

Report ITU-R RA.2574-0

(09/2026)

RA Series: Radio astronomy

Radio astronomy facilities on the Moon

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RA	Radio astronomy
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Note: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.

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REPORT ITU-R RA.2574-0

Radio astronomy facilities on the Moon

(Question ITU-R 260/7)

(2026)

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1 Introduction

Radio astronomy is defined in the Radio Regulations (RR) No. **1.13** as “astronomy based on the reception of *radio waves* of cosmic origin.” It is the study of naturally occurring radio radiation from cosmic sources to understand the properties and evolution of astronomical objects and the universe. Measurement of the intensity of radio waves from cosmic sources provides information about the physical processes that dominate the formation and evolution of structures, from the largest scales to the smallest in the universe. Radio astronomy observations include both measurement of line intensities, which arise from quantum mechanical transitions of atoms and molecules, and of continuum radiation, which arises from a variety of processes, including thermal and synchrotron radiation. Access to the full electromagnetic spectrum is important to probe these physical processes in both the local and distant universe.

As detailed in Recommendation ITU-R RA.479, however, much of the potential value of the electromagnetic spectrum for radio astronomy is unrealized due to its longstanding heavy use on Earth for other purposes and/or atmospheric attenuation. Scientific drivers to build radio telescopes on the shielded zone of the Moon therefore include the possibility to observe cosmic sources in radio frequency bands that are not accessible from Earth, either due to atmospheric absorption or due to human-made transmissions that overwhelm the faint natural radiation from cosmic sources. The shielded zone of the Moon, an area somewhat less than half of the lunar surface, is a zone in which passive observations remain unhindered by interference as this part of the Moon’s surface is always facing away from Earth and is therefore shielded from Earth-based and Earth-orbital radio signals. As such, it is crucial to protect this unique region for passive scientific research. Key technology developments for radio astronomy facilities to be built on the Moon include, e.g., broad bandwidth receivers to increase the radio telescope’s sensitivity for radio continuum observations.

The spectral lines of greatest interest to radio astronomy at frequencies below 275 GHz are listed in Table 1 of Recommendation ITU-R RA.314. These spectral lines occur at frequencies dictated by nature, but they may be observed at high redshifts within our own Galaxy or in external galaxies. Additionally listed in Table 1 of the same Recommendation are suggested minimum bandwidths that, in most cases, correspond to the widths of these lines, Doppler shifted within our own Galaxy. These minimum bandwidths are, however, not allocated or protected for radio astronomy uses on Earth in every instance. Further, many of the lines, of great astrophysical interest, can be observed at far lower frequencies, caused by the higher redshifts of external galaxies. One of the most prominent spectral lines is the one that arises due to the spin flip of neutral hydrogen at a rest frequency of 1 420.4058 MHz. Because hydrogen is ubiquitous in the universe, observations of this line provide the opportunity to probe the structure of the universe from the present day to the very distant past, including the epoch of reionization (EoR). However, due to the expansion of the universe, more distant cosmic radiation is redshifted relative to its rest-frame frequency (the redshift, z , is calculated as $(f_{\text{rest}} - f_{\text{obs}})/f_{\text{obs}}$ where f_{rest} is the laboratory rest frequency set by quantum physics, and f_{obs} is the observed frequency at the telescope). Thus, scientific observations of the neutral hydrogen line range from observations close to its rest frequency to below 65 MHz. Radio telescopes located in the Shielded Zone of the Moon (SZM) will be able to measure the faint radio radiation of the neutral hydrogen line from the most distant cosmic sources without contamination from human-made emissions and thus provide the most robust measure of the evolution of structure in the universe.

Table 3 of Recommendation ITU-R RA.314 lists the frequency bands allocated to the radio astronomy service on Earth for continuum observations. Continuum radiation occupies a large range of frequencies and arises through a number of mechanisms such as bremsstrahlung and synchrotron radiation. Continuum radiation is also of great importance for astronomical observations but in many cases, particularly for bands under 70 GHz, frequency allocations to the radio astronomy service are much narrower than would be desirable for the purposes of radio astronomy.

As designated in RR No. **22.22.1**, the SZM is the surface area and adjacent volume of space that are shielded from emissions originating from within 100 000 kilometres of Earth's centre. This geographic region is isolated both from Earth-based emissions and also from potential interference arising from satellites orbiting the Earth. As stated in Section V of RR Article **22**:

“22.22 1) In the shielded zone of the Moon emissions causing harmful interference to radio astronomy observations and to other users of passive services shall be prohibited in the entire frequency spectrum except in the following bands:

22.23 a) the frequency bands allocated to the space research service using active sensors;

22.24 b) the frequency bands allocated to the space operation service, the Earth exploration-satellite service using active sensors, and the radiolocation service using stations on spaceborne platforms, which are required for the support of space research, as well as for radiocommunications and space research transmissions within the lunar shielded zone.

22.25 2) In frequency bands in which emissions are not prohibited by Nos. **22.22** to **22.24**, radio astronomy observations and passive space research in the shielded zone of the Moon may be protected from harmful interference by agreement between administrations concerned.”

Numbers/Provisions **22.22** to **22.25** of the RR ensure that radio astronomy observations within the shielded zone of the Moon will be free from human-made interference throughout the majority of the radio spectrum. This unique resource will enable scientific discoveries that are not possible in the “radio loud” environment on Earth. This potential discovery space is especially favourable for the detection of time-variable phenomena, where radio frequency interference (RFI) is particularly insidious, as RFI corrupts measurements that can never be re-acquired for these sources.

Recommendation ITU-R RA.479 provides guidance on the protection of frequencies for radioastronomical measurements in the shielded zone of the Moon. In particular, Recommendation ITU-R RA.479 *recommends*:

- 1 that, in planning the use of the radio spectrum, both nationally and internationally, account should be taken of the need to provide for radio astronomy observations in the SZM;
- 2 that, in taking account of such a need, special attention should be given to those frequency bands in which observations are difficult or impossible from the surface of the Earth;
- 3 that the frequency spectrum should be used in the SZM in keeping with the preliminary guidelines contained in Annex 1;
- 4 that special attention be paid to emissions into the SZM from deep-space platforms, satellites in the halo orbits near the Sun-Earth L₂ point, satellites in the Earth-trailing orbits, or transmitters near or on the Moon;
- 5 that in the frequency bands which would be considered for joint use by active and passive space stations in the SZM, radio astronomy observations should be protected from harmful interference. To this end, appropriate discussions between concerned administrations may be conducted;
- 6 that in-situ radiocommunication equipment developed for the environment of Mars or other planets should not be deployed in the SZM, but the choice of frequencies for the close proximity link in the SZM should follow the preliminary guidelines contained in Annex 1.

Annex 1 to Recommendation ITU-R RA.479 includes an extensive discussion of frequency bands from 30 kHz to 1 THz. Annex 2 addresses frequency bands to be used for radiocommunications in the lunar environment proposed by Commissions 40 and 50 of the International Astronomical Union. As noted in these Annexes, all frequencies below 2 GHz in the SZM should be accessible to radio astronomy and frequency bands above this range should consider both spectral line and continuum

observations. In other words, when considering frequency allocations in the lunar environment, it is critical to recognize the scientific importance of retaining a “radio quiet” environment within the SZM to ensure this unique resource remains accessible for scientific discovery.

In addition to scientific discovery, there are societal benefits to the development and construction of radio astronomy telescopes on the Moon. For example, the technology development required to build a radio telescope in such a remote location includes not only the materials for the physical structures, but also the development of communications and data transfer relays. In addition, as evidenced by prior astronomical projects, building a radio telescope on the Moon will engage the broader community in scientific endeavours, particularly since the results of such a project will address big picture questions that are relevant to all humanity.

2 Concepts and designs for lunar radio astronomy missions

In part to enable access to frequency ranges not observable with ground-based telescopes on Earth, many of the initial concepts and designs for radio astronomy facilities to be built on the Moon are for low frequency radio telescopes¹. These early missions take advantage of the fact that low frequency observations typically do not require high precision telescope surfaces. However, it is anticipated that the next generation of radio telescopes on the Moon will operate in higher frequency bands as well. High frequency observations will be of great scientific importance for future missions.

2.1 Radio-wave Observations at the Lunar Surface of the photoElectron Sheath (ROLSSES)

As a first step toward measuring radio-wave propagation effects on the lunar surface, ROLSES consists of a low-frequency radio spectrometer operating from 2 kHz to 30 MHz using antennas at 1 m and 3 m above the surface, landed on the Moon as part of NASA’s Commercial Lunar Payload Serviced (CLPS) programme. ROLSES was designed to measure the photoelectron sheath density values during the lunar day. These values are expected to vary based on height and solar wind parameters. ROLSES’s goals also included measurements of reflection of radiation from the lunar surface, monitoring of radio frequency interference, detection of lunar dust impacts, and measurements of the Galactic radio spectrum from 1-30 MHz. ROLSES launched as part of the Intuitive Machines 1 (TO2-IM) mission on February 15, 2024 and landed on the rim of the Malapert A crater near the south pole on February 22, 2024. Data were collected from the ROLSES spectrometer both in transit to the Moon and over several days on the lunar surface despite the unfortunate tilt on the lander. Results have been published². An upgraded ROLSES-2 instrument is scheduled to launch on another CLPS lander to the lunar near side in 2026. Link: <https://www.colorado.edu/ness/projects/radiowave-observations-lunar-surface-photoelectron-sheath-rolses>)

¹ Note that the ITU designation for low frequency (LF) is the range 30-300 kHz. In this Report, however, the term “low frequency” is rather used to denote frequencies on the low end of radio astronomy observations (10 kHz to 110 MHz).

² Hibbard, Joshua, Burns, Jack, *et al.*, “Results from NASA’s First Radio Telescope on the Moon: Terrestrial Technosignatures and the Low-Frequency Galactic Background Observed by ROLSES-1 Onboard the Odysseus Lander.” March 18, 2025. <https://arxiv.org/pdf/2503.09842>

2.2 Farside Array for Radio Science Investigation of the Dark ages and Exoplanets (FARSIDE)

A concept currently under development within the United States, the notional concept for FARSIDE (see https://www.colorado.edu/project/lunar-farside/sites/default/files/attached-files/farside_finalrpt-2019-nov8.pdf) consists of a low frequency interferometric array of 128 dipole antennas deployed across a 10 km area. With a planned frequency range of 100 kHz to 40 MHz, FARSIDE will enable observations extending well below frequency bands accessible on Earth. In particular, the lunar environment allows sky noise limited observations at sub-MHz frequencies, since it is not subject to auroral kilometric radiation or to plasma noise from the solar wind. Observations in this frequency range will enable a variety of science programs including monitoring of the nearest stellar systems and measuring the neutral hydrogen line redshifted to $z \sim 50$ -100.

The technical characteristics of FARSIDE are still under development. One rendition includes:

Quantity	Value
Antennas	128 × 100 m length dipoles (100 kHz – 2 MHz), 128 × 5 m length dipoles (1-40 MHz)
Frequency Coverage	100 kHz – 40 MHz (1400 × 28.5 kHz channels)
Field of View (FWHM)	> 10,000 deg ²
Spatial Resolution	10 degrees @ 200 kHz / 10 arcminutes @ 15 MHz
Antenna efficiency	6.8×10^{-6} @ 200 kHz / 9.5×10^{-5} @ 15 MHz
System Temperature ^{a,b}	1.0×10^6 K @ 200 kHz / 2.7×10^4 K @ 15 MHz
Effective Collecting Area ^c	~ 12.6 km ² @ 200 kHz / 2,240 m ² @ 15 MHz
System Equivalent Flux Density (SEFD)	230 Jy @ 200 kHz / 2.8×10^4 Jy @ 15 MHz
1 σ Sensitivity ^b (60 seconds; bandwidth = $\nu/2$)	93 mJy @ 200 kHz ^d / 1.3 Jy (1.2 K) @ 15 MHz
1 σ Sensitivity ^b (1 hour; bandwidth = $\nu/2$)	12 mJy @ 200 kHz ^d / 170 mJy (160 mK) @ 15 MHz
1 σ Sensitivity ^b (1000 hours; bandwidth = $\nu/2$)	230 μ Jy ^e @ 200 kHz ^d / 3.8 mJy (5.2 mK) @ 15 MHz

^a System temperature includes contribution from the sky and ground due to the absence of a ground screen.
^b These values have been updated from the Astro 2020 report due to increased fidelity in the front-end design (see §3.5).
^c Effective area is impacted by loss of gain into the ground due to absence of a ground screen. Antenna efficiency not included.
^d Sensitivity calculations at 200 kHz assume night time conditions.
^e Deep confusion-free integrations are possible < 3 MHz due to the absence of extragalactic sources.

In this design, FARSIDE will have a central base station with 128 antenna pairs distributed along four independent spiral spokes. This distribution is designed to improve imaging performance while simultaneously minimizing rover travel on the lunar surface during deployment. Tethers between the base station and the antenna nodes provides power, signal processing, and telecommunications (via a relay) back to Earth (<https://www.colorado.edu/project/lunar-farside/>).

2.3 Lunar Crater Radio Telescope (LCRT)

A concept under development is to deploy a wire-mesh parabolic surface in an existing lunar crater to create an extremely large filled aperture radio telescope. The LCRT will observe low frequency bands that are blocked by Earth's ionosphere (6-30 MHz). To be sensitive to these long wavelengths, the LCRT will be built within a crater over 3 kilometres wide. The LCRT is similar in concept, but vastly larger, than the Arecibo 305 m and FAST telescopes built on Earth. The receiver is suspended by cables over a surface that will be entirely reflective to radio waves.

2.4 FarView

A concept under development via the NASA Innovative Advanced Concepts (NIAC) program, known as FarView, plans to deploy 100 000 low frequency dipole antennas over 200 km². As described at https://www.nasa.gov/directorates/spacetech/niac/2023/FarView_Observatory/, the

low frequency (5-40 MHz) antennas will be manufactured in situ by first extracting metals from the lunar regolith. The science goal is to measure the power spectrum of the first structures formed during the Dark Ages of the early Universe, thereby testing the fundamental models of physics and cosmology in a new epoch.

2.5 Lunar Surface Electromagnetic Experiment (LuSEE)

The LuSEE mission consists of two main components: the “Night” mission and the “Lite” mission on two separate CLPS landers to the lunar far side. “Night” will focus on low frequency (below 50 MHz) radio astronomy and deploy and operate largely autonomously (standalone operations). The “Lite” mission will carry out research into the lunar ionosphere, surface plasma physics and waves, DC electrostatic potentials, and dust impacts.

LuSEE Night will deploy autonomously and consist of four 3-meter antennas in a cross-dipole configuration. This assembly will be on a rotating turntable, and the attached receivers and spectrometer will send data back to the Earth via the Lunar Path finder satellite developed with funding from ESA. A radio beacon will also be deployed in lunar orbit to measure the LuSEE-Night radio beam. LuSEE-Night is scheduled to launch in 2025/26.

Relationship to the Shielded Zone of the Moon (RR Nos. 22.22-22.25)

The LuSEE Night mission, in particular, will make use of the radio-quiet conditions in the far side (Shielded Zone) of the Moon, as well as the ability for low-frequency radio waves to pass to the surface of the Moon relatively unhindered. On Earth, by contrast, such frequencies may be impacted by the ionosphere as well as other transmitted signals.

Astronomical signals in frequencies below 50 MHz will be particularly useful for cosmological studies of the early universe, including signals shifted to lower frequencies by the expansion of the universe, originally emitted by neutral hydrogen at 1 420.406 MHz.

2.6 TSUKUYOMI

TSUKUYOMI is a low-frequency radio astronomy observation facility currently under conceptual study in Japan. TSUKUYOMI consists of several self-supporting telescope antenna units. One unit contains a deployable dipole antenna, a signal processing system, and power supply and communication systems. The anticipated observing frequency range is 1-50 MHz, which is difficult to observe on Earth because of Earth’s ionosphere and radio interference from artificial sources. In the first phase of construction in late 2020s, one unit will be installed on the lunar surface to study solar and Jupiter’s radio burst. It also aims to pursue the science of the Moon and will make measurements to understand the electromagnetic environment of the lunar surface, including the nature of the lunar ionosphere and floating charged dust. For full-scale observations in 2030s, multiple units will be installed in the shielded zone of the Moon to function as a radio interferometer. The major objectives of TSUKUYOMI include the study of the very early universe before the formation of the first stars, i.e. “the Dark Ages”, and study of the environment of giant exoplanets through their auroras and radio-wave bursts of central stars.

2.7 Astronomical Lunar Observatory and Dark Ages EXplorer

The Astronomical Lunar Observatory (ALO) is a European led concept for a dedicated low frequency radio astronomy facility to be deployed on the lunar far side. ALO serves as an overarching architecture under which several instrument configurations can be developed, with the Dark Ages Explorer (DEX) forming its primary cosmological science instrument. DEX is designed to measure both the Global Signal and the angular power spectrum of the redshifted 21 cm line from neutral hydrogen across the Dark Ages ($z \approx 30-100$) and Cosmic Dawn ($z \approx 15-30$), targeting the critical

frequency range ~7-80 MHz that is inaccessible from Earth due to ionospheric opacity and pervasive RFI.

The DEX concept, developed through an ESA Concurrent Design Facility (CDF) study, consists of a dense interferometric array placed within a large, flat region on the lunar far side to take advantage of the unique radio-quiet environment of the SZM. The baseline design includes a compact, regularly spaced array (e.g. 32×32 elements) optimised for FFT correlation, enabling high sensitivity measurements of 21 cm spatial fluctuations with long integrations during lunar night. The ALO concept also includes a small number of well-characterised antennas for precision spectral measurements of the global 21 cm signal. While near-term deployments focus on pathfinder-scale arrays, the ALO/DEX architecture is explicitly scalable, enabling future expansions to $\geq 10^4$ antennas to image deeper into the Dark Ages. Beyond cosmology, ALO and DEX support a broad suite of secondary science objectives, including low frequency studies of the heliosphere, planetary magnetospheres, exoplanetary radio waves, radio transients, and characterization of the lunar electromagnetic environment. These measurements benefit greatly from the SZM's protection against RFI, offering unprecedented access to the ultra-long wavelength radio sky.

2.8 Chinese Lunar Low Frequency Radio Astronomy Experiments

China has conducted several pioneering low frequency radio astronomy experiments on and around the Moon as part of the Chang'e programme. The Netherlands-China Low Frequency Explorer (NCLE), flown on the Queqiao relay satellite at the Earth-Moon L2 point as part of Chang'e 4, performed measurements in the 80 kHz - 80 MHz range and provided the first long duration ultra long wavelength observations from cislunar space. These observations included detection of terrestrial radio frequency leakage and characterization of the low frequency Galactic background. In parallel, the Very Low Frequency Spectrometer on the Chang'e 4 lunar farside lander conducted surface-based measurements down to ~1 MHz, while the Low Frequency Interferometer and Spectrometer (LFIS) on the Longjiang 2 microsatellite recorded radio radiation between 1.5-30 MHz, demonstrating the Moon's effectiveness as a shield against interference originating on or around the Earth. The constellation is proposed to operate near the Earth-Moon L2 Lagrange point, where orbital stability and reduced terrestrial radio interference are advantageous. The spacecraft incorporate miniature solar sails to maintain passive formation control. The primary science objective is an all-sky survey at frequencies below 10 MHz with angular resolution finer than approximately one degree.

2.9 Orbiting Low Frequency Antennas for Radio Astronomy (OLFAR)

The Orbiting Low Frequency Antennas for Radio Astronomy (OLFAR) mission concept proposes deployment of a distributed array of identical small satellites near the Earth-Moon L2 point. Each satellite carries an extendable antenna operating in the 1 to 30 MHz range. The distributed design enhances scalability and robustness. The design allows continued functionality even in the event of individual satellite failures. The objective of OLFAR is to explore this largely uncharted frequency band for radio astronomy. It is anticipated that access to these frequencies will enable new scientific discoveries in astronomy, while also advancing engineering capabilities.

2.10 Lunar Farside Transient and Technology Telescope (LFT3)

The Lunar Farside Transient and Technology Telescope (LFT3)³ is a proposed radio astronomy facility to be deployed near the lunar antipode. The mission is intended to be launched and operational before 2030. LFT3 is designed to observe over a broad frequency range from 0.1 to 2 700 MHz using

³ DeBoer, D. R. *et al.*, (2026). *The Lunar Farside Transients and Technology Telescope (LFT3) Mission. Monthly Notices of the Royal Astronomical Society*. Preprint dated 29 July 2026.

three antenna systems: a low-frequency dipole covering 0.1-50 MHz, a VHF patch antenna covering 60-260 MHz, and a dual-polarization UHF Vivaldi array covering 300-2 700 MHz. The primary component is a phased, multibeam UHF array intended to conduct a spectral survey of the sky. The low-frequency components provide access to frequency ranges strongly affected by the Earth's ionosphere and radio-frequency interference, while the broad frequency coverage also enables studies of transient and other low-frequency radio phenomena. LFT3 is planned as a near-term lunar farside mission and is intended to demonstrate the scientific and technological capabilities of lunar radio astronomy.

2.11 Cosmic Background Radio Astronomy eXplorer (CobraX)

The Cosmic Background Radio Astronomy eXplorer (CobraX)⁴ is a mission concept based on a 12U CubeSat operating in low lunar orbit. The mission is designed to make precisely calibrated measurements of the cosmic radio background and Galactic radio emission at 1.55-2.2 GHz, using two deployable pyramidal horn antennas and a broadband spectrometer with approximately 330 kHz frequency resolution. The spacecraft would use a rotating scan pattern to map the entire radio sky, with observations conducted while shielded from terrestrial radio emissions by the Moon. The primary scientific objectives are to measure the sky-averaged radio brightness temperature, characterise Galactic synchrotron emission and its spectral variations, and measure large-scale anisotropies of the cosmic radio background. The use of a lunar orbit provides access to the S-band radio spectrum with reduced terrestrial interference and enables full-sky observations with controlled instrumental systematics. The mission is currently at the concept-development stage.

3 Preferred locations for lunar radio astronomy

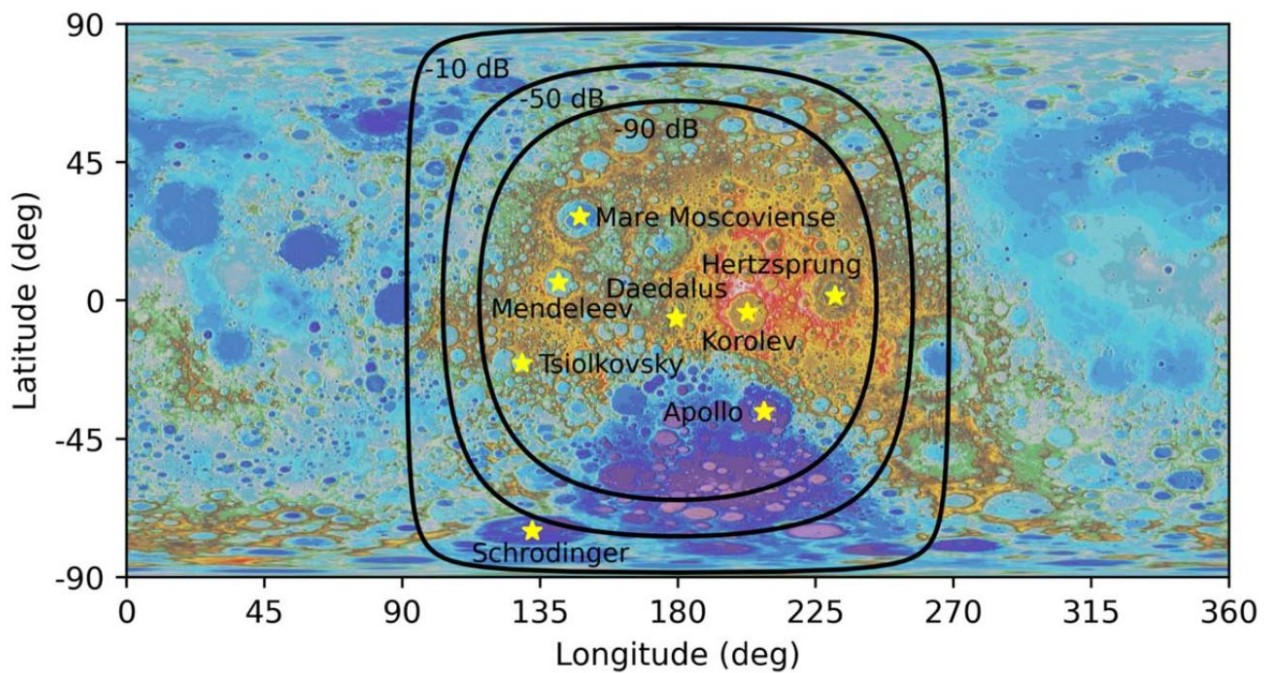
3.1 The Shielded Zone of the Moon

The Shielded Zone of the Moon comprises the surface area and adjacent volume of space that are shielded from emissions originating from within 100 000 kilometres of Earth's centre. This region is protected from Earth-based radio frequency interference and also from Earth's auroral kilometric radiation, which is a significant source of natural radio radiation below 500 kHz.

Specific landing sites need to take into consideration radio wave propagation characteristics in the lunar environment. In particular, low frequency radio waves can be diffracted around the Moon's limb, resulting in variations in the RFI environment based on location and the frequency bands under consideration. An example of the RFI suppression expected at 100 kHz is shown in Fig. 1. At higher frequencies, above 10 MHz for example, the RFI suppression is more than -90 dB within a few degrees of the limb. To reduce the potential for radio frequency interference, sites under consideration for the majority of low frequency projects currently under development are located within the region with highest expected RFI suppression, as indicated in Fig. 1.

⁴ Bull, P. *et al.*, (2026). *CobraX: Precision measurement of the cosmic radio background from space with deployable horn antennas. In UK Space Frontiers 2035: Astro thematic area.*

FIGURE 1
Map of RFI suppression at 100 kHz based on numerical simulations



Contours indicate suppression of -10 , -50 , and -90 dB relative to the incident intensity. Map colours indicate elevation. Potential landing sites are indicated by yellow stars. Adapted from Burns *et al.*, 2021, The Planetary Science Journal, volume 2, page 44. <https://doi.org/10.3847/PSJ/abdfc3>.

Further discussions of site selection for radio astronomy within the SZM can be found in Le Conte *et al.* 2023, RAS Techniques and Instruments, Volume 2, Issue 1, pages 360-377. <https://doi.org/10.1093/rasti/rzad022> as well as in Polidan *et al.*, 2024, Advances in Space Research, Volume 74, Issue 1, pages 528-546. <https://doi.org/10.1016/j.asr.2024.04.008>.

3.2 Lunar South Pole and other regions

The lunar south pole is also a preferred location for radio astronomy facilities, with significant shielding from radio frequency interference at frequencies above 10 MHz. Specifically, the South Pole Aitken Basin (the large low-elevation purple region in Fig. 1) is a potential location for higher frequency radio astronomy facilities.

3.3 Lunar Coordinate Systems and Reference Frames

A coordinate system is needed for specifying precise locations preferred for constructing radio astronomy facilities on the lunar surface. The Selenographic Coordinate System may be useful for this purpose. Also, the United States' 2022 National Cislunar Science and Technology Strategy report cites a need for a cislunar reference frame tied to the celestial reference frame and terrestrial reference frame; see page 13 of the report linked here: <https://www.space.commerce.gov/white-house-releases-national-cislunar-st-strategy/>.

4 Frequency usage by RAS and operational mission support in the lunar environment

4.1 Frequency bands used for science operations

For practical and scientific reasons, the majority of current mission plans and concepts are for radio telescopes operating at low frequencies, between 10 kHz and 110 MHz. These pathfinder missions will reveal the capability and challenges of building and operating radio astronomy facilities in the lunar environment. As noted in Recommendation ITU-R RA.479, future radio astronomy facilities are envisioned that will target frequency bands that are not accessible from Earth, either due to atmospheric absorption or human-made interference. Future mission concepts may observe in a wide range of frequencies from 10 kHz to 3 THz to access various frequency bands not accessible from Earth

4.2 Frequency bands used for operational mission support and data transfer rates

Radio astronomy facilities on the Moon will require operational support, including telescope control and data transfer. Any frequency bands under consideration for lunar communications should respect the requirements for scientific observations discussed in Recommendation ITU-R RA.479. For this purpose, bands are allocated to the space research service, space operation service, the Earth exploration-satellite service using active sensors, and the radiolocation service using stations on spaceborne platforms (as stated in RR No. **22.24**). In particular, frequency ranges that are not accessible on Earth, due to natural causes, such as the Earth's ionosphere and atmosphere, or due to human transmissions, should be avoided for lunar communications.

5 Summary

Radio astronomy facilities on the Moon represent a transformative opportunity for astronomical research, leveraging the unique advantages of the lunar environment. The SZM offers a pristine environment free from Earth-based radio signals and atmospheric noise, enabling unprecedented sensitivity for observing radio waves across a broad spectrum. A number of facilities and mission concepts have been proposed including the Radiowave Observations at the Lunar Surface of the photoElectron Sheath (ROLSSES), which already landed and collected data in 2024, among other projects already in development. Lunar-based radio astronomy holds immense potential to address fundamental questions about the universe. As stated in RR Nos **22.22** to **22.25**, in frequency bands in which emissions are not prohibited, concerned administrations should seek agreement to ensure protection of radio astronomy observations and passive space research in the SZM. The level of harmful interference is determined by agreement between the administrations concerned, with the guidance of the relevant ITU-R Recommendations.

6 Related ITU-R Recommendations/Reports

Recommendation ITU-R RA.314 – Preferred frequency bands for radio astronomical measurements

Recommendation ITU-R RA.479 – Protection of frequencies for radioastronomical measurements in the shielded zone of the Moon

7 Abbreviations/Glossary

ALO	Astronomical lunar observatory
CobraX	Cosmic background radio astronomy explorer
DAPPER	Dark ages polarimeter pathfinder

DEX	Dark ages explorer
EoR	Epoch of reionization
FAR SIDE	Farside array for radio science investigation of the dark ages and exoplanets
LCRT	Lunar crater radio telescope
LFIS	Low frequency interferometer and spectrometer
LFT3	Lunar farside transient and technology telescope
LuSEE	Lunar surface electromagnetic experiment
NCLE	Netherlands-China low frequency explorer
OLFAR	Orbiting low frequency antennas for radio astronomy
RFI	Radio frequency interference
ROLSSES	Radiowave observations at the lunar surface of the photoelectron sheath
RR	Radio Regulations
SZM	Shielded zone of the moon
