General Relativity and Quantum Cosmology

Addressing the spin question in gravitational-wave searches: Waveform templates for inspiralling compact binaries with nonprecessing spins

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This paper presents a post-Newtonian (PN) template family of gravitational waveforms from inspiralling compact binaries with non-precessing spins, where the spin effects are described by a single "reduced-spin" parameter. This template family, which reparametrizes all the spin-dependent PN terms in terms of the leading-order (1.5PN) spin-orbit coupling term \emph{in an approximate way}, has very high overlaps (fitting factor > 0.99) with non-precessing binaries with arbitrary mass ratios and spins. We also show that this template family is "effectual" for the detection of a significant fraction of generic spinning binaries in the comparable-mass regime (m_2/m_1 <~ 10), providing an attractive and feasible way of searching for gravitational waves (GWs) from spinning low-mass binaries. We also show that the secular (non-oscillatory) spin-dependent effects in the phase evolution (which are taken into account by the non-precessing templates) are more important than the oscillatory effects of precession in the comparable-mass (m_1 ~= m_2) regime. Hence the effectualness of non-spinning templates is particularly poor in this case, as compared to non-precessing-spin templates. For the case of binary neutron stars observable by Advanced LIGO, even moderate spins (L . S/m^2 ~= 0.015 - 0.1) will cause considerable mismatches (~ 3% - 25%) with non-spinning templates. This is contrary to the expectation that neutron-star spins may not be relevant for GW detection.

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