

RECOMMENDATION 314-8

PREFERRED FREQUENCY BANDS FOR RADIOASTRONOMICAL MEASUREMENTS

(Question 145/7)

(1953-1956-1959-1966-1970-1974-1978-1982-1986-1990-1992)

The CCIR,

considering

- a) that the development of radioastronomy has already led to major technological advances, particularly in receiving techniques, and to improved knowledge of fundamental radio-noise limitations of great importance to radiocommunication, and promises further important results;
- b) that protection from interference on certain frequencies is essential to the advancement of radioastronomy and the associated measurements;
- c) that revised lists of the frequencies of the astrophysically most important spectral lines were approved by the General Assembly of the International Astronomical Union (IAU), 1991;
- d) that astronomers also study spectral lines outside bands allocated to radioastronomy, as far as spectrum usage by other services allows;
- e) that account should be taken of the Doppler shifts of the lines, resulting from the motion of the sources;
- f) that, for other types of radioastronomical observation, namely continuum observations, a certain number of frequency bands are in use, the exact positions of which in the spectrum are not of critical importance, but of which the centre frequencies should be approximately in the ratio of two to one;
- g) that radioastronomers have made useful astronomical observations from the Earth's surface at frequencies as low as 2 MHz, as high as 800 GHz, and from space platforms at frequencies which extend down to lower than 10 kHz;
- h) that the movement of the Moon produces occultations of radio sources, permitting unique radioastronomical observations of high resolution which are particularly important at metre wavelengths;
- j) that some types of high-resolution interferometric observations require simultaneous reception, at the same radio frequency, by receiving systems located in different countries or on different continents;
- k) that World Administrative Radio Conferences have made improved allocations for radioastronomy, but that protection in many bands, particularly those shared with other services, will need careful planning,

recommends

1. that administrations should afford all practicable protection to the frequencies used by radioastronomers in their own and neighbouring countries;
2. that particular attention should be given to securing or maintaining adequate protection for the frequency bands listed in Tables 1 and 2, which contain rest frequencies and Doppler-shifted frequencies of the astrophysically most important spectral lines identified by the General Assembly of the International Astronomical Union (IAU), 1991, and in Table 3, which contains the frequency bands allocated to the radioastronomy service that are preferred for continuum observations;
3. that administrations should bear in mind the technical desirability of affording protection to radioastronomy at frequencies below 10 MHz while taking § f) and g) into account;
4. that consideration be given to securing improvement in the international protection of the series of frequency bands above 10 MHz, now available to the radioastronomy service, in accordance with the Radio Regulations;
5. that administrations be asked to provide assistance in the coordination of experimental observations of spectral lines in bands not allocated to radioastronomy.

TABLE 1
Radio-frequency lines of the greatest importance to radioastronomy
at frequencies below 275 GHz

Substance	Rest frequency	Suggested minimum band	Notes (1)
Deuterium (DI)	327.384 MHz	327.0- 327.7 MHz	
Hydrogen (HI)	1 420.406 MHz	1 370.0-1 427.0 MHz	(2), (3)
Hydroxyl radical (OH)	1 612.231 MHz	1 606.8-1 613.8 MHz	(4)
Hydroxyl radical (OH)	1 665.402 MHz	1 659.8-1 667.1 MHz	(4)
Hydroxyl radical (OH)	1 667.359 MHz	1 661.8-1 669.0 MHz	(4)
Hydroxyl radical (OH)	1 720.530 MHz	1 714.8-1 722.2 MHz	(3), (4)
Methyladyne (CH)	3 263.794 MHz	3 252.9-3 267.1 MHz	(3), (4)
Methyladyne (CH)	3 335.481 MHz	3 324.4-3 338.8 MHz	(3), (4)
Methyladyne (CH)	3 349.193 MHz	3 338.0-3 352.5 MHz	(3), (4)
Formaldehyde (H ₂ CO)	4 829.660 MHz	4 813.6-4 834.5 MHz	(3), (4)
Methanol (CH ₃ OH)	6 668.518 MHz	6 661.8-6 675.2 MHz	(3), (6)
Helium (3He ⁺)	8 665.650 MHz	8 657.0-8 674.3 MHz	(3), (6)
Methanol (CH ₃ OH)	12.178 GHz	12.17- 12.19 GHz	(3), (6)
Formaldehyde (H ₂ CO)	14.488 GHz	14.44- 14.50 GHz	(3), (4)
Cyclopropenylidene (C ₃ H ₂)	18.343 GHz	18.28- 18.36 GHz	(3), (4), (6)
Water vapour (H ₂ O)	22.235 GHz	22.16- 22.26 GHz	(3), (4)
Ammonia (NH ₃)	23.694 GHz	23.61- 23.71 GHz	(4)
Ammonia (NH ₃)	23.723 GHz	23.64- 23.74 GHz	(4)
Ammonia (NH ₃)	23.870 GHz	23.79- 23.89 GHz	(4)
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	(3)
Silicon monoxide (SiO)	86.243 GHz	86.16- 86.33 GHz	
Formylium (H ¹³ CO ⁺)	86.754 GHz	86.66- 86.84 GHz	
Silicon monoxide (SiO)	86.847 GHz	86.76- 86.93 GHz	
Ethynyl radical (C ₂ H)	87.3 GHz	87.21- 87.39 GHz	(5)
Hydrogen cyanide (HCN)	88.632 GHz	88.34- 88.72 GHz	(4)
Formylium (HCO ⁺)	89.189 GHz	88.89- 89.28 GHz	(4)
Hydrogen isocyanide (HNC)	90.664 GHz	90.57- 90.76 GHz	
Diazenylium (N ₂ H ⁺)	93.174 GHz	93.07- 93.27 GHz	
Carbon monosulphide (CS)	97.981 GHz	97.65- 98.08 GHz	(4)
Carbon monoxide (C ¹⁸ O)	109.782 GHz	109.67-109.89 GHz	
Carbon monoxide (¹³ CO)	110.201 GHz	109.83-110.31 GHz	(4)
Carbon monoxide (C ¹⁷ O)	112.359 GHz	112.25-112.47 GHz	(6)
Carbon monoxide (CO)	115.271 GHz	114.88-115.39 GHz	(4)
Formaldehyde (H ₂ ¹³ CO)	137.450 GHz	137.31-137.59 GHz	(3), (6)
Formaldehyde (H ₂ CO)	140.840 GHz	140.69-140.98 GHz	
Carbon monosulphide (CS)	146.969 GHz	146.82-147.12 GHz	
Water vapour (H ₂ O)	183.310 GHz	183.12-183.50 GHz	
Carbon monoxide (C ¹⁸ O)	219.560 GHz	219.34-219.78 GHz	
Carbon monoxide (¹³ CO)	220.399 GHz	219.67-220.62 GHz	(4)
Carbon monoxide (CO)	230.538 GHz	229.77-230.77 GHz	(4)
Carbon monosulphide (CS)	244.953 GHz	244.72-245.20 GHz	(6)
Hydrogen cyanide (HCN)	265.886 GHz	265.62-266.15 GHz	
Formylium (HCO ⁺)	267.557 GHz	267.29-267.83 GHz	
Hydrogen isocyanide (HNC)	271.981 GHz	271.71-272.25 GHz	

- (1) If Notes (4) or Note (2) are not listed, the band limits are the Doppler-shifted frequencies corresponding to radial velocities of ± 300 km/s (consistent with line radiation occurring in our galaxy).
- (2) An extension to lower frequency of the allocation of 1 400-1 427 MHz is required to allow for the higher Doppler shifts for HI observed in distant galaxies.
- (3) The current international allocation is not primary and/or does not meet bandwidth requirements. See the Radio Regulations for more detailed information.
- (4) Because these line frequencies are also being used for observing other galaxies, the listed bandwidths include Doppler shifts corresponding to radial velocities of up to 1 000 km/s. It should be noted that HI has been observed at frequencies redshifted to 500 MHz, while some lines of the most abundant molecules have been detected in galaxies with velocities up to 50 000 km/s, corresponding to a frequency reduction of up to 17%.
- (5) There are six closely spaced lines associated with this molecule at this frequency. The listed band is wide enough to permit observations of all six lines.
- (6) This line frequency is not mentioned in Article 8 of the Radio Regulations.

TABLE 2

**Radio-frequency lines of the greatest importance
to radioastronomy at frequencies between 275 and 811 GHz
(not allocated in the Radio Regulations)**

Substance	Rest frequency (GHz)	Suggested minimum band (GHz)
Diazenylium (N ₂ H ⁺)	279.511	279.23-279.79
Carbon monoxide (C ¹⁸ O)	329.330	329.00-329.66
Carbon monoxide (¹³ CO)	330.587	330.25-330.92
Carbon monosulphide (CS)	342.883	342.54-343.23
Carbon monoxide (CO)	345.796	345.45-346.14
Hydrogen cyanide (HCN)	354.484	354.13-354.84
Formylium (HCO ⁺)	356.734	356.37-357.09
Diazenylium (N ₂ H ⁺)	372.672	372.30-373.05
Water vapour (H ₂ O)	380.197	379.81-380.58
Carbon monoxide (C ¹⁸ O)	439.088	438.64-439.53
Carbon monoxide (¹³ CO)	440.765	440.32-441.21
Carbon monoxide (CO)	461.041	460.57-461.51
Heavy water (HDO)	464.925	464.46-465.39
Carbon (CI)	492.162	491.66-492.66
Water vapour (H ₂ ¹⁸ O)	547.676	547.13-548.22
Water vapour (H ₂ O)	556.936	556.37-557.50
Ammonia (¹⁵ NH ₃)	572.113	571.54-572.69
Ammonia (NH ₃)	572.498	571.92-573.07
Carbon monoxide (CO)	691.473	690.78-692.17
Hydrogen cyanide (HCN)	797.433	796.64-798.23
Formylium (HCO ⁺)	802.653	801.85-803.85
Carbon monoxide (CO)	806.652	805.85-807.46
Carbon (CI)	809.350	808.54-810.16

TABLE 3

**Frequency bands allocated to the radioastronomy service
that are preferred for continuum observations**

(Secondary allocations are contained within brackets)

Frequency band (MHz)	Bandwidth (%)	Frequency band (GHz)	Bandwidth (%)
13.360-13.410	0.37	10.6-10.7	0.94
25.550-25.670	0.49	15.35-15.4	0.33
(37.5-38.25)	(1.98)	22.21- 22.50	1.30
73-74.6 ⁽¹⁾	2.17	23.6 - 24.0	1.68
150.05-153 ⁽²⁾	1.95	31.3 - 31.8	1.58
322-328.6	2.03	42.5 - 43.5	2.33
406.1-410	0.96	86 - 92	6.74
608.614 ⁽³⁾	0.98	105 - 116	9.95
1 400-1 427	1.91	164 - 168	2.41
1 660-1 670	0.60		
2 690-2 700	0.37	217 - 231	6.25
(2 655-2 690)	(1.31)		
4 990-5 000	0.20	265 - 275	3.70
(4 800-4 990)	(3.88)		

⁽¹⁾ Allocation (primary) in Region 2, protection recommended in Regions 1 and 3.

⁽²⁾ Allocation (primary) in Region 1, Australia and India.

⁽³⁾ Allocation (primary) in Region 2, China and India.