Molecular Lines and the AT Frequency Bands

The choice of frequency coverage for the Australia Telescope depends largely on the frequencies of interstellar and circumstellar molecules. There are a very large number of molecular transitions which have been detected astronomically between 327 MHz and 116 GHz. These detections and observed antenna temperatures appear in a listing by Frank Lovas of the US National Bureau of Standards, revised in 1984 (currently in preprint form). There are over 200 entries below 120 GHz which have antenna temperatures above 0.35 K. This is about 20% of the complete list of detections.

A shorter list is recommended by the IAU as being of particular astrophysical importance. There are 30 transitions listed for frequencies below 120 GHz. This list has been used in attempts to gain protection for these frequencies against interference.

Another important factor in establishing frequencies of interest for astronomy is the atmospheric transparency. Water vapour has a strong absorption line at 22.3 GHz, and many more at higher frequencies. The wings of these high frequency features blend to cause a general increase in atmospheric opacity above 20 GHz. Atmospheric oxygen produces strong absorption over a broad band centred near 60 GHz and also a narrow band at 118.7 GHz.

It is important for the AT bands to overlap those of other major radioastronomy observatories, particularly those involved in VLBI. The frequencies chosen for the U.S. VLB array are of particular interest since it is likely that any new radioastronomy receivers built will be influenced by their choice, including QUASAT.

The attached tables list the frequency bands currently suggested for the AT and the VLBA, and the IAU recommended molecular lines. The IAU line frequencies, atmospheric attenuation curve and the currently specified AT bands are plotted on Figure 1. The line temperatures are given the values listed by Lovas as a guide to their strength. The atmospheric curve is in dB of attenuation at the zenith for dry weather. It exceeds 3 dB above 116 GHz and also between 50-70 GHz. The attenuation at 22.3 GHz is about 0.7 dB. The transitions listed by Lovas with Ta > 0.35 K are plotted on Figure 2.

The Lovas list was accurately transferred to a computer database by GwenAnne Manefield. The curve digitization and plotting program was written by Robina Otrupcek. John Whiteoak and Brian Robinson provided the information on atmospheric absorption.

J.R. Forster
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AT and VLBA proposed frequency coverage

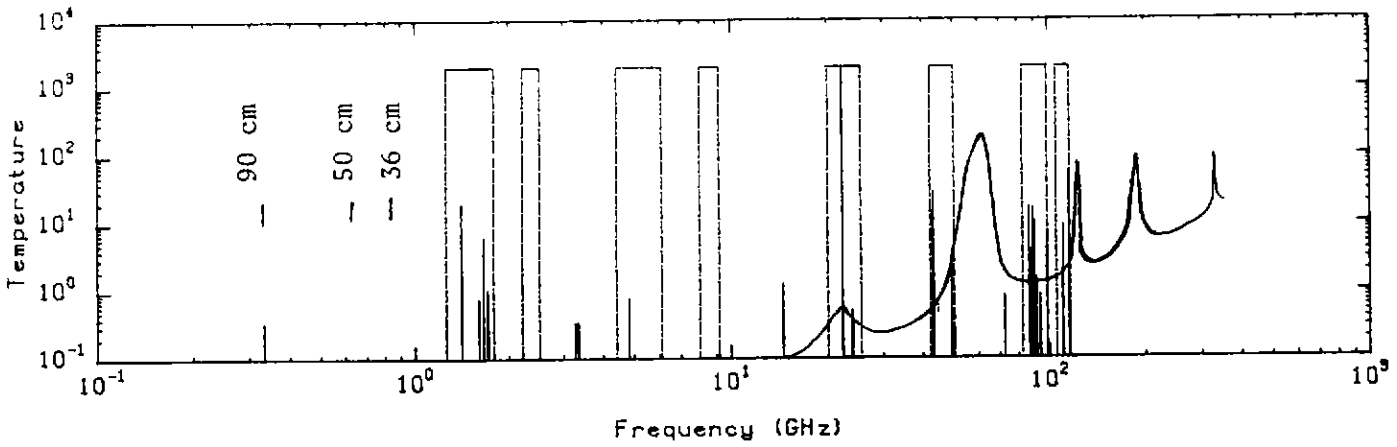
Band Name	VLBA coverage	AT coverage
90 cm	0.312 - 0.342	not specified
50 cm	0.580 - 0.640	not specified
36 cm	not covered	not specified
20 cm	1.35 - 1.75	1.25 - 1.78
13 cm	2.15 - 2.35	2.20 - 2.50
6 cm	4.60 - 5.10	4.40 - 6.10
[5 cm]	[5.90 - 6.40]	not covered
3 cm	8.00 - 8.80	8.00 - 9.20
[2.8 cm]	[10.2 - 11.2]	not covered
2.0 cm	14.4 - 15.4	not covered
1.3 cm	21.7 - 24.1	20.0 - 25.5
7 mm	42.3 - 43.5	42.0 - 50.0
3.5 mm	not covered	84.0 - 98.5
2.6 mm	not covered	105.0 - 116.0

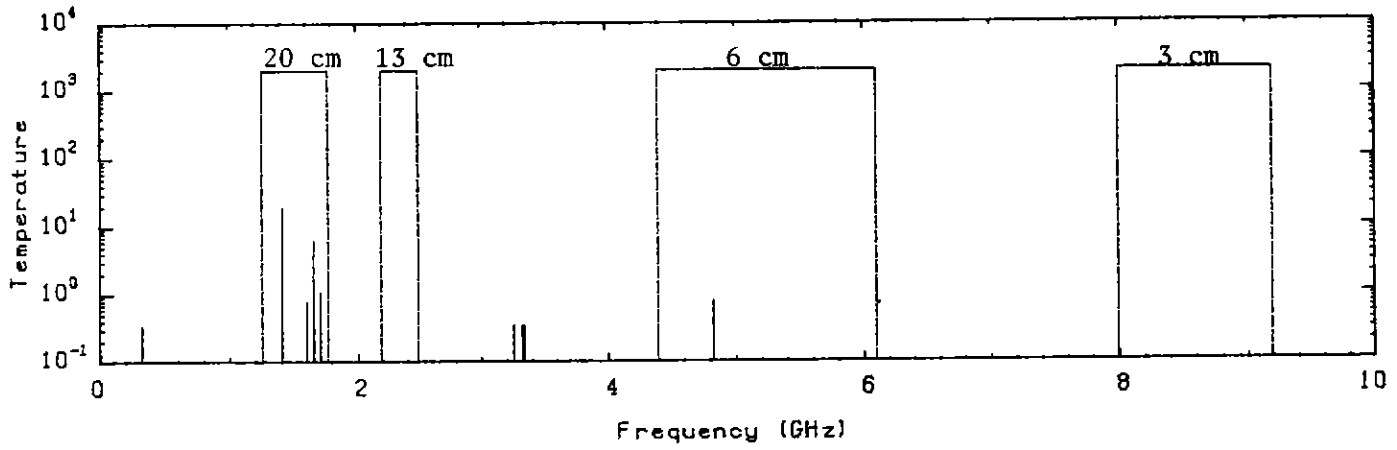
note: [5 cm and 2.8 cm are optional VLBA bands]

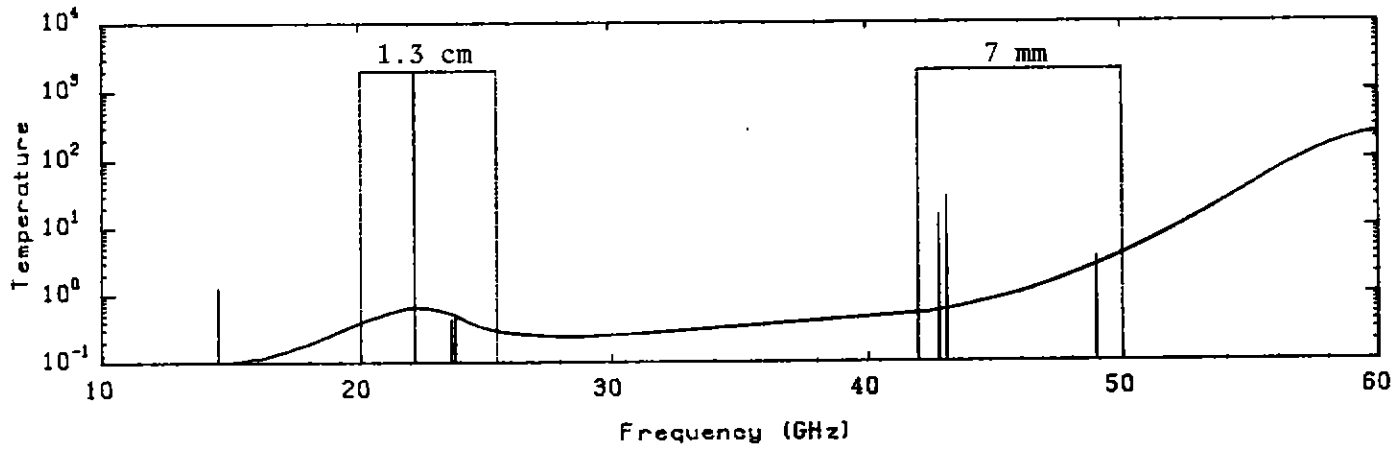
IAU recommended lines of astronomical importance

Substance	Rest frequency		Suggested minimum band			Notes[1]
Deuterium (DI)	327.384	MHz	327.0	- 327.7	MHz	
Hydrogen (HI)	1420.406	MHz	1370.	- 1427.	MHz	(2),(4)
Hydroxyl radical (OH)	1612.231	MHz	1606.8	- 1613.8	MHz	(3),(4)
Hydroxyl radical (OH)	1665.402	MHz	1659.8	- 1667.1	MHz	(3)
Hydroxyl radical (OH)	1667.359	MHz	1661.8	- 1669.0	MHz	(3)
Hydroxyl radical (OH)	1720.530	MHz	1714.8	- 1722.2	MHz	(3),(4)
Methyladyne (CH)	3263.794	MHz	3252.9	- 3267.1	MHz	(3),(4)
Methyladyne (CH)	3335.481	MHz	3324.4	- 3338.8	MHz	(3),(4)
Methyladyne (CH)	3349.193	MHz	3338.0	- 3352.5	MHz	(3),(4)
Formaldehyde (H_2CO)	4829.660	MHz	4813.6	- 4834.5	MHz	(3),(4)
Formaldehyde (H_2CO)	14.488	GHz	14.439	- 14.503	GHz	(3),(4)
Water vapour (H_2O)	22.235	GHz	22.16	- 22.26	GHz	(3),(4)
Ammonia (NH_3)	23.694	GHz	23.61	- 23.71	GHz	(3)
Ammonia (NH_3)	23.723	GHz	23.64	- 23.74	GHz	(3)
Ammonia (NH_3)	23.870	GHz	23.79	- 23.89	GHz	(3)
Silicon monoxide (SiO)	42.821	GHz	42.77	- 42.86	GHz	
Silicon monoxide (SiO)	43.122	GHz	43.07	- 43.17	GHz	
Carbon monosulphide (CS)	48.991	GHz	48.94	- 49.04	GHz	
Deuterated formylium (DCO^+)	72.039	GHz	71.96	- 72.11	GHz	(4)
Silicon monoxide (SiO)	86.243	GHz	86.16	- 86.33	GHz	
Formylium ($H^{13}CO^+$)	86.754	GHz	86.66	- 86.84	GHz	
Ethynyl radical (C_2H)	87.3	GHz	87.19	- 87.54	GHz	(5)
Hydrogen cyanide (HCN)	88.632	GHz	88.34	- 88.72	GHz	(3)
Formylium (HCO^+)	89.189	GHz	88.89	- 89.28	GHz	(3)
Hydrogen isocyanide (HNC)	90.664	GHz	90.57	- 90.76	GHz	
Diazenylium (N_2H^+)	93.17	GHz	93.07	- 93.27	GHz	
Carbon monosulphide (CS)	97.981	GHz	97.88	- 98.08	GHz	
Carbon monoxide ($C^{18}O$)	109.782	GHz	109.67	- 109.89	GHz	
Carbon monoxide (^{13}CO)	110.201	GHz	110.09	- 110.31	GHz	
Carbon monoxide (CO)	115.271	GHz	114.88	- 115.39	GHz	(3)

IAU lines and atmospheric extinction







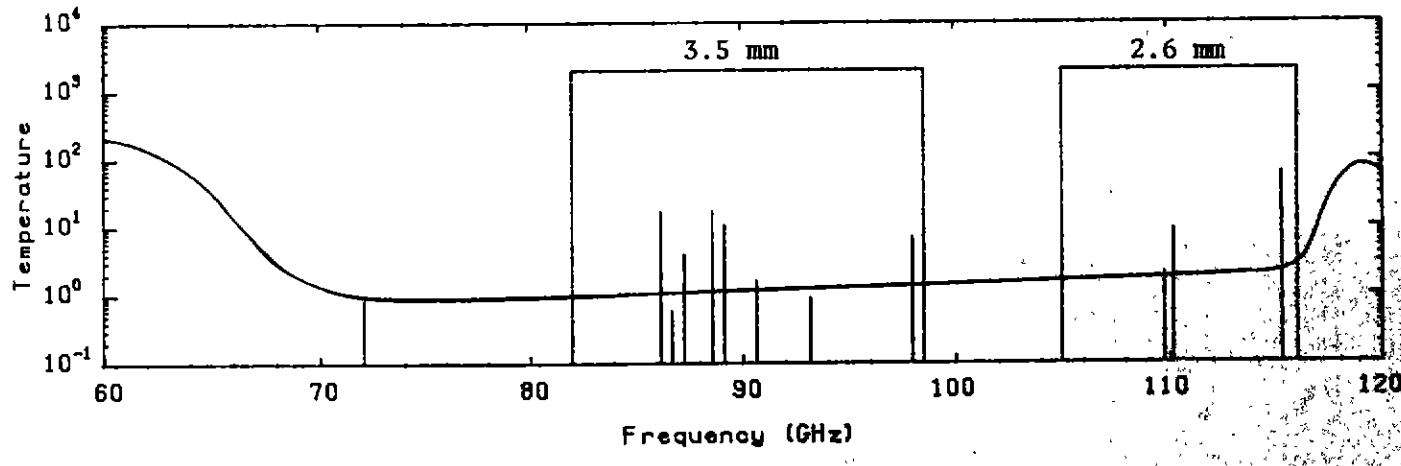
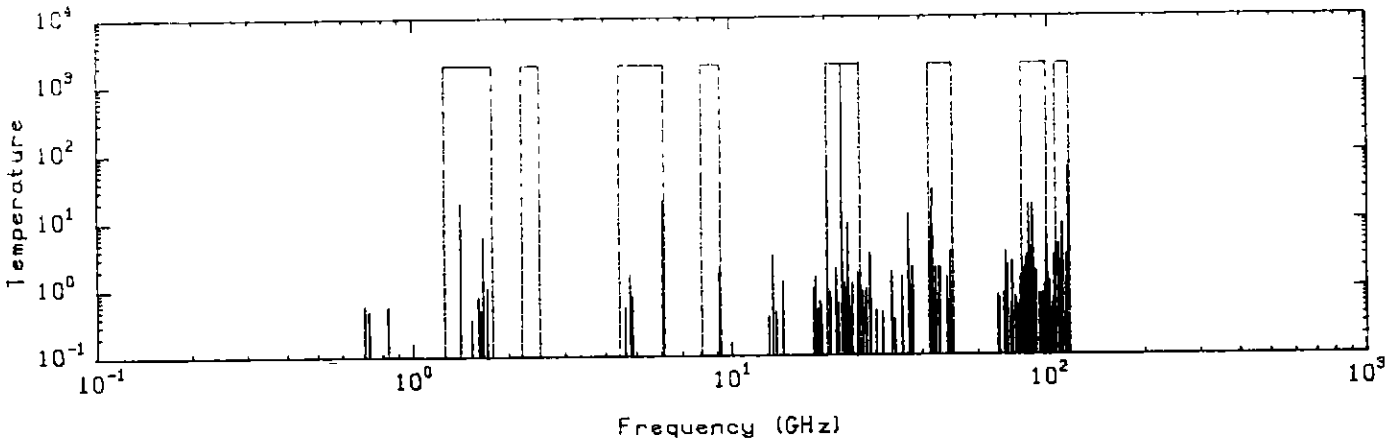
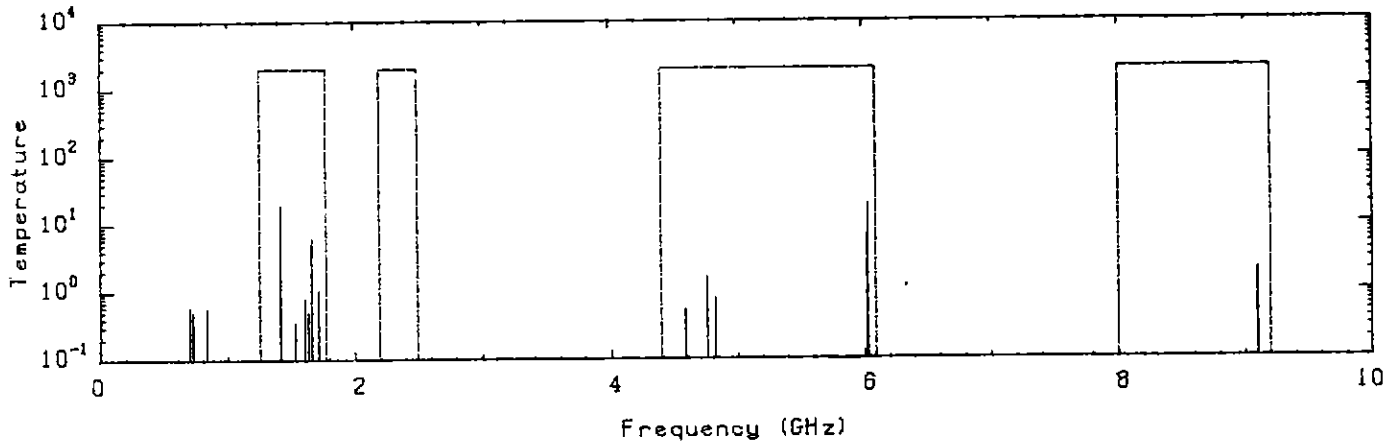
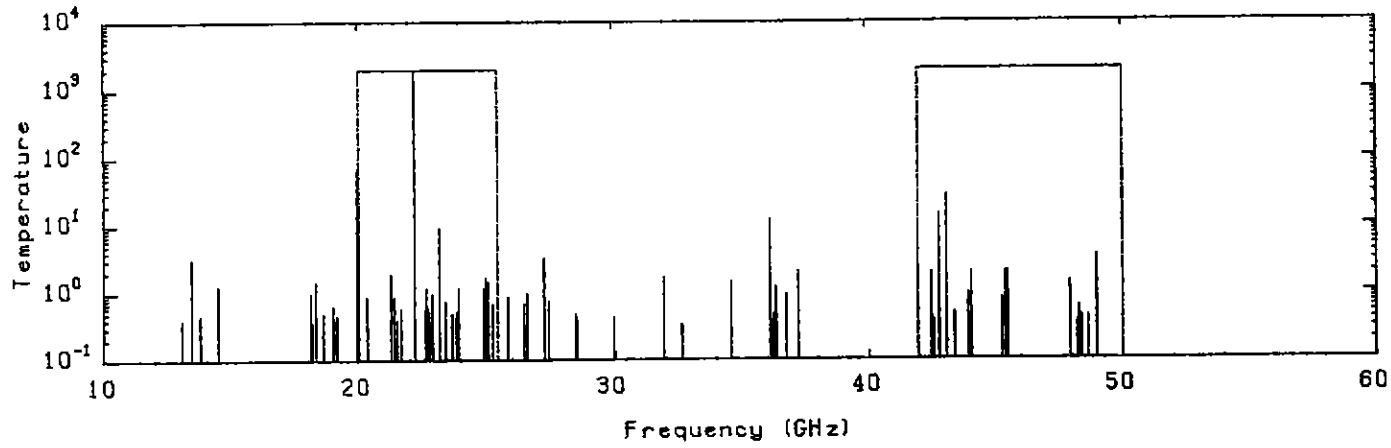


Figure 1

Detected lines (T_a > 0.35 K)







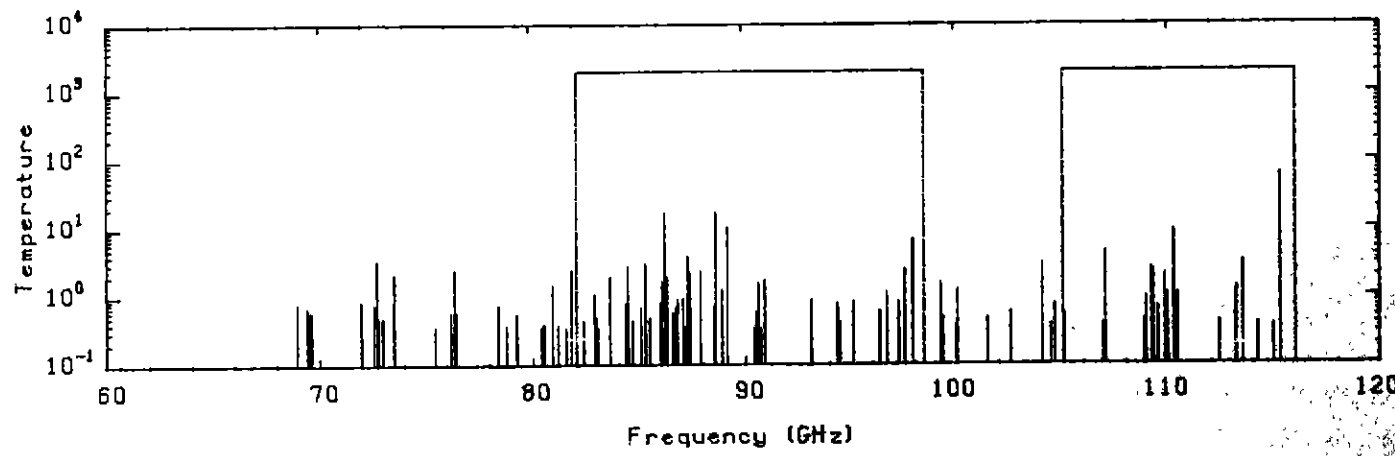


Figure 2