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Precession in black hole binary systems: toward calibrating precessing phenomenological waveform models to numerical relativity

Since 2015 the international advanced gravitational wave detector network has confidently detected tens of short transient signals, whose sources have been identified as mergers of compact objects, primarily binary systems of black holes. The main goal of this talk will be to discuss the phenomenon of precession in black hole binaries, as well as the first steps to further improve its description towards the next observational run, which will finally achieve design sensitivity for the LIGO and Virgo detectors. Binary black holes systems span a parameter space of nine intrinsic parameters: two spin vectors, the mass ratio, and two parameters associated with eccentricity. When the black hole spins are orthogonal to the orbital plane, there exists an equatorial symmetry of the spacetime that is preserved in time, and so are the spin directions and the orbital plane itself. The parameter space for these systems, referred to as non-precessing, reduces considerably. This is no longer true when the spins are misaligned with the orbital angular momentum: the spin-orbit and the spin-spin couplings induce a precessing motion of the orbital plane and spins, which breaks all the symmetries. Further, precession leads to a complex modulation of the signal which becomes hard to model due to the high dimensionality of the problem. This phenomenon can be simplified by using an approximate map between precessing signals in a non-inertial co-precessing frame and non-precessing signals. This approach is often called the "twisting-up approximation" and has typically been used in phenomenological waveform models. In this talk, we will discuss the main caveats of the approximation and the preliminary steps towards calibrating precession to numerical relativity simulations. These efforts may become essential to improve the accuracy of the current (fourth) generation of phenomenological waveform models developed in our group.

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