



A decade of a timing study of a black widow pulsar J1544+4937 with the GMRT

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We present results from long-term timing of a black widow millisecond pulsar (BW MSP) J1544+4937 discovered with the GMRT. This is the longest duration timing study of any galactic MSP with the GMRT. BW MSPs are compact binaries (orbital period < 1 day) in special evolutionary phases with a non-degenerate main-sequence companion with mass < 0.01 Msun. Initial 1.5 years of timing indicated that PSR J1544+4937, a 2.15 ms pulsar, is in a compact orbit with an orbital period of 2.9 hours (Bhattacharyya et al. 2013) where the pulsar wind is strongly interacting with its low mass companion. The current study extends the existing timing baseline to 11 years including multi-frequency GMRT observations combining 32 MHz and 200 MHz bandwidth systems and achieved a timing residual of 6.4 μ s. We report the first detections for a significant value of proper motion, first order orbital period derivative and 1st, 2nd, 3rd order dispersion measure (DM) derivatives for this system. Orbital period variation has been observed for this pulsar. Major contribution for it could be the variation of gravitational quadrupole moment of the companion. Although with the advent of Fermi gamma-ray telescope, a significant number of BWs are now available, it is hard to time them precisely in general, as most of them exhibit orbital variability along with DM variation. Therefore they are not considered to be suitable for Pulsar Timing Array (PTA). But Bochenek et al. 2015, using simulated data, emphasized that BW pulsars can be included in the PTA after proper modeling of the timing systematics using higher order orbital period derivatives and DM derivatives. From 4 years of timing using sensitive wide-bandwidth (200 MHz) uGMRT observations, we have achieved 2.9 μ s timing residual. With such precise timing aided with simultaneous multi-frequency observations with the uGMRT we aim to measure the intra-orbit DM variation for J1544+4937, which will provide input for hydrodynamical simulations of the orbit (Tavani et al. 1991) and will allow us to explore the possibility for inclusion of J1544+4937 in PTA.

1. Bhattacharyya, B., Roy, J., Ray, P. S., et al. 2013, ApJ, 773, L12, “GMRT DISCOVERY OF PSR J1544+4937: AN ECLIPSING BLACK-WIDOW PULSAR IDENTIFIED WITH A FERMI-LAT SOURCE”
2. Bochenek C., Ransom S., Demorest P., 2015, ApJ, 813, L4, “THE FEASIBILITY OF USING BLACK WIDOW PULSARS IN PULSAR TIMING ARRAYS FOR GRAVITATIONAL WAVE DETECTION”
3. Tavani et al. 1991, THE ASTROPHYSICAL JOURNAL 381: L21-1.24, “OUTFLOW HYDRODYNAMICS IN THE ECLIPSING MILLISECOND PULSAR BINARIES”