

Recommendation ITU-R RA.314-11

(12/2023)

RA Series: Radio astronomy

Preferred frequency bands for radio astronomical measurements below 1 THz

Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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Series of ITU-R Recommendations

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Series	Title
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BS	Broadcasting service (sound)
BT	Broadcasting service (television)
F	Fixed service
M	Mobile, radiodetermination, amateur and related satellite services
P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
V	Vocabulary and related subjects

Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

Electronic Publication
Geneva, 2024

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RECOMMENDATION ITU-R RA.314-11

Preferred frequency bands for radio astronomical measurements below 1 THz

(Question ITU-R 145/7)

(1953-1956-1959-1966-1970-1974-1978-1982-1986-1990-1992-2002-2003-2023)

Scope

This Recommendation provides information regarding the preferred frequency bands for radio astronomical measurements up to 1 000 GHz. Tables 1 and 2 list the frequency bands associated with atomic and molecular transitions; Table 3 lists the frequency bands preferred for observations of radio continuum emission; Table 4 lists the frequency bands for several specific applications of redshifted neutral hydrogen. Figures in the Annex illustrate the natural processes that dictate the preferred frequency bands for radio astronomy.

Keywords

Radio astronomy, fundamental physics, atomic and molecular transitions, continuum emission, atmospheric transparency

The ITU Radiocommunication Assembly,

considering

- a) that the development of radio astronomy has 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 the advancement of radio astronomy requires the protection of certain frequency bands from interference;
- c) that the International Astronomical Union (IAU) is maintaining and updating the list of spectral lines of the greatest importance to radio astronomy;
- d) that radio astronomers study spectral lines both in bands allocated to the radio astronomy service and, as far as spectrum usage by other services allows, outside the allocated bands, and that this has resulted in the detection of thousands of spectral lines as illustrated in Fig. 1 of Annex 1;
- e) that account should be taken of the Doppler shifts of the lines, due to the relative motion of source and observer;
- f) that the observed frequencies of highly redshifted (Doppler-shifted) atomic or molecular spectral lines from the distant Universe are significantly lower than their rest frequencies, as illustrated in Table 4 and Fig. 3 of Annex 1;
- g) that certain frequency bands have been allocated for continuum observations, and that the exact positions of these bands in the spectrum are not of critical importance, as illustrated in Fig. 4 of Annex 1, but that their centre frequencies should be in the ratio not more than two to one, taking the width of relevant atmospheric windows (see Fig. 1 of Annex 1) into account;
- h) that radio astronomers have made useful astronomical observations from the Earth's surface in all available atmospheric windows (see Fig. 1 of Annex 1) ranging from 2 MHz to 1 000 GHz and above;
- i) that the technique of space radio astronomy, which involves the use of radio telescopes on space platforms, provides access to the entire radio spectrum above about 10 kHz, including parts of the spectrum not accessible from the Earth due to absorption in the atmosphere;

j) that some types of high-resolution interferometric observations require simultaneous reception, at the same radio frequency, by receiving systems located in different countries, on different continents, or on space platforms;

k) that world administrative radio conferences and world radiocommunication conferences have made improved frequency allocations for radio astronomy, but that protection in many bands, particularly those shared with other services, may still need careful planning,

noting

that preferred bands between 1 and 3 THz are contained in Recommendation ITU-R RA.1860,

recommends

1 that administrations should afford all practicable protection to the frequencies used by radio astronomers 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 IAU, and in Table 3, which contains the frequency bands allocated to the radio astronomy service that are preferred for continuum observations;

3 that administrations be asked to provide assistance in the coordination of observations of spectral lines in bands not allocated to radio astronomy.

TABLE 1

Radio frequency lines of the greatest importance to radio astronomy at frequencies below 275 GHz

Substance	Rest frequency	Suggested minimum band	Notes ⁽¹⁾
Deuterium (D I)	327.384 MHz	327.0-327.7 MHz	
Hydrogen (H I)	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)
Methylidyne (CH)	3 263.794 MHz	3 252.9-3 267.1 MHz	(3), (4)
Methylidyne (CH)	3 335.481 MHz	3 324.4-3 338.8 MHz	(3), (4)
Methylidyne (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)
Helium (³ He ⁺)	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)

TABLE 1 (*continued*)

Substance	Rest frequency	Suggested minimum band	Notes ⁽¹⁾
Sulphur monoxide (SO)	30.002 GHz	29.97-30.03 GHz	(6)
Methanol (CH ₃ OH)	36.169 GHz	36.13-36.21 GHz	(6)
Silicon monoxide (SiO)	42.519 GHz	42.47-42.57 GHz	(6), (8)
Silicon monoxide (SiO)	42.821 GHz	42.77-42.86 GHz	
Silicon monoxide (SiO)	43.122 GHz	43.07-43.17 GHz	
Silicon monoxide (SiO)	43.424 GHz	43.37-43.47 GHz	
Dicarbon monosulphide (CCS)	45.379 GHz	45.33-45.44 GHz	(6)
Carbon monosulphide (CS)	48.991 GHz	48.94-49.04 GHz	
Molecular oxygen (O ₂)	61.1 GHz	56.31-63.06 GHz	(5), (6), (7)
Deuterated water vapour (HDO)	80.578 GHz	80.50-80.66 GHz	
Cyclopropenylidene (C ₃ H ₂)	85.339 GHz	85.05-85.42 GHz	
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)
Sulphur monoxide (SO)	99.300 GHz	99.98-100.18 GHz	
Methyl acetylene (CH ₃ C ₂ H)	102.5 GHz	102.39-102.60 GHz	(5)
Methanol (CH ₃ OH)	107.014 GHz	106.91-107.12 GHz	
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	
Cyano radical (CN)	113.5 GHz	113.39-113.61 GHz	(5)
Carbon monoxide (CO)	115.271 GHz	114.88-115.39 GHz	(4)
Molecular oxygen (O ₂)	118.750 GHz	118.63-118.87 GHz	(6), (7)
Formaldehyde (H ₂ ¹³ CO)	137.450 GHz	137.31-137.59 GHz	
Formaldehyde (H ₂ CO)	140.840 GHz	140.69-140.98 GHz	
Carbon monosulphide (CS)	146.969 GHz	146.82-147.12 GHz	
Nitric oxide (NO)	150.4 GHz	149.95-150.85 GHz	(5)
Methanol (CH ₃ OH)	156.602 GHz	156.45-156.76 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)
Cyano radical (CN)	226.6 GHz	226.37-226.83 GHz	(5)
Cyano radical (CN)	226.8 GHz	226.57-227.03 GHz	(5)