



Spectrum management and radio frequency interference at ALMA

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1 Extended Abstract

The Atacama Large Millimeter/submillimeter Array (ALMA) is a 66-element interferometer operating at 5000 m on the Chajnantor Altiplano in northern Chile. In this paper, we present an overview of the risks posed by radio-frequency interference (RFI) to ALMA today and in the near future from both ground-based and space-based sources of RF emissions. The ALMA operational spectrum spans from 35 GHz up to 950 GHz, divided into 10 non-contiguous frequency bands. Atmospheric water vapor attenuates emission strongly within a large fraction of this frequency range [1].

Some ALMA sub-systems have been identified as sources of self-inflicted RFI. Other observatories operating on the Altiplano are also potential sources of emissions with sufficient power to produce RFI at ALMA. To minimize these risks, operations between the observatories are coordinated by the ALMA spectrum management office in collaboration with the Chajnantor Working Group, that includes all the observatories on the Altiplano. The international highway between Chile and Argentina, CH27, passes within 10 km of the ALMA site and there is a risk of emissions from vehicles on the highway at a short distance to the ALMA antennas.

The Sub-secretariat of Telecommunications (SubTel) of the Ministry of Transport and Telecommunications of the Republic of Chile guarantees protection for ALMA against potential RFI through exempt resolutions granted to the European Southern Observatory (ESO) and the Associated Universities Inc. (AUI). These resolutions define a “protection zone” with a radius of 30 km and a “coordination zone” with a radius of 120 km from the array center. The authority of SubTel over these two zones applies only to the Chilean national territory, and coordination with neighbouring countries Bolivia and Argentina is desirable. When these resolutions were first emplaced in 2013, they only considered ground-based radio emissions. Consideration of the potential risks of RFI from the sky was not included. Today, the situation has changed dramatically due to the present day telecommunication satellite constellations consisting of several thousand satellites, and plans for much larger numbers of satellites in the near future.

The ALMA spectrum management office is evaluating measures that could prevent, at least partially, potential RFI from the sky due to telecommunication satellites operating over Chile. The SpaceX Starlink and Amazon Kuiper satellite constellations have been granted permission by SubTel to operate gateway stations in Chile. The nearest gateway station to ALMA is near Caldera, 540 km south-west of the ALMA site, a distance we consider sufficient to safeguard the ALMA systems from RFI from downlink signals to the gateway station. However, with the potential for other constellation operators in Chile, and the number of required gateway stations growing, it is important to seek suitable protections e.g. by defining a minimum distance of gateway stations from the observatory. It is important to consider that ALMA, with relatively high operating frequencies, is not affected by RFI from telecommunication satellites at this time. However, this situation is changing as constellation operators work towards higher frequency bands, motivated by larger bandwidth for higher data-transfer rates.

In order to remain informed and collaborate in defining common strategies to protect radio astronomy from RFI from satellites, the ALMA spectrum management office is maintaining a constructive dialog with SubTel and participating in a number of initiatives, both in Chile and internationally, including the Radio Committee of the Chilean astronomical society (SoChiAs), the Chilean Low Earth Orbit satellite group (CLEOsat), the Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference (CPS) of the International Astronomical Union (IAU), the Committee on Radio Astronomy Frequencies (CRAF) of the European Science Foundation (ESF), and the RFI Working Group of the National Radio Dynamic Zone (NRDZ) of the USA.

References

- [1] G. Siringo, S. Dougherty “ALMA Spectrum and Radio Frequency Interference — White Paper,” *ALMA RFI Memo #152*, July 2023, https://library.nrao.edu/public/memos/rfi/RFI_152.pdf