National Centre for Radio Astrophysics

Internal Technical Report

Testing the Sensitivity of the ORT at Declinations Below -60°

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Objective: To determine the relative sensitivity of the Ooty Radio Telescope (ORT) at declination lower than -60° in order to assess its usefulness towards observing some potential radio pulsar targets.

Document History

Revision	Date	Modification / Change
Ver. 1	23 September 2016	Initial version

1 Introduction

Two interesting targets showing potential for detection of radio pulsations were reported recently. They were magnetar 1E 1048.1−5937 (Archibald *et al.* 2016) and PSR J1119−6127 (Kennea *et al.* 2016), respectively. Both of them showed magnetar-like X-ray bursts. While 1E 1048.1−5937 is already a known magnetar, a magnetar-like X-ray burst was not expected from PSR J1119−6127 as its period of 408 ms is much smaller than what is seen for typical magnetars (2–12 s). Magnetars usually do not emit pulsed radio emission due to their slow rotation periods and large magnetic fields. Recently, coherent radio pulsations were detected from at least three magnetars shortly after high energy bursts (Serylak *et al.* 2009, Camilo *et al.* 2007, 2016). Given that the radio loud magnetars is such a rare class, radio follow-up observations of magnetars in outburst provide a unique opportunity of detection of pulsations.

The Ooty Radio Telescope (ORT) is an equatorial mounted telescope and can track a celestial source only along right ascension (RA). The declination (DEC) tracking is currently done by phasing the modules by adding varying delays. This helps in steering the telescope beam in declination. Even though, given the fixed shape of the cylindrical paraboloid, the surface illumination and hence effective aperture area is a function of the source declination. This makes the telescope less sensitive at very high ($> +50^\circ$) and very low ($< -50^\circ$) declinations. Thus, we wanted to test the sensitivity degradation at and around a declination of -60° to assess the usefulness of ORT for observing the above mentioned targets.

2 Observations

In order to assess the degradation in sensitivity at declinations around -60°, we chose two strong pulsars namely PSRs B1154−62 and B1240−64. The expected flux densities of these pulsars at 327 MHz are about 243.5 and 154.5 mJy, respectively. We observed both the pulsars for 30 minutes each near their transit time to ensure maximum illumination of the reflecting area. We also observed a flux density calibrator source, 1136−135 (flux density 14 Jy at 327 MHz) in the ON and OFF (30 m East in RA) source position for 2 minutes each. The observations were performed on September 4, 2016 (MJD 57635). The data were recorded using the PONDER back-end wherein, the 16 MHz band was divided into 1024 spectral channels and was sampled at 1 ms. The data were recorded in the filterbank format.

3 Data Analysis and Results

We analysed the data using SIGPROC (version 4.3) analysis package. We produced calibrated profiles of both pulsars in the following way:

1. We folded the ON and OFF calibrator scans at the period of the pulsar.
2. We then determined the mean for both of them.
3. We then equated the difference between ON and OFF mean levels in counts to the flux density of the calibrator source. This provided a scaling factor in terms of Jy/counts.
4. We then calibrated the pulsar profile by subtracting OFF-pulse mean and multiplying by the Jy/counts factor obtained in step 3.

We determined the mean flux density of each pulsar by adding the flux in all profile bins and then dividing by the total number of bins in the folded profile. The calibrated profiles for both pulsars are shown in Figure 1. We summarize our results and conclusions below:

1. The measured flux density of PSR B1154−62 was 41.7 ± 3.5 mJy as compared to the expected value of 243.5 mJy.
2. The measured flux density of PSR B1240−64 was 14.5 ± 3 mJy as compared to the expected value of 154.5 mJy.
3. This implies a sensitivity of about 17 ± 2% and 11 ± 2% at declinations of –62° and –64°, respectively.
4. The measured sensitivity of ORT on September 4, 2016 was 23. Thus the sensitivity at at declinations of –62° and –64° is 3.9 and 2.5, respectively.
5. These numbers are consistent with the expectations (see Figure 2).
6. A caveat to be noted here is that interstellar scintillation can drastically change the apparent flux density of a pulsar. This may result in either underestimating or overestimating the sensitivity through pulsar observations.

4 References

1. Archibald *et al.* 2016, ATEL #9316
2. Camilo *et al.* 2007, *ApJ*, 663, 497
3. Camilo *et al.* 2007, *ApJ*, 820, 110
4. Kennea *et al.* 2016, ATEL #9274
5. Serylak *et al.* 2009, *MNRAS*, 394, 295

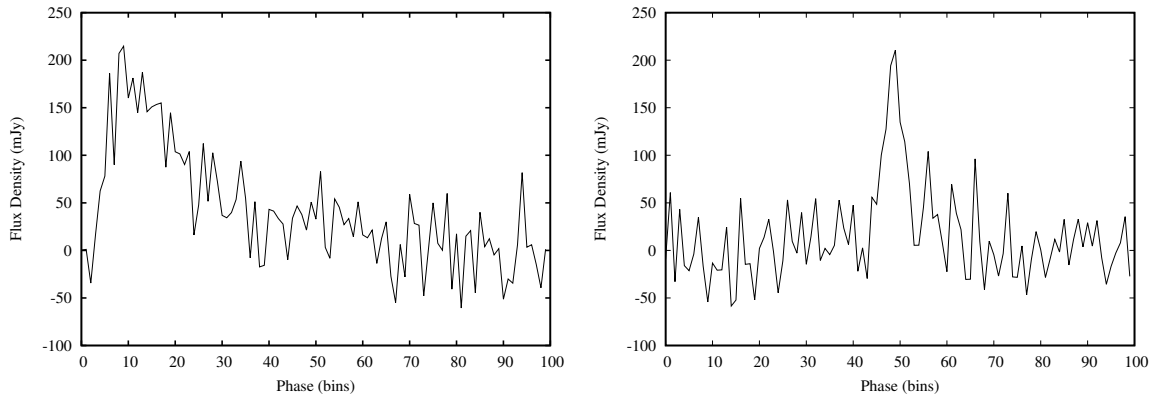

Figure 1: Calibrated profiles obtained for PSRs B1154−62 (left) and B1240−64 (right).

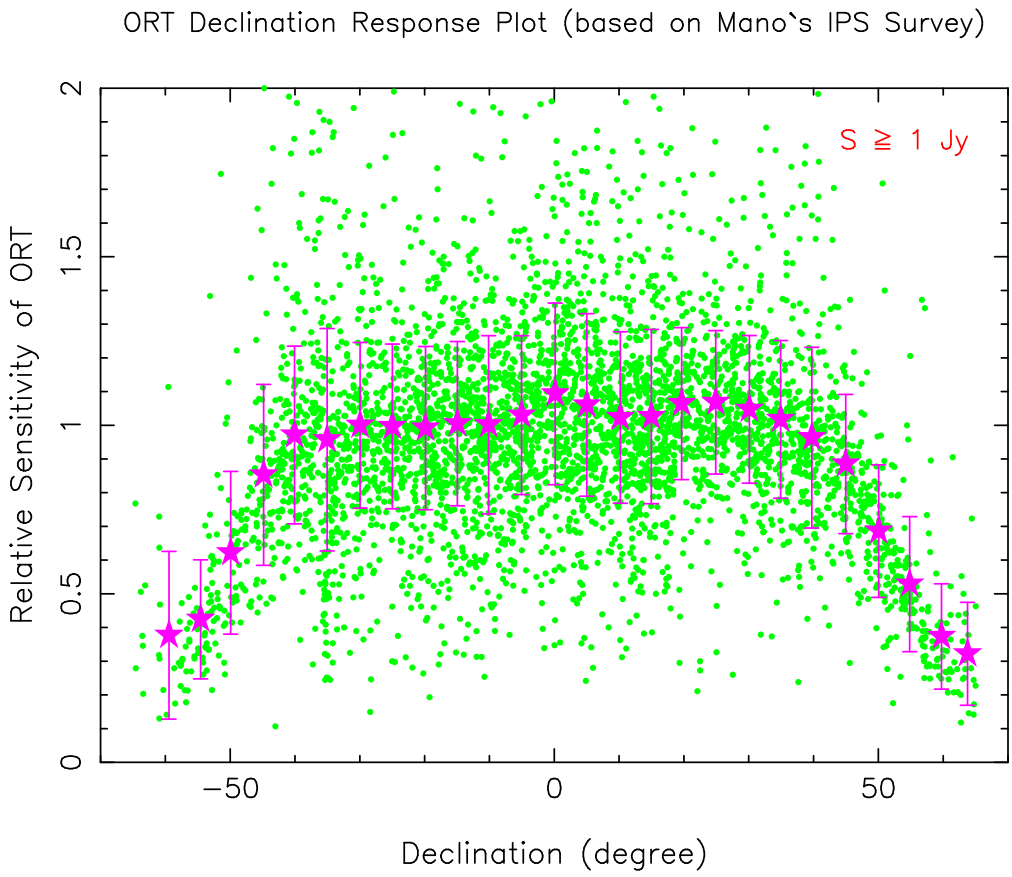

Figure 2: Relative sensitivity of the ORT as a function of source declination. This plot contains about 4400 radio sources with flux density more than 1 Jy. The filled stars with error bars indicate average response integrated over a 5° declination range. The plot was obtained by P. K. Manoharan from the interplanetary scintillation survey carried out between 1995–2008.