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Pulsar timing and binary black holes

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The merging binary black holes (BBHs) have been detected by the ground gravitational-wave observatories, but it is very difficult to detect BBHs before their mergers. Since millisecond pulsars (MSPs) are remarkable precise 'clocks' in Universe, they could be used to detect the hidden BBHs, if they exist in systems of BBHs. Doing so, we construct a triple system which consists of a BBH and a third outer MSP. The theoretical studies have shown that the inner binary could cause additional time residuals (i.e. Romer delay) on the orbit of the outer MSP, which can be used to detect inner BBHs. Using N-body simulations, in this paper, we calculate such time residuals, and analyse the periodic signals of them by Fast Fourier Transform, which allow us to explore the effects of the parameters of the inner BBHs. Specifically, we assume that the triple system is coplanar and stable; the distance from the earth is ~1 kpc; the mass of each black hole is 10 M⊙. We find that the amplitude of the time residual increases with the semimajor axis and eccentricity of the inner BBH. Moreover, we find that there are several prominent and characteristic periodic signals for different parameters of the inner BBHs. With the help of the analytic results, we find these frequencies are due to different orders of the eccentricities of both the inner and outer binaries. Thus, in principle, we can use these frequencies to determine the parameters of the inner BBHs.

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