

NATIONAL RADIO ASTRONOMY OBSERVATORY
GREEN BANK, WEST VIRGINIA

ELECTRONICS DIVISION INTERNAL REPORT No. 159

INTERFERENCE POTENTIAL FOR RADIO ASTRONOMY
OBSERVATIONS AT GREEN BANK, WEST VIRGINIA

CRAIG R. MOORE AND JAMES L. DOLAN

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Craig R. Moore and James L. Dolan

Introduction

This report attempts to summarize possible sources of radio interference to radio astronomy observations at the NRAO, Green Bank, WV. The interference is considered to originate from three categories of sources: radiometers and electronics equipment at Green Bank, FCC and IRAC licensed emitters within and outside the Radio Quiet Zone, and unintentional sources of interference, i.e., emissions from automobile ignitions, power lines, TV boosters, etc. This report is intended as an aid to line observers in particular, so that they might judge the magnitude of the interference problem before they begin observations. It is strongly urged that this report be consulted whenever observations at wavelengths longer than 21 cm are contemplated. The National Radio Quiet Zone does not guarantee that there will be no interference at Green Bank; it merely provides that we will know more about the sources and potential than at any other location in the U. S.

A. Green Bank Electronics Equipment

Most of our radiometers are potential sources of narrow-band interference. A list of possible spurious signals is attached.

The most likely sources of inter-telescope interference are the Universal Local Oscillators which can generate up to 1 watt in the frequency range 1-2 GHz. We have had cases of this occurring: (1) between 140-ft and 140-ft and (2) 140-ft and 300-ft. In these cases the RF output was tuned within the pass band of the line receivers.

The interferometer and 45-ft microwave link is also another known source of trouble, especially at 1300.0, 1347.4, 1347.5, and 1347.6 MHz. The link can be turned off for some observations; however, the 1347.5 signal might still be seen at the 300-ft telescope with the autocorrelator.

Spectral line observers would be well advised to check this list before observing. The Electronics Division engineer responsible for a system will attempt to minimize interference and warn the observers of possible problems.

It should be noted that only a few of these signals will be present at any one time, and most have never been seen as interference.

INTERFERENCE POTENTIAL OF EQUIPMENT AT GREEN BANK
LISTING BY FREQUENCY

Frequency MHz	Status	Potential Source	Location	Frequency MHz	Status	Potential Source	Location
30	P	Interferometer LO system	Interf. Baseline	1650-1950	*	2-4 GHz receiver	140'
35	P	Autocorrelator, Mark II, III	140' & 300' or Int.	1669-1731	*	Cooled 2 cm receiver	140'
40	P	Autocorrelator, Mark II, III	140' & 300' or Int.	1690-1930	*	Cooled 18 cm receiver	140' or 300'
43.0	†	VHF FM communications	Reber	1700	P	Universal LO	140' & 300'
100		Cooled 2 cm receiver	140'	1720-1780	*	Cooled 3 cm receiver	140'
100		Cassegrain receiver	140'	1823-1954	*	Cassegrain receiver	140'
100	P	Universal LO	140' & 300'	2100-2400	*	2-4 GHz receiver	140'
90-100	P	Hydrogen maser	140'	2445	*	13 cm VLB receiver	140'
103	P	IF Processor	140' & 300'	2545	*	11 cm receiver	140' or 300'
115	P	IF Processor	300' & 140'	2600-3100	*	2-4 GHz receiver	140'
100-160	P*	IF Processor - GR synthesizer	140' & 300'	2695		11 cm, 3-feed	300'
120	P	Autocorrelator, Mark II, III	140' & 300' or Int.	2695	P	Interferometer receivers	85' - 1, 2, 3
124-180	*	12.4-18 GHz line receiver	140'	3150-3270	*	Cassegrain receiver	140'
134.75		11 cm, 3-feed receiver	300'	3300-3900	*	2-4 GHz receiver	140'
240-300	P*	Universal LO - HP synthesizer	140', 300' & Int.	4400		Cassegrain receiver	140'
250-1150	*	100-1000 MHz receiver	140'	4680-5160	*	6 cm ALL receiver	140' or 300'
350-590	*	500-740 MHz receiver	140' or 300'	4680-4980	*	6 cm TRG receiver	140' or 300'
590-850	*	740-1000 MHz receiver	140' or 300'	5050-10,550	*	5.4-10.4 GHz receiver	140'
650-890	*	500-740 MHz receiver	140' or 300'	5390	P	Interferometer receivers	85' - 1, 2, 3
670	†	Temp. calibration receiver	Little Big Horn	5390		11 cm, 3-feed receiver	300'
890-1150	*	740-1000 MHz receiver	140' or 300'	6938	†	Interferometer 21 cm receiver	85' - 1, 2, 3
900		Cooled 2 cm receiver	140'	7550-7850	*	7.8 GHz cooled receiver	140'
900	P	Universal LO	140' & 300'	8085	P	Interferometer receivers	85' - 1, 2, 3
1000-1250	*	5.2-10.4 GHz receiver	140'	10,000-10,340	*	1-2 GHz receiver	140'
1000-1600	P*	IF Processor	140' & 300'	10,320-10,680	*	Cooled 3 cm receiver	140'
1000-2150	*	1-2 GHz receiver	140' & 300'	10,612		Cassegrain receiver	140'
1030	P	IF Processor	140' & 300'	11,320-11,390	*	2-4 GHz receiver	140'
1050-1090	*	Cassegrain receiver	140'	11,835		13 cm VLB receiver	140'
1050-1200	*	2-4 GHz receiver	140'	12,400-18,000	*	12.4-18 GHz line receiver	140'
1079-1121	*	7.8 GHz cooled receiver	140'	13,350-13,850	*	Cooled 2 cm receiver	140'
1100		Cassegrain receiver	140'	16,170	P	Interferometer receiver	85' - 1, 2, 3
1150	P	IF Processor	300' usually	17,450-19,050	*	Cassegrain receiver	140'
1220-1290	*	Cooled 21 cm receiver	140' or 300'	17,500	P	Link from 45'	45'
1222.5	*	13 cm VLB receiver	140'	19,150-20,150	*	Cassegrain receiver	140'
1250	†	Temp. calibration receiver	Little Big Horn	20,000-21,000		500-700, 740-1000 MHz receivers	140' or 300'
1272.5	*	11 cm Receiver	140' or 300'	20,000-22,000	†	Tourist receiver	2'
1300	P	Universal LO	140' & 300'	20,200-20,400		Cooled 21 cm receiver	140' or 300'
1300	P	Link to 45'	Interf. Tower	20,600		6 cm ALL receiver	140' or 300'
1300-1550	*	2-4 GHz receiver	140'	20,815		21 cm, 4-feed receiver	140' or 300'
1317.5	P	Interferometer LO	Interf. Baseline	20,815	†	Interferometer 21 cm receiver	85' - 1, 2, 3
1347.4	P	Link from 45'	45'	21,700		Cooled 18 cm receiver	140' or 300'
1347.5	P	Interferometer LO	Interf. Baseline	23,670		13 cm VLB receiver	140'
1347.6	P	Link to 45'	Interf. Tower	27,450		11 cm receiver	140' or 300'
1390-1630	*	Cooled 18 cm receiver	140' or 300'	31,400-35,600	*	5.2-10.4 GHz receiver	140'
1400	P	Hydrogen maser	140'	31,835		Cassegrain receiver	140'
1475-1575	*	Cassegrain receiver	140'	33,400		7.8 GHz cooled receiver	140'
1520-1590	*	Cooled 21 cm receiver	140' or 300'	39,700		6 cm TRG receiver	140' or 300'
1550		21 cm, 4-feed	300'	40,000		Cooled 3 cm receiver	140'
1560-1660	*	6 cm TRG receiver	140' or 300'	41,900		Cooled 2 cm receiver	140'
1560-1720	*	2-4 GHz receiver	140'				

P - ON SEMI-PERMANENTLY.

* - MOVES AROUND DURING OBSERVING SESSION.

† - INTERMITTENT USAGE.

INTERFERENCE POTENTIAL OF EQUIPMENT AT GREEN BANK
LISTING BY EQUIPMENT

Receiver	Signal on Cable	LO	Pump	Remarks
50- 80 MHz 110-250 MHz 250-500 MHz	None. None. None.	None. None. None.	None. None. None.	) IF Processor used as) frequency converter) for those receivers.
500-740	350-590, 650-890	350-590, 650-890	20-21 GHz	X2 downstairs.
740-1000	590-850, 890-1150	590-850, 890-1150	20-21 GHz	X2 downstairs.
100-1000	250-1150	250-1150	None.	X2 downstairs (if needed).
21 cm, 4-feed	1550	1550	20.215 GHz	
21 cm cooled	1220-1290, 1520-1590	1220-1290, 1520-1590	20.2-20.4 GHz	
18 cm cooled	1390-1630, 1690-1930	1390-1630, 1690-1930	21.7 GHz	
1-2 GHz	1000-2150 MHz	1000-2150	10.0-10.34 GHz	Set of four paramps.
2-4 GHz	1050-1200, 1300-1550, 1650-1950	2100-2400, 2600-3100, 3300-3900	11.23-11.39 GHz	Set of three multipliers and paramps.
2295 VLB	1222.5	2445	11,835 x 2	
11 cm, 3-feed	None.	2695	5390	2695 MHz oscillator locked to 134.75 MHz.
11 cm	1272.5	2545	27.45 GHz	
6 cm AIL	1560-1720	4680-5160	20.6 GHz	
6 cm TRG	1560-1660	4680-4980	39.7 GHz	
7.8 GHz cooled	1079-1121	7550-7850	33.4 GHz	
5.2-10.4 GHz	1000-1250	5050-10,550	31.4-35.6 GHz	Set of seven paramps.
3 cm cooled	1720-1780	10,320-10,680	40.0 GHz	
2 cm cooled	1669-1731 100	13,350-13,850 900	41.9 GHz	2nd LO.
12.4-18 GHz	124-180 MHz	12,400-18,000	None.	Locked BWO LO.
Interferometer	30.0, 1317.5, 1347.5	1347.5	NA	Multiplexed X2,X4,X6,X12
		2695	5390	S-Band receiver
		8085	16,170	X-Band receiver
		1347.5	6930 x 3	21 cm receiver
	1300, 1347.6	NA	NA	Link to 45'
	17,500, 1347.4	NA	NA	Link from 45'
140' Cassegrain	1823-1970	17,450-19,250	NA	K-Band receiver.*
	1475-1575	19,150-20,150	NA	Ku-Band receiver.*
	100	1100 x 4	10,612 x 3	6 cm receiver.
	1080-1090	NA	3150-3270	18/21 cm receiver.*
Little Big Horn	NA	670 or 1250	NA	GR unit oscillator LO.
2' Tourist	NA	20,000-22,000	NA	

* 6 CM RECEIVER REQUIRED FOR IF AND 2ND CONVERSION.

OTHER SOURCES

(Above 15 MHz)

Equipment	Frequency	Remarks
VHF-FM Communications Transmitter	43.0	Mobile communications to 45-ft.
Autocorrelator — Mark II and Mark III	120.0 40.0 35.0	Crystal oscillators within RF enclosure.
IF Processor — 140-ft and 300-ft	100- 160 1000-1600 103 1030 115 1150	GR synthesizer. Multiplier and locked oscillator. Locked oscillator. Multiplier output. Crystal oscillator. Multiplier output.
Universal Local Oscillator	240-300 100 900, 1300, 1700	HP synthesizer. Locked oscillator)) Frequency Multiplier output) counter
Hydrogen Maser — 140-ft	1400 90-100	1st LO Ionization oscillator.
Antenna Test Range	100 MHz - 90 GHz	Intermittent usage.

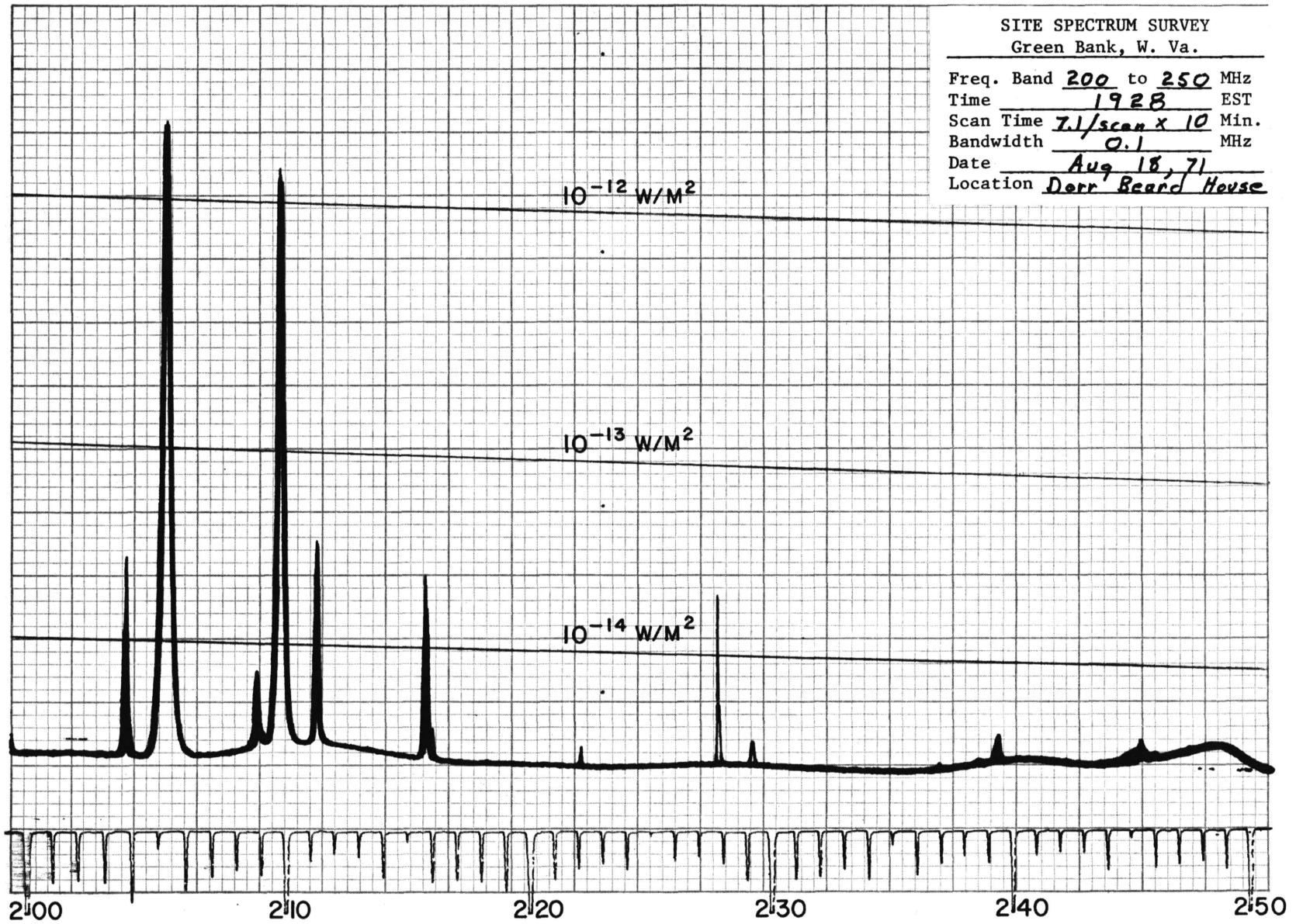
B. Licensed Transmitters Within the Radio Quiet Zone

When the radio controlled zone was authorized by the FCC and the IRAC in 1958, the NRAO started keeping records of all licenses issued within the area. Over the years some of the transmitters that were in existence before this time have been added to our records until at present the list is estimated to be about 97% complete. The computer printout of these licensed emitters is updated once each year, and copies are available to prospective observers; also, each telescope has at least one copy. The list includes pertinent technical parameters and a prediction of power density at Green Bank from each transmitter. Most of the transmitters are in point-to-point communications bands, FCC, or military aircraft bands, and broadcast bands. The list contains fixed licensed transmitters, other than amateur and citizen band, within the zone. A sample page from the report is attached.

However, stations outside the zone can also cause interference. In order to statistically sample band occupancy, a spectrum survey was made with wide-band radiometers and a spectrum analyzer. This survey was made during the summer of 1971. The data is still indicative of signals actually observable at Green Bank. The survey covered the spectrum from 100 MHz to 4.0 GHz, and copies of this Electronics Division Internal Report No. 116 are available at all telescopes. A sample page from this report is attached. It should be pointed out that the attached page from the transmitter printout shows no licensed emitters between 172 MHz and 218 MHz within the Quiet Zone, and the page from the Green Bank survey shows several strong TV signals in the 204-216 MHz band.

A brief description of the survey results follow.

From: Electronics Division Internal Report No. 116,
"Green Bank Environmental Spectrum Survey: Summer 1971".



FREQUENCIES ARE IN MHZ; BAND EDGES ARE APPROXIMATE.

- 1) 100-108: Commercial FM; no chance to observe.
- 2) 108-118: Radio location omni; possible to observe narrow band between transmitters.
- 3) 118-137: VHF aircraft, air-to-ground, ground-to-air. Very strong signals; no chance for effective observations.
- 4) 137-148: Government, 2-meter amateur band. Possible to observe on some frequencies; very little 2-meter amateur activity in the area. Bands should be kept narrow and tunable.
- 5) 148-200: Includes point-to-point communications bands and commercial television. Small chance of observations. Lots of spurious TV signals make measurements risky.
- 6) 200-250: More TV up to 216 MHz.
220-225 -- 1 1/4 meter amateur band should be good spot to observe; no amateur activity in this area.
225-250 -- fixed mobile; not much activity here; may be possible to observe with narrow bandwidth and tunable front-end.
- 7) 250-375: Mostly government band, with some aircraft. It may be possible to observe with selected bands and tunable front-end. Some aircraft activity and point-to-point communications.
- 8) 375-500: Fixed and mobile, and some meteorological aids around 400 MHz.
406.1-410 -- allocated to radio astronomy. May be possible to observe in 410-470 MHz region, but 450-470 MHz is heavily assigned.
470 -- beginning of UHF TV channels. Channel 15 is at Roanoke, Virginia and exceeds 10^{-12} W/m² at Green Bank.
- 9) 500-1000: TV broadcast to 806 MHz. Channel 37 (608-614 MHz) can be used for radio astronomy for the present. The remainder of the band is doubtful because of TV assignments outside the zone. It may be possible to select a band that is not assigned near Green Bank. This would have to be done on an individual basis.
- 10) 1000-2000: DME-TACAN on 1.1 GHz \pm 100 MHz. Avoid this area; these aircraft signals make observing virtually impossible.
1200-1350 -- considerable radar signals in this area. Possible to observe only under carefully controlled conditions. Some satellite signals just above radio astronomy band, extending up to 1700 MHz. Also radiosondes around 1680 MHz. SMS series satellites centered around 1681 MHz with sidebands extending through the 1660-1670 MHz band.
1800-2000 -- mostly government; may be possible to observe under controlled conditions.
- 11) 2000-4000: Regular observations carried out on 2695 MHz (11 cm) and 3100 MHz (9 cm). Some trouble with ATS series satellites but not expected to be permanent -- at present only about 2 to 3 hours per week. Not much known about remainder of band, but it should be possible to observe relatively interference-free in selected areas.

C. Other Sources of Interference

The potential interfering signals discussed in the preceding paragraphs are intended, man-made signals of one type or another. Possibly the more troublesome type of interference is unintended radiation from various sources, particularly in the range from 100 to 1000 MHz. Interference from commercial power lines, oscillating TV boosters, gasoline engine ignition systems, defective switches, relays, etc., adinfinitum, are definite possibilities.

An effort is made to keep local sources suppressed, but astronomers and operators should report instances of this type of interference to the Electronics Division.

ADDENDUM

NATIONAL RADIO ASTRONOMY OBSERVATORY

TECHNICAL DATA SHEET

MAY 1975

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INTERFERENCE POTENTIAL AT GREEN BANK, WEST VIRGINIA

BANDS WHERE OBSERVATIONS ARE SUBJECT TO INTERFERENCE:

88	-	108 MHz	.....	FM commercial.
118	-	137 MHz	.....	VHF communications bands.
174	-	216 MHz	.....	Commercial VHF TV.
240	-	250 MHz	.....	Wideband computer noise.
470	-	590 MHz	.....	Commercial UHF TV.
1000	-	1200 MHz	.....	DME, TACAN, Elkins radar 1179 MHz.
1275	-	1325 MHz	.....	Radar.
1300	±	1 MHz	.....	Interferometer link.
1347.5	±	1 MHz	.....	Interferometer link.
1683	±	5 MHz	.....	SMS satellites, radiosondes.
2660	±	30 MHz	.....	ATS-6 satellite.
17500	±	1 MHz	.....	Interferometer link.

BANDS WHERE OBSERVATIONS MAY BE MADE UNDER CONTROLLED CONDITIONS:

108	-	118 MHz		
137	-	174 MHz		
216	-	470 MHz		
590	-	1000 MHz	.....	UHF TV. (Some channels available on high end.)
1200	-	1275 MHz	.....	Airport radar at 1209 MHz.
1275	-	2000 MHz		
2000	-	4000 MHz		
4000	-	8000 MHz	.....	Common carrier: 4000 MHz ± 300 MHz. Satellite : 6100 ± 300 MHz, 7300-7750 MHz.
8600	-	16000 MHz	.....	Satellites around 8000-8400 MHz and 11.7-12.2 GHz. Airborne radar 9.0-9.2 GHz.
16000	-	25000 MHz	.....	Interferometer link at 17.5 GHz.

BANDS PRESENTLY USED OR THAT HAVE BEEN USED SUCCESSFULLY:

<u>Frequency</u>	<u>Bandwidth</u>	
144 MHz	1 MHz	
184 MHz	1 MHz	
236 MHz	1 MHz	
258 MHz	3 MHz	
321.5 MHz	10 MHz	
394 MHz	10 MHz	
440 MHz	3 MHz	
515.5 MHz	3 MHz	(between TV video and audio)
610 MHz	10 MHz	
770 MHz	10 MHz	
835 MHz	10 MHz	
920 MHz	10 MHz	
970 MHz	10 MHz	

Plus all allocated radio astronomy bands to 40 GHz.

For detailed information, refer to Electronics Division Internal Reports Nos. 116, 147, 155, and 159. For information on licensed transmitters, see "National Radio Quiet Zone Transmitter Printout" (updated each year). It should be noted that below about 500 MHz local power distribution lines are an intermittent problem, and on-line computers can cause interference to local and adjacent instruments, particularly in the 240-250 MHz band. It is the observer's responsibility to inquire about these problems. Contact Jim Dolan, NRAO, Green Bank (304-456-2011, ext. 203).

