interest."

Good Neighbors

Mr. Sizemore and his colleagues have spent several months working with officials at Snowshoe Mountain, a nearby ski resort that is setting up Wi-Fi hot spots for wireless computing. The scientists studied dozens of potential locations to cause the least interference back at Green Bank. The two sides have agreed to adjust the Wi-Fi antennas and receivers so the hot spots don't reach high floors of buildings and to limit the number of users that can connect at any one spot.

"We are very restricted, but Green Bank does do everything they possibly can to develop a system that works for us and works for them," says Jim Haas, Snowshoe's vice president of resort services. "Unfortunately it costs you more money, but we understand. They were there before we were."

The scientists are also working with a family that wants to set up satellite Internet access at its mountaintop home, which sits in direct line of sight of the telescope. Direcway satellite service, part of **Hughes Network Systems** Inc., is the only way to get high-speed Internet access at the house, because of its remote location. (It's not connected to the power grid and is too isolated for DSL service.) At the observatory's request, the family spent hundreds of dollars to place the dish on the far side of the mountain and 700 feet below the ridge. The terrain blocks the signal from reaching Green Bank. In turn, the observatory helped the family find special cables that could carry the signal over such a long distance.

"We try to be a good neighbor," says Mr. Sizemore, who has made several trips to help the homeowner with the cabling and installation. "In a rural area like this, you never know when you'll need someone's help."

Unsound Ground

A few local businesses and politicians have tangled with the observatory over the years about the Quiet Zone restrictions. Opponents say it places unnecessary burdens on small businesses and local governments because they must operate their radio systems with reduced power, install extra antenna sites and place transmitters in less than optimal locations.

"The whole notion of this thing needs to be re-examined as to its cost on local governments and impact on the ability to deploy radio systems in a [mountainous] terrain that's very difficult to begin with," says Michael Hunter, president of RCC Consulting Inc. The Woodbridge, N.J.-based firm, which helps police and fire departments install radio networks, has petitioned the FCC unsuccessfully, most recently last year, to ease the Quiet Zone restrictions.

The radio astronomers review hundreds of applications for new wireless licenses in the Quiet Zone each year and must stay on top of regulatory issues in Washington. The scientists and their lawyer, Mr. Reynolds, regularly file legal briefs and lobby the FCC on decisions that could weaken the Quiet Zone protections. The FCC is constantly reviewing a variety of issues or new technologies that directly or indirectly affect Green Bank, such as the use of cognitive or "smart" radios, which seek out unoccupied radio frequencies and increase their output levels in rural areas. Such radios are still being tested and haven't yet received FCC approval.

"When I first got here three years ago, I might see [an FCC-proposed] rule-making that looked like it would have an impact on the Quiet Zone maybe once per quarter," says Jeff Acree, former head of Green Bank's radio frequency interference team, who recently went to work at a Defense Department weapons lab in Dahlgren, Va. "Now it seems like there is never a month that something doesn't come out, sometimes more than once a month."

Power Play

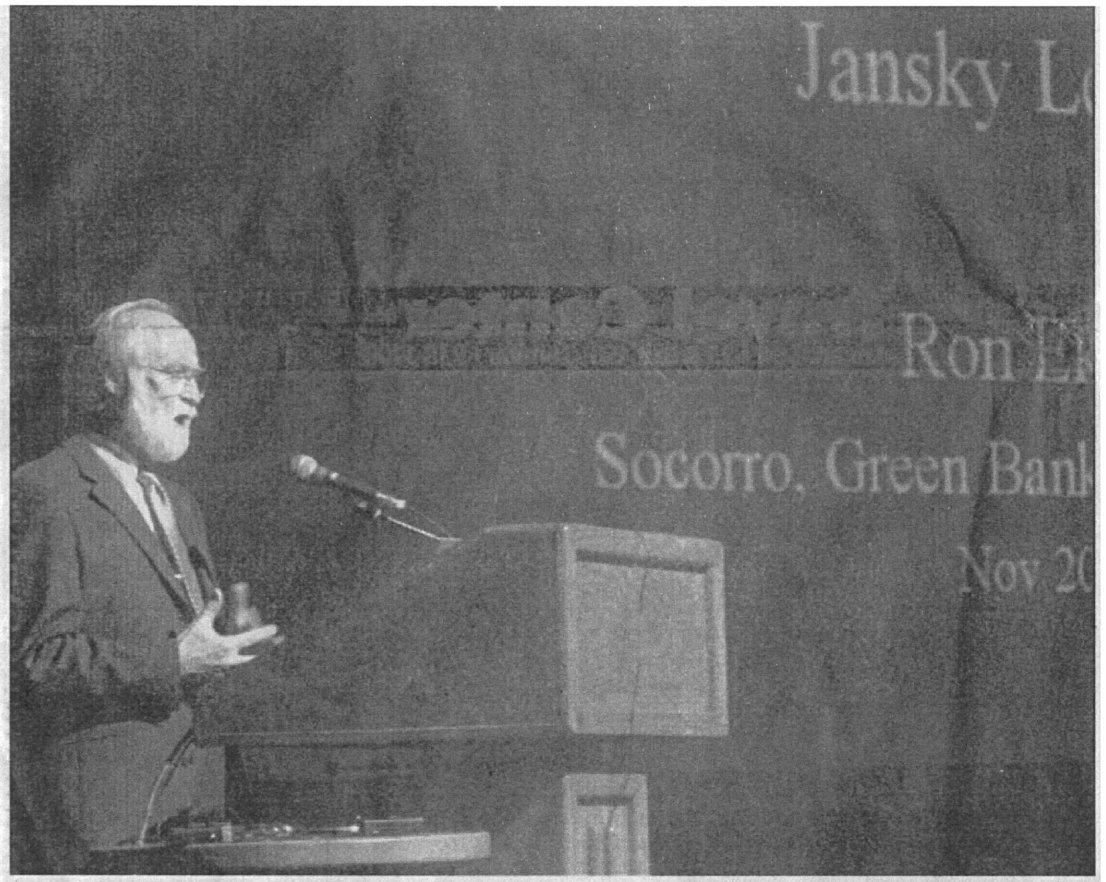
In a setback for the scientists, the FCC last month endorsed the use of broadband through power lines, or BPL, technology. Radio astronomers and others oppose the technology, which provides high-speed Internet access to homes by routing digital information over the power grid, because it generates electromagnetic interference. In essence, it turns power lines into radio antennas. The FCC decided the interference concerns could be addressed by BPL providers, and set some technical requirements for BPL gear.

Another challenge is a move by the FCC to grant licenses that cover geographic areas, rather than site-specific licenses, says Mr. Reynolds, the observatory lawyer. When scientists know the source of radio interference, they can often adjust the telescope to filter out the "noise." But it becomes more difficult and time-consuming when they don't know the location of an interfering signal, he explains.

"The Quiet Zone really does protect us," says Green Bank Director Philip Jewell. "Without it, I'm sure we wouldn't be able to do our science." ▦

El Defensor Chieftain

November 13, 2004



Tom Treweek/El Defensor Chieftain

Dr. Ronald Ekers, president of the International Astronomical Union, delivered his message on serendipty to an audience at the Macey Center. Ekers is the 2004 Jansky Fellowship Lecturer.

Jansky lecturer stresses importance of serendipity

By Tom Treweek
El Defensor Chieftain Reporter
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Dr. Ronald Ekers stressed the importance of serendipity in cosmological discovery during his recent presentation, the first in the Karl G. Jansky Lecture series. Ekers' appearance at Macey Center was the first stop on a lecture tour that also includes Green Bank, W.Va. and Charlottesville, Va.

Ekers gave a brief history in the advances of radio astronomy, starting, of course, with Jansky and finishing with Ekers' vision of the field's future. As he touched on events and discoveries, he pointed out how serendipity played a part.

Serendipity, as Ekers defined it, is discovering something you are not in search of. Ekers also laid out a pattern that most serendipitous discoveries follow.

First, Ekers said, they are technology driven. Most serendipitous discoveries, he said, occur within five years of the invention of a new technology.

Second, the discoveries are unanticipated. Jansky, for example, discovered radio signals from outside the Milky Way while investigating static.

Third, the discoverers must know their equipment. They must be able to know the difference between an error or malfunction in the equipment and an unexpected result. John Bolton, a former Jansky lecturer and Ekers' mentor, required his students to build their own radio telescopes before they could use the existing equipment, so they had a working knowledge of how the machines functioned.

Fourth, Ekers said, the observers must have curiosity and persistence. In the example of Jansky, Bell Telephone, Jansky's employer, said the interference was negligible and did not want him to pursue it.

The fifth element is a flash of insight, as when Jansky realized that the signal was coming from a distance that was beyond our sun.

Finally, serendipitous discoveries must be made in the right time. Black holes were rumored to exist, but could not be proven until the discovery of quasars in 1963.

The biggest obstacle facing serendipitous discovery today is government funding. The federal government, Ekers said, wants to know exactly what is being studied and a timetable for discovery before they are willing to fund the research.

Ekers said that often research will go in a direction that was original unintended.

"If you build a great radio telescope, it will do great things, but it might not be the things you proposed," said Ekers.

"You can't plan a discovery," said Ekers. He added that you can plan an environment that fosters serendipity.

Another hinderence to discovery, according to Ekers is people who "know too much." Ekers said that if you already know what to expect, you may miss the unexpected.

"If you know too much, sometimes you won't make the obvious discovery."

Ekers outlined his view of future research. He said that he saw the only remaining advancement in radio astronomy as an increase in observing area.

"The volume of space sampled is the biggest area remaining," said Ekers, who described a telescope he envisioned that would be able to accomplish this feat.

Ekers said that he wanted to speak in Socorro because of his time spent at the VLA. He was an assistant director for the National Radio Astronomy Observatory, and in charge of the VLA from 1980 to 1987.

The community news and information site for Socorro County, New Mexico

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Thursday, Feb. 17, 2005

Wednesday, November 10, 2004

VLA study offers galactic clue

Dave Finley National Radio Astronomy Observatory

Astronomers using the National Science Foundation's Very Large Array radio telescope to study the most distant known quasar have found a tantalizing clue that may answer a long-standing cosmic chicken-and-egg question: Which came first, super-massive black holes or giant galaxies?

For years, astronomers have noted a direct relationship between the mass of a galaxy's central, super-massive black hole and the total mass of the "bulge" of stars at its core. The more massive the black hole, the more massive the bulge. Scientists have speculated extensively about whether the black hole or the stellar bulge formed first. Recently, some theories have suggested that the two may form simultaneously.

However, the new VLA observations of a quasar and its host galaxy seen as they were when the Universe was less than a billion years old indicate that the young galaxy has a super-massive black hole but no massive bulge of stars.

"We found a large amount of gas in this young galaxy, and, when we add the mass of this gas to that of the black hole, they add up to nearly the total mass of the entire system. The dynamics of the galaxy imply that there isn't much mass left to make up the size of stellar bulge predicted by current models," said Chris Carilli, of the National Radio Astronomy Observatory, in Socorro.

The scientists studied a quasar dubbed J1148+5251 that, at more than 12.8 billion light-years, is the most distant quasar yet found. Discovered in 2003 by the Sloan Digital Sky Survey, J1148+5251 is a young galaxy with a bright quasar core seen as it was when the Universe was only 870 million years old. The Universe now is 13.7 billion years old.

Aiming the VLA at J1148+4241 for about 60 hours, the researchers were able to determine the amount of molecular gas in the system. In addition, they were able to measure the motions of that gas, and thus estimate the total mass of the galactic system. Earlier studies of the system had produced estimates that the black hole was 1 to 5 billion times the mass of our Sun.

The new VLA observations indicate that there are about 10

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billion solar masses of molecular gas in the system, and that the system's total mass is 40-50 billion solar masses. The gas and black hole combined thus account for 11-15 billion solar masses out of that total.

"The accepted ratio indicates that a black hole of this mass should be surrounded by a stellar bulge of several trillion solar masses. Our dynamical measurement shows there's not much mass left over, excluding the black hole and the gas, to form a stellar bulge. This provides evidence that the black hole forms before the stellar bulge," said Fabian Walter, of the Max Planck Institute for Radioastronomy in Heidelberg, Germany, who was a Jansky Postdoctoral Fellow at NRAO in Socorro when the observations were made.

"One example certainly doesn't make the case, but in this object we we apparently have an example of a black hole without much of a stellar bulge. Now we need to make detailed studies of more such objects in the far-distant, early Universe," Carilli said.

"With the vastly improved sensitivity of the Expanded VLA and the Atacama Large Millimeter Array, which will come on line in a few years, we will have the tools we need to resolve this question definitively," Carilli added.

"Studies like this are the key to understanding how galaxies first formed," Walter said.

Walter and Carilli worked with Frank Bertoldi and Karl Menten of the Max Planck Institute in Bonn; Pierre Cox of the Institute of Space Astrophysics of the University of Paris-South; Fred K.Y. Lo of the NRAO in Charlottesville, Va.; Xiahui Fan of the University of Arizona's Steward Observatory; and Michael Strauss of Princeton University, on the project. Their research results are being published in the Astrophysical Journal Letters.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities Inc.

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Serving Socorro and Catron Counties • November 8, 2004

Lecture Highlights Birth of Radio Astronomy And Its Discoveries

An internationally-reknowned astronomer will present a lecture entitled "Paths to Discovery (Birth, Growth, and Discoveries of Radio Astronomy)," at 8 p.m. Wednesday, Nov. 10, at Macey Center on the New Mexico Tech campus in Socorro. The lecture is free and the public is invited.

Dr. Ronald D. Ekers, an Australian Federation Fellow and former Foundation Director of the Commonwealth Scientific and Industrial Research Organization's (CSIRO) Australia Telescope National Facility, will present the lecture as the recipient of the annual Karl G. Jansky Lectureship, an honor recognizing outstanding contributions to astronomy. Professor Ekers also is President of the International Astronomical Union, the world's professional body for promoting astronomy through international cooperation.

A reception will follow the lecture.

Ekers is being honored for his long series of accomplishments in radio astronomy, especially in the study of radio galaxies. He has been an innovator in the development of new techniques and instrumentation for radio astronomy.

Ekers' lecture will cover what he describes as "one of the most important events of twentieth-century astronomy, the birth of radio astronomy." He will talk about the early pioneers of this new way of observing the Universe and how they "discovered a plethora of cosmic phenomena that revolutionized our knowledge of the Universe."

Ekers' interests include extragalactic astronomy, especially cosmology, and galactic nuclei, radio astronomical techniques and image formation theory. He was Assistant Director at the National Radio Astronomy Observatory (NRAO) in charge of the Very Large Array from 1980 to 1987 and Foundation Director of the CSIRO's Australia Telescope National Facility from 1988 to 2003, where he is credited with building it into one of the world's top radio observatories. Ekers is best known for his extensive work in imaging the radio emission and in identifying optical counterparts of extragalactic radio sources.

Ekers' deep insight and understanding of a broad spectrum of contemporary astrophysical problems has been the driving force during the development of innovative interactive techniques for the analysis of radio interferometric data, and his crucial contributions to the design, development, and effective operation of radio telescopes including the Westerbork Synthesis Array in the Netherlands, the Very Large Array in New Mexico, and the Australia Telescope.

He was elected a Fellow of the Australian Academy of Science and a Foreign Member of the Royal Dutch Academy of Science in 1993, and a Foreign Member of the American

Philosophical Society in 2003.

This is the 39th Jansky Lectureship, an honor established by the trustees of Associated Universities Inc., to recognize outstanding contributions to the advancement of astronomy. First awarded in 1966, it is named in honor of the man who, in 1932, first detected radio waves from a cosmic source. Karl Jansky's discovery of radio waves from the central region of our Milky Way Galaxy started the science of radio astronomy. Other recipients of the Jansky award include five Nobel laureates (Drs. Subrahmanyan Chandrasekhar, Arno Penzias, Robert Wilson, William Fowler, and Joseph Taylor) as well as Jocelyn Bell-Burnell, discoverer of the first pulsar, and Vera Rubin, discoverer of dark matter in galaxies.

Ekers' public lecture in Socorro will follow a day-long technical symposium, in which astronomers from universities, observatories and national laboratories throughout New Mexico will present recent research results.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities Inc.

Additional information is available on the NRAO website at www.nrao.edu

The community news and information site for Socorro County, New Mexico

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INTERNET EDITION

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Thursday, Feb. 17, 2005

Saturday, November 6, 2004

Cosmic corkscrew reveals microquasar details

Dave Finley National Radio Astronomy Observatory

Making an extra effort to image a faint, gigantic corkscrew traced by fast protons and electrons shot out from a mysterious microquasar paid off for a pair of astrophysicists, who gained new insights into the beast's inner workings and also resolved a longstanding dispute over the object's distance.

The astrophysicists used the National Science Foundation's Very Large Array radio telescope to capture the faintest details yet seen in the plasma jets emerging from the microquasar SS 433, an object once dubbed the "enigma of the century." As a result, they have changed scientists' understanding of the jets and settled the controversy over its distance "beyond all reasonable doubt," they said.

SS 433 is a neutron star or black hole orbited by a "normal" companion star. The powerful gravity of the neutron star or black hole draws material from the stellar wind of its companion into an accretion disk of material tightly circling the dense central object prior to being pulled onto it. This disk propels jets of fast protons and electrons outward from its poles at about a quarter of the speed of light. The disk in SS 433 wobbles like a child's top, causing its jets to trace a corkscrew in the sky every 162 days.

The new VLA study indicates that the speed of the ejected particles varies over time, contrary to the traditional model for SS 433.

"We found that the actual speed varies between 24 percent to 28 percent of light speed, as opposed to staying constant," said Katherine Blundell, of the University of Oxford in the United Kingdom. "Amazingly, the jets going in both directions change their speeds simultaneously, producing identical speeds in both directions at any given time," Blundell added. Blundell worked with Michael Bowler, also of Oxford. The scientists' findings have been accepted by the Astrophysical Journal Letters.

The new VLA image shows two full turns of the jets' corkscrew on both sides of the core. Analyzing the image showed that if material came from the core at a constant speed, the jet paths would not accurately match the details of the image.

"By simulating ejections at varying speeds, we were able to

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produce an exact match to the observed structure," Blundell explained. The scientists first did their match to one of the jets. "We then were stunned to see that the varying speeds that matched the structure of one jet also exactly reproduced the other jet's path," Blundell said. Matching the speeds in the two jets reproduced the observed structure even allowing for the fact that, because one jet is moving more nearly away from us than the other, it takes light longer to reach us from it, she added.

The astrophysicists speculate that the changes in ejection speed may be caused by changes in the rate at which material is transferred from the companion star onto the accretion disk.

The detailed new VLA image also allowed the astrophysicists to determine that SS 433 is nearly 18,000 light-years distant from Earth. Earlier estimates had the object, in the constellation Aquila, as near as 10,000 light-years. An accurate distance, the scientists said, now allows them to better determine the age of the shell of debris blown out by the supernova explosion that created the dense, compact object in the microquasar. Knowing the distance accurately also allows them to measure the actual brightness of the microquasar's components, and this, they said, improves their understanding of the physical processes at work in the system.

The breakthrough image was made using 10 hours of observing time with the VLA in a configuration that maximizes the VLA's ability to see fine detail. It represents the longest "time exposure" of SS 433 at radio wavelengths, and thus shows the faintest details. It also represents the best such image that can be done with current technology. Because the jets in SS 433 are moving, their image would be "smeared" in a longer observation. In order to see even fainter details in the jets, the astrophysicists must await the greater sensitivity of the Expanded VLA, set to become available in a few years.

SS 433 was the first example of what now are termed microquasars, binary systems with either a neutron star or black hole orbited by another star, and emitting jets of material at high speeds. The strange stellar system received a wealth of media coverage in the late 1970s and early 1980s. A 1981 Sky & Telescope article was entitled, "SS 433 — Enigma of the Century."

Because microquasars in our own Milky Way Galaxy are thought to produce their high-speed jets of material through processes similar to those that produce jets from the cores of galaxies, the nearby microquasars serve as a convenient "laboratory" for studying the physics of jets. The microquasars are closer and show changes more quickly than their larger cousins.

Katherine Blundell is a University Research Fellow funded by the UK's Royal Society.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities Inc.

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AIR&SPACE Smithsonian
November 2004

Radio Tidal Waves

During the wee hours of last July 17 and 18, Scott Ransom was searching the sky with the new 100- by 110-meter radio telescope at the National Radio Astronomy Observatory in Green Bank, West Virginia. In one six-hour observation, Ransom, an NRAO staff astronomer, found 13 new binary and millisecond pulsars. It has taken 25 years to find just 100 of these exotic stars; Ransom's find of a baker's dozen in one day is unprecedented.

But Ransom almost missed his discoveries because "XM Rock," "XM Roll," and three Sirius satellites were blasting music and information to their terrestrial listeners. To radio astronomers, the new satellite-based radio services go by a different name: RFI, or radio frequency interference.

Radio astronomers are finding it increasingly difficult to study the weak radio signals coming from the edges of the universe. The explosion of satellite-based services, combined with rapid growth in cable TV, cell phones, wireless networking, and two-way radios has created a cacophony of radio noise in the skies that is drowning out the infinitesimal signals that help reveal the secrets of the universe.

Using a receiver capable of searching across 800 MHz of the radio spectrum and able to detect signals as weak as .00000000000000000000000001 watt, Ransom had previously studied the same area of the sky. But the frequencies used by "Rock" and "Roll" and their three competitors, with relatively enormous power loads, were in the middle of Ransom's target frequencies. Transmitting as much as 13,000 watts of power, the satellites wrecked Ransom's observations by drowning the vastly weaker pulsar signals. "The data was garbage," Ransom says. He describes the first observations as "trying to find a candle on a far hillside with someone shining a spotlight in your eyes."

Even in a sky full of satellites, the new radio service satellites stand out. "These are the worst," says NRAO engineer Jeff Acree. "You can pick up these birds with a coat hanger." Acree's job is to make Green Bank as free of RFI as possible—which can entail hopping in a truck with a directional antenna to locate radio waves leaking out of a corroded cable TV connector on a utility pole.

To cut down on the overwhelming interference, Acree suggested that Ransom sacrifice a sizeable chunk of his searchable bandwidth and bypass the data-wrecking signals by redoing his observations, but scanning only the frequencies just below those used by the satellites. It worked. "This turned data which could have been terrible into data that is exceptional," says Ransom. "It made a huge difference in our observations."

Acree's solution may not work for very long. Despite the enormous strength of the signals, the satellites' bandwidths are somewhat confined. The big threat to radio astronomy is the proliferation of broadband wireless networking and the multiplicity of other broadband wireless devices. Even though the power of such devices is typically limited to one watt, "one watt is a lot of power around here," says a wary Acree. Inevitably, people near Green Bank will make wide use of low-power broadband devices, which will fill the local airwaves with a dull roar.

Unlike the strong interference from TV stations and satellites, which can be filtered out or sidestepped, equipment like the 802.11 "WiFi" computer network devices and the Family Radio Service walkie-talkies are spread so far across the radio spectrum that the interference they cause is "almost impossible to remove," Ransom says.

Despite his concerns, Ransom confesses to being part of the problem. "I'm a huge wireless computer user," he says. "I think it's fantastic. I just don't want it anywhere near my radio telescopes."

—Tim Wright

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November 1, 2004

By Dave Finley
NRAO

Astronomers using the National Science Foundation's Very Large Array (VLA) have overcome longstanding technical hurdles to map the sky at little-explored radio frequencies that may provide a tantalizing look deep into the early Universe. The scientists have released images and data covering half of the sky visible from the VLA, and hope to complete their survey within a year.

The VLA Low-frequency Sky Survey (VLSS) is producing sky images made at an observing frequency of 74 MHz, a far lower frequency than used for most current radio-astronomy research.

"Because of the Earth's ionosphere, such a low frequency has proven very difficult for high-quality imaging, and it is only in the past few years that we have developed the techniques that make a project like the VLSS possible," said Rick Perley, of the National Radio Astronomy Observatory in Socorro.

Because the high-quality VLSS images will give astronomers a look at the Universe through what essentially is a new "window," they expect the images to reveal some rare and important objects.

"We expect to find very distant radio galaxies – galaxies spewing jets of material at nearly light speed and powered by supermassive black holes," said Joseph Lazio of the Naval Research Laboratory in Washington, DC. "By determining just how distant these radio galaxies are, we will learn how early the black holes formed in the history of the Universe."

Another tantalizing possibility is that the low-frequency images may reveal "halos" and "relics" produced by collisions of galaxies in clusters. If the halos and relics are found in the distant, and thus early, Universe, it will give scientists important clues about the timetable for formation of large-scale structure. In addition, the astronomers hope that the VLSS images may show previously-undiscovered pulsars — super-dense, spinning neutron stars.

Massive planets – "super Jupiters" circling stars beyond the Sun – also might reveal themselves through bursts of radio emission at the frequency of this survey, the astronomers speculated.

Images from the survey are being made available to other scientists as soon as they are completed. The survey will use some 800 hours of VLA observing time. The newly-released images and data are available via the NRAO Web site.

"By doing this survey and making the results available, we are bringing low-frequency radio data, previously quite difficult to produce, to all astronomers in a simple and easy manner," Perley said.

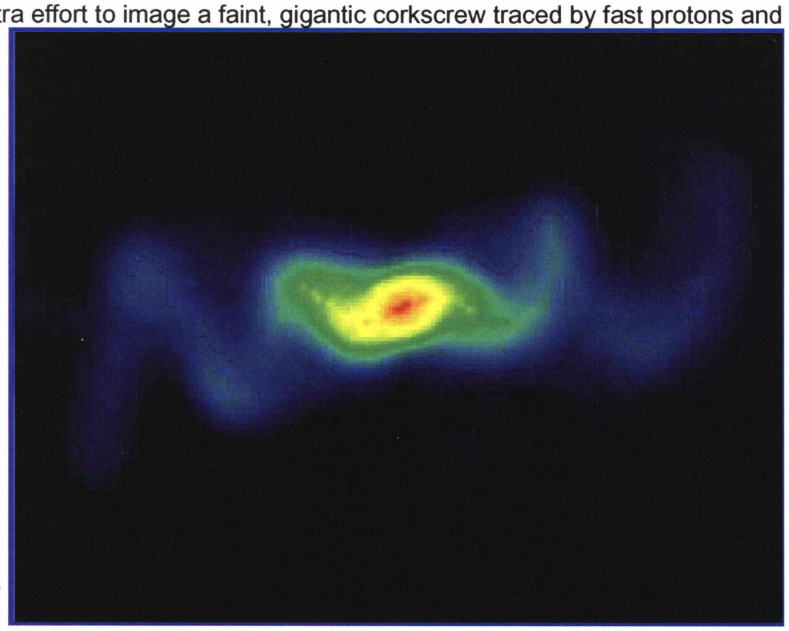
"We also expect that this survey will spur additional research into objects that scientists find puzzling or interesting," Perley saidd. "We really will have to wait for years to know the full scientific benefit of this survey," he said.

In addition to Perley and Lazio, the VLSS team includes James Condon and William Cotton of NRAO; Aaron Cohen and Wendy Lane of the National Research Council and the Naval Research Laboratory; Namir Kassim of the Naval Research Laboratory; and William Erickson of the University of Maryland and University of Tasmania.

Cosmic Corkscrew

Summary - (**Oct 27, 2004**) Astrophysicists using the National Science Foundation's Very Large Array (VLA) radio observatory have revealed new details about a puzzling object called SS 433; a microquasar with bizarre corkscrew-shaped jets blasting out. SS 433 is probably a black hole or neutron star that's feeding on material from a normal companion star. Some of this material is consumed, but much of it is blasted back out at a quarter the speed of light. SS 433 wobbles like a child's top every 162 days, which causes the unusual corkscrew shape of the jets.

Full Story - Making an extra effort to image a faint, gigantic corkscrew traced by fast protons and electrons shot out from a mysterious microquasar paid off for a pair of astrophysicists who gained new insights into the beast's inner workings and also resolved a longstanding dispute over the object's distance.



The astrophysicists used the National Science Foundation's Very Large Array (VLA) radio telescope to capture the faintest details yet seen in the plasma jets emerging from the microquasar SS 433, an object once dubbed the "enigma of the century." As a result, they have changed scientists' understanding of the jets and settled the controversy over its distance "beyond all reasonable doubt," they said.

SS 433 is a neutron star or black hole orbited by a "normal" companion star. The powerful gravity of the neutron star or black hole draws material from the stellar wind of its companion into an accretion disk of material tightly circling the dense central object prior to being pulled onto it. This disk propels jets of fast protons and electrons outward from its poles at about a quarter of the speed of light. The disk in SS 433 wobbles like a child's top, causing its jets to trace a corkscrew in the sky every 162 days.

The new VLA study indicates that the speed of the ejected particles varies over time, contrary to the traditional model for SS 433.

"We found that the actual speed varies between 24 percent to 28 percent of light speed, as opposed to staying constant," said Katherine Blundell, of the University of Oxford in the United

Kingdom. "Amazingly, the jets going in both directions change their speeds simultaneously, producing identical speeds in both directions at any given time," Blundell added. Blundell worked with Michael Bowler, also of Oxford. The scientists' findings have been accepted by the Astrophysical Journal Letters.

The new VLA image shows two full turns of the jets' corkscrew on both sides of the core. Analyzing the image showed that if material came from the core at a constant speed, the jet paths would not accurately match the details of the image.

"By simulating ejections at varying speeds, we were able to produce an exact match to the observed structure," Blundell explained. The scientists first did their match to one of the jets. "We then were stunned to see that the varying speeds that matched the structure of one jet also exactly reproduced the other jet's path," Blundell said. Matching the speeds in the two jets reproduced the observed structure even allowing for the fact that, because one jet is moving more nearly away from us than the other, it takes light longer to reach us from it, she added.

The astrophysicists speculate that the changes in ejection speed may be caused by changes in the rate at which material is transferred from the companion star onto the accretion disk.

The detailed new VLA image also allowed the astrophysicists to determine that SS 433 is nearly 18,000 light-years distant from Earth. Earlier estimates had the object, in the constellation Aquila, as near as 10,000 light-years. An accurate distance, the scientists said, now allows them to better determine the age of the shell of debris blown out by the supernova explosion that created the dense, compact object in the microquasar. Knowing the distance accurately also allows them to measure the actual brightness of the microquasar's components, and this, they said, improves their understanding of the physical processes at work in the system.

The breakthrough image was made using 10 hours of observing time with the VLA in a configuration that maximizes the VLA's ability to see fine detail. It represents the longest "time exposure" of SS 433 at radio wavelengths, and thus shows the faintest details. It also represents the best such image that can be done with current technology. Because the jets in SS 433 are moving, their image would be "smeared" in a longer observation. In order to see even fainter details in the jets, the astrophysicists must await the greater sensitivity of the Expanded VLA, set to become available in a few years.

SS 433 was the first example of what now are termed microquasars, binary systems with either a neutron star or black hole orbited by another star, and emitting jets of material at high speeds. The strange stellar system received a wealth of media coverage in the late 1970s and early 1980s. A 1981 Sky & Telescope article was entitled, "SS 433 -- Enigma of the Century."

Because microquasars in our own Milky Way Galaxy are thought to produce their high-speed jets of material through processes similar to those that produce jets from the cores of galaxies, the nearby microquasars serve as a convenient "laboratory" for studying the physics of jets. The microquasars are closer and show changes more quickly than their larger cousins.

Katherine Blundell is a University Research Fellow funded by the UK's Royal Society.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

Original Source: NRAO News Release

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PRESS RELEASE
Date Released: Tuesday, October 26, 2004
Source: National Radio Astronomy Observatory

Gigantic Cosmic Corkscrew Reveals New Details About Mysterious Microquasar

Making an extra effort to image a faint, gigantic corkscrew traced by fast protons and electrons shot out from a mysterious microquasar paid off for a pair of astrophysicists who gained new insights into the beast's inner workings and also resolved a longstanding dispute over the object's distance.

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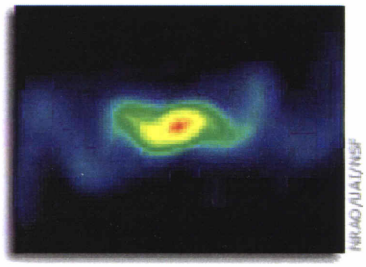

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Posted on: Thursday, 21 October 2004, 07:36 CDT

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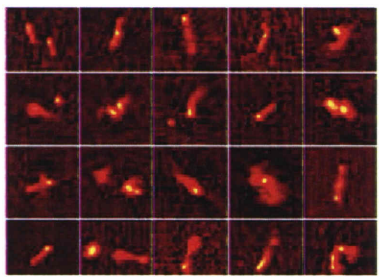
Telescope Provides New Radio View of Universe



A "rogues' gallery" of radio galaxy types seen in the VLSS. White regions indicate radio bright emitting regions in the galaxies, while deep red/black indicate regions of little or no radio emission. Credit: NRAO

NRAO -- Astronomers using the National Science Foundation's Very Large Array (VLA) have overcome longstanding technical hurdles to map the sky at little-explored radio frequencies that may provide a tantalizing look deep into the early Universe. The scientists have released images and data covering half of the sky visible from the VLA, and hope to complete their survey within a year.

The VLA Low-frequency Sky Survey (VLSS) is producing sky images made at an observing frequency of 74 MHz, a far lower frequency than used for most current radio-astronomy research.

"Because of the Earth's ionosphere, such a low frequency has proven very difficult for high-quality imaging, and it is only in the past few years that we have developed the techniques that make a project like the VLSS possible," said Rick Perley, of the National Radio Astronomy Observatory (NRAO) in Socorro, NM.

Because the high-quality VLSS images will give astronomers a look at the Universe through what essentially is a new "window," they expect the images to reveal some rare and important objects.

"We expect to find very distant radio galaxies -- galaxies spewing jets of material at nearly light speed and powered by supermassive black holes," said Joseph Lazio of the Naval Research Laboratory in Washington, DC. "By determining just how distant these radio galaxies are, we will learn how early the black holes formed in the history of the Universe," he added.

Another tantalizing possibility is that the low-frequency images may reveal "halos" and "relics" produced by collisions of galaxies in clusters. If the halos and relics are found in the distant, and thus early, Universe, it will give scientists important clues about the timetable for formation of large-scale structure. In addition, the astronomers hope that the VLSS images may show previously-undiscovered pulsars -- superdense, spinning neutron stars.

Massive planets -- "super Jupiters" circling stars beyond the Sun -- also might reveal themselves through bursts of radio emission at the frequency of this survey, the astronomers speculated.

Images from the survey are being made available to other scientists as soon as they are completed. The survey will use some 800 hours of VLA observing time. The newly-released images and data are available via the NRAO Web site.

"By doing this survey and making the results available, we are bringing low-frequency radio data, previously quite difficult to produce, to all astronomers in a simple and easy manner," Perley said.

"We also expect that this survey will spur additional research into objects that scientists find puzzling or interesting," Perley saidd. "We really will have to wait for years to know the full scientific benefit of this survey," he said.

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October 21, 2004

VLA scoops black hole data

By Sue Vorenberg
Tribune Reporter

The Very Large Array might soon be dishing up data on some of the oldest black holes in the universe.

Equipment on the group of radio telescopes near Socorro was upgraded over the last decade to get cleaner radio signals, which let astronomers see deeper and older objects, such as galaxies and black holes.

That work is finished, and the first data analysis from a massive sky survey is finally starting to come back, said Joe Lazio, an astronomer at the Naval Research Laboratory who is part of the project.

"The very distant radio galaxies we can see with this technology - some might have formed only 1 billion years after the Big Bang," Lazio said. "We think galaxies at those frequencies are formed around super-massive black holes. Some of those may be the first black holes in the universe."

Scientists estimate the age of the universe at somewhere between 10 and 20 billion years old, so seeing objects from the first billion years of formation could tell the scientific community a lot about how the early universe was created and how it works, Lazio said.

Data coming from the radio survey is different than data seen by optical telescopes like Hubble, Lazio added.

"Radio telescopes can see different objects and types of light than optical telescopes," Lazio explained. "If you look with just visible light, you only see a fraction of what's out there in the universe. Radio signals give us another part of that equation."

In late 2003, VLA scientists, funded by the Naval Research Laboratory and the National Radio Astronomy Observatory in Socorro, started surveying the sky with the upgraded telescopes.

Almost a year later, the first chunks of data have been processed with a computer to make them more understandable. The first images were released this week on the observatory's Web site, www.nrao.edu.

"By doing this survey and making the results available, we are bringing low-frequency radio data, previously quite difficult to produce, to all astronomers in a simple and easy way," said Rick Perley, an astronomer at the observatory, adding that astronomers all over the globe have shown interest in the information.

The first survey will look at a large portion of the sky and

is about a third complete, Lazio said.

So far astronomers have imaged about 32,000 radio objects, like galaxies, stars and black holes.

From that data, they will pick about 600 objects that look interesting and do more powerful observations of them. The astronomers have just started selecting objects for further study, Lazio said.

After that, they will select 50 objects for even more study, he added.

Some of the other interesting objects are relics of early collisions between galaxies and newly discovered planets that are bigger than Jupiter, Lazio said.

"In our own galaxy we also hope to find pulsars, which are the remnants of very massive stars that rotate very rapidly," Lazio said. "Some of those are very bright in radio frequencies and hard to see with optical telescopes."

The data takes a long time to crunch because each hour of observation needs about 12 hours of computer processing. During the survey time, which ended in the late spring, astronomers were just trying to keep up with the equipment, he added.

"We really will have to wait for years to know the full scientific benefit of this survey," Perley said.

The next part of the sky survey should start this winter. Data collection should be finished sometime in 2006, Lazio said.

Eventually, the scientists want to build a new telescope array in New Mexico specifically designed to detect very faint radio signals, he added.

"This VLA work is just the beginning," Lazio said. "With a new telescope we might see even fainter things. We hope to do that in the next few years, but we haven't even had a chance to digest all the data from this survey yet."

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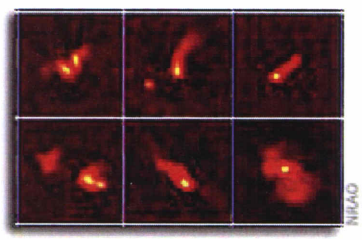
PRESS RELEASE
Date Released: Wednesday, October 20, 2004
Source: National Radio Astronomy Observatory

NRAO Project Releases New Sky View Made with VLA



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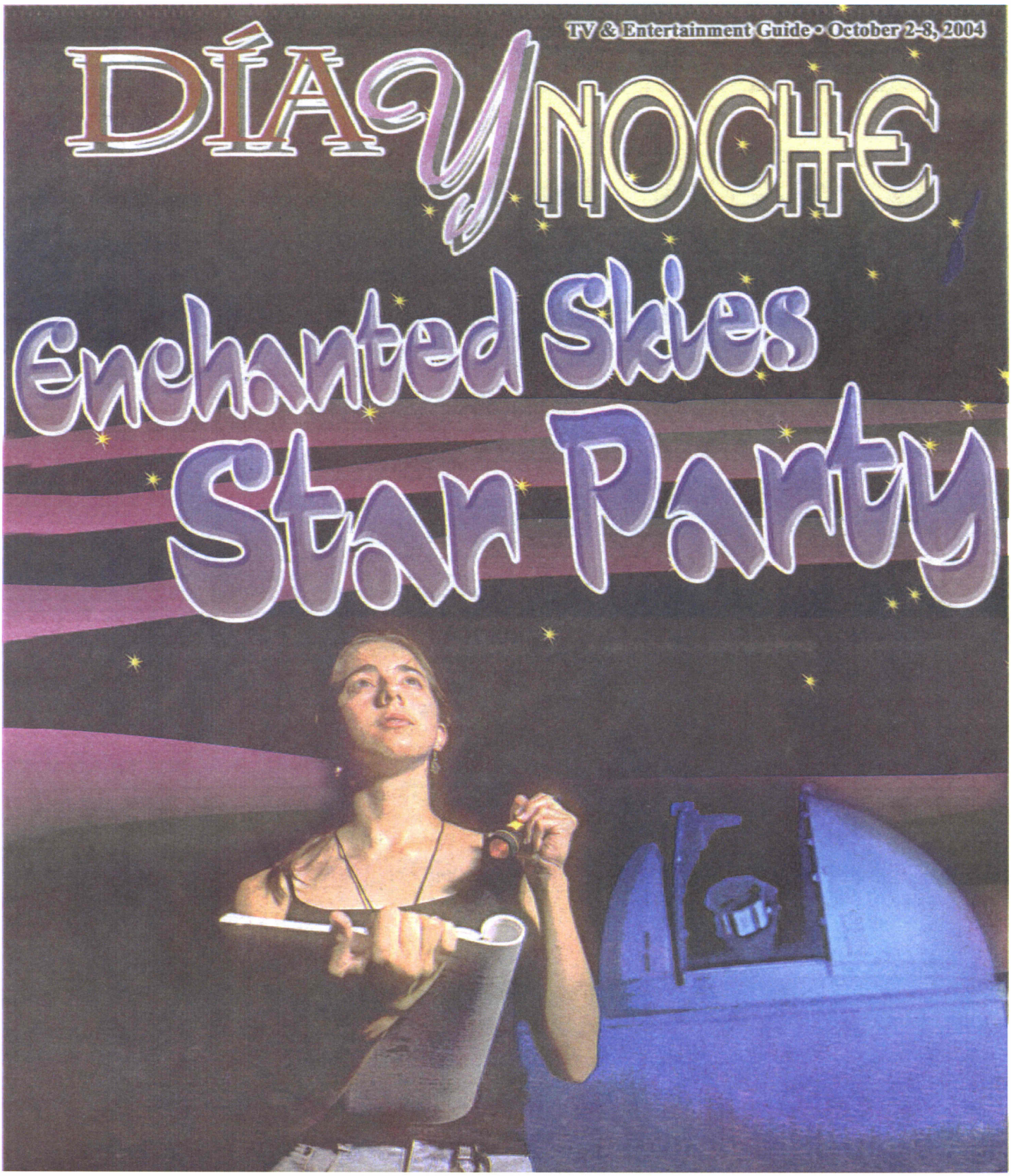
October 2-8, 2004



ON THE COVER

Nationally acclaimed astronomy event starts Oct. 5

By Dave Finley
National Radio Astronomy Observatory

Boasting an expanded schedule and new attractions, Socorro's Enchanted Skies Star Party gets underway Tuesday, Oct. 5, and offers five days of exciting events for anyone fascinated with the night sky. On Friday, Oct. 8, the star party's evening events are free and open to the public.

The eleventh annual Enchanted Skies Star Party includes new features such as hands-on workshops and a rare opportunity for telescopic viewing of the night sky at a 10,000-foot-high observing site. The star party has received extensive publicity, both national and in-state, this year, and astronomy enthusiasts from more than a dozen states across the nation already have registered.

On Friday evening, the keynote lecture entitled, "The VLA: Past Glory and Future Discoveries," by James Ulvestad, Director of VLA/VLBA Operations for the National Radio Astronomy Observatory, will be open to the public at 7 p.m., in Macey Center. Following Ulvestad's lecture, the telescopic observing session at the Etscorn Campus Observatory on the New Mexico Tech campus also is open and free to the public.

A new highlight of the star party will be a night atop Socorro County's South Baldy peak, a 10,700-foot mountain that soon will host the Magdalena Ridge Observatory, a state-of-the-art research facility now under development. Other highlights include an insider's tour of the VLA, and the now-legendary night at Socorro County's Pound Ranch with its Southwestern pit-cooked chuck-wagon dinner, cowboy entertainment and dark-sky astronomical observing.

The Tuesday-through-Saturday schedule also features a series of hands-on workshops on astronomical imaging, computer applications for astronomy, and public education and outreach for amateur astronomers. These workshops will be in addition to a daytime lecture series by astronomers from the National Radio Astronomy Observatory, the National Solar Observatory, the National Park Service, and others.

Ulvestad, the keynote speaker, will recount the VLA's exciting history of scientific discovery, a legacy that has impacted nearly every specialty of astronomy. In addition, he will tell about the impressive technical effort now underway to expand the VLA and bring its operating technology up to the current state of the art. This

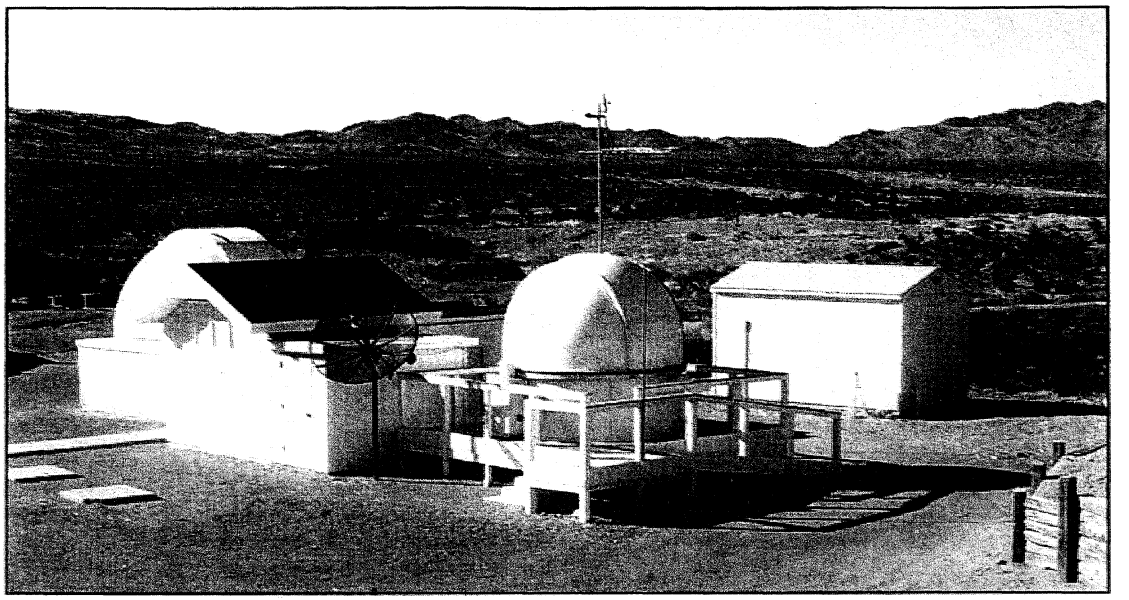


Photo by Dan Klinglesmith

Etscorn Observatory on the New Mexico Tech campus has lots to offer amateur astronomers.

VLA Expansion Project will, when complete, make the VLA ten times more powerful as a scientific instrument. Ulvestad will give a look at the types of discoveries that this new power will make possible.

Ulvestad joined the NRAO in Socorro, in 1996, after 12 years on the technical staff of NASA's Jet Propulsion Laboratory in Pasadena, Calif. He was promoted to Director of VLA/VLBA Operations in 2001. He received a Ph.D. in astronomy from the University of Maryland in 1981, and was a postdoctoral research associate at NRAO from 1981 to 1984. Hé is an active researcher specializing in active and starburst galaxies, compact extragalactic radio sources and the techniques of using orbiting radio telescopes. He is an adjunct professor at New Mexico State University and New Mexico Tech, and serves on NASA's Subcommittee on the Structure and Evolution of the Universe, the American Astronomical Society's Committee on Astronomy and Public Policy, and the AAS Committee on the Status of Women in Astronomy.

Registered attendees are automatically eligible for numerous door prizes, including the Grand Prize — a night of observing at Kitt Peak National Observatory in Arizona.

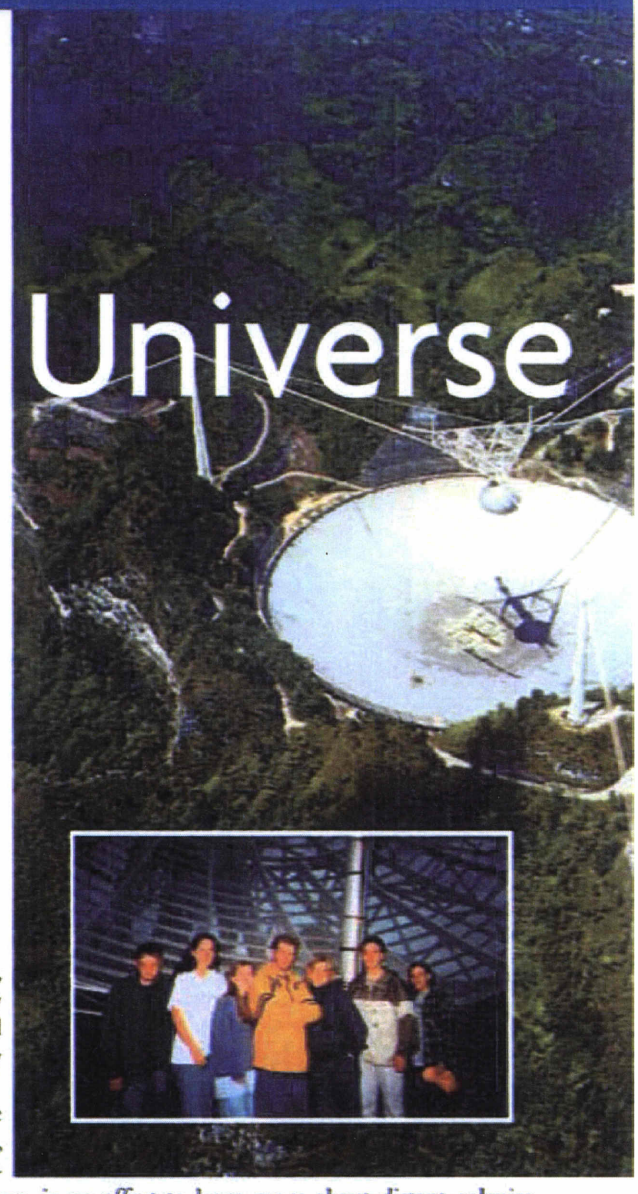
For more information on the Eleventh Annual Enchanted Skies Star Party, see the Web site, at: http://www.socorronm.com/starparty.

The Enchanted Skies Star Party is sponsored by the New Mexico Tech Astronomy Club, the Socorro County Chamber of Commerce, the National Radio Astronomy Observatory, the City of Socorro, and the Bureau of Land Management.

A VOYAGE Through the Radio Universe

Students learn about distant galaxies by analyzing data from the world's largest single dish radio telescope

Timothy Spuck



Each year, professionals and amateurs alike make significant contributions to the field of astronomy. High school students can also conduct astronomy research. Since 1992, the Radio Astronomy Research Team from Oil City Area Senior High School (OCHS) in Oil City, Pennsylvania, has traveled each year to the National Radio Astronomy Observatory (NRAO) in Green Bank, West Virginia. There, students design and conduct investigations in radio astronomy using the facility's Forty Foot Telescope (inset).

The team embarked on a special project titled "Mapping the Universe" at the start of the 2000 school year. For the project, students analyzed data from the Arecibo Radio Telescope pictured to the right, the world's largest single dish radio telescope, in an effort to learn more about distant galaxies. Students used the information they gathered to calculate the Hubble constant—an accomplishment usually only achieved by professional astronomers.

History of success

Students from OCHS have a long history of conducting research in astronomy. OCHS is one of a limited number of schools in the United States to offer a course in astronomy at the high school level. In 1994, two OCHS students provided professional astronomers with some of the most valuable supernovae data on record. Working with the Hands-On Universe project, sponsored by the Lawrence Hall of Science at the University of California, Berkeley, the students used a .76 m robotic telescope at Leuschner Observatory to capture first light from SN 1994I in the Whirlpool Galaxy. This turned out to

Background on the Hubble constant and its relationship to the Mapping the Universe project.

In 1913, V.M. Slipher at Lowell Observatory reported that spectra of faint nebulous objects, later identified as distant galaxies, appeared to have redshifts indicating they were moving away from Earth. In 1929, Edwin Hubble and Milton Humason published a graph that plotted this velocity of recession versus distance for 30 relatively close galaxies (Seeds 2003). They discovered that the points fell along a straight line and labeled the slope of this the Hubble constant. This discovery lead to the development of the equation $V = Hd$, where V is the recessional velocity, H is the Hubble constant, and d is the distance to the galaxy.

Since Hubble's discovery, astronomers have spent a great deal of time and effort trying to establish an accurate value for the Hubble constant. The relationship between redshift and velocity, or the Doppler Effect, is well documented—an object moving away from us that is emitting light will stretch the wavelength and cause the light and its spectral lines to be shifted toward the red end of the spectrum. Measuring this redshift allows astronomers to accurately determine the recessional velocity of an object in space. Depending on the research method and instrumentation used, Hubble constant values have ranged between 50–100 km/s/Mpc, but recently astronomers using the Hubble Space Telescope have established a broadly accepted value of 70 km/s/Mpc. A megaparsec (Mpc) is a huge distance in space equal to 3.26 million light-years or 3.08 x 10^{19} km. Therefore, if we accept a Hubble constant of 70 km/s/Mpc, a galaxy receding at a velocity of 70 km/s is 3.26 x 10^{6} light-years away from the observer. Likewise, a galaxy receding from us at twice the velocity, 140 km/s, would be twice this distance or 6.52 x 10^{6} light-years.

An accurate Hubble constant value is extremely valuable to astronomers. The OCHS Radio Astronomy Research Team used the Tully-Fisher relation in an attempt to measure the distances to galaxies and thereby determine the Hubble constant. In the 1970s, Brent Tully and J. Richard Fisher discovered that the width of the hydrogen 21 cm emission line of a spiral galaxy is related to the galaxy's absolute magnitude (Comins and Kaufmann 2003). When observing a rotating spiral galaxy, some stars move toward the observer and some move away from the observer. Light from the stars moving toward the observer will be slightly blueshifted, and light from stars that are moving away will be slightly redshifted causing the 21 cm emission line to broaden. Measuring the width of the line allows us to determine the rotational velocity of the galaxy. If the mass of a galaxy is bound together by gravity, one can conclude the faster a galaxy is spinning the more massive it is, and the more massive the galaxy the more stars it contains and the brighter it will be. Students used the Tully-Fisher relation to determine absolute magnitudes of the galaxies, and then compared these values to apparent magnitudes to determine their distance. With distances known and recessional velocities determined via redshift of the spectra, the team was able to calculate the Hubble constant.

The Hubble constant has many implications since it is used to establish distances to far away objects. The greater the distance, the farther back in time the observer is looking. Light from a galaxy two billion light-years away left that galaxy two billion years ago. When we observe this light we are seeing part of the universe as it was two billion years ago. This allows astronomers to see back to a time when the universe was much younger and explore how it has evolved over time. Will the universe expand to a point and stop? Will it implode into the Big Crunch? Is the universe expanding at such a high velocity, much like a rocket launched at sufficient velocity to break free from Earth's gravitational pull that it will continue to expand infinitely? The Hubble constant is a key to unlocking these cosmological mysteries.

be some of the earliest data ever collected from a supernova caught in its period of rapidly increasing luminosity. Again in 1998, working with the Hands-On Universe Asteroid Search, students from OCHS and Northfield Mount Herman High School in Northfield, Massachusetts, discovered a Kuiper Belt Object. The distant asteroid/comet type object, now identified as 1998 FS144 by the Minor Planet Center, was one of the first 100 Kuiper Belt Objects to be discovered (Hands-On Universe Project 2003).

Given this history of success, it was not surprising that in 2000 the OCHS Radio Astronomy Research Team enthusiastically volunteered for the Mapping the Universe project.

The research team consisted of student volunteers from grades 9–12. The project was an extension of my own work in the summer of 2000 with NRAO astronomer J. Richard Fisher. During that summer I participated in a Research Experience for Teachers (RET) program sponsored by the National Science Foundation. In the program, educators work cooperatively with scientists to conduct various research studies, and scientists work with educators to develop innovative educational experiences for students. In October of 1999, Fisher used the Arecibo Radio Telescope to collect data for more than 500 galaxies; my RET task during the summer of 2000 was to prepare the AIPS++ computer scripts needed for data analysis and work toward the reduction of this data. AIPS++ is a Linux-based data analysis package developed by a team of astronomers at the NRAO (*aips2.nrao.edu/does/aips++.html*). I spent eight weeks working closely with Fisher to measure neutral hydrogen (HI) luminosity-linewidth profiles for observations of these faint galaxies. The HI profile (Figure 1) is a radio scan of a galaxy and is a valuable tool in radio astronomy, helping to determine distances, rotational velocities, and hydrogen composition in distant galaxies (Spuck and Fisher 2004).

Involving my students

When school resumed in the fall of 2000, I shared my NRAO experiences with my students. The astronomy club was eager to continue working on analyzing the data collected by Fisher. Students realized early on that the total project would take a two-year commitment, but they were very willing to participate.

In an effort to bring the astronomy team up to speed, I met with them on a weekly basis to discuss the basics of radio astronomy and to explore the advantages of observations with radio telescopes. Once students were ready, they participated in two investigations through NRAO—"The Radio Moon" and "From Hubble to Hubble: Measuring the Age of the Universe." For the Radio Moon project, students compared images of the Moon generated by the NRAO 140 Foot Radio Telescope with optical images (Heatherly, Maddalena, and Spuck 2003). Students then further analyzed the images to determine the temperature at 1 m below the Moon's surface. For the From Hubble to Hubble project, students analyzed radio scans and optical images of 10 galaxies (Heatherly and Maddalena 2003). By analyzing this data, the team determined a rough estimate of the age of the universe and (most importantly) decided that more data was necessary in order to reach a valid conclusion.

Taking the next step

The research team's next step was to develop its own investigation using NRAO's Forty Foot Radio Telescope. The group came up with two ideas; first to determine if different types of astronomical objects produced unique radio scans, and second to generate a radio map of an area of sky near the center of the Milky Way. We spent the next couple of months conducting research on galaxies, supernovae remnants, nebulae, and planning out how we would use the telescope when we visited NRAO.

Soon enough, we headed for Green Bank to begin using the telescope. While there, the team continued their research at the on-site library, collected data using the telescope, and most importantly met with Fisher. My students and I first became acquainted with Fisher in 1992. During our annual trips to NRAO he consistently made time to meet with my students and discuss their current research and science in general.

The visit with Fisher gave students the opportunity to interact with a professional scientist. The student-driven discussion went in many directions; from the origins of Fisher's interest in radio astronomy to how HI luminosity-linewidth profiles are used to determine distances to galaxies.

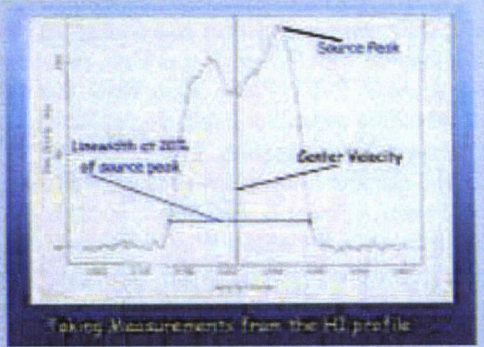
We ended the 2000–2001 school year on a positive note. Working with NRAO's telescope, the team observed various sources and mapped the Sagittarius Region near the center of the Milky Way (Figure 2). With a fundamental understanding of radio astronomy, and a growing knowledge of how astronomers measure the distances and velocities of far away galaxies, we were ready for year two.

Returning to the lab

In September of 2001, the students were back to work, meeting for three to four hours after school each week. Our goal was to look at as many of the more than 500 radio scans possible and attempt to use the data to measure the Hubble constant (see sidebar, p. 49). The team determined quickly that while it was important for all members

FIGURE 1

HI luminosity-linewidth profile.

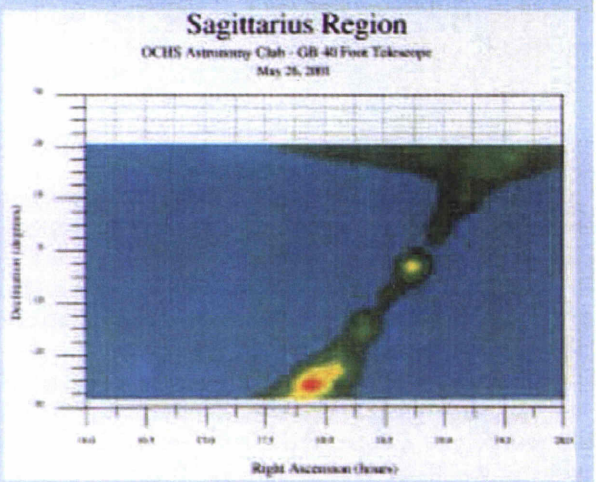


(Note: The center velocity is the velocity at which the galaxy is moving away from Earth. The width of the profile taken at 20 percent of the peak value tells scientists how fast the galaxy is rotating, and therefore can be used to determine the mass of the galaxy.)

FIGURE 2

Radio image of the Sagittarius region

The image was produced by the NRAO Forty Foot Telescope. The red area indicates intense radio emission from the center of the Milky Way Galaxy.



to have a fundamental knowledge of the project, it was of great value to have individuals become "experts" in the various aspects of the research project. Although all members of the team experienced different roles, team members identified and developed their own area of expertise in equipment and software, science content, data analysis, research of existing data, and data entry.

During the work sessions, students used AIPS++ and the NASA/IPAC Extragalactic Database (NED) to collect data for the candidate galaxies. Students used the software to view and measure HI luminosity-linewidth profiles for data collected by the Arecibo Radio Telescope. With the data acquired and verified, a second team of students used NED to identify published data (where available) for the galaxies. NED, with its Internet accessibility and extragalactic database of over 7.5 million objects, proved to be a priceless resource (NED 2003). Data from these two resources were then combined into a single database using a computer spreadsheet program.

With the number crunching capabilities of the spreadsheet program, distances and galactocentric velocities (velocity relative to the Milky Way) for nearly 100 galaxies were determined. Although the team analyzed over 200 galaxies, a significant number of candidates were eliminated due to insufficient data. Through their investigation of distant galaxies, the OCHS Team measured a Hubble constant of 61.2 km/sec/Mpc, close to what professional astronomers have determined. Using the Hubble Space Telescope, for example, the Hubble Key Project determined a Hubble constant of 70 km/sec/Mpc, with an uncertainty of 10 percent. By characterizing the detailed structure of the cosmic microwave background fluctuations, a second study, the Wilkinson Microwave Anisotropy Probe, recently indicated a Hubble Constant of 71 km/sec/Mpc, +0.04/–0.03 (Spergel 1997).

The only thing missing now was an opportunity for students to share their findings with colleagues. Sue Ann Heatherly, NRAO's Education Director, set up a colloquium at the Observatory for Monday, May 13, 2002, at 10:00 AM. Once again, the OCHS Team traveled to NRAO, this time delivering their findings to a group of attentive and interested scientists, including Fisher. The presentation not only focused on the students' final results, but also their journey along the way. The challenge of learning and using a different computer operating system, working around scheduling conflicts, utilizing a range of abilities and interests within the team itself, and making judgments in the data analysis process were all obstacles students had to overcome in achieving their goal.

On their voyage through the radio universe, these young scientists did something once only thought possible by professionals. The project was an incredible experience made possible by scientists who care about education and educators who care about the nature of science. ■

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Acknowledgments

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THE WASHINGTON POST MONDAY, SEPTEMBER 27, 2004

Space Sugar a Clue to Life's Origins

Discovery of Molecule in Region of Extreme Cold Indicates Possibility the Beginning Came From "Out There"

By Guy Gugliotta
Washington Post Staff Writer
Monday, September 27, 2004; Page A07

A cotton candy-like cloud of simple sugar drifts in the unspeakably cold center of the Milky Way about 26,000 light years away, offering a remote, yet tantalizing, hint of how the building blocks of life may have reached Earth billions of years ago.

This frigid cloud is composed of molecular glycolaldehyde, a sugar that, when it reacts with other sugars or carbon molecules, can form a more complex sugar called ribose, the starting point for DNA and RNA, which carry the genetic code for all living things.

Astronomers have known about sugar in space for some time, but new research reported last week in the Astrophysical Journal Letters showed that gaseous sugar could exist at extremely low temperatures, as are found in regions on the fringes of the solar system where comets are born.

Thus, while many scientists agree that life probably derived from a rich "primordial soup" concocted in the warm-water puddles of early Earth, the new research offers fresh evidence for another popular view -- that life, or at least some of its basic ingredients, may have flown in from interstellar space aboard a comet or asteroid.

"These are long-standing questions," said astronomer Philip R. Jewell, of the Robert C. Byrd Green Bank Telescope in West Virginia. "You want to know what sort of molecules would form in the interstellar medium. This is a clue."

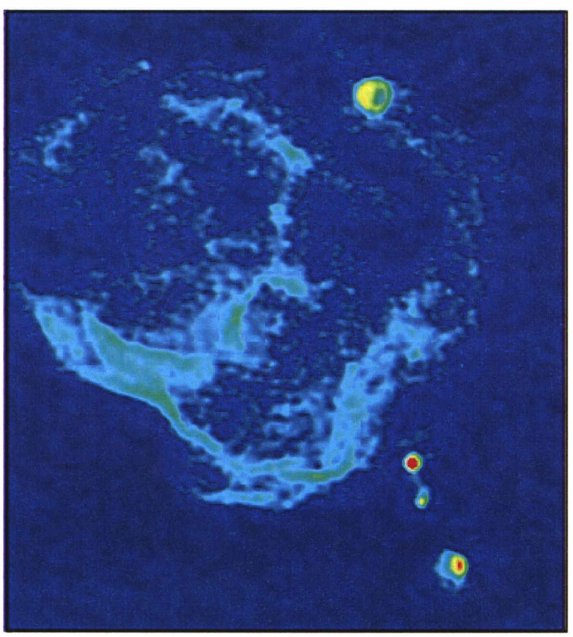
A four-member team led by Jan M. Hollis, of NASA's Goddard Space Flight Center, and Jewell, used Green Bank's 115-yard-diameter parabolic reflector to examine Sagittarius B2, a cloud of dust and gas several light-years wide at the heart of the Milky Way, in the direction of the constellation Sagittarius.

Green Bank is a radiotelescope that identifies specific molecules in the cosmos by analyzing their radio emissions as they rotate end over end in space. Each molecule has its own unique signature frequencies, derived and catalogued through testing on Earth.

Jewell said the team had found glycolaldehyde in a warmer part of the cloud in 2000, but this time detected it in an area where temperatures were only 8 degrees above absolute zero, that is, minus 445 degrees Fahrenheit. All molecular motion stops at absolute zero (minus 459 Fahrenheit).

"Being that cold is interesting," said research astrophysicist Scott A. Sandford, of NASA's Ames Research Center. "At 8 degrees kelvin, molecules aren't going to be hopping off into the gas phase."

Finding complex molecules floating free in cold space so that their radio signatures could be recognized was something of a surprise, Jewell said, because at such low temperatures, they are much more likely to be found frozen solid to dust particles in the cloud.



The simple sugra molecule glycolaldehyde was found in this dust and gas cloud, Sagittarius B2. The colors indicate radio emissions of different strengths. (R. Gaume, M. Claussen, C. De Pree -- National Science Foundation)

"You need something non-thermal to get the sugar molecules off the dust grains," said Sandford, speaking from his Mountain View, Calif., office. "A shock wave could go through the cloud, cause grain collisions and blow the molecules into the gas phase." Heat will not work, he added, because it would break down the sugar molecules into simpler compounds.

Jewell said shock waves are quite likely what happened: "This is a star-forming region, and while star formation is a pretty hot process, the shock waves would pass through the center of the region and out into the colder outer areas," jarring the dust to release the sugar molecules.

It is unclear whether the glycolaldehyde, a simple "two-carbon" sugar containing two carbon atoms, two oxygen atoms and four hydrogen atoms, was frozen to the dust particles before the shock wave came by, or was formed by interstellar chemistry after the shock wave liberated simpler molecules.

In either case, however, "the conclusions are pretty exciting," said University of Arizona astrochemist Lucy M. Ziurys, director of the Arizona Radio Observatory. Ziurys, an expert in developing radio signatures for carbon molecules, has criticized the Green Bank team for not being thorough enough, but said her own students had replicated the Green Bank results.

"If sugar's in space, it's an important thing," Ziurys said in a telephone interview. "You add a few more carbons, and you end up with a sugar called ribose, and ribose is an essential component" of DNA and RNA.

What that means, however, is anybody's guess: "So suppose we have these interstellar clouds that are producing sugar molecules, and they're found throughout the galaxy," Ziurys said. "The big question is: Did the basic ingredients of life begin out in these clouds or on a planet?"

"We don't have a clue," Sandford said. "This seems to raise the odds that life could get started out there, but we don't know. That's why most of these arguments tend to be of a general nature."

In our solar system, and presumably elsewhere, the colder reaches of space are areas where particles of dust, ice and other debris bond in ever-larger clumps that eventually become comets.

Most comets in the solar system were formed about 4.5 billion years ago near the planets Uranus and Neptune and were subsequently cast into deep space well beyond Pluto. They reenter the solar system when nearby stars or large planets perturb their orbits.

Scientists long ago raised the possibility that early impacts from comets -- or asteroids from the belt between Mars and Jupiter -- may have brought Earth most of its water supply as well as the sugars and other compounds that served as the building blocks of life. The Green Bank research provides further evidence that this may have occurred.

Once liberated from their icy embrace and allowed to steep in warm water on the Earth's surface, the sugars could have combined with other carbon compounds to form ribose and, eventually, DNA and RNA.

But while this view appears to clash with more traditional thinking -- that the early Earth mixed its own soup without any help from space -- there is no reason why both phenomena could not have occurred.

"Current thinking is that sugars formed on the planet, but they could have been deposited on the planet by a comet or by interstellar dust," Ziurys said. "The important thing is that one method does not exclude the other."

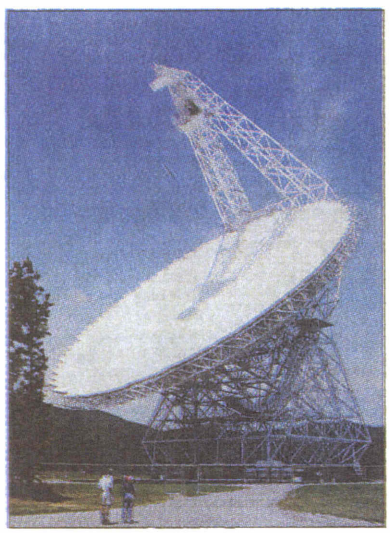
And "nothing says that the stuff that fell out of the sky was the key thing, or the stuff that came from hydrothermal vents was the key thing, or the stuff that was struck by lightning was the key thing," Sandford said. "In the end, the chemical system that made life on Earth wasn't worried about 'Made in' labels. It just grabbed what it needed."

Richmond Times-Dispatch

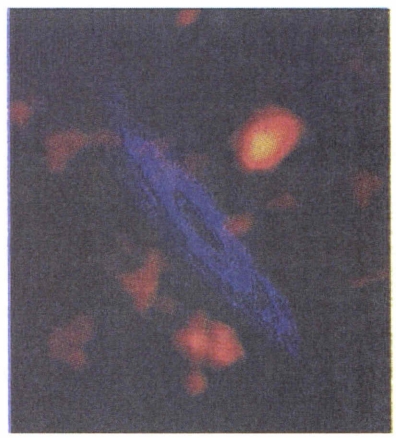
RICMOND TIMES-DISPATCH SUNDAY, SEPTEMBER 26, 2004

Shhhh . . . listen and learn about search for cosmic radio waves

BY KATHERINE CALOS
TIMES-DISPATCH STAFF WRITER
Sunday, September 26, 2004



KATHERINE CALOS



NRAO/AUI/NSF, WRST

Visitors (left) are dwarfed by the Green Bank Telescope, which collects radio waves from space to form a picture (above) showing faint hydrogen clouds in the Andromeda Galaxy.

GREEN BANK, W.Va. If your cell phone can't get a signal around here, there's a reason. If your car radio searches in vain for a station, the reason is the same.

It's the Robert C. Byrd Green Bank Telescope, the largest fully steerable telescope in the world. Completed four years ago as part of the National Radio Astronomy Observatory, it probes the universe searching not for light rays but for cosmic radio waves.

To stay free from earthly interference, the telescope is surrounded by a 13,000-square-mile National Radio Quiet Zone. Man-made sources of radio waves are monitored for interference with Green Bank.

Results have been spectacular.

In June, scientists announced two new molecules found in an interstellar cloud near the center of the Milky Way. In February, studies of the Andromeda Galaxy detected neutral hydrogen clouds - the first conclusive detection of what appear to be leftover building blocks of galaxy formation.

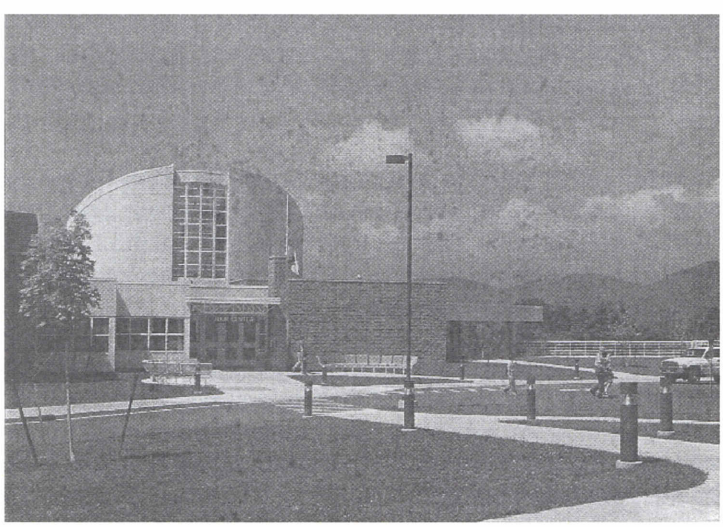
For visitors, the building blocks of understanding are located in the site's new science center, where exhibits were designed by Richmonders John and Tania Moser.

The center opened last year with just a handful of exhibits. It's now about 75 percent complete, the Mosers estimate. Just last week, they added an infrared camera exhibit that allows visitors to see themselves in a way that's different from visible light.

Exhibits explain how the radio telescope works as well as the celestial objects it's studying.

The centerpiece is a 9-foot scale model of the Green Bank Telescope, which visitors can control with a touchscreen computer.

Touch the constellation Orion on the screen, for example, and the model rotates and tilts to aim itself



KATHERINE CALOS

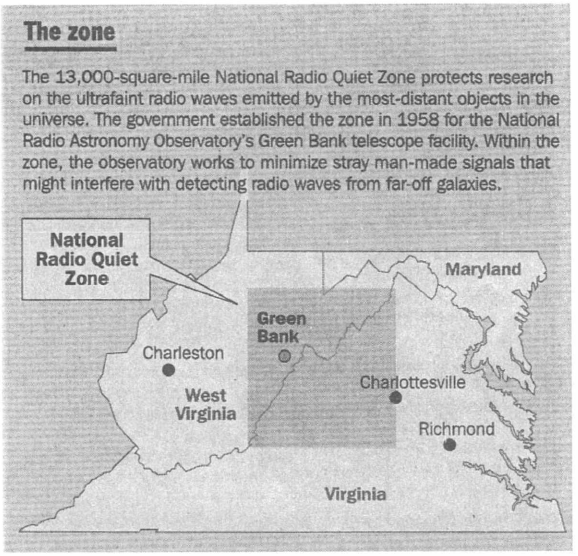
New exhibits in the Science center at the Green Bank Telescope help visitors understand the technology before they begin a tour.

where Orion is in real time. A radio image of Orion appears on the telescope screen.

There the reality ends. "It's pointing to a real point in the sky, but it can't really take a reading from inside the room," Moser said. Of course not. It's not a real telescope.

On guided tours, visitors can get up close to the massive receiving dish that looms over a mountain-rimmed meadow in Deer Creek Valley. Seven smaller radio telescopes share the surroundings.

The real Robert C. Byrd Green Bank Telescope, at 485 feet tall, stands higher than the Statue of Liberty and nearly as high as the Washington Monument. The surface of its receiving dish comprises 2,004 adjustable metal panels that cover almost two acres. Laser beams check for alignment of the panels, which can be tuned individually with motor-driven pistons.



Though it weighs 16 million pounds (the same as 19 Boeing 747s), it can be pointed with an accuracy of one arcsecond. That's equivalent to the width of a human hair seen 6 feet away.

Or, as tour guide Andrew Lacasse described it, the telescope could focus on individual pepperoni in a pizza from 3 miles away.

As the telescope collects radio data from space, scientists create pictures, dot by dot.

"A radio telescope is like a one-pixel camera," explained Sue Ann Heatherly, education officer. "To build an image, you have to move the telescope to one point after another point after another point. You record the intensity of the radio signal at each spot, and you end up with a grid of numbers. . . . Then you color by number."

Astronomers choose whatever colors they like.

"That's why you see some images in a flame color, some in rainbow hues," Heatherly said. "No matter what color palette they use, they will have something explaining what the shades mean. The easiest is to use shades of gray, with darker shades meaning a stronger signal. Sometimes, by changing from a red to green palette, out pop details or features that you didn't know were there at all."

The radio waves that the astronomers are searching for typically aren't the same frequency as the radio waves that carry songs over the airwaves. Whereas your favorite station might be at 98.1 on the FM dial, the favorite frequency for radio astronomers is 1420.4. That's the frequency at which hydrogen atoms give off radio waves.

"Hydrogen is the most abundant element or atom in the universe, we think," Heatherly said. "You do a lot of looking around for hydrogen in distant galaxies to see how they were formed, how dense they are, how hot they are. Green Bank is so big that it can pick out the very small amounts [of hydrogen] that had not been seen before."

Radio waves come from anything that produces energy, we learned from tour guide Lacasse. Electricity is a form of energy, so it produces radio waves. Anything that produces heat also produces radio waves. Anything with a strong gravitational pull produces radio waves. That means stars, planets and black holes all produce radio waves.

Getting there: Green Bank is in Pocahontas County, W.Va., about 185 miles west of Richmond. From Richmond, go west on Interstate 64 to Staunton and exit on U.S. 250 west. From there you have two choices, both on two-lane roads. You can stay on U.S. 250 into West Virginia and go south on WV 92 to Green Bank. (But be prepared for many hairpin turns on U.S. 250 west of Monterey.) Or, you can leave Staunton on VA 254, go south on VA 42 and west on VA 39 to West Virginia, and then north on WV 92.

Taking the tour: Free tours of the Green Bank Telescope begin at the top of the hour from 9 a.m. through 6 p.m. Wednesday through Sunday until the end of October. In winter and spring, tour hours are 11 a.m., 1 and 3 p.m. The Green Bank Science Center is open from 8:30 a.m. to 7 p.m. Wednesday through Saturday until the end of October, then 10 a.m. to 5 p.m. in winter and spring. The site is open daily from Memorial Day to Labor Day. Where to stay: In Green Bank, the Sweet Thyme Inn offers lodging, $50-$100, and vegetarian fare, (304) 456-5535 or online at *www.sweetthymeinn.com.* Snowshoe Mountain Resort is 16 miles away, (877) 441-4386 or online at *www.snowshoemtn.com.*

Info: For Pocahontas County, W.Va., call (800) 336-7009 or visit online at www.pocahontascounty-wv.com. For the Green Bank observatory, call (304) 456-2150 or visit online at *www.gb.nrao.edu.*

Astronomers haven't found any radio signals that seem to indicate intelligent life on other planets, though they've been looking off and on since 1960. The first Search for Extraterrestrial Intelligence, or SETI, was conducted on Green Bank's first radio telescope, the 85-foot Tatel Telescope built in 1959.

"We've looked for aliens before, and we will probably look again," Lacasse said. "They haven't found anything yet as far as I know. It's a big universe."

The size of our own solar system becomes apparent as we ride from the Science Center to the Green Bank Telescope. Along the way, each planet is represented by a flag that marks its distance from the sun, with one earthly foot representing 3 billion feet in space. From the sun to Pluto takes up the entire 2 miles. To position a flag representing the closest star, Lacasse said, you'd have to go to Hawaii.

Compared with the distances from which the Green Bank Telescope seeks radio waves, that's just a step away.

Contact Katherine Calos at (804) 649-6433 or kcalos @timesdispatch.com

THE SCOTSMAN
Wed 22 Sep 2004

printer friendly email article

Frozen sugar at centre of Milky Way

RHIANNON EDWARD

ASTRONOMERS have found a cloud of frozen sugar near the centre of our galaxy, the Milky Way, it was revealed yesterday.

The discovery heightens the possibility of early building blocks of life originating in interstellar space.

Molecules of a simple sugar, glycolaldehyde, were detected in a cloud of gas and dust called Sagittarius B2 about 26,000 light years away.

Observations indicated large quantities of the sugar frozen to a temperature only a few degrees above absolute zero, the point at which all molecular movement stops.

Glycolaldehyde consists of two carbon atoms, two oxygen atoms and four hydrogen atoms.

This type of molecule is known as a two-carbon sugar. Significantly, it can react with a three-carbon sugar to produce the five-carbon sugar ribose - the molecule which forms the backbone of DNA.

The discovery adds to the growing evidence that the foundations of life can be traced to chemical reactions within interstellar clouds.

The clouds, which are often many light years across, provide the raw material from which new stars and planets are formed.

Radio astronomer Dr Jan Hollis, from the American space agency NASA's Goddard Space Flight Centre in Green- belt, Maryland, said: "Many of the interstellar molecules discovered to date are the same kinds detected in laboratory experiments specifically designed to synthesise prebiotic molecules.

"This fact suggests a universal prebiotic chemistry."

Gravitational attraction causes lumps to form in interstellar clouds which eventually condense into stars and planets.

The process generates so much heat that any prebiotic molecules within the planetary lumps would probably be destroyed.

But the new findings show that life's building blocks could exist in the frozen wastes beyond the planet-building zone of an embryonic solar system, where comets form.

A collision with a comet or a brush with a comet's tail could then "seed" a young planet with the material needed to kick-start life.

The Green Bank Telescope which was used in the study is the world's largest fully-steerable radio telescope. Its dish covers more than two acres of signal-collecting area.

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Dr Philip Jewell, another member of the Green Bank team, said: "The large diameter and great precision of the telescope made this discovery possible, and also holds the promise of discovering additional new complex interstellar molecules."

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Page 1 of 5

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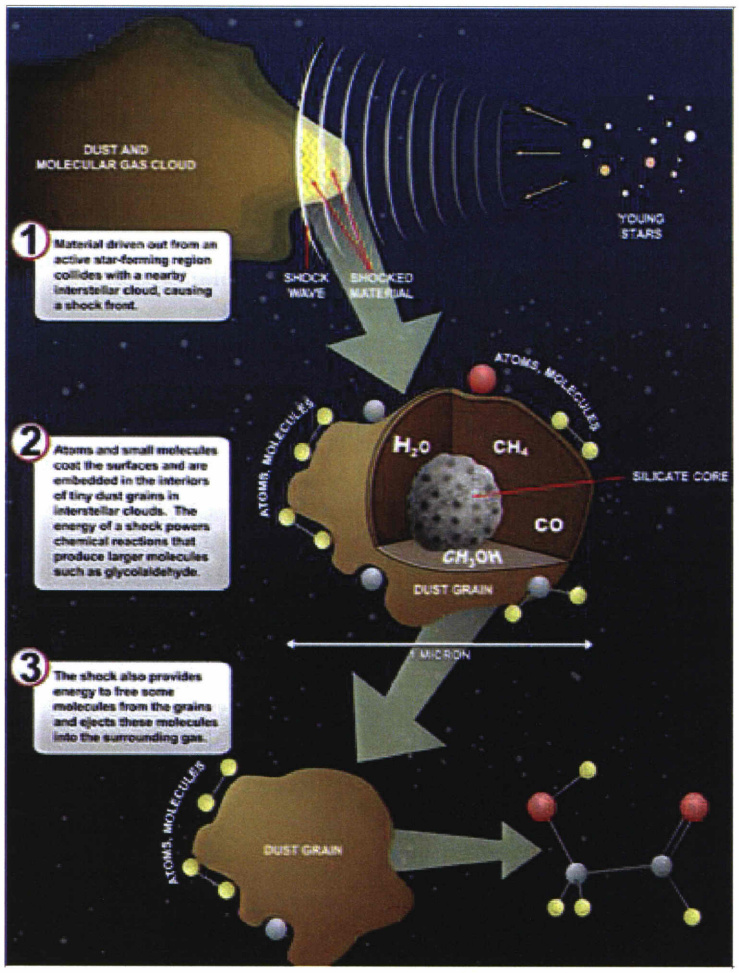
Sugar in space provides clue to origin of life

NATIONAL RADIO ASTRONOMY OBSERVATORY NEWS RELEASE
Posted: September 21, 2004

Astronomers using the National Science Foundation's giant Robert C. Byrd Green Bank Telescope (GBT) have discovered a frigid reservoir of simple sugar molecules in a cloud of gas and dust some 26,000 light-years away, near the center of our Milky Way Galaxy. The discovery suggests how the molecular building blocks necessary for the creation of life could first form in interstellar space.



Credit: NRAO

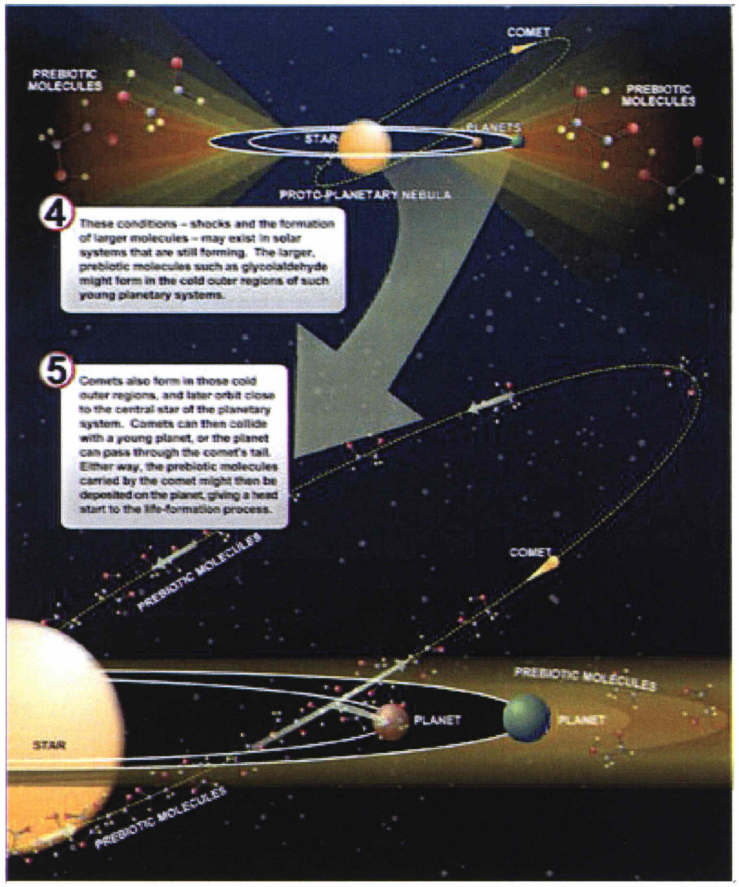
The astronomers detected the 8-atom sugar molecule glycolaldehyde in a gas-and-dust cloud called Sagittarius B2. Such clouds, often many light-years across, are the raw material from which new stars and planets are formed. The astronomers detected the same molecule in a warmer part of that cloud in 2000, but the new detection shows that the sugar

exists at an extremely low temperature -- only 8 degrees above absolute zero, the temperature at which all molecular motion stops. The cold glycolaldehyde detections were surprisingly strong when compared to the original detections and indicate that a considerable quantity of this simple interstellar sugar exists at extremely low temperatures.

Glycoaldehyde is composed of 2 carbon atoms, 2 oxygen atoms and 4 hydrogen atoms and is called a 2-carbon sugar. Glycolaldehyde can react with a 3-carbon sugar to produce a 5-carbon sugar called ribose. Ribose molecules form the backbone structure of the molecules DNA and RNA, which carry the genetic code of living organisms.

On Earth, most chemical reactions occur in liquid water. Conditions are quite different in interstellar space, and most of the complex molecules appear to form on or under the surfaces of tiny dust grains. In this scenario, smaller molecules such as water, formaldehyde, methane, ammonia, carbon dioxide, or methanol, coat the surfaces and interiors of dust grains in the clouds. When a shock wave, caused by the infall or outflow of material in the star-formation process, hits the dust grains, it provides the energy to assemble more-complex molecules from the simpler ones, and also to free the newly-formed molecules from the dust grains. Once the shock has passed, the molecules cool into a cold, thin gas.

Although the chemistry on Earth and in interstellar clouds is much different, the results can be very similar. This and other recent studies show that prebiotic chemistry -- the formation of the molecular building blocks necessary for the creation of life -- occurs in interstellar clouds long before that cloud collapses to form a new solar system with planets. "Many of the interstellar molecules discovered to date are the same kinds detected in laboratory experiments specifically designed to synthesize prebiotic molecules. This fact suggests a universal prebiotic chemistry," said Jan M. Hollis of NASA's Goddard Space Flight Center in Greenbelt, MD. This suggests that the molecular building blocks for the creation of life on a new planet might get a head start in the dust of interstellar clouds.



Credit: NRAO

The actual formation of a planetary system is such a hot process that any prebiotic molecules would likely be destroyed. However, this study has shown that such molecules may form in very cold regions following the passage of a shock wave. Such conditions might be typical of the outer regions of a young solar system following the star-formation process. A repository of prebiotic molecules might exist in these outer regions, which is also where comets are formed, the scientists said. It has long been suggested that a collision with a comet or an encounter with the passing tail of a comet might "seed" a young planet with prebiotic material.

Hollis worked with Philip Jewell of the National Radio Astronomy Observatory in Green Bank, WV, Frank Lovas of the National Institute of Standards and Technology in Gaithersburg, MD, and Anthony Remijan of NASA's Goddard Space Flight Center. The scientists reported their findings in the September 20 issue of the Astrophysical Journal Letters.

The discovery of the cold glycolaldehyde was made by detecting faint radio emission from the molecules. Molecules rotate end-for-end. When they change from a higher rotational energy level to a lower energy level, they emit radio waves at precise frequencies. Conversely, they can absorb radio waves at specific frequencies and change from a lower rotational energy level to a higher one. A set of frequencies emitted or absorbed by a particular molecule forms a unique

"fingerprint" identifying that molecule. The cold glycolaldehyde was identified both by emission from the molecules and by absorption of radio waves emitted by a background source, all between 13 GHz and 22 GHz in frequency.

"The large diameter and great precision of the GBT made this discovery possible, and also holds the promise of discovering additional new complex interstellar molecules," Jewell said. The GBT, dedicated in 2000, is the world's largest fully-steerable radio-telescope antenna. Its dish reflector has more than 2 acres of signal-collecting area.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities, Inc.

INDEX | PLUS | NEWS ARCHIVE | LAUNCH SCHEDULE
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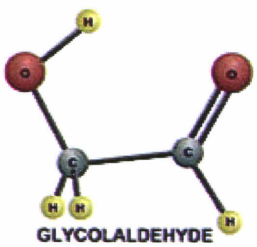
PRESS RELEASE
Date Released: Monday, September 20, 2004
Source: National Radio Astronomy Observatory

Cold Sugar in Space Provides Clue to the Molecular Origin of Life



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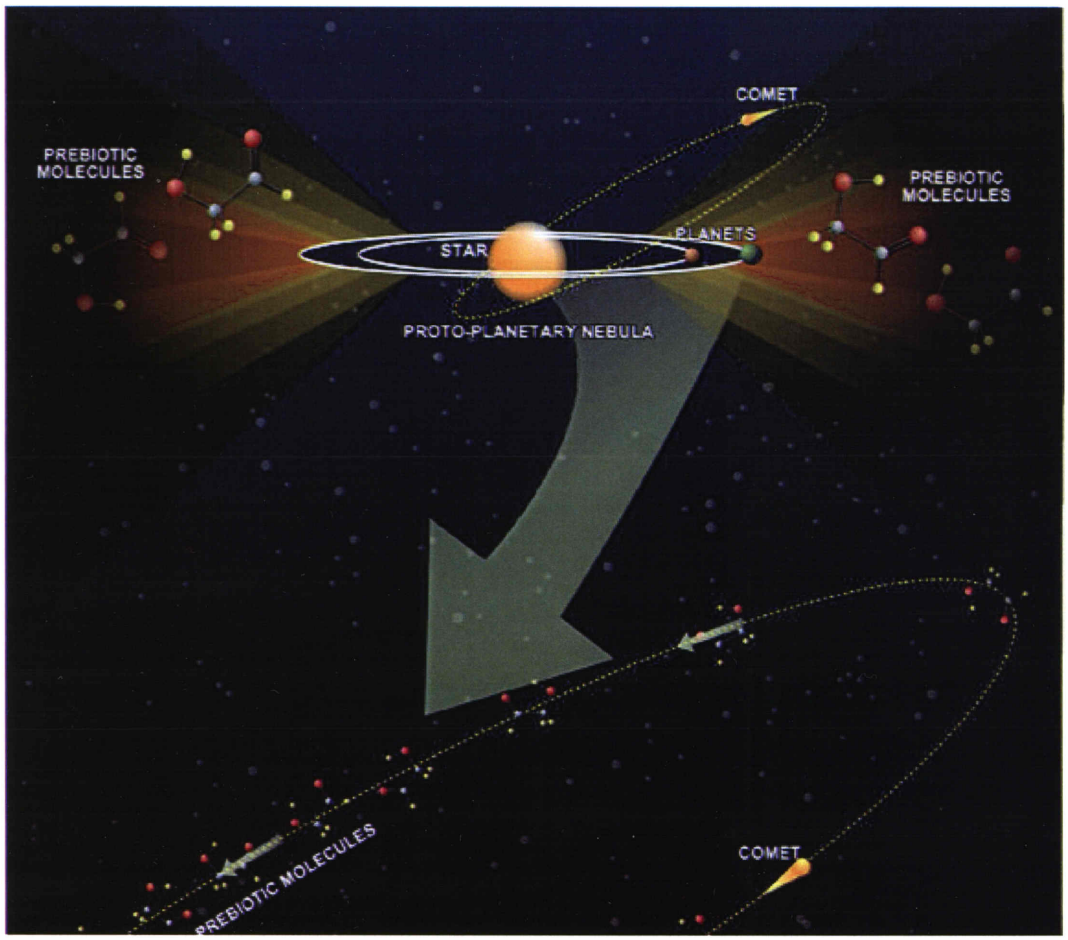

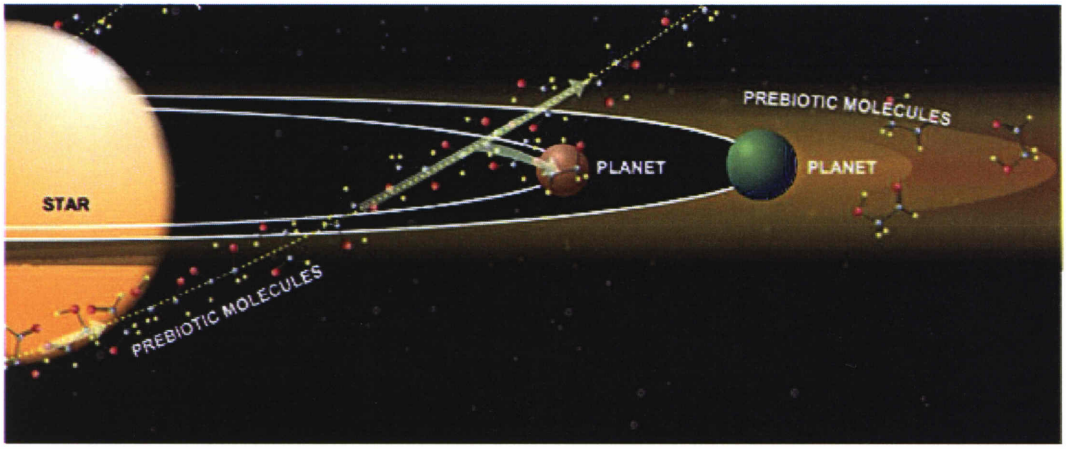

NOTE: This release, with graphics, is available on the NRAO Web site, at:
http://www.nrao.edu/pr/2004/coldsugar

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The Pocahontas Times

THE POCAHONTAS TIMES AUGUST 26, 2004

Gear-Up students reach for the stars

By Drew Tanner
Staff Writer

While many students were relishing the precious few mornings they had left to sleep in before the start of school, a handful were putting in long days of research until late at night and waking up early the next morning to do it again.

During an early morning presentation, Harry Cain holds up a chart illustrating his teams's observations using the 40-foot telescope over the previous two evenings. *D. Tanner, photo*

From Sunday through Wednesday seven Pocahontas County freshmen participated in the Gear-Up Camp at the National Radio Astronomy Observatory in Green Bank.

During the four-day camp, the students had a packed schedule that included social activities, journal time, guest speakers and‹the highlight for many of the students‹team assignments on the NRAO's 40-foot radio telescope.

The students were divided into two teams, named "Swanson University" and "The Archer Institute." Each team was assigned one known galaxy, star or nebula and one "mystery object" to observe on Monday and Tuesday nights.

Based on their observations, the teams had to compare the two objects and conduct research to find out the identity of their assigned mystery object.

The students were trained by NRAO staff on how to calibrate the 40-foot telescope and aim it at a region of the sky to be observed.

In the evenings, each team worked independently on the 40-foot telescope, making observations of their known objects and doing research into the identity of their mystery objects. As they worked, the students kept journals of their research and observations, preparing for a presentation of their findings on Wednesday morning.

While preparing for their presentations, the eighth-graders got a taste of college life, staying up past midnight on Tuesday to pull together their research for Wednesday's 9 a.m. presentation.

"We looked at different galaxies and super novas," said Evan Dale, a 2004 PCHS graduate who served as a counselor at the camp. "We were up until 1:00 (a.m.)."

In addition to Dale, Micah Johnson, a 2003 PCHS graduate, also helped with the camp.

"I think we probably had more fun than the kids did," Dale added.

On Wednesday morning, the groggy students did some last minute revising of their notes. Lengths of graph paper with red and blue radio wavelengths printed on them‹print-outs from the 40-foot telescope‹ were spread across the tables.

"I think that's the galactic center of the Milky Way," said Harry Cain, referring to a dramatically peaked radio wave on his group's print-out.

The Swanson University team, made up of Tara Holiday, Janessa Sharp and Nicholas Irvine, made the first presentation.

The group's known object was a distant galaxy, explained Holiday.

"We think our unknown object was gas from a super nova," said Irvine.

During the group's question and answer session, Sue Ann Heatherly, the NRAO's education officer, noted that the Swanson University team's observations showed the galaxy was brighter than it was according to data gathered by scientists in the 1960s.

"When you see something that doesn't match up with what other scientists have said, you might have a discovery," Heatherly told the students.

The Archer Institute team, made up of Zach Grimes, Kelly Starr, Harry Cain and Floyd Hanna, made the second presentation of the morning.

Grimes explained how the group had a reading on its mystery object that went off the chart on Monday and subsequently recalibrated the telescope on Tuesday and pointed it at a slightly different angle.

"We determined that it was the galactic nucleus," said Grimes.

"When we measured the first time, we didn't get anything... Then (on Tuesday) we got it right," added Starr.

Heatherly congratulated each of the teams on a job well done and for accurately identifying their mystery objects.

"You worked so hard, and you were game to try anything," Heatherly told the students.

Before leaving NRAO for some wrap-up sessions and a family barbecue at Mountain Quest Institute, in Frost, the students were presented with certificates for the hard work they had put into their projects.

"It was a blast here!" Starr said as the students prepared to leave the observatory.

"I would want to stay longer," added Holiday.

"I'd love to come back and use the 40-foot again," said Grimes, who is now thinking about putting together a project for the state science fair in the future.

In addition to enjoying the work they were doing at the observatory, several of the students talked about the good time they had playing games and hanging out with each other in the evenings. Most expressed a desire to stay longer or return to the camp in the future.

Luther Crouthamel, the AmeriCorps*VISTA volunteer who helped organize the camp, hopes the students' enthusiasm will get their peers interested in coming to next summer's Gear-Up camp.

At the start of camp, each student was also given a disposable camera to take photographs during the course of the camp, Crouthamel said.

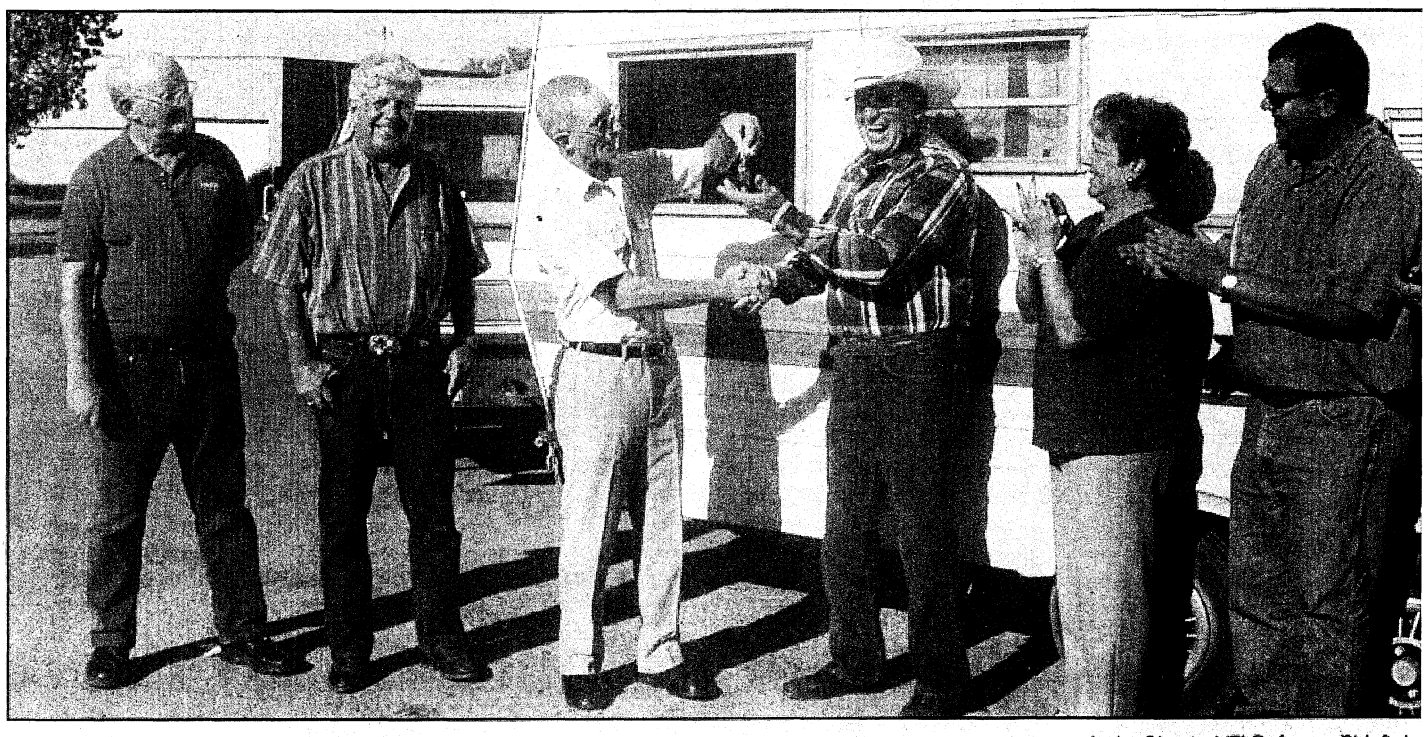
Crouthamel explained that the students will use their photographs next spring in a presentation to help recruit seventh- and eighth-graders for next summer's camp.

"We have an unbelievable resource here," said Crouthamel, who was excited about the prospect of regular, yearly camps that would bring Pocahontas County students to the observatory.

El Defensor Chieftain

July 17, 2004

IT'S ALL YOURS



Audry Olmsted/El Defensor Chieftain

Dave Finley (left center), of the National Radio Astronomy Observatory, hands over the keys to a trailer to County Commission Chairman Dennis Harris at a ceremony before the commission meeting Tuesday. The 16-foot travel trailer was donated by NRAO to Socorro County to be used as a mobile communications command center in emergency situations. Joining in are (from left) Ed Wood, president of the Amateur Radio Association; Toby Jaramillo, county emergency preparedness director; and Commissioners Rosie Tripp and Danny Monette.

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Serving Socorro and Catron Counties • July 15, 2004

Observatory Donates Radio Trailer For Emergency Response

By John Larson
Mountain Mail
johnl@socorroisp.com

SOCORRO – Thanks to a donation by the National Radio Astronomy Observatory, county emergency personnel will be better prepared to handle emergency situations through communications.

The NRAO donated a 16-foot travel trailer to Socorro County for use as a mobile emergency communications command post. The trailer will be equipped as a self-sufficient, mobile center to provide communications among local public-service agencies as well as links to agencies outside the local area in disaster situations.

According to Dave Finley, NRAO Public Information Officer, the trailer is rigged to be able to use ham radios, medical radios, FEMA transmissions, cell phones, and land-line capabilities.

"It is self contained and powered by a 2-kilowatt generator, and a portable solar panel array," he said.

The trailer was formally transferred from NRAO to the county at a ceremony in front of the Socorro County Courthouse before the regularly scheduled County Commission meeting Tuesday. Finley made the presentation to County Commission Chairman Dennis Harris.

According to Finley, the trailer was originally used by the observatory for evaluating the suitability of potential sites for stations of the Very Long Baseline Array (VLBA), the continent-wide system of radio telescopes operated from the NRAO in Socorro.

"On behalf of the observatory and the National Science Foundation, we are proud to be able to make a positive and important contribution to the community," he said at the County Commission meeting.

Commissioner Rosie Tripp told Finley, "Thank you so much. This is a good example of how government agencies and local communities can work together to benefit everybody."

The trailer will be outfitted with communications equipment by the Socorro Amateur Radio Association, a ham-radio organization founded in 1976. The group already owns radio equipment capable of both local and world-wide communication, including a mobile repeater that receives the low-power signals from handheld 2-way radios and retransmits them at high power, allowing the smaller units to communicate over a large area.

"Reliable communications are absolutely vital for effectively responding to an emergency, and can make a difference that saves lives," said Jonathan Spargo, Emergency Coordinator for Socorro County's Amateur Radio Emergency Service.

El Defensor Chieftain

June 30, 2004

150 attend NRAO astronomy school

By Dave Finley
National Radio Astronomy Observatory

The National Radio Astronomy Observatory and New Mexico Tech were hosts to more than 150 students June 15-22 at a summer school aimed at teaching astronomers how to use radio telescopes such as the Very Large Array and the Very Long Baseline Array. The students came from across the U.S. and 12 foreign countries.

Held in Socorro every two years, the Synthesis Imaging Summer School teaches the intricacies of using multi-antenna radio telescopes to produce finely detailed images of celestial objects. Participants in the school included undergraduates, graduate students and working astronomers. Instructors for the school included scientists from NRAO, New Mexico Tech, the Owens Valley Radio Observatory, and the University of Hawaii.

"The purpose of this summer school is to prepare the next generation of astronomers to use our facilities to do the cutting-edge astronomical research of the future," said James Ulvestad, NRAO's director for New Mexico operations.

"The techniques we teach are applicable not only to our radio telescopes, but also to similar radio telescope systems around the world and to future telescopes that still are on the drawing boards," Ulvestad added.

New Mexico Tech President Dan Lopez welcomed the attendees and pointed out to them that Tech's Magdalena Ridge Observatory will apply some of the same techniques to visible-light astronomy.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities Inc.

Richmond Times-Dispatch

Thursday, June 24, 2004

QUIET ZONE

Galaxies far, far away call out faintly, but will modern life drown them out?

BY A.J. HOSTETLER
TIMES-DISPATCH STAFF WRITER

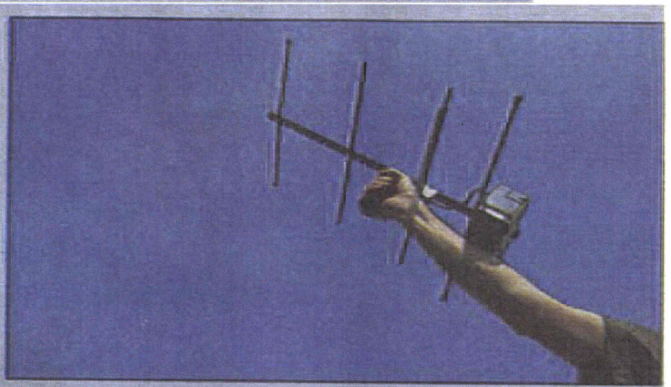
GREEN BANK, W.Va.

Heading west toward the West Virginia line, the car passes through Monterey, Va., where cellphone service dies. A little farther, radio reception flickers like the haze showing through the leafy trees and pines along state Route 92.

Finally, the Go-Go's "We Got the Beat" spits and crackles to a staticky hum as the blacktop curls around the Pocahontas County mountains.

Welcome to the Quiet Zone.

The National Radio Quiet Zone, the only one of its kind in the world, is 13,000 square miles spread out over West Virginia, Virginia and Maryland. It protects the National Radio Astronomy Observatory from manmade radio waves that can disrupt the pursuit of ultrafaint signals emitted by some of the largest, most distant objects in the universe.



The National Radio Astronomy Observatory's staff uses power-line locating tools such as this to track down sources of wayward radio waves in the mountainous area surrounding the Green Bank Telescope.

Pulsars. Quasars. Galaxies. Comets. Disks of dust possibly spinning into planets.

Radio waves can reveal the composition, structure and even motion of cosmic sources. Astronomers studying that radiation have won a half-dozen Nobel prizes, including one for detecting remnants of the Big Bang.

The federal government established the Quiet Zone in 1958, soon after the observatory set up shop in this remote setting about three hours' drive from Charlottesville, Va., home to the NRAO. The zone means that anyone seeking a license for a fixed, land-based transmitter in the zone must work with the NRAO to win approval.

With more than 25,000 licenses granted over the past two decades, the zone is not free of radio waves. Even the Green Bank observatory has cable TV (the lines are buried), personal computers,

land telephone lines and air conditioning.

The zone functions like a library — patrons (radio transmitters) must talk quietly when seated close to the librarian (the telescopes) but can speak up when wandering out of sight of the librarian.

Observing the signals from far-away galaxies while suppressing the manmade radio "noise" known as radio frequency interference, or RFI, is a growing challenge for the nearly 200 astronomers a year who come to work in the zone.

"The world is becoming more and more populated with electronic devices," said Phil Jewell, who directs the 2,700-acre Green Bank site.

Garage-door openers and walkie-talkies, which don't require licenses from the Federal Communications Commission. TV or cell-phone towers and satellites, which do. Military radar. Wi-Fi.

"In radio astronomy, [we're] looking for tiny signals from the cosmos," Jewell said. "Even just ordinary wireless communications . . . can just completely swamp what we are trying to detect from the cosmos.

"We're trying to go deeper and deeper to unlock more and more secrets of the universe and at the same time, the noise coming from radio frequency devices used in everyday life is getting higher and higher."

Learn more:

- **Radio astronomy:** www.nrao.edu/whatisra/
- **National Radio Quiet Zone:** www.gb.nrao.edu/nrqz/nrqz.html
- **Detect home interference:** www.gb.nrao.edu/epo/interf.html

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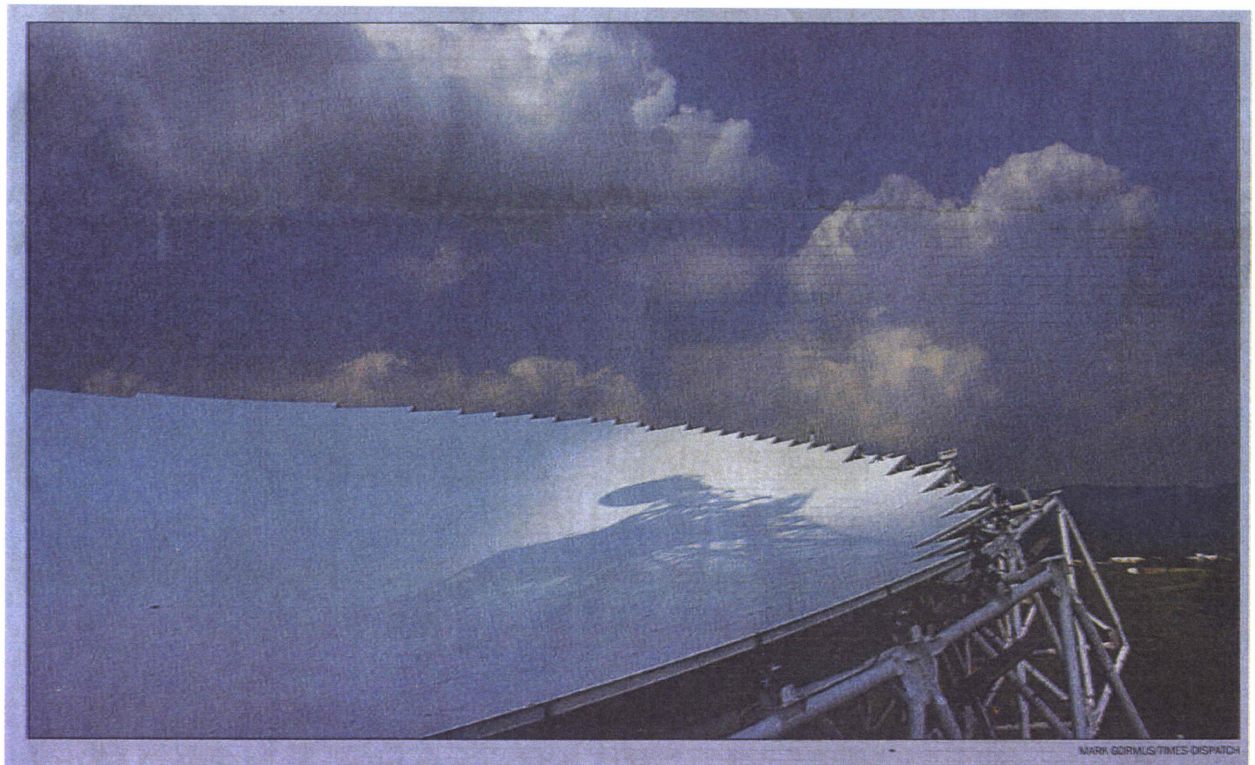
Until the 1930s, knowledge of the universe was limited to those objects that give off visible light. Visible light, how-

SEE QUIET, PAGE F2 ▶



MARK GORMUS/TIMES-DISPATCH

The Green Bank Telescope can pick up the faintest radio waves. Astronomers using the telescope say they discovered two new molecules 26,000 light-years away in a dust cloud near the center of the Milky Way. The work will help them better understand how large molecules form in space.

Quiet

— FROM PAGE F1

ever, is just one of the many types of radiation on the electromagnetic spectrum. Radio waves are the longest form of this radiation.

Then an engineer accidentally found radio waves emanating from space, providing a new way to learn about cosmic objects that can't be seen. Radio astronomers can now observe distant celestial bodies when clouds smother the Earth's atmosphere or galactic gases obscure an optical telescope's sight.

More than 95 percent of the radio sources in the sky are distant galaxies at the far reaches of the universe, which emit enormous amounts of radio energy. Radio telescopes detect that energy, pulling in a signal much like a car radio.

A basic radio telescope consists of a large concave dish with a small antenna at the center, tuned to a specific wavelength and aimed at a small portion of the sky. Radio energy from space falls upon the dish's parabolic surface.

The NRAO's Robert C. Byrd Green Bank Telescope, the world's largest movable object on land, boasts a dish 360 feet across. Other radio telescopes or telescope arrays may be bigger, but Green Bank sees more of the universe from more spots along the radio spectrum.

Still, the incoming signals are so weak that all of the radio signals from space ever detected by all the telescopes in the world could not light a single Christmas tree bulb. They must be focused to a point and amplified before being transmitted through fiber-optic cables to receivers in the control room, where a computer processes the signal and displays it on-screen for scientists.

Because they are weak, cosmic radio waves are susceptible to manmade interference, which can lead astronomers astray when they try to interpret their significance. Under international agreements, radio frequencies are divided into bands and designated for different uses. Sometimes commercial transmitters using frequencies close to radio bands cause interference by spilling over, or "bleeding," into those allocated to astronomy.

Before the advent of the electronic age, this didn't present much of a problem for scientists.

"Twenty-five years ago, radio astronomers were accessing the spectrum wilderness where nobody else was operating," said Tomas Gergely, program manager for electromagnetic-spectrum management at the National Science Foundation, which funds much of the country's radio astronomy research. "That is changing."

Passing airplanes, a worn-out gasket on cable TV lines or an elementary school's wayward thermostat can ruin expensive, time-consuming radio observations. Satellites such as GPS systems soaring overhead can especially send the telescopes into a tizzy.

"Satellite systems are probably the most difficult problem for us," Jewell said. "The National Radio Quiet Zone gives us some protection against fixed, land-based transmitters, but we don't have any particular protection against satellites, which are overhead all the time."

Sometimes, the observing astronomers can find ways to cope with the interference. Pulsating, regular signals can be "blanked," which means turning off the receiver during those intervals and not taking data, Jewell said.

That is not always possible. Filters on the telescope that catch unwanted signals can too easily erase the cosmic wave. And sometimes there's too much interference for astronomers to study.

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Protecting the zone while permitting access to radio transmissions for residents and businesses requires vigilance from Green Bank's radio-frequency interference team.

Technical specialist Wes Sizemore, who has guarded the zone against RFI for more than 20 years, says it's a battle to preserve this haven for those who would explore the radio universe.

"It's like Yellowstone. It's a wilderness area, and once it's gone, it's gone," he said.

As the FCC loosens regulations covering the electromagnetic spectrum, the observatory's research needs increasingly compete with commercial interests, Sizemore said.

Most FCC applications from within the zone are for 21st-century lifestyle needs, such as pager transmitters and cellular towers. Those are generally fine as long as they are not aimed at Green Bank, Jewell said.

"We try to be good neighbors," said Sizemore, a West Virginia native who lives about 10 miles from his work. "We don't want to stop people from having wireless access, but at the same time we need to protect our science," he said at the end of a day reviewing an application for Direcway, a satellite service that provides Internet access.

A mountaintop resident who lives within sight of the Green Bank Telescope wants the service, which Sizemore calls one of his biggest headaches because the license allows a dish to go anywhere within a specified geographic area — but the astronomers need to know exactly where it is going to be placed.

"The trouble is, in order for that dish to work, the signal will most likely cause harmful interference to the observatory," Sizemore said.

Sizemore's safeguarding includes working with the nearby Snowshoe Mountain ski resort to find a way to provide wireless Internet access to its guests. The resort is now testing "spread spectrum" technology, which spreads energy over the spectrum, protecting the telescopes, while allowing for more powerful transmissions, Sizemore said.

Gergely said the FCC and the National Telecommunications and Information Administration, which oversees the government's use of the spectrum, are also looking for ways for commercial and astronomy interests to co-exist. New computer programs developed by the agencies could someday be routinely used to alert commercial interests when their proposed transmitters would conflict with observatories' research.

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Observatories, packed with electronic equipment, are themselves sources of interference. If the devices are not shielded by Faraday cages of metal or metallic meshwork, that radiation can be picked up, potentially zapping an amp on the telescope and ruining expensive, time-consuming observations.

Without shielding, "we would be our own worst enemy," Jewell said.

So to avoid spark-plug emissions while ferrying people around the site, the Green Bank staff drive old diesel Checker cabs and trucks, painted sky-blue, or pedal one of the observatory's single-speed bikes.

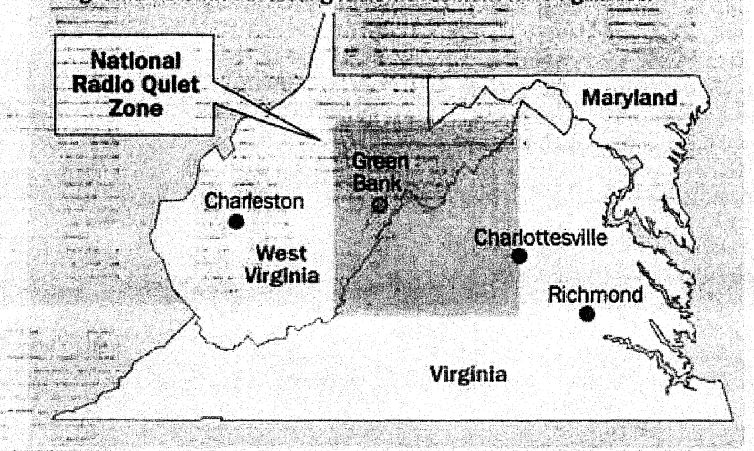
All equipment aboard Green Banks' telescopes is checked for signal leakage. Almost 2 miles away, the observatory's public educational exhibits are shielded, as is the cafeteria's microwave oven.

The aim is to ensure that whatever radio waves that are generated in the observatory's control room stay in the control room, says staff astronomer Frank Ghigo.

For example, the walls, floor and ceiling of the control room are lined with copper sheets to ensure that stray radiation does not escape and interfere with Ghigo's study of neutral hydrogen emitted from the Coma Berenices cluster, a faint constellation chock-full of galaxies. Neutral hydrogen's characteristic 21-centimeter-long waves are an important "tracer" for star formation.

The zone

The 13,000-square-mile National Radio Quiet Zone protects research on the ultrafaint radio waves emitted by the most-distant objects in the universe. The government established the zone in 1958 for the National Radio Astronomy Observatory's Green Bank telescope facility. Within the zone, the observatory works to minimize stray man-made signals that might interfere with detecting radio waves from far-off galaxies.



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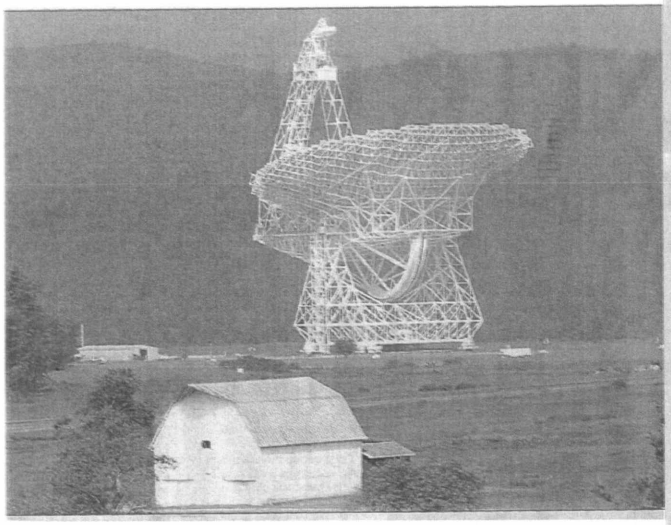


If another source interfered with the signal, the computer-generated graph would show "spikes jumping up there or the whole thing jumps," Ghigo said.

In that case, Ghigo and other astronomers call on the observatory's RFI team to hunt down the errant sources.

The suppression area most critical to Green Bank's telescopes is right at its doorstep, a 4-mile stretch in the valley along state Route 92. That is where Green Bank's RFI manager, Jeff Acree, headed late one night last fall after several frantic calls from astronomer David Nice of Princeton University.

Nice studies millisecond pulsars, those rapidly spinning collapsed-star remnants. Because of their spin, their radio signals come in like a lighthouse beacon 15 times a second.

But that Friday night, a man-made source burst in every second, "blowing away this tiny astronomical signal," he said. "It was just impossible."

Acree

It took Acree three days to spot the errant electric fence causing the trouble. On the third night, as he drove around the zone, he tuned his Ford Bronco's AM radio. As he fiddled with the dial in the midnight darkness, he heard the pulsating "tssss, tssss, tssss" that so annoyed Nice.

The malfunctioning fence was timed to run from dusk to dawn to keep deer out of the homeowner's garden. Fence fixed, case closed.

❖ ❖ ❖

That same stretch of Route 92, Jewell fears, will bring new threats to Green Bank. More residents will insist on wireless Internet communication. More cars passing by the observatory are equipped with automotive radar systems that warn drivers of tailgating.

"They have us worried," he said.

Not far from the highway, in the observatory's main parking lot, Acree pulls from his diesel Bronco pieces of his hand-held RFI tool kit, including a home-made RFI sniffer that hunts leakage from the cable TV system. Acree and his team often find energy coming from the cable distribution packs that hang on power lines. The packs leak when their gaskets erode.

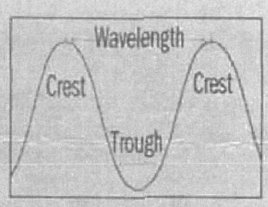
The RFI team takes the tool kit hunting about once a week to check for problems or track down spontaneous sources of RFI in the community. After three years at Green Bank, Acree has met many of the valley residents as well as the maintenance workers for the power and cable companies.

"It's fun to go back with the power company or cable company and actually fix" the problem, Acree said. "I kind of feel like a kid out there," he added before taking off with Sizemore to handle a recurring RFI issue nearby.

Moments later, as the car heads back on Route 92, the observatory disappears from the rear-view mirror. The radio scanner slowly settles onto 103.5 FM, a community-run station out of Durbin.

Arising from the static, Roy Rogers calls out a farewell to the Quiet Zone: "Happy trails to you."

• Contact A.J. Hostetler at (804) 649-6355 or ahostetler@timesdispatch.com



Ride the wave

Light consists of electromagnetic waves, which differ from one another in wavelength, the distance between one wave crest to the next.

From longest wavelength to shortest, the electromagnetic spectrum includes: radio waves, microwaves, infrared, optical, ultraviolet, X-rays and gamma rays.

Radio waves can be as long as several miles and as short as a dime is thick. Astronomers study these waves to learn about objects millions and even billions of light-years away.

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New Molecules Discovered in Milky Way

Associated Press

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CHARLESTON, W.Va. - Astronomers have discovered two new molecules in an interstellar cloud of gas and dust near the center of the Milky Way Galaxy.

The discovery, announced Monday by the National Radio Astronomy Observatory's headquarters in Charlottesville, Va., marks the Green Bank Telescope's first detection of new molecules.

The discovery is helping astronomers better understand the complex processes by which large molecules form in space, according to the NRAO.

The eight-atom molecule propenal and the 10-atom molecule propanal were detected 26,000 light years from Earth in an area known as Sagittarius B2. Interstellar clouds such as the one in which the molecules were detected are often many light-years across, and contain the raw material from which new stars are formed.

"These interstellar clouds are the sites of complex chemical reactions that occur over hundreds of thousands or millions of years," said Jan M. Hollis of NASA (news - web sites)'s Goddard Space Flight Center in Greenbelt, Md., and a member of the team that discovered the molecules.

"Over time, more and more complex molecules can be formed in these clouds," Hollis said. "At present, however, there is no accepted theory addressing how interstellar molecules containing more than five atoms are formed."

About 130 different molecules, most of them containing a small

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number of atoms, have been discovered in interstellar clouds.

The molecules found by using the Green Bank Telescope were among a few newly discovered molecules consisting of eight or more atoms. Each new discovery of a molecule helps to define the formation chemistry and nature of interstellar dust grains, believed to be the formation sites for most complex interstellar molecules.

Collaborating with Hollis in the discovery were Anthony Remijan, also of NASA Goddard; Frank J. Lovas of the National Institute of Standards and Technology in Gaithersburg, Md.; Harald Mollendal of the University of Oslo in Norway, and Philip Jewell, site director at the National Radio Astronomy Observatory at Green Bank.

Their results have been accepted for publication in the Astrophysical Journal of Letters.

Molecules consisting of carbon, hydrogen and oxygen atoms, such as those discovered through the Green Bank observations, are of particular interest to scientists, since they could contain the building blocks for life to begin on a new planet.

Complex molecules in space like those detected with the Green Bank Telescope could have been brought to our solar system by comets and could have played a role in the formation of biologically significant molecules on Earth.

"The Green Bank Telescope can be used to fully explore the possibility that a significant amount of pre-biotic chemistry may occur in space long before it occurs on a newly formed planet," Remijan said.

"Comets form from interstellar clouds and incessantly bombard a newly formed planet early in its history. Craters on our Moon attest to this. Thus, comets may be the delivery vehicles for organic molecules necessary for life to begin on a new planet."

The large diameter and high precision of the Green Bank Telescope, the world's largest fully steerable radio telescope, "allowed us to study small interstellar clouds that can absorb the radiation from a bright background source," Jewell said. "The sensitivity and flexibility of the telescope gave us an important new tool for the study of complex interstellar molecules."

The National Radio Astronomy Observatory is a facility of the National Science Foundation (news - web sites), operated under cooperative agreement by Associated Universities, Inc.

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June 23, 2004

Green Bank telescope finds new molecules in Milky Way

Two new molecules have been discovered in an interstellar cloud of gas and dust near the center of the Milky Way Galaxy by a team of scientists using the new Robert C. Byrd Green Bank Telescope.

The discovery, announced by the National Radio Astronomy Observatory's headquarters in Charlottesville, Va., marks the Green Bank Telescope's first detection of new molecules. The discovery is already helping astronomers better understand the complex processes by which large molecules form in space, according to the NRAO.

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So far, about 130 different molecules, most of them containing a small number of atoms, have been discovered in interstellar clouds. The molecules found through the search using the Green Bank Telescope were among a relative few newly discovered molecules consisting of 8 or more atoms.

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Complex molecules in space such as those detected with the Green Bank Telescope

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could have been transported to our solar system by comets, and played a role in the formation of biologically significant molecules on the early Earth.

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/ Virginia News

Norfolk, Virginia
Wednesday June 23, 2004 9:17 a.m. Eastern Standard Time

Astronomers find new molecules in Milky Way

06/23/2004

Associated Press

Astronomers using the Robert C. Byrd Green Bank Telescope have discovered two new molecules in an interstellar cloud of gas and dust near the center of the Milky Way.

The discovery, announced Monday by the National Radio Astronomy Observatory's headquarters in Charlottesville, Va., marks the Green Bank Telescope's first detection of new molecules. It is helping astronomers better understand the complex processes by which large molecules form in space, according to scientists.

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The molecules found by using the Green Bank

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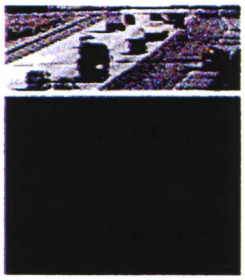

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Table of Contents

News
Local News Home
City-by-City
13News Investigates
Medical Report
Military News
13News Daybreak
Virginia News
N.C. News
Nation/World
Politics
Iraq
Business
Entertainment
Photo Galleries
Discussion Boards

Weather
Weather Home
Forecast
7-Day Forecast
Radar & Satellite
Imagery
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Hurricane Center
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Closings & Delays

Traffic
Traffic Cameras & Incidents
Traffic News

Sports
Sports Home
Sports Columns

Business
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Local Business

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June 23, 2004

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Complex molecules in space such as those detected with the Green Bank Telescope

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- Preston woman notifies DNR, surrenders illegal African snails
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- Deputies unable to locate armed, masked suspects in Putnam
- Dunbar considers pay bonus
- Third lawsuit filed against ex-Madison cop
- Demolition planned soon for East End Burger King

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could have been transported to our solar system by comets, and played a role in the formation of biologically significant molecules on the early Earth.

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Albuquerque Journal North

June 22, 2004

Short Circuits in Space May Solve Secrets on Earth

By Adam Rankin
Journal Staff Writer

Scientists at Los Alamos, studying strands of tangled electromagnetic spaghetti light years across, believe they have discovered a source for the pervasive cosmic rays streaming through the universe.

Unlocking this galactic secret could one day help scientists harness the power of nuclear fusion.

A massive collision of stars on the cusp of black holes likely drives electromagnetic jets across millions of light years of space, ending in powerful magnetic short circuits, according a quartet of Los Alamos scientists.

That theorized short circuit, called "magnetic reconnection" could explain cosmic ray formation. In an April paper published in the science journal Astrophysical Journal Letters, the scientists, headed by Philipp Kronberg, propose that magnetic reconnection may explain how electrons, and possibly other particles, are accelerated to velocities near the speed of light and propagate as cosmic rays through the universe.

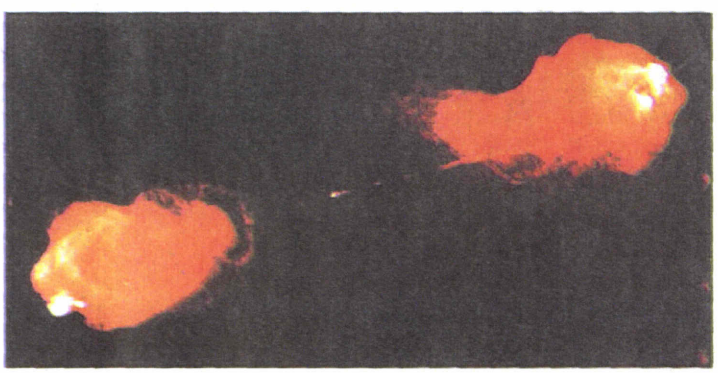
"If we can understand magnetic reconnection in an astrophysical context, it is an area that has potentially wide-ranging implications for the technology of the next couple centuries," Kronberg said.

"This is one of the biggest puzzles of modern astrophysics — how it all happens," he said. "We think we've clarified an important general direction for this whole process."

LANL scientists Stirling Colgate, Hui Li, and Quentin W. Dufton were co-authors of the paper.

Magnetic reconnection is one

See **'RECONNECTION'** *on* **PAGE 2**



COURTESY NATIONAL RADIO ASTRONOMY OBSERVATORY

Los Alamos National Laboratory scientists studying Giant Radio Galaxies similar to this one suspect that magnetic short circuits in the bright lobes at either end are one likely source of cosmic rays.

'Reconnection' Excites Scientists

from **PAGE 1**

impediment to developing and containing sustained nuclear fusion, a possible future energy source, he said. By understanding better how reconnection occurs in space, scientists in the laboratory might be able to better control reconnection in fusion reactors, he said.

At the heart of their theory is the notion that magnetic field lines, in combination with a dense lobe of charged gases sucked from the lip of a black hole, occasionally short circuit, destroying themselves.

In the process, the electromagnetic energy is converted into highly charged particle energy, or cosmic rays, which are eventually emitted into intergalactic space.

All this activity takes place hundreds of millions of light years from our Milky Way galaxy in what scientists call Giant Radio Galaxies for the characteristic radio waves they emit.

Kronberg said their study used data from a detailed analysis of the 100 largest radio galaxies known, but focused only on the seven largest. Much of the data was acquired using the National Radio Astronomy Observatory's Very Large Array, near Socorro.

Previous explanations for the creation and acceleration of the cosmic rays from radio galaxies failed to account for the incredibly efficient conversion of electromagnetic energy taken from around the rim of black holes and emitted at the tips of giant electromagnetic jets, Kronberg said.

The jets are created — according to a theory proposed by Stirling Colgate — when dense stars crash into a rotating disk of hot gases circling the rim of a black hole at the radio galaxy's core.

The stars are estimated to be traveling at about 20,000 kilometers a second when they puncture the disk, Kronberg said. The collision causes a great disturbance in the magnetic fields within the disk of hot gases, creating large loops of magnetic field lines.

Kronberg said the loops merge to create a giant helix, which becomes the base of an electromagnetic jet, which usually form in symmetric pairs.

The jets suck electromagnetic energy from the disk of hot gases before the gas is pulled into the black hole's core, he said. The energy gathers in lobes at the end of the jets, where it bumps against intergalactic space.

The whole process takes millions of years and the jets can span millions of light years.

"It takes something like 50 to 100 million years for the jet to get all the energy out to one extreme," Kronberg said.

The largest jets the scientists observed covered distances up to 10 million light years, or about 10 times the distance from the Milky Way galaxy to the Andromeda galaxy, our nearest neighbor.

At the end of the jets, where the magnetic field lines and particle energy accumulate in a cluster or lobe, the conditions are just right, Kronberg said, for magnetic reconnection to occur.

"The magnetic fields are sort of like a tangle of spaghetti," said Cornell University physicist Richard Lovelace.

He said a lot of evidence supports the LANL research team's theory that magnetic reconnection can explain the efficient conversion of electromagnetic energy into cosmic rays.

"It is growing acceptance ... and receiving growing attention," he said. "Reconnection has really been a super challenge."

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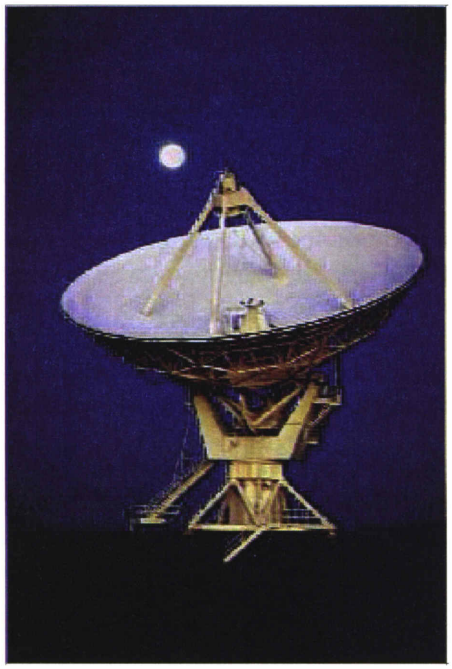
21 June 2004

Massive "Blazar" Black Hole Sheds Light On Big Bang



In an article appearing on the *Astrophysical Journal Letters* website, astrophysicists at Stanford report spotting a black hole that's more than 10 billion times the mass of our sun. Its so far away that the researchers think it formed when the first stars and galaxies began to light up and it may provide a window into our cosmological origins.

"In cosmology, it turns out that 'a galaxy a long time ago' and 'far, far away' really do go together," says Associate Professor Roger Romani, who with David Sowards-Emmerd, Professor Peter Michelson and Lincoln Greenhill, spotted the supermassive black hole, known as a 'Blazar'. "In this case, we're looking far enough away that it's within a billion years of the origin of it all, the Big Bang."

The supermassive black hole sits in the center of a galaxy. A disk of stars and gas swirl around the black hole and eventually get sucked in. "That generates enormous amounts of power, enormous amounts of energy," Romani says. "It's far more efficient even than nuclear fusion. These gravity-powered sources are the most powerful sources in the universe."

As black holes go, this one is a messy eater. Gobbling up its galaxy so quickly that not everything is making it down its throat past the point of no return - the event horizon - where not even light can escape gravity's strongest pull. The matter

that doesn't make it past the event horizon is spewing back up in the form of accelerated high-energy particles. If a black hole amid a galaxy shoots out high-energy particles in narrow jets that just happen to be aimed at Earth, astrophysicists name it a 'Blazar'. Distant blazars seem to dominate the gamma-ray sky and can obscure other objects of interest. Pulsars, spinning neutron stars nearby in our own galaxy, can also emit gamma rays, but far fewer of them are known. Romani, whose main interest is pulsars, wanted to identify and discard blazars so he could concentrate on the neutron stars.

"I got started working on the blazars as a way of culling the wheat from the chaff," Romani says. "But then the chaff proved just as interesting."

The co-authors have surveyed 200 blazars and they eventually hope to survey 2,000. The survey is in preparation for a mission planned for 2007. Led by Michelson, the researchers will use the Gamma Ray Large Area Space Telescope (GLAST) to study high-energy sources of radiation in the universe, such as supermassive black holes, merging neutron stars and hot streams of gas moving at nearly the speed of light.

"Something really new is waiting to be found in the gamma-ray sky," Romani says. "If we could identify all the blazars, tag the pulsars - the things that are left over, that's where the really new discoveries will be."

Greenhill led the effort to obtain radio images of the blazar jet using the Very Long Baseline Array (VLBA). Funded by the National Science Foundation and operated by the National Radio Astronomy Observatory, the VLBA is essentially a radio camera. It consists of 10 dish antennas - 25 meters wide and distributed from Hawaii across the United States to St. Croix - slaved together with computers to create a composite image with a resolution Greenhill calls "comparable to what they would get with a single antenna about as large as a continent."

"It's amazing to find something so interesting and unique in a relatively small survey," says Sowards-Emmerd. "We immediately realized that a high-redshift blazar and gamma-ray source would allow us to test our understanding of relativistic radio jets and their interaction with the cosmic microwave background leftover from the Big Bang," Greenhill says.

"It's a searchlight that's set so far away that it illuminates matter and radiation all the way between us, between time one billion years after the Big Bang and now," Romani says. "If you can detect it with a gamma-ray telescope, you have a handle on the birth of stars and galaxies between then and now that you never had before."

Scientists are curious about how a black hole could have gotten so big so fast. How do you take something big enough to hold 1,000 solar systems and as heavy as all of the stars in our Milky Way galaxy put together, and quickly crunch-collapse it? Scientists think the universe formed 13.7 billion years ago with the Big Bang. The distance of the blazar indicates it formed a billion years after that.

"What's interesting about a billion years after the Big Bang is that this marks the end of the 'Dark Age'," Romani says. "The universe first formed with an enormous flash of light and heat - that's the Big Bang - and then cooled off. And everything's dark for about a billion years. And toward the end of that period, the first stars and black holes and galaxies start collapsing and forming and turning on. We talk about that as the end of the Dark Age. So it's very interesting, and this is one of the big pushes in cosmology, to find objects back in the tail end of the Dark Age, when things are first lighting up, and then to use those to figure out how everything we have in the universe formed."

In the next year, the scientists hope to use the VLBA to take a better picture of the jet detected with radio waves and then observe its X-ray spectrum. This will help illuminate the matter between the supermassive black hole and Earth, clarify the black hole's size and characterize the jet's material as it moves away from the black hole at nearly the speed of light.

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New Mexico Business Weekly - June 21, 2004
http://albuquerque.bizjournals.com/albuquerque/stories/2004/06/21/focus2.html

NEW MEXICO BUSINESS WEEKLY

IN DEPTH: TECHNOLOGY

From the June 18, 2004 print edition

Since 'Contact,' VLA is a very large attraction

Ben Madden
NMBW Staff

For travel marketers who spend millions annually to entice tourists, the Very Large Array's (VLA) predicament must seem irksome. Without spending a dime, the western New Mexico radio astronomy observatory hardly knows what to do with the estimated 50,000 visitors who now show up on its doorstep each year.

And what public relations exec wouldn't envy Dave Finley, who issued a mundane press release announcing VLA tours, and found it statewide, front-page news the next day. "Because of the papers and the TV coverage, we had 1,500 people show up," he says.

It wasn't quite like the scene in the movie "Contact," where the whole world descends on the photogenic observatory with its huge radio dishes, but at the time, it nearly felt that way. "It was amazing to see all of those cars coming in -- not quite that crazy, but it was a lot of people," he says. "Very quickly, we realized that the four or five [guides] we had weren't going to be enough."

Finley ultimately needed 25 docents to handle the visitors for that 2002 tour, which the VLA now repeats on a quarterly basis.

If Finley had to blame someone for the challenges and perils that come with success, it would probably be Jodie Foster, star of the 1997 Warner Bros. film. Significant scenes were shot on location at the VLA, including several involving Foster. The actess, however, is only one of millions of stars who keep the VLA's visitors coming. Most come via astronomical word of mouth.

"All of these amateur astronomers knew of the VLA, so there was always public interest from the time construction started in 1974," says Finley.

The VLA became operational in 1980, and the current, state funded visitors' center opened in 1983. Visitors have since remarked of the center, "'Great use of my tax money' -- and they're not kidding," Finley adds.

Finley, public information officer for the National Radio Astronomy Observatory (NRAO), the VLA's funding agency, has conducted school tours himself since 1992, and has recently hired an educational officer to keep up with the demand for tour requests.

Students working on summer research projects at the VLA are now offering limited tours as well.

One reason guides are necessary at the VLA is that, in truth, there currently isn't a whole lot to see, aside from the radio dishes. The 27 photogenic receivers, each weighing 230 tons and measuring about 80 feet by 80 feet can be scattered, via a heavy-duty railcar system, across hundreds of square miles, nearly all of which is off-limits to the public. Most of the scientists assigned to the VLA actually work in Socorro.

In addition, the self-guided walking tour is sparse at best -- Finley refers to it as a "marked and signed walking path" -- and the visitor center is little more than a wall of photos, a slide show and a modest gift shop. The Antenna Assembly Building, a 10-story repair hangar big enough to hold one dish, can be viewed as well, but only from a distance.

"We will have more interaction as we progress toward bigger plans," Finley says, as both the NRAO and the Department of Tourism are working to see positive change.

"We think it could be much bigger," Finley says. "We are looking into preliminary ideas and business plans for a new center that would be much larger, with more and better displays."

The expanded center could have a staff of docents offering guided tours daily, along with increased educational programs. "We would like to see every kid in New Mexico visit the VLA before they graduate from high school," Finley says.

In the meantime, visits to the quarterly tour have picked up again since Finley scheduled the April and October dates to coincide with the two days per year that Los Alamos National Laboratory (LANL's) Trinity Site tour is held, about 80 miles east, on the White Sands Missile Range. "That seems to have worked," Finley says. "Visitors from St. Louis said they made the trip because they could see Trinity and the VLA in the same weekend."

Though he's sure the observatory has added a significant economic boost to the state's tourism industry, he says he lacks data to quantify the amount.

"I don't think anyone has done a study," Finley says. "Until we get a good handle on numbers, it's hard to calculate the impact." The relationship with the state's tourism department is a two-way street, with the state providing advice, and the VLA providing a very unique tourist attraction.

Noting the Department of Tourism's familiarization, or fam tours -- which bring travel editors and other editors to the VLA, Finley says, "We also realize we're valuable to the state as a whole. We're world famous."

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El Defensor Chieftain

June 16, 2004

Radio telescopes reveal youngest stellar corpse

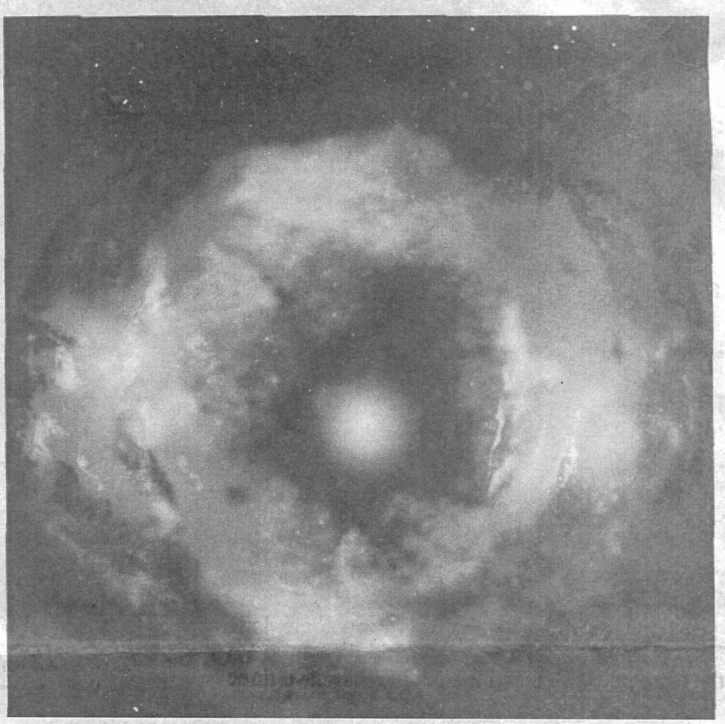
By Dave Finley
National Radio Astronomy Observatory

Astronomers using a global combination of radio telescopes to study a stellar explosion some 30 million light-years from Earth have likely discovered either the youngest black hole or the youngest neutron star known in the Universe.

Their discovery also marks the first time that a black hole or neutron star has been found associated with a supernova that has been seen to explode since the invention of the telescope nearly 400 years ago.

A supernova is the explosion of a massive star after it exhausts its supply of nuclear fuel and collapses violently, rebounding in a cataclysmic blast that spews most of its material into interstellar space. What remains is either a neutron star, with its material compressed to the density of an atomic nucleus, or a black hole, with its matter compressed so tightly that its gravitational pull is so strong that not even light can escape it.

A team of scientists studied a supernova called SN 1986J in a galaxy known as NGC 891. The supernova was discovered in 1986, but astronomers believe the explosion actually occurred about three years before. Using the National Science Foundation's Very Long Baseline Array, Robert C. Byrd Green Bank Telescope, and Very Large Array, along with radio telescopes from the European VLBI Network, they made images that showed fine details of how the explosion evolves over time.



Artist: G. Arguner
Courtesy of Norbert Bartel and Michael F. Bietenholz/York University

This is an artist's impression of Supernova 1986J. The newly discovered nebula around the black hole or neutron star is in the center of the expanding, fragmented shell of material thrown off in the supernova explosion.

"SN 1986J has shown a brightly emitting object at its center that only became visible recently. This is the first time such a thing has been seen in any supernova," said Michael Bietenholz, of York University in Toronto, Ontario. Bietenholz worked with Norbert Bartel, also of York University, and Michael Rupen of the National Radio Astronomy Observatory in Socorro on the project. The scientists reported their findings in the June 10 edition of "Science Express."

"A supernova is likely the most energetic single event in the Universe after the big bang. It is just fascinating to see how the

smoke from the explosion is blown away and how now after all these years the fiery center is unveiled. It is a textbook story, now witnessed for the first time," Bartel said.

Analysis of the bright central object shows that its characteristics are different from the outer shell of explosion debris in the supernova.

"We can't yet tell if this bright object at the center is caused by material being sucked into a black hole or if it results from the action of a young pulsar, or neutron star," said Rupen.

"It's very exciting because it's either the youngest black hole or the youngest neutron star anybody has ever seen," Rupen said. The youngest pulsar found to date is 822 years old. Finding the young object is only the beginning of the scientific excitement, the astronomers say.

"We'll be watching it over the coming years. First, we hope to find out whether it's a black hole or a neutron star. Next, whichever it is, it's going to give us a whole new view of how these things start and develop over time," Rupen said.

For example, Rupen explained, if the object is a young pulsar, learning the rate at which it is spinning and the strength of its magnetic field would be extremely important for understanding the physics of pulsars.

The scientists point out that it will be important to observe SN 1986J at many wavelengths, not just radio, but also in visible light, infrared and others.

In addition, the astronomers also now want to look for similar objects elsewhere in the Universe.

The National Radio Astronomy Observatory is a facility of the National Science Foundation, operated under cooperative agreement by Associated Universities Inc.

Albuquerque Journal

June 11, 2004

Celestial Dot a Unique Find

■ *N.M. telescope helps in discovery of what exploding star left behind*

By John Fleck
Journal Staff Writer

Michael Rupen's cosmic blast started back in 1986 with a bit of luck. The results have led 18 years later to the discovery of something astronomers have never seen before — the fiery ember left behind by an exploding star.

That ember may be a strange beast known as a neutron star, Rupen and his colleagues report today in the online edition of Science magazine. Or it may be a black hole.

Rupen, a Princeton graduate student at the time, was using New Mex-

See **CELESTIAL** *on* **PAGE A2**

COURTESY NORBERT BARTEL AND MICHAEL BIETENHOLZ, YORK UNIVERSITY

Astronomical artist G. Arguner's vision of the burning ember left behind by a supernova.

from **PAGE A1**

ico's Very Large Array telescope back in 1986 to study a galaxy known as "NGC891."

Located in the constellation Andromeda, NGC891 is an astronomical classic. Backyard sky-watchers prize it for its beauty and professional astronomers have closely studied it for years.

"It's a famous galaxy," said Rupen, now a staff astronomer at the National Radio Astronomy Observatory in Socorro. "People look at it all the time."

At the time, Rupen was studying the distribution of the galaxy's mass. Exploding stars were the furthest thing from the Ph.D. student's mind.

But there was something strange in his VLA images. NGC891 had changed.

"There was this big dot in the galaxy where a big dot wasn't supposed to be," Rupen said in an interview this week.

A search of old telescope images confirmed the discovery. Rupen's "big dot" was new. Something dramatic had happened in galaxy NGC891 — the explosion of a star, what astronomers call a "supernova."

That discovery created an opportunity for Rupen and a group of colleagues to trace the evolution of a supernova, one of the universe's most spectacular events.

The supernova was bright and nearby — 30 million light-years away, just an astronomical stone's throw for astronomers armed with today's high-powered telescopes.

"I lucked out," Rupen explained.

Training their telescopes on it repeatedly over the years, they saw an expanding shell of matter thrown off by the blast. Astronomers have seen such a shell before, but when they pointed a cluster of radio telescopes at NGC891 in November 2002 and again last June, they saw something new.

At the center of the expanding shell of gas was another tiny new dot. Something small but bright had formed at the very center of the void left by the expanding blast.

They do not yet know what it is. But there are only two possibilities — a neutron star or a black hole.

A supernova happens when a star runs out of fuel.

Nuclear fusion constantly burns in the heart of a normal star, like our sun. The outward pressure from the fusion fire offsets the inward pressure of gravity from the star's mass, creating a delicate stability.

But when the fusion fuel runs out, the star collapses in an instant, then explodes outward with a dramatic bang. A supernova can be brighter than billions of stars.

From the point of view of Rupen's observations, the interesting part is what happens next. While much of the star's matter is blown outward in an expanding shell, what remains collapses again on itself, but more gently this time.

If the remaining mass is small, it becomes a neutron star. These strange objects have a mass greater than our sun packed into a sphere five to 10 miles in diameter.

If it is larger, it will become a black hole, an object so massive and dense that light itself cannot escape the pull of its gravity.

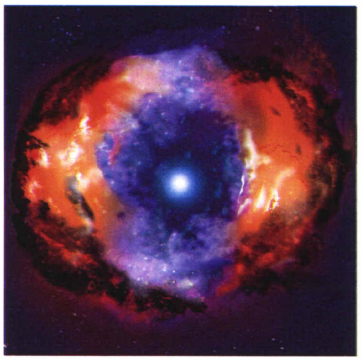
Rupen and his colleagues — Michael Bietenholz and Norbert Bartel of York University in Toronto — have seen the light created by this central object as it sucks in dust and gas from space around it. That dust and gas heats up and emits radiation as it spirals in toward the object, though at this point there is no way to distinguish whether it is neutron star or black hole.

Black holes and neutron stars have been spotted before, but no one has ever seen one at the heart of a newly formed supernova.

This sort of thrill — seeing things that are fundamentally new to humanity — plays a big role in driving the science, according to Rupen.

"That's why we do astronomy," he said.

SPACE.COM June 10, 2004



Youngest Possible Black Hole Spotted Near Birth

By Robert Roy Britt
Senior Science Writer
posted: 02:15 pm ET
10 June 2004

Startled astronomers peered through an apparent crack in the expanding bubble from an exploded star to glimpse what may be the youngest black hole ever detected.

It is the closest researchers have come to witnessing the birth of a black hole, from the explosion two decades ago to the recent emergence of a dense object amid the chaotic scene. The object may be a neutron star instead of a black hole, however. Scientists hope to figure that out with continuing observations, they said Thursday.

Other teams have recorded many stellar explosions, called supernovas. And they've discovered many black hole candidates presumed to be the result of previous supernovas. But no one has confirmed the connection so strongly.

"This is the first time we've seen it happen," said Michael Bietenholz of York University in Toronto, Ontario. "We've never seen a supernova leave behind a black hole, and the only supernovae we've seen that left behind neutron stars are several centuries or more old, and we only know them from historical records."

Bietenholz and his colleagues described the series of events as a textbook example of how things were theorized to go.

"No matter whether the central source is a black hole or neutron star, it would be by far the youngest of either ever observed," he told SPACE.com.

In fact this explosion occurred a long time ago, too. The star, SN 1986J, is about 30 million light-years away, so observations of the scene over the past 20 years represent light that took 30 million years to arrive. That in mind, here's what happened, in terms of the observations:

Around 1983, the core of the star ran out of fuel and was no longer able to support itself against its own gravity. It began to collapse.

"This collapse is extremely fast, and the core collapses into a neutron star in about one second," Bietenholz explained. "It stops, at least momentarily at this point."

The outer layers of the star were then thrown outward with a bounce, generating a classic supernova explosion that was first spotted in 1986. Exactly what happened next is not known.

"If the core winds up with less than about 1.4 times the mass of our Sun, it will remain stable as a neutron star," Bietenholz said. "If the core mass is larger, it will continue to collapse into a black hole, with this further collapse occurring in a fraction of a second."

The star's original mass is not known, so there's a roughly equal chance that the remaining central object is a neutron star or a black hole. Either dense object would generate intense magnetic fields, creating charged particles that would have allowed the researchers to detect it.

The outer layers of the star initially raced into space at more than 44 million mph (20,000 kilometers per second). The expansion continues but has slowed since.

The layers of material remain "pretty dense and we didn't yet expect to see through them right into the center to see the neutron star or black hole nebula," Bietenholz said. "The fact that we can suggests that, as they expand, they are also fragmenting, so we are seeing in through a crack that has developed in the shell."

The discovery required several radio telescopes: the National Science Foundation's Very Long Baseline Array, Robert C. Byrd Green Bank Telescope and Very Large Array; and telescopes from the European Very Long Baseline Interferometry Network.

More observations are planned.

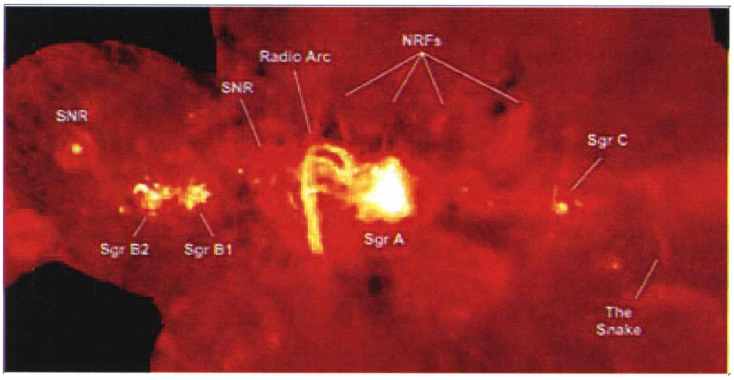
"We'll be watching it over the coming years," said Michael Rupen of the National Radio Astronomy Observatory in Socorro, New Mexico. "First, we hope to find out whether it's a black hole or a neutron star. Next, whichever it is, it's going to give us a whole new view of how these things start and develop over time."

The discovery is detailed in Thursday's online version of the journal Science.

Origin of enigmatic galactic-center filaments revealed

NORTHWESTERN UNIVERSITY NEWS RELEASE
Posted: June 7, 2004

Twenty years ago, astronomers discovered a number of enigmatic radio-emitting filaments concentrated near the center of the Milky Way Galaxy. These features initially defied explanation, but a new study of radio images of the Galactic center may point to their possible source.



Combined radio image from the Very Large Array and Green Bank Telescope. The linear filaments near the top are some of the nonthermal radio filaments (NRFs) studied by the researchers. Other features, such as supernova remnants (SNRs) and the area surrounding our Galaxy's supermassive black hole (Sgr A) are shown. Credit: NRAO/AUI/NSF Yusef-Zadeh, et.al

By combining data from the National Science Foundation's Very Large Array (VLA) and Robert C. Byrd Green Bank Telescope (GBT), astronomer Farhad Yusef-Zadeh of Northwestern University has found evidence that at least some of the filaments spring from the concentrated star-formation regions that populate the Galactic center.

Yusef-Zadeh presented his findings at the Denver, Colo., meeting of the American Astronomical Society. William Cotton of the National Radio Astronomy Observatory (NRAO) in Charlottesville, Va., and William Hewitt of Northwestern University also contributed to this research.

"Astronomers have long puzzled over the cause of these striking features," said Yusef-Zadeh, professor of physics and astronomy, "and the turbulent nature of the Galactic center has made detailed analysis difficult. With new multi-wavelength radio images of the Galactic center, however, we can finally see a link between areas of starburst activity and these long-linear filaments."

The filaments, which range from 10 to 100 light-years in length and are perhaps little more than 1 to 3 light-years across, occur only in a very narrow area, within approximately two degrees of the Galactic center (which translates to approximately 900 light-years across.)

Hubble

NASA Administrator Sean O'Keefe announces plans to examine a robotic servicing mission to the Hubble Space Telescope. (33min 51sec file)

- Play video

Station supply ship

Ride along with the Progress 14P resupply ship as it makes the final approach and docking to the International Space Station on May 27 as seen by a camera mounted on the craft's nose. (9min 02sec file)

- Play video

Results from Spitzer

Scientists present new discoveries from the Spitzer Space Telescope, including their findings of raw ingredients for life detected around young stars. (53min 03sec file)

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Spacewalk previewed

The Expedition 9 crew describes their upcoming spacewalk in Russian spacesuits, life aboard the space station and the view of Earth in this interview with Bill Harwood of CBS News. (20min 19sec file)

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Progress undocking

The Progress 13P cargo ship departs the International Space Station on May 24 carrying trash and unneeded items to burn up in the atmosphere. (2min 56sec file)

- Play video

AP interviews the crew

The Associated Press

Early theories about the origin of these filaments suggested that they were somehow related to the Milky Way's own magnetic field. This was due to the fact that the first filaments detected were oriented perpendicular to the plane of the Galaxy, which would have aligned them with the Galaxy's own magnetic field.

"The problem with this hypothesis is that more recent images have revealed a population of weaker filaments oriented randomly in relation to the plane of the Galaxy," said Yusef-Zadeh. "This makes it difficult to explain the origin of the filaments by an organized Galactic magnetic field."

In March and June of 2004, a team of astronomers using the GBT made images of the Galactic center at various wavelengths. The purpose of these surveys was to help identify radio features produced by hot gas (thermal emission) and those produced in magnetic fields (non-thermal emission). In general, thermal features radiate more strongly at shorter wavelengths and non-thermal at longer wavelengths.

By comparing the GBT images with earlier VLA data taken of the same region, Yusef-Zadeh determined that a number of the non-thermal filaments seemed to connect to concentrated areas of thermal emission, which identify pockets of star formation.

"What this showed us is that two seemingly disparate processes, thermal and non-thermal radio emission, can be created by the very same phenomenon," said Yusef-Zadeh. "In this case, that phenomenon is pockets of starburst activity."

Yusef-Zadeh notes that the exact mechanism for how the areas of starburst generate the magnetic fields is still being investigated. "There are many ideas about the mechanism that generates these filaments," added Yusef-Zadeh, "but one possibility is that they are produced by the collision of winds blown off from individual stars."

The star-forming regions associated with the filaments may contain about 100 massive stars each.

The center of the Milky Way Galaxy is shrouded from optical telescopes by dense clouds of dust and gas. Radio telescopes, however, are able to pierce through the optical veil and see the features within. Concealed at the very heart of our Galaxy is a supermassive black hole. Known as Sagittarius A* (pronounced A-star), this area is a very powerful source of radio waves and was first detected by Karl Jansky in 1932.

While the VLA can image fine-scale structures with great precision, it can not always detect extended radio emission. The GBT, however, can help fill in the gaps. Together, they create a more complete image than either instrument could produce separately.

"The ability to combine the data from the two telescopes," said

interviews the two-man Expedition 9 crew living aboard the International Space Station on May 24. (9min 36sec file)

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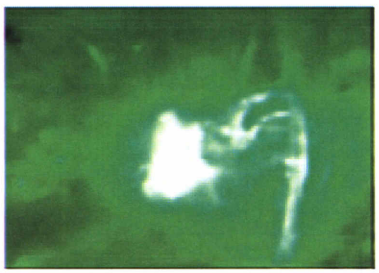
Cotton, "gives us a very powerful tool for understanding how the smallest features relate to the overall structure. This is particularly important when you want to study an area like the center of our Galaxy."

SPACE.COM June 7, 2004



Puzzling Filaments in Milky Way Explained

By Robert Roy Britt
Senior Science Writer
posted: 06:30 am ET
07 June 2004

New observations of the center of our Milky Way Galaxy have revealed the origin of radio-emitting filaments that puzzled astronomers for two decades.

The filaments range from 10 to 100 light-years in length and 1 to 3 light-years across. They occur only in a very narrow area, within about 900 light-years of the galactic center, a region crowded with old and new stars.

A light-year is the distance light travels in a year, about 6 trillion miles (10 trillion kilometers). The Milky Way in its entirety spans more than 100,000 light-years.

The filaments emerge from pockets of intense star formation, the new study found.

"We can finally see a link between areas of starburst activity and these long-linear filaments," said Farhad Yusef-Zadeh, a Northwestern University astronomer who presented the results last week at a meeting of the American Astronomical Society in Denver.

The center of the Milky Way is dominated by a supermassive black hole, which is surrounded by an intense magnetic field and pockets of rampant star formation.

Scientists had theorized that the filaments were related to the magnetic field, because the first filaments spotted were aligned with it.

"The problem with this hypothesis is that more recent images have revealed a population of weaker filaments oriented randomly," Yusef-Zadeh said. "This makes it difficult to explain the origin of the filaments by an organized galactic magnetic field."

The center of the galaxy is shrouded by dense clouds of dust and gas, making optical observations impossible. So Yusef-Zadeh's team probed the area with radio observatories, the National Science Foundation's Very Large Array and Robert C. Byrd Green Bank Telescope.

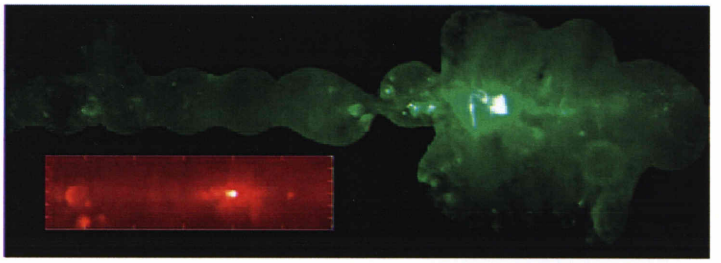
The researchers found that some filaments seemed to connect to concentrated areas of thermal emission, which in turn identify pockets of star formation. The star-forming regions associated with the filaments may contain 100 massive stars each.

The exact mechanism that creates the filaments remains to be discovered.

"One possibility is that they are produced by the collision of winds blown off from individual stars," Yusef-Zadeh said.

This article is part of SPACE.com's weekly Mystery Monday series.

* Mystery Monday Archives
* The Milky Way's Central Black Hole



A combined image from the Very Large Array and Green Bank Telescope (green) of the Galactic center, with red inset of GBT data only (red). Bright region on right is location of supermassive black hole. Linear filaments are visible above this area.

Alamogordo Daily News

June 4, 2004

National Radio Astronomy Observatory home to VLA

Photos by Elva K. Österreich

SKY HIGH — (Above) Each NRAO antenna is 82 feet in diameter and weighs 230 tons. The Very Large Array is an interferometer, which means it operates by multiplying the data from each pair of telescopes together to form interference patterns. The structure of those interference patterns, and how they change with time as the earth rotates, reflect the structure of radio sources on the sky. These patterns are used in a mathematical technique called the Fourier transform to make maps.

ANTENNA MAINTENANCE — (Left) An antenna undergoes repairs in an enclosed area. It can take anywhere from two to 100 people working to keep a VLA antenna in good working condition.

Socorro is home to New Mexico's National Radio Astronomy Observatory operations. Located on the campus of New Mexico Tech, the Array Operations Center houses scientific, engineering, technical, computer and support staff for both the Very Large Array and the Very Long Baseline Array.

The Very Large Array, one of the world's premier astronomical radio observatories, consists of 27 radio antennas in a Y-shaped configuration on the Plains of San Agustin fifty miles west of Socorro.

Each antenna is 82 feet in diameter. The data from the antennas is combined electronically to give the resolution of an antenna 22 miles across, with the sensitivity of a dish 422 feet in diameter.

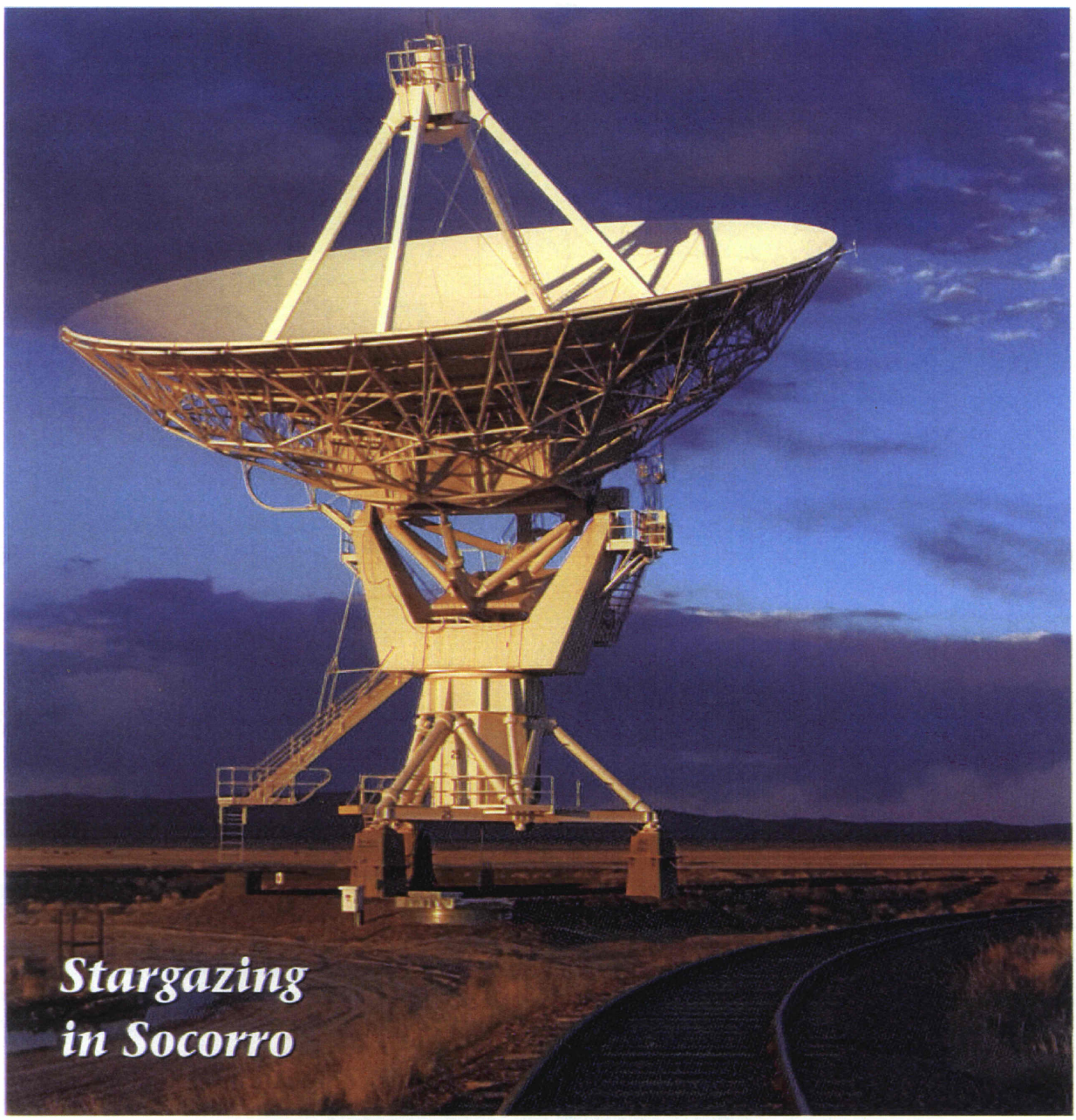
The VLA is used primarily by astronomers from around the world. It's also occasionally used for atmospheric and weather studies, satellite tracking and other miscellaneous science.

Summer students will be available for guided tours of the area on Saturdays and Sundays from June 12 through August 15. Tours will begin at 10 a.m., with the last tour leaving the visitor center at 4 p.m.

Fall tours will be held on October 2 beginning at noon. Tours will leave the visitor center every half hour, with the last tour beginning at 4 p.m. Each tour takes a bit more than one hour, they are free, and no reservations are required.

This information was taken from the Web site www.vla.nrao.edu/

Network



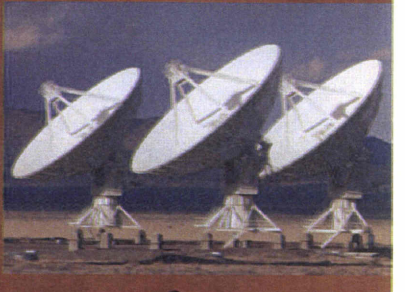
Stargazing in Socorro

Tri-State Generation and Transmission Association

Summer 2004

CENTRAL NEW MEXICO

Where the old Southwest



meets the new frontier

Story by Tonya Sandman, photos by Terry Shapiro

Editor's Note: *Tri-State member Socorro Electric Cooperative serves approximately 12,000 consumers in Catron, Cibola, Socorro and Valencia counties in central New Mexico. With a service territory covering about 10,000 square miles, the co-op is the second largest in area in Tri-State's 44-member system. The co-op is based in Socorro (population 9,000), located in the central Rio Grande Valley. The following profiles a few of the co-op's customers and their economic impact to the Socorro area.*

For centuries, El Camino Real — the oldest and, at one time, longest road leading into North America — guided settlers, livestock and Christianity into a new southwestern frontier through the heart of Socorro County in south-central New Mexico. Today, centuries-old Spanish and Mexican heritage can be found in the midst of new growth, opportunity and a robust science and technology hub based in the city of Socorro.

As the economic cornerstone of Socorro, the New Mexico Institute of Mining and Technology (New Mexico Tech) is the largest employer in the county and accounts for about 45 percent of the county's payroll. Within New Mexico Tech is the Energetic Materials Research and Testing Center (EMRTC), a 50-year-old, world-class research, development, test and evaluation complex. The center has more than 30 test facilities, gun ranges and storage sites located within a 40-square-mile territory adjacent to the university's campus.

"We work or have worked with almost any agency you can think of — the departments of defense, state, transportation, all branches of the military, the FAA (Federal Aviation Administration) — and contractors," said Rudy Correa, deputy director for EMRTC. "We can't test a missile here, but we can test the components of that system. But, we don't just test for destructive devices. We like to think all of our testing is safety oriented — to protect life and property."

One program that demonstrates EMRTC's commitment to safety is its "first responders training" offered through the U.S. Department of Justice. The program is aimed at training emergency medical technicians, firefighters, elected officials, public works employees and others to respond to terrorism.

"What we want to do is teach people how to protect evidence, preserve it, set up perimeters and notify bomb experts, either military or civilian," said Josh Carrillo, EMRTC research engineer. "We're teaching them how to respond to a crisis, we're not teaching them how to be a bomb technician. They are getting real-time, live access to what the destruction looks like. People don't know what kind of damage these explosives can cause."

Participants, such as Neil Taylor with the Utah Department of Environmental Quality, go back to train their respective departments or units with 34 hours of training from high-level instructors, most of whom are still active duty or retired ATF and FBI agents. "This is the best training I've ever been to," said Taylor.

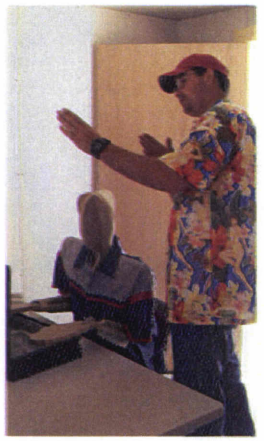
Business owners and residents of Socorro reap the benefits of EMRTC because it brings about 300 people to the community on a monthly basis.

"Tourism is alive and well in the area and one of the reasons is the first responders training at EMRTC," said Harold Baca, a business owner and member of the board of directors for Socorro Electric Cooperative. "It brings people to the area from all over the United States. They stay in our motels, eat in our restaurants and shop in our gift shops."

Fifty miles west of Socorro, another organization entices over 50,000 people to visit the area annually and puts the small southwestern city on the map, at least in international astronomy circles.

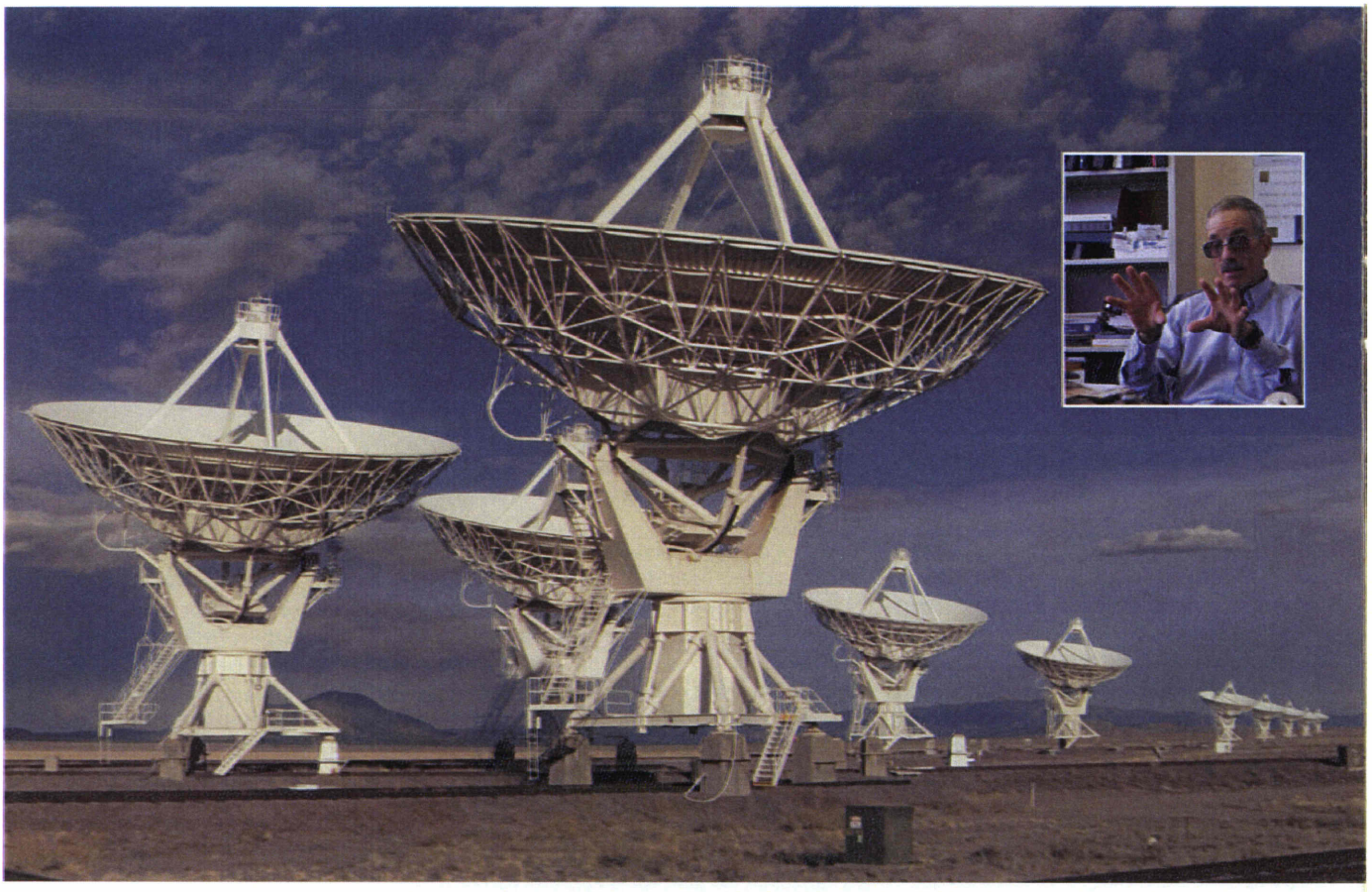
"In terms of the impact on the community, there are not many cities the size of Socorro that truly have a world-class facility like this in its midst," said David Finley, public information officer for National Radio Astronomy Observatory. "I can go to any astronomy club in the world, and if I mention 'Socorro' there will be at least one person who can tell me who we are and what we do."

Finley is referring to one of the world's premier astronomical radio observatories called the Very Large Array (VLA), a collection of 27 radio antennae, each measuring 82 feet in diameter and weighing about 230 tons. The VLA, located on the plains of San Agustin, is an interferometer, which means that the data from each antenna can be combined electronically so that the array effectively functions as one giant antenna.



An ordinance technician sets the scene for what will happen during a briefcase bomb exercise. The supervised explosions show first responders what they could expect to see in a similar, real-life situation.

Below: *Firefighters, emergency medical technicians, law enforcement and other personnel gather around a car that will be used in bomb scenarios during the first responders training on EMRTC's 40-square-mile field laboratory site.*



The Very Large Array, featured in the movie "Contact," is used primarily by astronomers from around the world. It's also occasionally used for atmospheric/weather studies, satellite tracking and other scientific studies.

***Inset above:** David Finley, public information officer for the National Radio Astronomy Observatory, explains that the resolution of the VLA is set by the size of the array — up to 22 miles across. "At its highest frequency (43 GHz) this gives a resolution of 0.04 arcseconds — sufficient to see a golf ball held by a friend 100 miles away."*

"We're very proud, because if you do the statistics on the number of discoveries — based on the number of scientific papers published, made per year by a telescope — we are the most scientifically productive telescope of any kind on the face of the earth," said Finley. "I was careful to say 'on the face of the earth,' because the Hubble Space Telescope is the only thing that has beat us in terms of scientific papers published annually."

Approved by the United States Congress in 1972 and formally dedicated in 1980, the VLA is used annually by 600 to 800 astronomers from around the world to study everything from black holes to planetary nebulae. "One of the best things about the VLA is its versatility," said Finley. "We've looked at the moon, the sun and almost all the planets. In virtually every field of astronomy, the VLA has made major contributions. Go to any college library or bookstore, open a book on astronomy and you will find that in almost any chapter there will be information that was learned for the first time from the VLA."

Currently, the VLA is undergoing an expansion effort that includes new antennae and fiber optic links, which will create an instrument capable of producing higher resolution coverage. The enhanced VLA will be 100 times faster, more frequency-agile and 50 times better at resolving details. "By taking today's off-the-shelf technology, we are able to make the VLA 10 times more capable in every category and we're doing that for less than the replacement cost of the VLA," said Finley, "so we're getting 10 VLAs for the price of one!"

A continent-wide version of the VLA, called the VLBA, is run from a control room in the Array Operation Center located on the New Mexico Tech campus. The VLBA is a system of 10 radio telescopes. Antennae are spread across the United States from St. Croix in the Virgin Islands to Mauna Kea on the island of Hawaii, making it the world's largest dedicated, full-time astronomical instrument.

"There are people who might disagree with me, but I think that right here in Socorro with the combination of VLA and VLBA, we constitute the premier radio observatory in the world," said Finley.

Magadalena Mountain Mail

April 22, 2004

Astronomers Lift "Fog" on Milky Way's Dark Heart

By Dave Finley
National Radio Astronomy Observatory

Thirty years after astronomers discovered the mysterious object at the exact center of our Milky Way Galaxy, an international team of scientists has finally succeeded in directly measuring the size of that object, which surrounds a black hole nearly four million times more massive than the Sun. This is the closest telescopic approach to a black hole so far and puts a major frontier of astrophysics within reach of future observations. The scientists used the National Science Foundation's Very Long Baseline Array (VLBA) radio telescope to make the breakthrough.

"This is a big step forward," said Geoffrey Bower, of the University of California-Berkeley. "This is something that people have wanted to do for 30 years," since the Galactic center object, called Sagittarius A* (pronounced "A-star"), was discovered in 1974. The astronomers reported their research in the April 1 edition of Science Express.

"Now we have a size for the object, but the mystery about its exact nature still remains," Bower added. The next step, he explained, is to learn its shape, "so we can tell if it is jets, a thin disk, or a spherical cloud."

The Milky Way's center, 26,000 light-years from Earth, is obscured by dust, so visible-light telescopes cannot study the object. While radio waves from the Galaxy's central region can penetrate the dust, they are scattered by turbulent charged plasma in the space along the line of sight to Earth. This scattering had frustrated earlier attempts to measure the size of the central object, just as fog blurs the glare of distant lighthouses.

"After 30 years, radio telescopes finally have lifted the fog and we can see what is going on," said Heino Falcke, of the Westerbork Radio Observatory in the Netherlands, another member of the research team.

The bright, radio-emitting object would fit neatly just inside the path of the Earth's orbit around the Sun, the astronomers said. The black hole itself, they calculate, is about 14 million miles across, and would fit easily inside the orbit of Mercury. Black holes are concentrations of matter so dense that not even light can escape their powerful gravity.

The new VLBA observations provided astronomers their best look yet at a black hole system. "We are much closer to seeing the effects of a black hole on its environment here than anywhere else," Bower said.

The Milky Way's central black hole, like its more-massive cousins in more-active galactic nuclei, is believed to be drawing in material from its surroundings, and in the process powering the emission of the radio waves. While the new VLBA observations have not provided a final answer on the nature of this process, they have helped rule out some theories, Bower said. Based on the latest work, he explained, the top remaining theories for the nature of the radio-emitting object are jets of subatomic particles, similar to those seen in radio galaxies; and some theories involving matter being accelerated near the edge of the black hole.

As the astronomers studied Sagittarius A* at higher and higher radio frequencies, the apparent size of the object became smaller. This fact, too, Bower said, helped rule out some ideas of the object's nature. The decrease in observed size with increasing frequency, or shorter wavelength, also gives the astronomers a tantalizing target.

"We think we can eventually observe at short enough wavelengths that we will see a cutoff when we reach the size of the black hole itself," Bower said. In addition, he said, "in future observations, we hope to see a 'shadow' cast by a gravitational lensing effect of the very strong gravity of the black hole."

In 2000, Falcke and his colleagues proposed such an observation on theoretical grounds, and it now seems feasible. "Imaging the shadow of the black hole's event horizon is now within our reach, if we work hard enough in the coming years," Falcke added.

Another conclusion the scientists reached is that "the total mass of the black hole is very concentrated," according to Bower. By making the

"most precise localization of the mass of a supermassive black hole ever," the astronomers said that a mass of at least 40,000 Suns has to reside in a space corresponding to the size of the Earth's orbit. Most likely, however, all the black hole's mass — equal to four million Suns — is concentrated well inside the area engulfed by the radio-emitting object.

To make their measurement, the astronomers had to go to painstaking lengths to circumvent the scattering effect of the plasma "fog" between Sagittarius A* and Earth. "We had to push our technique really hard," Bower said.

Bower likened the task to "trying to see your yellow rubber duckie through the frosted glass of the shower stall." By making many observations, only keeping the highest-quality data, and mathematically removing the scattering effect of the plasma, the scientists succeeded in making the first-ever measurement of Sagittarius A*'s size.

In addition to Bower and Falcke, the research team includes Robin Herrnstein of Columbia University, Jun-Hui Zhao of the Harvard-Smithsonian Center for Astrophysics, Miller Goss of the National Radio Astronomy Observatory, and Donald Backer of the University of California-Berkeley. Falcke also is an adjunct professor at the University of Nijmegen and a visiting scientist at the Max-Planck Institute for Radioastronomy in Bonn, Germany.

Sagittarius A* was discovered in February of 1974 by Bruce Balick, now at the University of Washington, and Robert Brown, now director of the National Astronomy and Ionospheric Center at Cornell University. It has been shown conclusively to be the center of the Milky Way, around which the rest of the Galaxy rotates. In 1999, Mark Reid of the Harvard-Smithsonian Center for Astrophysics and his colleagues used VLBA observations of Sagittarius A* to detect the Earth's motion in orbit around the Galaxy's center and determined that our Solar System takes 226 million years to make one circuit around the Galaxy.

In March 2004, 55 astronomers gathered at the National Radio Astronomy Observatory facility in Green Bank, West Virginia, for a scientific conference celebrating the discovery of Sagittarius A* at Green Bank 30 years ago. At this conference, the scientists unveiled a commemorative plaque on one of the discovery telescopes.

The Very Long Baseline Array, part of the National Radio Astronomy Observatory, is a continent-wide radio-telescope system, with 10, 240-ton dish antennas ranging from Hawaii to the Caribbean. It provides the greatest resolving power, or ability to see fine detail, of any telescope in astronomy, on Earth or in space.

Sunday Gazette
SCIENCE
April 4, 2004

Galaxy's central black hole observed 30 years ago

Astronomers, historians gather at Green Bank to mark event, talk about newest research

By Rick Steelhammer
rsteelhammer@wvgazette.com

GREEN BANK — Thirty years ago in the hills of Pocahontas County, Sagittarius A*, the radio signature of what is generally believed to be the super-massive black hole at the center of the Milky Way, was discovered by a pair of thirtysomething astronomers.

"The theory taking shape at the time was that perhaps all galaxies have black holes at their centers," said Robert L. Brown, who, with Bruce Balick, made the discovery. To provide a gravitational anchor, "A lot of mass of some kind is needed to keep things from flying off into space. But how do you confirm its presence? You look for small radio signals."

Scientists had long known that the center of the Milky Way could be found somewhere in the vicinity of the constellation Sagittarius. The field of radio astronomy was spawned by engineer Karl Jansky's 1932 discovery of cosmic radio waves coming from the direction of that constellation. But the nature and source of those radio waves could not be explained by astrophysical models of the day.

To see through the dense cosmic dust and find the relatively small, very discrete radio source in the area surrounding the center of the galaxy, invisible to astronomers using optical telescopes, a special radio telescope was needed.

That telescope was assembled and put into operation here in the late 1960s at the National Radio Astronomy Observatory. The Green Bank Interferometer consisted of three linked 85-foot antennas at the observatory campus, connected by microwave link to a fourth 45-foot telescope installed in a hillside clearing near Huntersville, 35 kilometers away.

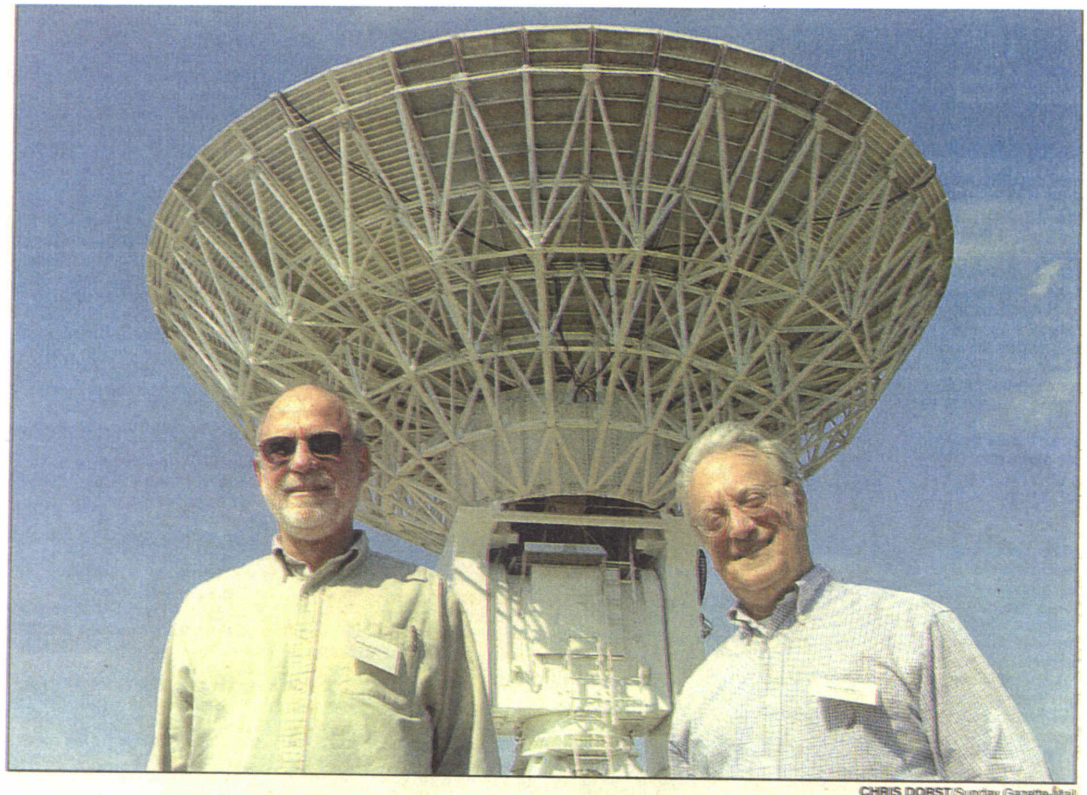
The Huntersville dish, installed in a patch of Monongahela National Forest land, was added to the Green Bank array to give the interferometer greater angular resolution, making it easier to observe finer details.

The assembly of linked antennas served as the prototype of the Very Large Array, the oft-photographed series of parabolic antennas that was then under construction in Socorro, N.M.

"Observations were being made of the center of the galaxy then, but they weren't of good resolution," Brown recalled. "Using the Green Bank Interferometer, we had the resolution of a telescope 35 kilometers in diameter. It was an instrument no one had before. We pointed it in what we thought was the right direction, and we found what we were looking for."

Over two days in February 1974, Brown and Balick detected within an area known as Sagittarius A — the zone surrounding the suspected galactic center — a suspected super-massive black hole with 3 million times the mass of the sun, at a distance of about 24,000 light-years.

"I was very surprised at how bright it was," Brown said of what was later named Sagittarius A* (pronounced 'A-star'). "We were expecting something very



CHRIS DORST/Sunday Gazette-Mail

Robert Brown (left) and Bruce Balick stand in the shadow of a 45-foot radio-telescope antenna at Green Bank National Radio Astronomy Observatory used 30 years ago to locate Sagittarius A*, a radio source marking what is believed to be a super-massive black hole at the center of the Milky Way.

faint, but the instrument we were using was very good. The engineers and the programmers here are the reason it worked so well, and we're extremely grateful to them."

After confirming their discovery with a second day of observations, Balick and Brown celebrated their discovery with a few close friends.

"We were elated," Brown recalled. "It was the feeling you get when you win a softball championship. But we didn't want to celebrate too much and spill the beans to everyone until our findings were published. Astronomy is a very competitive environment — science thrives on that — and we weren't the only people looking for it."

Data from the observations were processed at NRAO's Charlottesville, Va., office, and the pair's findings were published nine months later.

"That's about as fast as things can happen in this business," Brown said. "We weren't senior scientists, we were just a couple of 30-year-old guys interested in learning more about what's out there. It's a real pleasure to see if your idea turns out to be right or wrong."

Brown and Balick returned to Green Bank last week to take part in a symposium on the 30th anniversary of the discovery of Sagittarius A* and new center-galaxy research. The event drew 50 radio, X-ray and infrared astronomers and scientific historians from around the world.

"The discovery of Sagittarius A* stimulated a whole range of research, and galactic center science remains a very active field, these days," said Phil Jewell, director of operations at the Green Bank observatory.

"There's so much activity going on in the area near Sagittarius A*," said Robin Hernstein, a Columbia University post-graduate student who took part in the seminars and was making center galaxy observations with the new Green Bank Telescope. "It's not just a radio source. It's been observed simultaneously producing X-ray and infrared flares."

Roughly 10 million stars are known to orbit within a light year of Sagittarius A*, traveling at speeds in excess of 3 million miles per hour. Such an intense concentration of stars traveling at phenomenal speeds provides evidence that something massive lies at the center of the Milky Way.

Several years ago, NASA's Chandra X-ray Observatory satellite recorded an intensive X-ray flare as the black hole apparently sucked in a comet-sized cloud of dusty gas. Scientists believe matter swirling into a black hole approaches the speed of light and becomes superheated prior to entering the event horizon, the theoretical sphere at the rim of the black hole marking the point of no return.

> *"It's a real pleasure to see if your idea turns out to be right or wrong."*
>
> Robert Brown

According to Einstein's general theory of relativity, anything that falls through the event horizon effectively disappears from the universe. It would require traveling faster than the speed of light to exit a black hole, which Einstein theorized is impossible.

By continually monitoring Sagittarius A*, "We'll be able to place limits on how much material is falling onto the black hole, and learn more about why it produces relatively little radiation," Hernstein said.

With Sagittarius A* now being observed with a globally coordinated array of radio, infrared and X-ray telescopes, while optical telescopes observe stars orbiting around it, "It's really an exciting time for astronomy," said Brown. "In the years to come, we'll be confronting Einstein's ideas about general relativity."

"In 30 years, we've come from not knowing if black holes existed in the middle of galaxies to being on the threshold of opening up a new region of physics," said conference attendee Geoff Brown of the University of California at Berkeley.

Brown and Balick, who both attended the conference, remain actively involved in astronomy. Brown, who served as director of operations at Green Bank for three years during the late 1970s, is currently director of the National Astronomy and Ionosphere Center at Cornell University, which manages the world's largest single-dish radio astronomy antenna at the Arecibo Observatory in Puerto Rico. Balick researches the late stages of stellar evolution at the University of Washington.

A plaque commemorating the discovery by Brown and Balick has been installed at the base of the 45-foot scope used in the 1974 observation. That telescope is being reconfigured to monitor temperature and chemical changes on the sun.

To contact staff writer Rick Steelhammer, use e-mail or call 348-5169.

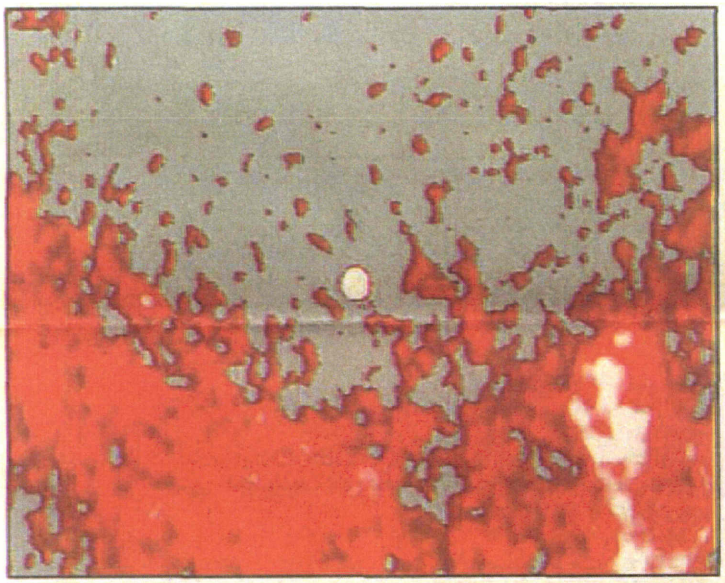


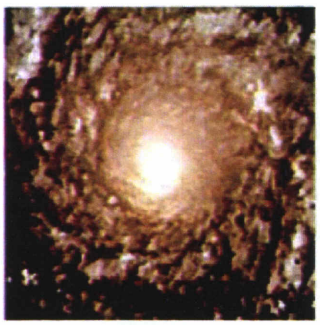
Image courtesy of NRAO/AUI

Sagittarius A*, the bright object at the center of this image, signals the presence of what is generally believed to be a super-massive black hole at the center of the Milky Way. All the stars, dust and gas in the galaxy, including our solar system, orbit this central point.

Zeroing in on the Milky Way's black hole

By Robert Roy Britt, SPACE.com

A new look deep into the heart of our Milky Way Galaxy comes closer to the central supermassive black hole than ever before, promising a way to see the very shadow of the mysterious object in coming years.



Scientists estimate the black hole at the heart of the Milky Way Galaxy to be about 14 million miles across.

Handout

In the study, radio telescopes provided the best measurement yet of the diameter of a chaotic region of emissions surrounding the supermassive object.

The black hole, which holds a mass equal to nearly 4 million suns, was previously estimated to be about 14 million miles (23 million kilometers) across, much smaller than the orbit of Mercury around the Sun. It can't be seen, because everything that approaches it, including light, is swallowed. But on the way in, matter is superheated to millions of degrees, generating emissions in many wavelengths of the electromagnetic spectrum, from radio waves to X-rays.

Astronomers have for 30 years sought to learn exactly what causes the radio emissions and how near to the black hole they originate. The radio-emitting region is no more than 93 million miles (150 million kilometers) across, or less than the distance from Earth to the Sun, the researchers reported Thursday in the online edition of the journal Science.

Mysteries remain

"We don't know yet the complete nature of the radio emitting region, but as a result of our measurement we now have a tight constraint on its size," said Geoffrey Bower of the University of California-Berkeley. "We are much closer to seeing the effects of a black hole on its environment here than anywhere else."

Bower told SPACE.com that the radio emissions might originate from material that is falling onto the black hole, or perhaps they are spawned by a jet of stuff flowing away from the black hole at a significant fraction of the speed of light.

Further observations may solve that remaining mystery, he said.

For now, the new observations come closer to a black hole — as measured in relation to the presumed size of the given black hole — than any previous, Bower said. The primary work was done with the National Science Foundation's Very Long Baseline Array of telescopes.

Blurry vision

The radio-emitting region is called Sagittarius A* (meaning A-star). It was discovered in 1974 and later determined to be associated with a central, supermassive black hole. The whole setup is about 26,000 light-years from Earth.

The area is shrouded in dust, so visible-light telescopes can't study Sagittarius A*.

USA TODAY Tech

April 1, 2004

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Radio waves penetrate the dust but are scattered by the turbulent, hot gas in the area. The astronomers said this scattering had frustrated previous attempts to peer into the very core of the action. Bower likened the task to trying to spot a yellow rubber duck through the frosted glass of a shower stall.

To cut through the cosmic fog, the team employed higher radio frequencies, which correspond to shorter wavelengths. They also used longer wavelength observations to determine the effects of the scattering, then removed those effects from the short-wavelength data.

"After 30 years, radio telescopes finally have lifted the fog and we can see what is going on," said fellow investigator Heino Falcke of the Westerbork Radio Observatory in the Netherlands.

The researchers say the new observations rule out some less popular ideas for the cause of the radio emissions.

And there is room for improvement, Falcke and Bower say, by using even shorter wavelengths to drill down to the cutoff point — the outer sphere of the black hole — and essentially see a shadow of the immense dark object. Such an observation was proposed, based solely on theory, by Falcke and other colleagues more than four years ago.

"Imaging the shadow of the black hole's event horizon is now within our reach, if we work hard enough in the coming years," Falcke said.

IQ ALERT: BIG BRAINS HEAD THIS WAY

PUBLISHED MARCH 25, 2004 IN ISSUE #0312 OF THE HOOK

BY COURTENEYSTUART STUART@READTHEHOOK.COM

The National Radio Astronomy Observatory is getting bigger in Charlottesville. PHOTO BY JEN FARIELLO

Astronomers note that masses are hurtling toward Charlottesville. But don't worry, they may not wreak destruction on our historic hamlet, and they could raise the average IQ a few points.

Those masses are masses of flesh, astrophysicists who'll be moving to town over the next two years. They'll make Charlottesville the center of the universe, so to speak, for the study of radiation emitted as long as 13.5 million years ago by the Big Bang and other celestial activity.

Since when is Charlottesville such an astronomic mecca?

It dates back to 1965, when the National Radio Astronomy Observatory put its headquarters in Charlottesville. And although NRAO is not directly affiliated with UVA (it's under the umbrella of the National Science Foundation), proximity to the university played a role, says NRAO spokesman Chuck Blue.

The reason for the sudden growth is ALMA, a massive "array telescope" similar to the Socorro, New Mexico-based Very Large Array, or VLA, seen in the movie Contact and also operated by NRAO.

The ALMA itself (it stands for Atacama Large Millimeter Array) won't be here in Charlottesville, but rather 16,500 feet above sea level in the Chilean Andes. When completed in 2012, ALMA will be the world's largest array telescope with 64 dishes compared to VLA's 27-- operating in unison to pick up millimeter and submillimeter wavelength light. Scientists here in Charlottesville and Europe (location TBA) will spend years pouring over the data, hoping to get the Biggest Bang for their buck (or Euro).

NRAO is probably best known for its giant radio telescope in Green Bank, West Virginia. At 17 million pounds, 485 feet in height, and diameter over 100 yards, it's the largest moving machine on the planet. It was built during the 1990s after an earlier dish at the same site collapsed under its own weight in 1988.

That dish, just slightly smaller than the current one, lasted about 26 years, and NRAO's Blue says it was never meant to last. "It was built for a 10-year project," he explains. Fortunately, the collapse of the massive dish didn't injure anyone. "It gracefully laid itself down in the middle of the night," says Blue.

Radio telescopes are complicated instruments. Unlike optical telescopes that rely on mirrors to reflect light to a focal point, radio telescopes use a dish to collect radio waves that are then sent through a computer for analysis. But these are not your DirecTV dishes. At millions of dollars apiece, the radio telescope dishes have unbelievable accuracy. Blue says ALMA would be able to measure the diameter of the period at the end of a sentence from over a mile away.

While VLA focuses on centimeter and larger wavelengths, ALMA, which will cost over $550 million, will be the first array telescope to focus on the smallest wavelengths those that provide a look billions of years back in time. Galaxy and star formations can be studied using millimeter and submillimeter radiation, while longer wavelengths allow the study of phenomena such as black holes.

Because of the wavelength specificity, ALMA, though powerful, would not be used to identify alien life forms intent on an earthly encounter. (Rood says a telescope called Arecibo in Puerto Rico spends a few weeks each year seeking extraterrestrial contact.)

NRAO's presence has been a major boon for Jefferson's university, says UVA Astronomy Chair Robert Rood.

"It helps us recruit grad students and faculty," says Rood, whose says it helped lure him to UVA in 1973. "I probably wouldn't have come here when I did," he adds, "if it weren't for NRAO."

NRAO currently has 104 local employees, including scientists, engineers, and administrative staff, according to Blue, but that number will increase by at least 35 by 2006.

To make room for the added brainpower, NRAO is expanding its primary location, a stately campus commonly known as Stone Hall, at 520 Edgemont Road at the foot of UVA's Observatory Hill.

NRAO has also begun renting the former Institute of Textile Technology building about two miles from Charlottesville across from the Boar's Head Inn. That 9.2-acre property was purchased by Ivy Road Properties LLC in August for $6.6 million.

Since ALMA will have 64 dishes spread out over as much as 10 kilometers, collapse won't be a concern. However, keeping all dishes functioning as a unit will be a constant challenge.

It's a challenge NRAO assistant director Mark Adams says the astronomy world is buzzing about.

"We're all very excited," he says.

Magadalena Mountain Mail

March 25, 2004

VLA, Trinity Site Host Open Houses Saturday, April 3

Mountain Mail staff reports

Thanks to enlightened thinking at the National Radio Astronomy Observatory, it is now possible to visit the Very Large Array on the Plains of San Agustin and Trinity Site at the edge of the Jornado del Muerto on the very same days, specifically the first Saturday in April and October each year.

The next free open house for both is Saturday, April 3. It will be the fourth time that NRAO has scheduled tours of one of the world's premier astronomical radio observatories to coincide with the semi-annual Trinity Site Open House.

Trinity Site, 17 miles east of San Antonio on Highway 380, is where the world's first atomic bomb was exploded July 16, 1945. To reach Trinity Site turn into White Sands Missile Range at Stallion Range Center gate, located at about Milepost 12 on US-380. Adults should bring a picture ID and proper vehicle registration and insurance papers. Vehicles are subject to search, according to the missile range's news release.

Trinity Site is currently being considered by Congress as part of a Manhattan Project unit of the National Park System.

Also on the Trinity tour is the McDonald Ranch House, where the bomb was assembled.

Equally dramatic is the VLA tour off Highway 60, west of Magdalena. Two years ago the NRAO decided to run its free tours in tandem with the Trinity Site tours for the benefit of tourists.

The Very Large Array Tours start at noon, and run every 30 minutes until 4 p.m. Trinity Site gates are open from 8 a.m. until 2 p.m. It's about a two hour drive between the sites, according to Robyn Harrison, spokesman for NRAO.

The VLA consists of 27 radio antennas in a Y-shaped configuration, 50 miles west of Socorro. The tours do not include the visitor center itself, so extra time should be factored in for the new center.

If visitors have to make a choice between the two sites, they should probably pick Trinity Site since the VLA tours are run several times during the year.

Saturday, March 20, 2004

The Inter-Mountain
REGION

NRAO's Science Center Takes Visitors to Outer Space

Star Party Is Tonight in Green Bank

By SAM Di STEFANO
Staff Writer

The National Radio Astronomy Observatory's Science Center in Green Bank offers an interesting and educational look at how humans are reaching out to the heavens to learn about the space Earth occupies.

This Memorial Day weekend will mark a year since Green Bank's Science Center opened. It's also the first year that the site has been open for touring all year long.

"It has been great," NRAO Tour Director Cara Rose said. "We have a brand new, wonderful facility with an exhibit hall, an auditorium; we have a cafe, and the response from the public has been great."

In the new Science Center, NRAO offers a plethora of educational activities, mostly for free. Basic tours at the center are free and introduce visitors to the general history of astronomy and radio astronomy, with displays in the exhibit hall that explain what radio waves are and how radio telescopes work, as well as galactic occurrences and matter such as "some really neat objects like pulsars. We have some really cool exhibits for pulsars," Rose said.

Also free and available every sunny afternoon are solar views. At 2:45 p.m., visitors can view Sol through an optical telescope and with a radio telescope. Rose said these are popular activities, "particularly if there are sun spots that are visible."

In Rose's opinion, one of the most popular activities is High Tech Wednesdays. Fifteen visitors get to take an extended tour of the facility to see things that are normally off-limits to the general public such as the labs where receivers are built and the control rooms for the telescopes. High Tech tours are on the second Wednesday of each month at 3:30 p.m and cost $3 per person.

Weather permitting, star parties are also a big draw. On certain weekends visitors to the Science Center can view the night sky with optical telescopes on the center's Star Patio. What makes this an exceptional experience is the direction and instruction offered at the parties. Thirty minutes before dark, stargazers attend an orientation in the center's auditorium where they are acquainted with the major constellations and skills like star chart reading.

"We can get a lot of people for the star parties if the weather's nice," Rose said. "It's a lot of fun.

The next scheduled Star Party is tonight, and the National Weather Service forecast for Green Bank is clear with a 20 percent chance of rain.

For stargazers who don't want to go outside there are StarLab Thursdays. Every Thursday at 2 p.m., 15 people get an educational indoor look at the nighttime sky in the observatory's mobile planetarium. Cost for the StarLab is $3, and calling ahead is recommended.

The first Friday of every month is a film fest. Visitors and staff gather in the Science Center auditorium at 6:30 p.m. for a science-related movie. All movies for this event are to be announced, and admission is free.

Visit www.gb.nrao.edu or call (304)456-2150 for schedules, costs and more information.

Visitors to the Web site may also tour Orion or the Solar System or be an interference (as in radio interference) detective. The Web site's Image Gallery offers the chance to view Andy Warholesque images taken with radio telescopes.

(Photos courtesy of the National Radio Astronomy Observatory)
EXPLANATIONS FOR THE UNIVERSE — Clockwise from top right, exhibits about pulsars are reputed to be some of the National Radio Astronomy Observatory's "coolest" exhibits at the facility in Green Bank. Understanding radio waves goes a long way toward understanding radio astronomy; several displays, including the case to the left, orient visitors to the concept. Creative teaching tools are employed, such as a large mirror, top left, in the NRAO's Science Center.

Richmond Times-Dispatch

Thursday, March 4, 2004

Tech center aids astronomers

Charlottesville facility works on technology for radio telescopes

BY PETER CLEARY
MEDIA GENERAL NEWS SERVICE

Charlottesville's place among the stars burned a little brighter last week as the National Radio Astronomy Observatory opened a new technology center.

The facility, on the grounds of the former Institute of Textile Technologies on Ivy Road, provides a central location for the engineers and technicians who develop new technology for the observatory's telescopes.

"The center houses the people and equipment to develop the state-of-the-art technology that's used in the radio telescopes," said Mark Adams, assistant to the director of the observatory. By bringing the engineers to a central location, he added, the facility increases their ability to work collaboratively.

Engineers at the center are working on technology for all of the observatory's telescopes, including the Atacama Large Millimeter Array under construction in the high Andes of Chile.

The new telescope will observe the sky on the millimeter and sub-millimeter wavelength scale — a frontier in astronomy — and cutting-edge technology is needed to enable it to work. That technology is being developed at the center, Adams said. "They are building the hardware that will make ALMA work with the sensitivity and accuracy that it needs."

In addition to the technology center, the Ivy Road facility will be home to a science center providing technical support and assistance to astronomers using the telescope.

"It will be the entryway for North American astronomers to use the new telescope," observatory spokesman Charles Blue said.

The telescope, scheduled to begin operating in 2007, will be used to search the sky for clues to the early history of the universe and star formation. Rather than travel to the site in Chile, astronomers using the telescope will visit the Charlottesville center. Adams said it is common to locate the support facility far from the telescope itself. The high elevation of the telescope in Chile would make working on-site especially difficult.

While not included in the plans for the new facility, Blue said the observatory would like to open a visitor center. "It is our hope that we will have some presence here in Charlottesville at some time," he said.

Forty-five engineers and technicians had moved in by the official opening last week. A total of 78 employees will work in the center once it is at full capacity. Blue said the additional employees would include new hires as well as people moving from a facility in Tucson, Ariz.

• Peter Cleary is a staff writer at the Daily Progress in Charlottesville.

Wednesday, February 25, 2004

The Cavalier Daily

www.cavalierdaily.com

Wednesday, February 25, 2004

University professor involved in efforts to view distant galaxies

Charlottesville organization participates in astronomy project to permit scientists to see farther into space than ever before

By Irina Bocarnea

Cavalier Daily Staff Writer

Scientists say they someday hope to see as far back in time as the Big Bang with new telescoping technology developed in part by Arthur Lichtenberger, a University professor of Electrical and Computer Engineering.

The National Radio Astronomy Observatory, headquartered in Charlottesville, is one of the organizations participating in the joint development of detectors that are to go into the Atacama Large Millimeter Array telescope project.

"This is the largest land-based astronomy project," Lichtenberger said. "It is the largest superconducting detector project underway."

According to the ALMA Web site, the telescope will detect and study the earliest and most distant galaxies and will examine the details of star and planet formation. The array will make major contributions to virtually all fields of astronomical research.

"As the universe is expanded, it moves so far it goes to radio waves," ALMA Proj-

Please see TELESCOPE, Page A2

Telescope | Project set to be completed by year 2007

Continued from page A1

ect Scientist Al Wootten said. "What we see is objects that are very far away. Those that are the farthest away and closest to the time of the Big Bang are what we are trying to reach. For ALMA, the peak of brightness is red-shifted to optimal place so we can see way back in time."

The telescope will be the world's largest sensitive radio telescope that operates at millimeter wavelength. The 128 telescope detectors will have the capability of looking at objects in space as a unit, greatly increasing mapping capabilities and resolutions.

Scientists from around the world hope to complete and have the telescope in operation by 2007. There currently are 15 countries involved in the project.

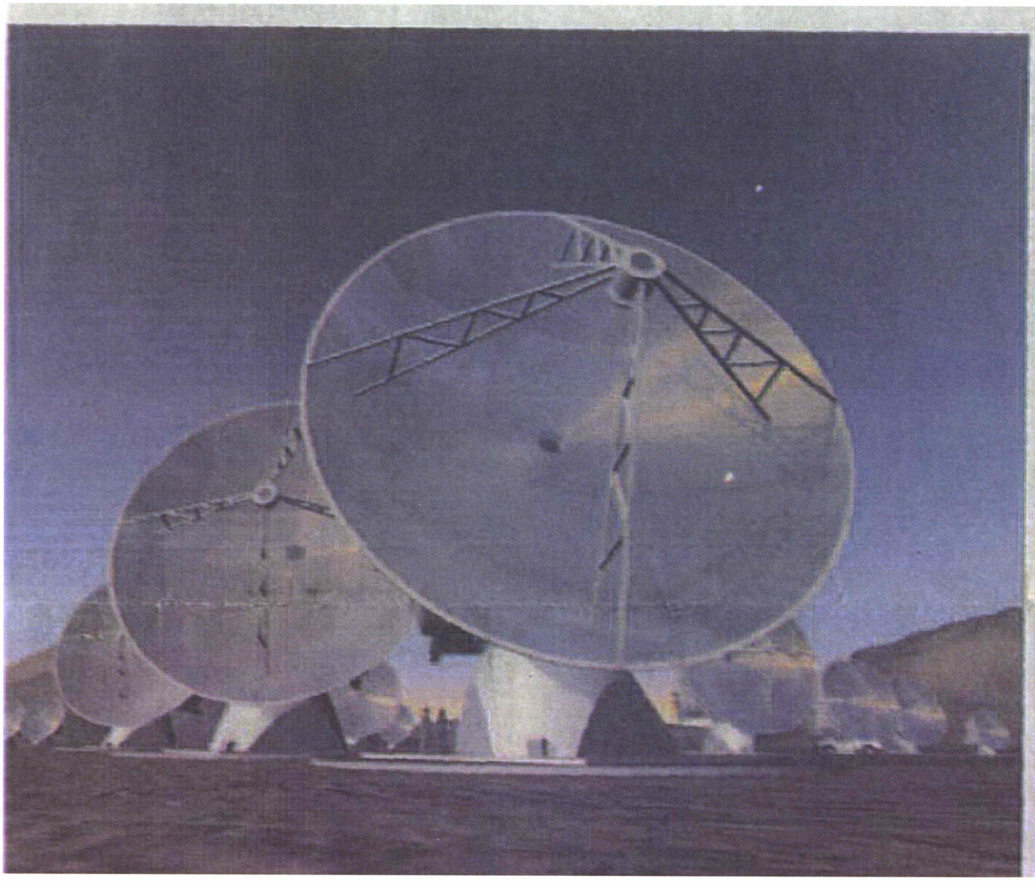
Lichtenberger has been developing detectors for this specific project for four years, but he said advances that have been made in the past 50 years have had a huge impact on the project. The development of faster and more sensitive detectors has been phenomenal, Lichtenberger said.

Wootten credited Lichtenberger's dedication and skill.

"Lichtenberger has been more successful in the production of detectors than most people," Wootten said.

Though others say Lichtenberger is a driving force behind the production of the detectors, Lichtenberger praised Anthony Kerr and S-K Pan, two scientists in the research development laboratory, as also fundamental in developing the project.

"We have been collaborating on scientific projects since 1985, and Anothony Kerr and S-K Pan have made incredible advances in the field," Lichtenberger said.



Telescope detectors in the Andes are part of a world-wide project to develop the capability to view occurences as far away — and as old — as the Big Bang.

The Daily Progress

Wednesday, February 25, 2004

Observatory opens center on Ivy Road

By Peter Cleary
Daily Progress correspondent

Charlottesville's place among the stars burned a little brighter Tuesday as the National Radio Astronomy Observatory opened a new technology center on the grounds of the former Institute of Textile Technologies on Ivy Road.

The facility provides a central location for the engineers and technicians who develop new technology for the observatory's telescopes.

"The center houses the people and equipment to develop the state of the art technology that's used in the radio telescopes," assistant to the director of the observatory Mark Adams said. By bringing the engineers to a central location, he added, the facility increases their ability to work collaboratively.

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See **CENTER** on **A8**

Center

Continued from **A1**

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WIRED MAGAZINE

February 2004

The Quiet Zone

Cell phones, pagers, Wi-Fi, Bluetooth - the wireless revolution is everywhere. Except here.

By John Geirland

Photo by Jonathan Manzo

I'm 1 mile east of command central in the Quiet Zone, sitting in a Dodge pickup with Wesley Sizemore, Keeper of the Quiet. In a world saturated with radio waves, the Quiet Zone is a haven and an anomaly. A unique combination of geography and legislation has rendered its 13,000 square miles nearly free of electromagnetic pollution. Sizemore's job is to keep it that way. On this freezing afternoon, he's showing me the scene of his most storied success: a double-wide modular home amid brown grass and patches of snow in Pocahontas County, West Virginia (population 8,996).

One morning several years ago, Sizemore got a call. Broadband interference - noise, in common parlance - was wreaking havoc with the sensitive equipment at command central. After loading up his truck with a receiver, amp, spectrum analyzer, and directional antenna, he thundered into the countryside. Every quarter mile or so, he stopped, whipped out the antenna, and scanned the electromagnetic spectrum for spikes of activity. He methodically triangulated his way to this spot, where an elderly couple live with a nasty old dog penned in back. The couple had given the mutt a heating pad to lie on, but the pad had become worn; cracks in the wiring were causing tiny electric arcs to leap across the gaps. "Not enough electricity to shock the dog," Sizemore explains, but enough to produce a radio-frequency signal. He promptly disposed of the heating pad and bought the couple a new one. Just one more small step in humankind's exploration of the cosmos.

The Quiet Zone is a generous margin of mountainous terrain and rustic communities surrounding the Robert C. Byrd Green Bank Telescope, a 485-foot, 17 million-pound structure that emerges improbably from this remote valley. Astronomers here observe the universe by studying faint radio waves emitted by stars, evaporating comets, and distant galaxies. These signals inhabit many areas of the electromagnetic spectrum - often the same areas prized by broadcasters, cellular providers, and other communications companies.

The subjects of radio astronomy are astronomically large, but the signals they produce are astronomically weak by the time they reach Earth. These emissions are measured in Janskys, named for the father of radio astronomy, Karl Jansky. A Jansky is based on 0.00000000000000000000000001 watts - and that's a big signal at Green Bank. Even a musical greeting card playing at the base of the telescope could produce anomalous spikes in the data of an unlucky astronomer trying to study stellar gases. If the interference is strong enough, the telescope's ultrasensitive first amplifier - cooled by liquid helium to minimize internal noise - shuts down.

Sizemore, 49, has safeguarded the telescope and its mission since 1983. One minute he's running signal propagation models, the next he's sledgehammering the base of a power-line pole to rejigger its insulation, and then he's alerting the site director about an unexpected incursion: North American flying squirrels

tagged with telemetry transmitters, a project of the US Fish & Wildlife Service.

In the past few years, however, Sizemore's job has become overwhelming. The wireless revolution has swept the country beyond the Zone. First pagers and cell phones, then satellite radio, souped-up walkie-talkies, Wi-Fi, and Bluetooth - one after another, these technologies have cranked up the surrounding cacophony. There are even sources of radio-frequency interference raining from the sky: Transmissions from a Russian Glonass satellite recently derailed efforts to study a faraway cluster of galaxies.

Photo by Jonathan Manzo

Chief antenna engineer Robert Anderson surveys the 13,000-square-mile National Radio Quiet Zone from the center of the world's largest fully steerable radio telescope.

Sizemore's efforts to shield Green Bank's radio waves from the encroachment of civilization may make him seem a quaint relic of the past. Actually, he's a harbinger of the future: The problems that keep him awake at night are increasingly everyone else's problems, too.

While electromagnetic spectrum is a finite resource, the number and variety of gadgets emitting electromagnetic energy continue to grow. As the airwaves become more crowded, signals from devices operating in neighboring frequencies spill into one another's bands. When spectrum allocation frays at the edges, devices go haywire: Garage doors open and close by themselves, phone conversations blare over baby monitors. The stakes also can be frighteningly high, as when emergency workers can't coordinate a disaster response effort. Some observers fear that interference is becoming so severe that soon there won't be enough spectrum to go around.

Sizemore has been feeling that way for a long time. He has been tracking down and stifling stray signals for more than two decades; engineers and regulators are just beginning to explore ways of operating in a spectrum-saturated environment. "In terms of the RFI issue," says Green Bank site director Philip Jewell, "we're the canary in the coal mine."

The astronomers who selected Green Bank as the site for the telescope in the mid-1950s chose carefully. The surrounding Allegheny Mountains provided a natural shield against radio and television broadcasts. Flanked by national forests teeming with black bears and wild turkeys, the area would remain undeveloped in perpetuity. And for all its physical isolation, it was only a day's drive from many East Coast universities. Even back in the '50s, though, farsighted scientists feared that radio-frequency emitters would eventually creep into the area. More aggressive protection would be necessary.

Thus, in 1958 the FCC set aside a rectangular-shaped territory the size of Massachusetts and Connecticut combined and called it the National Radio Quiet Zone, to be administrated by the National Radio Astronomy Observatory, a government-funded research facility in Charlottesville, Virginia. The NRAO later built other radio telescopes - in Socorro, New Mexico (the setting for the film Contact with Jodie Foster), and Tucson, Arizona - but it never again had the clout to impose quiet around them. Today, Green Bank is radio astronomy's crown jewel. Over the years, the telescope has played a key role in understanding the behavior of pulsars, searching for extraterrestrial life, and probing the halo of hydrogen that surrounds the Milky Way galaxy. It's one of the few facilities on the planet where radio astronomers can make observations at most points along the electromagnetic spectrum.

All major transmitters in the Zone are required to coordinate their operations with the national observatory. Radio stations point their antennas away and operate at reduced power. Cell phone base stations are few and far between, and entirely absent deep in the Zone. Even incidental electromagnetic emitters are regu-

lated: Power lines must be buried 4 feet belowground. The wireless LAN card in your laptop? Forget about it.

"Your cell phone and pager won't work here," Sizemore warned me before I came out for a visit. He was right. As I negotiate the snowy switchbacks on Route 250 West, my cell phone passes out of service while the FM dial gradually becomes depopulated. By the time I reach the tiny burg of Green Bank, all I can get is a static-shrouded episode of A Prairie Home Companion from a radio station outside the Zone.

The facility itself looks like any high tech office building, except for the full-scale replica of the antenna Jansky used in 1932 to discover "mysterious radio waves" emanating from the Milky Way - a natural phenomenon that, for a time, he mistook for communications from an alien civilization.

The next morning, I meet Sizemore for breakfast in the dining hall. He shows up in a black leather jacket and an earth-toned, Navajo-print flannel shirt. His beard is a thicket of graying bristles. Sizemore grew up in the mountain hamlet of Trout, West Virginia. He spent six years in the Navy, during which he was stationed in the Bahamas and the Mediterranean before returning to West Virginia to attend Bluefield State College. Then he was off to the Cleveland Institute of Electronics, where he earned an associate degree in electrical engineering. He's an Appalachian-high tech hybrid who makes his own wine and listens to NPR.

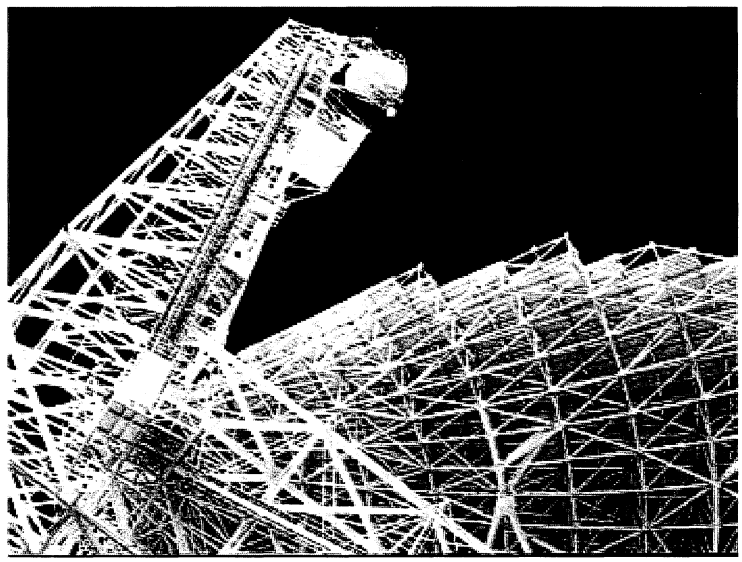

Photo by Jonathan Manzo

Sections of the 100-by-110-meter telescope, which is made up of 2,004 actuator-driven panels.

He's also a verbal snowplow when he gets worked up about the Quiet Zone. Once he latches onto a subject like "tropo-scatter" or "free space loss," he's unstoppable. "I take the maintaining of the Quiet Zone very personal," he explains in a West Virginia lilt. "It's my way of making a contribution to the body of mankind's knowledge."

The quiet lets astronomers measure electromagnetic waves thrown off by space-borne molecules when they become heated or collide. Each type of molecule emits energy in a unique frequency band; hydrogen, the most abundant molecule in the universe, is in the 1,400 to 1,427-MHz range. This band and a few others have been set aside by international treaty exclusively for radio astronomy. In practice, spillage from neighboring bands can cause interference even in these tiny slivers of spectrum.

Although just about any electronic or electromechanical device can blind Green Bank's telescope, the biggest culprit in the first category is the observatory itself. After all, it's a high tech operation crammed with sophisticated electronics and PCs. Green Bank director Jewell believes that some of the steps taken to mitigate interference at the facility may someday be adopted in the wider world, such as innovative circuit board designs and extensive shielding. The cafeteria's microwave oven is kept in a shielded cage. Large chambers designed to absorb radio waves - including a 5,000-square-foot conference room - have been built to make sure that, as Sizemore tells it, "radiation generated in the

building stays in the building." Outside, spark plugs are notorious radio-frequency emitters, so Green Bank maintains a fleet of diesel-powered, electronics-free '69 Checker cabs and '70s Dodge trucks.

Thousands of tourists visit Green Bank each year, many of them stuffing their day packs with cell phones, two-way radios, and similar wireless gadgetry. The good news is that these devices operate at low power levels. The bad news is that they're mobile. The FCC doesn't control unlicensed transmitters, but West Virginia's Radio Astronomy Zoning Act prohibits any RFI-generating device - licensed or not - within 2 miles of the telescope.
Sizemore is more anxious about pervasive emitters: cellular telephones, two-way pagers, wireless email. Under FCC rules known as geographic area licensing, service providers can erect transmitters anywhere in a designated region without notifying the commission of the exact location. The policy worries Sizemore. "We don't know where the final transmitter sites will be," he says, which makes it difficult to assess the impact of a new transmitter on the telescope's operations ahead of time.

Meanwhile, there are more immediate challenges. Sizemore wants to show me a transmitter that poses a direct danger to the telescope, a kind of electromagnetic sword of Damocles. "Dress warmly," he warns.

The next morning, we're standing on the icy patio of the Sunrise Backcountry Hut, a remote cabin on top of a mountain a couple miles from the Snowshoe Mountain ski resort. Sizemore was right about bundling up. It's 14 degrees, and snow flurries whirl overhead.

Snowshoe wants to install a transmitter to relay the cabin's smoke-detector alarm to headquarters. But the cabin is only 7.5 miles from the telescope, with no mountains in between. If the alarm went off and the transmitter relayed its signal, the result, Sizemore says, would be "catastrophic."

Before the resort can install the transmitter, it must obtain a waiver from Green Bank. And when it comes to waivers, Sizemore's standard line is "If you're going to make a buck with it, don't ask!" But this case is different. Public safety trumps research.

The trick is to configure the system so it won't blow an amp at Green Bank the moment a hapless lodger attempts to cook blackened salmon. It may be possible to equip the emergency transmitter with a directional antenna aimed at a 90-degree angle away from the telescope toward a Verizon wireless base station in Warm Springs Mountain, Virginia, about 40 miles south. Then the base station would redirect the signal back to Snowshoe. Sizemore and Nathan Sharp, a lanky Green Bank technician, test the idea with their own equipment, which includes an antenna that looks like a high tech coatrack. "Slow and easy. Keep going to the right," he tells Sharp, who is gripping the antenna. "That's a nice strong signal there."

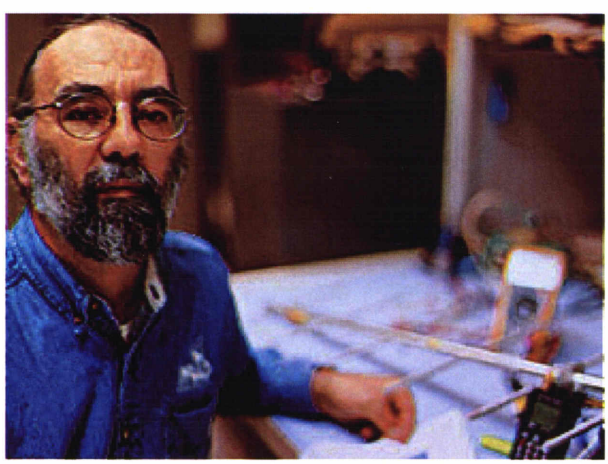

Photo by Jonathan Manzo

Wesley Sizemore at his desk with a directional antenna.

While Sizemore and Sharp fiddle with the antenna, I catch a bumpy snowmobile ride down the mountain to talk to Jim Haas, VP of resort services at Snowshoe. Haas, a pale, beefy man with a wispy soul patch, wears a blue jacket and matching Snowshoe cap.

The smoke detector is just one detail in a much larger system that Snowshoe has had to adapt to Quiet Zone priorities, Haas tells me. "It has made our communications more difficult and cost us more money," he says without rancor. The resort has staff operating on both sides of the mountain, and nor-

mal practice would be to install a repeater at the peak to boost signals to employees' handsets. But that would fry the telescope, so he's had to install hardwired components at double the cost.

Still, Haas isn't complaining. "Wesley has worked as hard as anyone to find ways for us to operate," he says. Haas has been an employee at Snowshoe for more than 25 years - he knows the rules of the Quiet Zone. Skiers are a different matter. "People are bringing Motorola Talkabouts on the mountain," he says, and there's little Sizemore can do about that.
By the time I get back up to the Sunrise Lodge, Sizemore is showing the Snowshoe staff how the directional antenna can be placed under the metal roofing, further shielding the telescope from the transmitter's signal. The beauty of the scheme is in its economical use of power and spectrum. A typical antenna would radiate 48 watts of power in all directions. The directional antenna concentrates only 3 watts in one direction - toward the Verizon tower - accomplishing the same goal far more efficiently.

Sizemore's solution is typical of his stingy approach toward spectrum. He uses an optical analogy to make his point. "Why do we have streetlights that shine up into the night sky?" he asks. "We're illuminating the bellies of airplanes for no reason. So why would you have an antenna radiating in all directions when you want to communicate in one direction?"

As I gaze out over the snowy Allegheny Mountains, I imagine the area surrounding the Quiet Zone as a huge mosaic of RF emitters. Sizemore's job is to fit all the pieces into a harmonious whole - and to do so constantly, in an ever changing landscape. This concept, as it happens, may be the ultimate solution to the interference problem everywhere.

There's no question that use of the electromagnetic spectrum is sharply increasing. In 1994, the FCC projected that by 2000 there would be 54 million users of mobile wireless services in the US; the actual number reached 110 million. In spite of industry woes, the number of cellular base stations worldwide is expected to climb from 1.3 million in 2003 to 1.6 million by 2006, serving 1.8 billion wireless users. Meanwhile, short-range and satellite transmissions are multiplying.

The parts of the spectrum set aside for unlicensed devices - the 900-MHz, 5.7-GHz, and 2.4-GHz bands - are getting especially noisy. Recent technologies like Bluetooth and Wi-Fi are choking these frequencies. To make matters worse, the popular 2.4-GHz band shares space with medical, scientific, and industrial devices, like the huge microwave ovens used to dry plywood.

The soft signs of a growing interference problem are everywhere. Cordless phones in the 2.4-GHz band interfere with Wi-Fi. Until recently, some radar detectors (popular among truckers for spotting police) disrupted terminals used to authorize credit cards at gas stations or pipe Muzak into burger joints.

Some RFI effects are as comical as they are unexpected. Errant radio waves caused mischief on the Spider-Man movie set when emissions from a high-powered walkie-talkie tweaked a timing processor on a generator, killing the lights in the middle of a tear-jerking scene.

Other incidents have been more serious. Six years ago, broadcasts from Dallas-based WFAA, the country's first digital TV station, interfered with wireless heart monitors at Baylor University Medical Center. (The hospital spent $200,000 on new machines.) And last May, a baby monitor hindered air-traffic control communications as pilots approached London's Luton Airport.

Some experts fear this is the leading edge of a spectrum meltdown, but others have high hopes for new technology. Dennis Eaton, chair of the Wi-Fi Alliance, is undaunted by reports of Bluetooth devices hopping all over Wi-Fi connections or interference between overlapping hot spots operating on the same frequency. "I put my faith in the engineers who are designing new equipment," he says.

Eaton may be right. Already, phased-array antennas can make more efficient use of existing spectrum. An approach known as cognitive radio might have an even bigger impact. Unlike your local Top 40 radio station, which transmits 24/7, unlicensed wireless devices tend to use the airwaves intermittently. At any particular moment, the spectrum is rife with unoccupied frequencies, or "white holes." Cognitive radio hunts out these holes and makes temporary use of them. If this technology catches on, every Wi-Fi base station or cordless phone could contain its own little Wesley Sizemore.
Indeed, radios are getting smarter. In January 2003, the US Department of Defense reached an agreement with technology companies requiring manufacturers to enable Wi-Fi devices to detect activity in frequencies used by military radar and, if they sense it, to avoid those parts of the spectrum. FCC rule changes are enabling manufacturers to produce Bluetooth devices that sniff out Wi-Fi signals and dodge them by broadcasting in other frequencies.

Such strategies may ease interference problems in the larger world, but the Quiet Zone is a different matter. Sizemore fears that cognitive radio would allow people to use spectrum bands that previously had been quiet - creating another source of noise rather than a solution. The more the FCC loosens the regulatory reins - allowing cognitive radio, instituting geographic area licensing, opening more spectrum to unlicensed users - the more difficult it becomes to maintain the quiet in the Zone. Even if the outside world does evolve into a laissez-faire commons, as some observers advocate, the Quiet Zone must remain an embattled bastion of command and control.

Sizemore gives me a final spin around the observatory grounds. He looks tired. He drives past one of the smaller radio telescopes, used in 1961 by astronomer Frank Drake, who created the famous equation for estimating the number of intelligent civilizations in the universe. Sizemore is playing a high-stakes endgame. He's determined to protect this last clear portal to the cosmos. "The Quiet Zone is like a wilderness," he says softly. "Once it's gone, it's gone for good."

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Serving Socorro and Catron Counties • Monday, January 5, 2004

New, Improved Star Party Starts Tuesday

By John Larson
Mountain Mail
johnl@socorroisp.com

SOCORRO – Maybe it's because of the dark skies in Socorro County, or it's because of the world-class astronomers at the Tech and the National Radio Astronomy Observatory, but the Enchanted Skies Star Party brings in students, star-gazers and astronomy buffs from all over the country.

It's one of America's leading star parties, and it gets bigger and bigger every year.

The 11th Annual star party begins Tuesday, Oct. 5, and continues through Saturday, Oct. 9.

The event includes new features such as hands-on workshops and a rare opportunity for telescopic viewing of the night sky at a 10,000-foot-high observing site. The star party has received extensive publicity, both national and in-state, this year, and astronomy enthusiasts from more than a dozen states across the nation already have registered, according to NRAO spokesman Dave Finley.

Highlights of the five-day program include an insider's tour of the Very Large Array, dark-sky observing with chuck-wagon dinner at the Pound Ranch, and a night visit to the top of South Baldy Mountain, the site of the Magdalena Ridge Observatory, now under construction.

Finley says the Enchanted Skies Star Party is recognized as one the best in world.

"The September issues of the national publications Astronomy Magazine and Sky and Telescope have given us coverage, so we're expecting more than the 150 or so people we normally get," Finley said. "The majority are out-of-state. We've even had attendees from as far away as Canada, Mexico, the Caribbean, and Europe."

He credits three events that make the Socorro star party so attractive.

"The things they get no where else are the big chuck-wagon dinner at the Pound Ranch, the outstanding lectures, and this year, the overnight trip up to South Baldy Mountain," Finley said. "Most of our attendees come from big cities and the experience here can be once-in-a-lifetime events for them. They not only experience skies with no light pollution, but also a taste of western life and culture. And the lectures offered are by highly recognized astronomers, as opposed to other star parties in which often you find amateurs giving lectures to other amateurs."

Finley said local residents will be admitted free to the Friday night sessions at Etscorn Observatory at Tech, and the keynote lecture by VLA Director Dr. James Ulvestad.

See STARS on page 5

Stars: Week-long Event Culminates With Barbecue Feast

Continued from front page

The chow-down at the Pound ranch is on the last night.

Joe Pound says star-gazers will be well fed at the chuck-wagon dinner Saturday night.

"We're going cook up about 120 pounds of beef, six or seven 18-pound turkeys, 45 to 50 pounds of cole slaw, seven to eight gallons of pinto beans, and eight dozen cookies," Pound said. "And they'll eat about a gallon and a half of green and red chile, and drink 12 gallons of coffee and five or six gallons of tea and punch. We're expecting to serve around 200 people. It's our eighth year for doing this."

Pound said he gets a lot of help from family and friends. His wife, Cathy, and daughters, Julie, Corrie Lynn, and Ashley, all pitch in to help get the dinner together.

Along with a bonfire, entertainment is provided, too.

"We stay the whole night with them," Pound said. "Last year, Doug Figg brought his guitar and we serenaded them till about 2 a.m., the year before that till four. Doug will be back again, of course."

Enchanted Skies Star Party Schedule

Tuesday, Oct. 5

1 p.m. Bringing Astronomy to the Public: Educational Outreach, Dr. Suzanne Chippendale, Astronomical Society of the Pacific, Skeen Library.

3 p.m. CCD Imaging. Dr. Scott Teare, New Mexico Tech, Skeen Library.

8 p.m. Observing at NM Tech's Etscorn Campus Observatory, including demonstrations of state-of-the-art CCD imaging system and software.

Wednesday, Oct. 6

12:30 p.m. Welcome and Orientation, Skeen Library.

1p.m. Using The Sky Software, Tom Bisque, Software Bisque, Skeen Library.

3 p.m. Mandatory Meeting for all participants planning to go to South Baldy, ,Skeen Library.

Observing at 10,000 Feet — atop Socorro County's South Baldy peak. Convoy leaves Socorro approximately 5:00 p.m.

Thurday, Oct. 7

2 p.m. Insider's Tour of the National Science Foundation's Very Large Array Radio Telescope at the VLA site..

8 p.m. Observing at the Etscorn Observatory

Friday, Oct. 8

1 p.m. Orientation Presentation, Macey Conference Center, New Mexico Tech Campus.

1:30 p.m. Lecture: Many colors of the Sun: Exploring the solar spectrum, Dr. Han Uitenbroek, National Solar Observatory, Sunspot, N.M., Macey Center.

3:00 p.m Lecture: Cosmic Nurseries: How Stars and Planets Form, Dr. Debra Shepherd, National Radio Astronomy Observatory, Macey Center.

4:30 p.m. Lecture: Fighting Light Pollution – Effective Strategies, Shannon L. Papin, Director, Night Sky Program, New Mexico Heritage Preservation Alliance, Macey Center.

7 p.m. Keynote Lecture: The VLA: Past Glory and Future Discoveries, Dr. James Ulvestad, National Radio Astronomy Observatory, Macey Center.

8:30 p.m. Observing at the Etscorn Observatory. Open to the public.

8:30 p.m. Bill Spargo Memorial Lecture: Learning the Constellations, G.B. Cornucopia, U.S. National Park Service, Etscorn Observatory

Sat. Oct. 9

1:30 p.m. Lecture: Solar Storms and Space Weather, Dr. Alexi Pevtsov, National Solar Observatory, Sunspot, N.M., Macey Center.

5 p.m. Saturday-night chuck-wagon dinner and observing at one of the darkest star-party sites in the U.S., Socorro County's Pound Ranch. Shuttle Service to Pound Ranch begins at 3 p.m.

7 p.m. Campfire Lecture: Star Tales of the Ancients, G.B. Cornucopia, U.S. National Park Service.

The National Radio Astronomy Observatory is a facility of the National Science Foundation
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