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Eccentric orbits in disk-embedded EMRIs : Orbital evolution and observability trend in LISA.

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The purpose of this work is to study the orbital evolution under the combined effect of disk-drag and GW-emission for E/IMRIs endowed with accretion disk. We study the dependence of disk-torque and GW-torque on the orbital parameters of compact companions. We employ a semi-relativistic technique to study E/IMRI dynamics evolving under most general elliptical-orbits in the equatorial plane and assume natural transonic disk in the Kerr space-time around a supermassive black-hole (SMBH). To conduct an accurate investigation, we fix the disk attributes and alter orbital-parameters, mass-ratio of E/IMRIs and spin of SMBH. We notice that high-eccentric orbits with smaller semi-major axis exhibit a more prominent impact of accretion-drag on the companion-dynamics. The magnitude of disk-torque is greater and almost one order higher in retrograde-spins than prograde spins. We identify the best-fitted orbital parameters, which can potentially enhance detectability of accretion-disk effect on the observed GW-signal. Prioritizing such orbital-configuration, we obtain substantial impact on the dephasing for maximum disk-torque and high signal-to-noise-ratio (SNR) in emitted signals. Employing a threshold-SNR (> 8), we finally identify the detectability trend of those systems in LISA-band. A key aspect of our findings is the ability to constrain the orbital parameters by GW-detection and estimate orbital-ellipticity or other orbital characteristics by comparing two SNRs. Hence, the study will be important in understanding the orbital-evolution, predicting orbital-configuration, and finding detectability for such gas-rich E/IMRIs. The predictions of E/IMRI formation pathways from ground and more certainly from future space-borne detectors, would also be possible from the likelihood of such eccentric-E/IMRIs in the sky.

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