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ALMA misc.

REMARKS ON THE SCIENTIFIC SIGNIFICANCE OF ALMA  
By RICCARDO GIACCONI at the  
Groundbreaking Ceremony on November 6, 2003

I HAVE BEEN ASKED TO MAKE A BRIEF STATEMENT ABOUT THE SCIENTIFIC SIGNIFICANCE OF THE EVENT WE CELEBRATE HERE TODAY. THE EXCITING DISCOVERIES IN ASTRONOMY AND ASTROPHYSICS OF THE LAST DECADE AND THE GREAT TECHNOLOGICAL ADVANCES IN ASTRONOMICAL INSTRUMENTATION HOLD THE PROMISE THAT IN THE BEGINNING OF THIS NEW MILLENNIUM WE WILL TAKE A GIANT STEP FORWARD IN OUR UNDERSTANDING OF THE COSMOS. IN THE LAST DECADE WE HAVE, FOR THE FIRST TIME, DISCOVERED THE EXISTENCE OF NUMEROUS PLANETS AROUND STARS OTHER THAN THE SUN; WE HAVE PEERED AT THE VERY EDGE OF THE VISIBLE UNIVERSE ONLY A FEW HUNDRED THOUSAND YEARS AFTER THE BIG BANG TO STUDY THE SEEDS OF GALAXY FORMATION; WE HAVE FOUND EVIDENCE OF A NEW FORM OF ENERGY THAT MIGHT BE THE LARGEST CONSTITUENT OF THE UNIVERSE. WE HAVE FOUND THAT GALAXIES AND CLUSTERS OF GALAXIES WERE FORMED MUCH EARLIER THAN WE HAD THOUGHT AND THAT MOST GALAXIES (INCLUDING OUR OWN) HARBOR MASSIVE BLACK HOLES. THE STUDY OF BLACK HOLE PHYSICS AND OF THE PHENOMENA OCCURRING IN  $\Gamma$  RAY BURST SOURCES HAS MADE GREAT ADVANCES AND HOLDS THE PROMISE TO TEST THEORIES OF GRAVITY, INCLUDING GENERAL RELATIVITY, UNDER STRONG FIELD CONDITIONS. FOR THE FIRST TIME WE HAVE DETECTED NEUTRINOS FROM A SUPERNOVA EXPLOSION AND EXTENDED ASTROPHYSICAL OBSERVATIONS OF SPECIFIC PHENOMENA TO PARTICLE DETECTION.

AN AMBITIOUS PLAN OF STUDY HAS EMERGED FOR THE NEXT TWENTY OR THIRTY YEARS WHICH COMBINES THE STUDY OF THE EXTREMELY LARGE WITH THAT OF THE EXTREMELY SMALL. TO UNDERSTAND THE UNIVERSE WE NEED TO FURTHER ADVANCE OUR KNOWLEDGE OF THE FUNDAMENTAL LAWS OF PHYSICS AND OF THE ELEMENTARY CONSTITUENTS OF MATTER. THE UNIVERSE ITSELF IS BECOMING THE LABORATORY WHERE THE VERY HIGH ENERGIES, HIGH DENSITIES, AND STRONG FIELDS

PROVIDE THE TESTING GROUND FOR THESE NEW LAWS. THIS PLAN ANTICIPATES THE DEVELOPMENT OF NEW AND MORE POWERFUL OBSERVATIONAL FACILITIES IN ALL THE WAVELENGTHS OF THE ELECTROMAGNETIC SPECTRUM, AS WELL AS PARTICLE DETECTORS, THROUGH INTERNATIONAL COLLABORATIONS ON A SCALE NEVER SEEN BEFORE. ALMA WILL BE AT THE FOREFRONT OF THESE FACILITIES AND HOPEFULLY WILL PROVIDE A MODEL FOR SUCH COLLABORATIVE EFFORTS. ALMA OBSERVATIONS WILL SERVE TO ELUCIDATE MANY OF THE MOST IMPORTANT QUESTIONS IN ASTROPHYSICS TODAY.

ALMA WILL PERMIT US TO STUDY THE DISTANT UNIVERSE AND OBSERVE THE FIRST SEEDS OF GALAXY FORMATION AND THE SUBSEQUENT GALAXY EVOLUTION. IT WILL HAVE THE REQUIRED SENSITIVITY, RESOLUTION AND BANDWIDTH TO OBSERVE THE SMALL SCALE ANISOTROPIES IN THE COSMIC MICROWAVE BACKGROUND IMPRINTED BY THE INITIAL FLUCTUATIONS AT  $Z \sim 100$  AND THE DISTORTIONS DUE TO THE SUNYAEV-ZELDOVICH EFFECT IN CLUSTERS OF GALAXIES. TOGETHER WITH X-RAY OBSERVATION THIS WILL PERMIT DIRECT MEASUREMENT OF THE SIZE AND CURVATURE OF THE UNIVERSE.

ALMA WILL HAVE UNSURPASSED SENSITIVITY AND IMAGING CAPABILITIES FOR MOLECULAR SPECTROSCOPIC STUDY OF EXTERNAL GALAXIES AND WILL BE ABLE TO DETECT THE FIRST GALAXIES FORMED THROUGH THEIR DUST EMISSION AT  $Z > 20$ . IT WILL BE ABLE TO STUDY STAR FORMATION CORES IN NEARBY GALAXIES AND ASSESS THE ROLE OF MORPHOLOGY AND ENVIRONMENT IN THEIR DYNAMIC AND CHEMICAL EVOLUTION. THE SITING OF ALMA IN THE SOUTHERN HEMISPHERE WILL PERMIT DETAILED STUDIES OF THE LARGE AND SMALL MAGELLANIC CLOUDS. THE STUDY OF ORGANIC MOLECULES IN INTERSTELLAR SPACE WILL PROVIDE INDISPENSABLE CLUES TO THE ORIGIN OF LIFE IN THE UNIVERSE.

ALMA WILL OFFER UNIQUE CAPABILITIES TO STUDY SUPER MASSIVE BLACK HOLES IN ALL GALAXIES INCLUDING OUR OWN. WITH THE SAME ANGULAR RESOLUTION OF THE

HUBBLE SPACE TELESCOPE, ALMA CAN RESOLVE THE DISKS FUELING THE CENTRAL BLACK HOLES IN GALAXIES AS FAR AS VIRGO AND YIELD GEOMETRY, PHYSICAL CONDITIONS AND KINEMATICS OF THE GAS. FINALLY IF USED AS THE PRIME COMPONENT IN A WORLD WIDE MILLIMETER WAVE VLBT NETWORK, ALMA WOULD ALLOW US TO MAP THE STRUCTURE OF ACTIVE GALACTIC NUCLEI WITH A RESOLUTION OF 10 MICRO ARC SECONDS, THE HIGHEST RESOLUTION ACHIEVABLE IN ASTRONOMY. THUS ALMA WILL CONTRIBUTE TO THE ALL WAVELENGTH ATTACK ON THE FUNDAMENTAL PROBLEMS OF THE ORIGIN OF THE UNIVERSE, OF DEVELOPMENT OF STRUCTURES AND POSSIBLY OF ORGANIC LIFE.

I WOULD LIKE TO CONCLUDE WITH A VERY BRIEF PERSONAL REMARK. I CONSIDER MYSELF EXTREMELY FORTUNATE IN HAVING LIVED IN THIS EPOCH OF ADVANCES IN ASTRONOMY NOT EQUALED SINCE THE TIME OF COPERNICUS, GALILEO, KEPLER, TYCHO AND NEWTON. I WAS PRIVILEGED IN BEING ASSOCIATE WITH SOME OF THE GREAT ENTERPRISES IN OUR FIELD: THE START OF X-RAY ASTRONOMY AND THE DEVELOPMENT OF CHANDRA, THE OPERATION OF THE HUBBLE SPACE TELESCOPE, THE DEVELOPMENT OF THE VERY LARGE TELESCOPE ON PARANAL AND NOW THE START OF THE ALMA PROJECT. IN SOME OF MY RECENT PAPERS I FOUND MYSELF USING DATA FROM CHANDRA, HST AND VLT TO CLARIFY, AFTER FORTY YEARS OF WORK, THE MYSTERY OF THE X-RAY BACKGROUND. STILL SOME OF THE X-RAY SOURCES WE OBSERVE IN THE DEEPEST SURVEY ARE SO FAINT THAT NEITHER HST NOR VLT CAN IDENTIFY THEM, AND THEY MAY WELL BE NEW TYPES OF CELESTIAL OBJECTS. I HOPE ALMA WILL BE ABLE TO SOLVE THIS NEW MYSTERY IN MY LIFETIME. I WOULD LIKE TO END BY THANKING OUR HOST, CHILE, FOR JOINING US IN THIS NOBLE VOYAGE OF DISCOVERY AND MAKING THIS ENCHANTED LAND THE HOME FOR SOME OF THE MOST IMPORTANT OF THESE GREAT ENTERPRISES.