Measuring parameters of massive black hole binaries with partially aligned spins

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The future space-based gravitational wave detector LISA will be able to measure parameters of coalescing massive black hole binaries, often to extremely high accuracy. Previous work has demonstrated that the black hole spins can have a strong impact on the accuracy of parameter measurement. Relativistic spin-induced precession modulates the waveform in a manner which can break degeneracies between parameters, in principle significantly improving how well they are measured.
Recent studies have indicated, however, that spin precession may be weak for an important subset of astrophysical binary black holes:
those in which the spins are aligned due to interactions with gas. In this paper, we examine how well a binary's parameters can be measured when its spins are partially aligned and compare results using waveforms that include higher post-Newtonian harmonics to those that are truncated at leading quadrupole order. We find that the weakened precession can substantially degrade parameter estimation, particularly for the ``extrinsic'' parameters sky position and distance. Absent higher harmonics, LISA typically localizes the sky position of a nearly aligned binary about an order of magnitude less accurately than one for which the spin orientations are random. Our knowledge of a source's sky position will thus be worst for the gas-rich systems which are most likely to produce electromagnetic counterparts. Fortunately, higher harmonics of the waveform can make up for this degradation. By including harmonics beyond the quadrupole in our waveform model, we find that the accuracy with which most of the binary's parameters are measured can be substantially improved. In some cases, the improvement is such that they are measured almost as well as when the binary spins are randomly aligned.