32nd URSI GASS, Montreal, 19-26 August 2017

Tools for avoiding satellite interference at the upgraded GMRT

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Abstract

Ever increasing presence of man made satellites and their radio transmissions pose a significant challenge of RFI to radio astronomy observatories, especially with increasing sensitivity and wider range of radio frequencies of the modern radio telescopes. The upgraded GMRT (uGMRT), now getting released for use by the global community, offers near seamless frequency coverage from about 120 to 1500 MHz, and thus faces the threat of RFI from satellite transmissions. We present here a summary of the measures adopted to characterise, predict and avoid satellite RFI at GMRT.

There are a very large number (several thousand) of satellites which transmit over a wide range of radio frequencies. Of these, we have identified most of the ones (about 80 satellites) that can affect the uGMRT receiver bands. Some of these are geo-stationary, others are geo-synchronous, and the rest are low and medium earth orbiting satellites. We have carefully characterised all such satellites, obtained the required ephemerides, and developed algorithms to track these with the GMRT antennas. Using this, we have characterised their frequencies, power levels and beamwidths, and worked out a zone of avoidance for each satellite, where it's signal can saturate the receiver system of the uGMRT. The observatory's monitor and control system has then been augmented to keep track of the positions of all the relevant satellites in the sky; and by comparing these with the current pointing directions of the GMRT antennas during normal observations, it generates an alarm for the operator whenever an antenna pointing enters within the zone of avoidance of any of the satellites that would affect the given radio band.

Furthermore, this tool can be run on any proposed observing schedule to check for such conflicts with satellites, and generate warnings for the users, so that they can make appropriate changes in their planned schedule. The tool can also be run post facto for any observation carried out at a past date, and by examining the header file of the acquired data file, it can mark out regions of the observing durations that would have been corrupted by RFI from any of the satellites, which can be used as flags by the user when analysing their data.

We describe the details of the implementation of the scheme, including how the zone of avoidance is defined and calculated, and the effectiveness of the tool in keeping track of the satellites in real-time, and also present some results. We also discuss ideas for further refinement of this scheme, including plans for generating real-time masks that the digital filtering techniques in the back-end can utilise for masking spectral line RFI. We also describe the plans for generalizing this tool and making it available for any other radio observatory.

Index Terms — radio telescope, radio frequency interference, satellites, GMRT.