Highlights of Astronomy, Volume 15
XXVIIth IAU General Assembly, August 2009
Ian F. Corbett, ed.

doi:10.1017/S1743921310008999

Timing of binary pulsars and the search for the low-frequency gravitational waves

Vladimir A. Potapov[1] **and Sergei M. Kopeikin**[2]

[1]Pushchino Radio Astronomy Observatory of P.N.Lebedev Physical Inst.,
142290, Pushchino, Russia
email: potap@prao.ru

[2]Department of Physics & Astronomy University of Missouri-Columbia
223 Physics Bldg. Columbia, Missouri 65211 USA
email: kopeikins@missouri.edu

Abstract. Millisecond and binary pulsars are the most stable natural standards of astronomical time giving us a unique opportunity to search for gravitational waves (GW) and to test General Relativity. GWs from violent events in early Universe and from the ensemble of galactic and extragalactic objects perturb propagation of radio pulses from a pulsar to observer bringing about stochastic fluctuations in the times of arrival of the pulses (TOA). If one observes the pulsar over a sufficiently long time span, the fluctuations will be registered as a low-frequency, correlated noise affecting the timing residuals in the frequency range $10^{-12} \div 10^{-7}$ Hz. This work demonstrates how the standard procedure of processing of the pulsar timing data can bias the estimate of the upper limit on the density of the GW background (GWB).

Keywords. gravitational waves, binary pulsars, data analysis

We have analyzed the statistical method proposed in Jennet *et al.* (2005) (hereinafter referred to as D05) for possible detecting of GWB with Pulsar Timing Array (PTA) consisting of binary pulsars. To this end we have used the analytic formalism of our joint paper (Kopeikin and Potapov, 2004) that determines dependence of TOA residuals and pulsar's parameters on characteristics of timing noise induced by the GWB.

We have found that the procedure of fitting of the binary pulsar parameters increases the significance of the GWB detection as compared with that given in D05, in proportion to the number of orbital revolutions, $N_{orb} = T/P_{orb}$, where T is the span of observation and P_{orb} is the orbital period of the binary pulsar. The spectral sensitivity of PTA at the frequencies close to the orbital frequencies of binary pulsars is inversely proportional to the number of PTA pulsars.

We calculated the GWB detection significance for PTA with the "target parameters" of Parkes PTA (250 TOAs, 20 pulsars, TOA residuals standard deviation 100 ns, $T = 5$ yrs.). It was shown that for the long period binary pulsars ($P_{orb} \approx 1/2$ yr.) the estimated upper limit for the energy density of GWB is about two times larger as compared with the estimate obtained by the method from D05. These two estimates asymptotically converge as the number N_{orb} increases, and became practically equal after $N_{orb} > 30$. We conclude that the method of D05 can be used without restrictions for any PTA that consists of binary pulsars with rather short orbital periods ($\simeq$ a few days).

(This work is supported by RFBR under grant No 09-02-00922).

References

F. A. Jennet, G. B. Hobbs, K. J. Lee, & R. N. Manchester 1985, *Ap.J.*, **625**, L123–L126
S. M. Kopeikin & V. A. potapov 2004, *Mon.Not.R.Astron.Soc.* **355**, 395–412