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Observability of spin precession in the presence of a black-hole remnant kick

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Remnants of binary black-hole mergers can gain significant recoil or kick velocities due to the anisotropic emission of gravitational waves, which may leave a characteristic imprint in the observed signal. So far, only one gravitational-wave event supports a non-zero kick velocity: GW200129_065458. This signal is also the first to show evidence for spin-precession. For most other gravitational-wave observations, spin orientations are poorly constrained as this would require large signal-to-noise ratios, unequal mass ratios or inclined systems. We investigate whether the imprint of the kick can help to extract more information about the spins. We perform an injection and recovery study comparing binary black-hole signals with significantly different kick magnitudes, but the same spin magnitudes and spin tilts. To exclude the impact of higher signal harmonics in parameter estimation, we focus on equal-mass binaries that are oriented face-on. We find that signals with large kicks necessarily include large asymmetries, and these give more structure to the signal, leading to more informative measurements of the spins and mass ratio. Our results also complement previous findings that argued precession in equal-mass, face-on or face-away binaries is nearly impossible to identify. In contrast, we find that in the presence of a remnant kick, even those signals become more informative and allow determining precession with signal-to-noise ratios observable already by current gravitational-wave detectors.

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