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Effects of spin-orbit coupling on gravitational waveforms from a triaxial non-aligned neutron star in a binary system

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Spinning neutron stars (NSs) can emit continuous gravitational waves (GWs) that carry a wealth of information about the compact object. If such a signal is detected, it will provide us with new insight into the physical properties of matter under extreme conditions. According to binary population synthesis simulations, future space-based GW detectors, such as LISA and TianQin, can potentially detect some double NSs in tight binaries with orbital periods shorter than 10 minutes. The possibility of a successful directed search for continuous GWs from the spinning NS in such a binary system identified by LISA/TianQin will be significantly increased with the proposed next-generation ground-based GW observatories, such as Cosmic Explorer and Einstein Telescope. Searching for continuous GWs from such a tight binary system requires highly accurate waveform templates that account for the interaction of the NS with its companion. In this spirit, we derive analytic approximations that describe the GWs emitted by a triaxial non-aligned NS in a binary system in which the effects of spin-orbit coupling have been incorporated. The difference with the widely used waveform for the isolated NS is estimated and the parameter estimation accuracy of an example signal using Cosmic Explorer is calculated. For a typical tight double NS system with a 6 min orbital period, the angular frequency correction of the spinning NS in this binary due to spin precession is $\sim 10^{-6}$ Hz, which is in the same order of magnitude as the angular frequency of orbital precession. The fitting factor between the waveforms with and without spin precession will drop to less than 0.97 after a few days ($\sim 10^5$ s). We find that spin-orbit coupling has the potential to improve the accuracy of parameter estimation, especially for the binary inclination angle and spin precession cone opening angle, by up to 3 orders of magnitude.

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