

Chromatic noise reverses the band preference of the Indian Pulsar Timing Array: a standalone gravitational-wave sensitivity analysis

Hardik Sher Singh

Department of Electronics and Computer Engineering,
Thapar Institute of Engineering and Technology, Patiala, Punjab, India
hsingh_be23@thapar.edu

Abstract

The Indian Pulsar Timing Array (InPTA) observes millisecond pulsars simultaneously in two widely separated uGMRT bands, the 300–500 MHz and 1260–1460 MHz bands. This is a configuration unique among the member arrays of the International Pulsar Timing Array. Its first standalone search for a gravitational-wave background has placed an upper limit on the background amplitude, but no sensitivity curve study of InPTA as a standalone array, or of what each band contributes has been published. We construct characteristic strain sensitivity curves by applying the `hasasia` formalism to the complete 27-pulsar noise budget of InPTA Data Release 2 and vary the observing band, the pulsar selection, the cadence and baseline. We find that the lower band’s better raw timing precision is reversed by propagation effects. With chromatic noise disabled the array is about 1.5 times more sensitive at 400 MHz, but including it imposes a chromatic penalty of approximately 2.9 there against 1.2 at 1360 MHz, leaving the upper band at about 1.7 times more sensitive. This ordering holds for individual pulsars and for the full array. This also survives removing every pulsar with a fitted rather than physically fixed chromatic index and tolerates a twofold misestimation of the white noise proxy. Sensitivity rests on a few well-timed pulsars and quadrupling the cadence improves the sensitivity minimum by only about 1.5 because the array is red noise limited rather than white noise limited. For a fiducial supermassive black hole binary spectrum, standalone InPTA DR2 would need a background roughly 17 times stronger than the amplitude measured by NANOGrav to reach $\text{SNR} = 3$. This threshold lies within 0.02 dex of the upper limit that InPTA’s own Bayesian search obtained from Band 5 data alone. For InPTA’s low band the binding constraint is chromatic modelling rather than timing precision.

Keywords—Pulsar timing arrays; nanohertz gravitational waves; chromatic noise; InPTA.