*URSI - RCRS 2022, IIT (Indore), India, 1 - 4 December, 2022*

# Polarisation calibration of phased array observation with uGMRT

S. Kudale*(1), Y. Gupta(1)
(1) National Centre for Radio Astrophysics, Tata institute of Fundamental Research, Pune, India
e-mail: ksanjay@ncra.tifr.res.in; ygupta@ncra.tifr.res.in

Pulsars are one of the most polarised sources in the radio sky. Polarisation studies of pulsars provide very useful information on the pulsar radio emission process and the propagation effect of pulsar signals through the interstellar medium and the ionosphere. The state of the polarisation such as the polarisation type, percentage and polarisation angle convey significant information on these astrophysical processes.

Radio telescopes are inherently sensitive to the polarisation of the incoming radiation. Two orthogonal polarisation signals are received and carried through the receiver system as two channels, and later converted to Stokes parameters. Imperfections in the receiving feed or electronic system can cause signal to leak between the two polarisation channels, thereby altering the measured Stokes parameters. The observed Stokes parameters are generally modeled as true Stokes parameters operated on by the telescope transfer function (Muller matrix). A polarisation calibration observation is required to estimate the elements of the Muller matrix. For a single dish, this calibration can be performed by observing a highly linearly polarised pulsar across a large range of parallactic angles and fitting with suitable model to estimate the elements of the Muller matrix. Following Hamaker et. al[1], Johnston[2] developed such a methodology and demonstrated it for Parkes telescope.

In an antenna array, polarisation calibration is more involved. For the interferometry mode, cross-spectrum for every pair of antenna is separately recorded and there exists standard calibration techniques in post processing by which an individual antenna's gain is obtained by observing suitable calibration source in sky. For the phased array mode (used for pulsars), voltages from all available antennas are added to produce the equivalent of a single dish. The aggregate polarisation characteristics of such a single dish will depend on the properties of the antennas being combined, and hence the calibration needs to be carried out for every observation. Nevertheless, the methodology developed by Johnston[2] for a single dish has been demonstrated successfully for phased array of GMRT for narrow bandwidths, S. Kudale & Y. Gupta[3]. The recently upgraded GMRT (uGMRT, Gupta et. al.[4]), with larger bandwidths offers enhanced sensitivity. However it imposes challenges to carry out full Muller matrix calibration, as the parameters can vary significantly over the wide bands and need to be estimated carefully, and additional complexity is introduced.

In this paper, we start with our experience of polarisation calibration for the phased array of the original GMRT system, and describe the attempts to extend it to the uGMRT system. Further, we describe a new technique for calibration of the phased array of the uGMRT system, using an approach that avoids the need to observe a highly polarised pulsar over long range of parallactic angles. In this method, a test pulsar with a stable, well known profile and polarisation properties, needs to be observed for a short duration. By comparison of test pulsar with its calibrated profile one can obtain the parameters of the Muller matrix. We present preliminary results from this alternate method.

1. J.P. Hamaker, J.D. Bregman and R.J. Sault, 1996, “Understanding radio polarimetry”, Astron. Astrophys. Suppl. Ser. 117, 137-147.

2. Simon Johnston, 2002, “Single dish polarisation calibration”, Publ. Astron. Soc. Aug. 19, 277-281.

3. S. Kudale & Y.Gupta, 2008, “Polarisation Studies with GMRT”, M.Sc. Thesis, Technical Report NCRA-T1400

4. Gupta, Y., et al., 2017, “Upgraded GMRT : Opening new windows”, Current Sci, 113, 707.