Merger Rates and the Electromagnetic Counterparts to Misaligned Supermassive Black Hole Binaries

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ABSTRACT

This work investigates the accretion rates and the gravitational wave emission produced when a secondary supermassive black hole spirals toward a primary one, both embedded in a circumprimary gaseous disc. We use for this study SPH (Smoothed Particle Hydrodynamics) simulations performed with 3D PHANTOM code. We extend previous investigations of co-planar accretion discs to the case where the disc and binary orbital planes are misaligned. We consider a geometrically thin disc with inclination angles varying from 1 to 180 degrees and a binary with mass ratio $q=10^{-3}$. We find that discs with small inclination angles (< 10 degrees) produce an increase in luminosity exceeding the Eddington limit. By contrast, discs with inclinations between 20 and 30 degrees show a less pronounced rise in the accretion rate, whilst discs inclined by 180 degrees show no peak in the mass accretion rate, as predicted analytically by previous work. The results of estimate of the accretion rates showed the possibility of electromagnetic counterparts prior to the signal of gravitational waves emitted in the last stages of orbital decay of the supermassive black hole binary. The electromagnetic signature may occur a few days before the binary merger. Motivated by numerical results, we estimate the event rates per year expected by LISA and gLISA detectors, assuming an astrophysical scenario with disc-binary systems at different inclination angles. We find the detection rate for misaligned disc and SMBH binary orbital planes at small angles may produce roughly 10 events per year, while highly misaligned disc-binary systems may provide rates as high as 28 events per year. The estimates obtained in this work predict the optimist number of expected events at high inclinations for space-based detectors like LISA/gLISA and the possibility of a promising scenario to the first evidence of a linkage between a SMBH merger and an electromagnetic signal for systems at small inclinations. These missions may be able to contribute significantly to astrophysics, discerning the different evolutionary scenarios that lead to the formation of SMBHs.

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