A novel mode of observing with the GMRT dual-band (610/240 MHz) feed - science prospects

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Abstract

This note describes important scientific programmes that can pursued using the unique dual frequency band capability of GMRT which allows simultaneous observations in the 610 MHz and 240 MHz bands. The novel scheme proposed here exploits the different beamsizes of the 610 and 240 MHz feeds to define scientific programmes ranging from shallow imaging for an all sky survey to deep imaging of fields allowing an extensive study of radio transients and variables. An instantaneous spectral index map of unresolved sources in the sky can be generated and released for public use.

This note describes the novel scheme for using the unique mode which can be implemented while observing with the dual frequency feed at GMRT and which has not been used till now. Astronomers have generally used the dual band mode to image the central region of the field common to the primary beams at the two frequencies. However the widely different beamwidths at 610 and 240 MHz can be used in a novel way so that if the pointing of GMRT antennas is changed in steps of the half power beamwidth of 610 MHz, the entire 240 MHz beam is mapped - this also automatically results in additional integration at 240 MHz for each 610 MHz pointing for non-variable radio source population. This unique mode of observing using the dual band feed already available at GMRT would immediately facilitate two important scientific studies :
(1) radio transients/variables recognised by a change in flux density at 240 MHz. Each small 610 MHz field will be observed multiple times at 240 MHz due to the beamsize difference shown in Figure 1. Thus, each 610 MHz pointing will be included in several 240 MHz pointings. The scientific relevance of transients is discussed in, for example
https://science.nrao.edu/science/surveys/vlass/Hallinan_WP_r1.pdf and the importance of simultaneous radio observations of transients is nicely demonstrated, for example, in
http://adsabs.harvard.edu/abs/2005ChJAS...5...87I and
http://adsabs.harvard.edu/abs/2007ApJ...667L.171K.
(2) simultaneous maps at two frequencies and an instantaneous spectral index for the entire mapped region - a sort of spectral index survey of unresolved sources.

Implementing mosaicing techniques will also make images at both frequencies sensitive to large angular scale structure, thus benefitting studies of diffuse emission in clusters and groups of galaxies, haloes of disk galaxies etc in addition to Galactic objects such as supernova remnants and HII regions. A few of the specific **unique** projects with this special mode of observing can be
(a) a dual band sky survey - either the entire GMRT sky (like TGSS) or selected regions/strips of the sky.
(b) deep dual frequency imaging of existing multi-band deep fields.

These projects are best done with the existing dual band feed at GMRT which can give a factor of 2.5-3 in frequency. To quantify, the error on spectral index for a factor of 2 in frequency is 50% higher than for a factor of 3 in frequency. assuming that the flux densities and errors on these are equal for both sets of frequencies. It is important to note that the radio spectral index is an important tool for investigating physical conditions in Galactic sources, nearby galaxies and distant extragalactic radio sources.

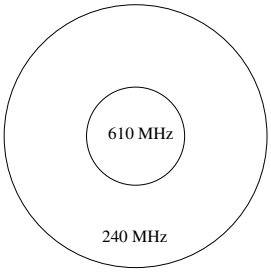

Figure 1: A schematic showing the different beamsizes at 610 MHz and 240 MHz which can be used in a novel way to probe several different science questions.

A quick literature search shows that (1) LOFAR is currently involved in MSSS - surveys at 60 and 150 MHz which are quasi-simultaneous (2) NRAO and NRL are enabling a facility on VLA to make simultaneous observations at low frequency bands (75 and/or 325 MHz) when higher frequencies are executing their science project - they are enabling a dual-frequency mode of observing on their antennas. (3) White papers have been submitted for transient search with the VLA Sky Survey (VLASS) which is currently in the planning stage. (4) ASTROSAT which is scheduled to be launched in 2015 will repeatedly scan the sky for transients - the GMRT dual-band feed can allow a quick followup which will result in simultaneous flux densities at both frequencies and hence instantaneous spectral index. More details can be found, for example, in http://www.iucaa.ernet.in/ astrosat/MIT-IUCAA_workshop_presentations/SplSessionJan17/ishwar-astrosat.pdf.

One can be ambitious and implement smart novel options at GMRT for a survey which is optimised for (a) simultaneous continuum mapping at 240 and 610 MHz (b) red-shifted HI in the 240 and 610 MHz bands by providing sufficient spectral resolution (c) pulsar surveys namely single pulse studies, timing, pulsar search (e.g.
http://adsabs.harvard.edu/abs/2002MNRAS.332...55V,
http://adsabs.harvard.edu/abs/2000ApJ...543..979V,
http://adsabs.harvard.edu/abs/1998MNRAS.295..397I) (d) linear polarisation observations at both bands of e.g. pulsars (http://adsabs.harvard.edu/abs/1999JApA...20...37R). The data, as is obvious from the range of science questions that can be tackled, can be useful to many astronomers.

Since we already have a readymade dual band feed/receiver at GMRT, it is suggested that this mode of observing be optimised and rigorously tested. Moreover the RFI environment further examined and steps taken to remove sources of RFI and excision algorithms developed for dealing with RFI which is difficult to eliminate from the GMRT environment. Discussions on further refinement for this observing mode can be planned. Using this unique facility at GMRT will result in GMRT maintaining a frontline position even when the next generation telescopes go online. This is due to the potential unique results this novel mode of observing can deliver, in addition to the science which is already being done in every observing cycle. In fact, GMRT has been maximally used for radio continuum observations as a quick search through the database on GMRT publications shows.

I would like to add that the references in this note are not comprehensive but indicative. I gratefully acknowledge discussions on this novel mode with colleagues. In particular, I would like to thank Govind Swarup, Avinash Deshpande and Gopal-Krishna for insightful discussions, suggestions and comments on the manuscript. I thank Ishwara-Chandra and Bhal-Chandra Joshi for discussions and pointing me to useful references. I also acknowledge discussions with Sandeep Sirothia, Subhashis Roy and Divya Oberoi.