Predictions for LISA and PTA based on SHARK galaxy simulations (Corrigendum)

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A&A, 660, A68 (2022), https://doi.org/10.1051/0004-6361/202141987

Key words. gravitational waves – galaxies: evolution – errata, addenda

We have realized that there is an error in our code for the calculation of the gravitational wave background (GWB), specifically an incorrect source sampling and their contribution to the GWB. The corrected amplitudes for the GWB for the two binary lifetime scenarios (100 Myr and 1 Gyr) at the reference frequency of 1 yr\(^{-1}\) are \(h_{c,\text{MYR}} = 8.41 \times 10^{-16}\) and \(h_{c,\text{GYR}} = 7.88 \times 10^{-16}\), whereas the original were \(h_{c,\text{MYR}} = 1.1 \times 10^{-15}\) and \(h_{c,\text{GYR}} = 1.4 \times 10^{-16}\), respectively. The conclusions of the original paper are therefore unchanged as, although the previously calculated amplitudes were overestimated, they are still lower than the signal recently reported by the Pulsar Timing Array experiments (EPTA Collaboration et al. 2023; Agazie et al. 2023; Reardon et al. 2023).

From a finite population of massive black hole binaries retrieved from simulations, we can obtain multiple realisations by drawing the true number of binaries in a given comoving volume from a Poisson distribution \(P\) centered at (Kelley et al. 2017)

\[
\Lambda_{ij} = \frac{1}{V_s} \frac{dV_c(z_i)}{dz_i} \Delta z_i.
\]  

(1)

where \(V_s\) is the comoving volume of the simulation, \(dV_c(z)\) is the comoving volume element, and \(\Delta z_i\) is the redshift step size with indices \(i\) and \(j\) iterating over each binary and time step, respectively.

The corrected GWB was calculated by multiplying Eq. (15) (original paper) by \(\Lambda_{ij}\), which effectively can be written as the following (Kelley et al. 2017):

\[
h_c^2(f) = \sum_{ij} P(\Lambda_{ij}) \sum_k \frac{f_r}{\Delta f} \Delta z_i (f_r),
\]  

(2)

where \(f\) and \(f_r\) are observed and source rest-frame GW frequencies, respectively, and index \(k\) iterates over all binaries.

As various models presented in the original paper were indistinguishable in terms of their GWB amplitude, in Fig. 1 provided in this erratum, we present the results only for the default model (B4H10). The solid colored lines show the median characteristic strain averaged over 300 iterations, while the solid red line corresponds to the amplitude assuming a pure power law \(h_c = A_{\text{yr}^{-1}} \left( \frac{f}{f_0} \right)^{-2/3}\), where \(f_0 = \text{yr}^{-1}\). For reference, we also show the amplitude of the signal as measured by the PTA experiments, specifically the European and Indian PTA (EPTA Collaboration et al. 2023), the North American Nanohertz Observatory for Gravitational Waves (Agazie et al. 2023), and the Parkes PTA (Reardon et al. 2023).

References


Fig. 1. Characteristic strain of the GWB for the default model B4H10. Black lines show the amplitude of the signal constrained by the PTA experiments, while solid colored lines show median amplitudes for 100 Myr, 1 Gyr, and 5 Gyr scenarios.