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Symphony of Spacetime: Tuning into EMRI resonances with LISA

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Extreme-mass-ratio inspirals (EMRIs) are binary systems composed of a primary supermassive black hole and a secondary compact object of stellar mass. Owing to their significant mass disparity, EMRIs emit gravitational waves in the millihertz frequency band, making them accessible only to future space-based detectors such as LISA. These systems evolve adiabatically, with the secondary effectively tracing the spacetime geometry of the primary. This unique characteristic allows EMRIs to serve as precise probes for testing General Relativity and investigating the complex astrophysical environments surrounding supermassive black holes.

Their gradual evolution also implies that EMRIs may pass through orbital resonances —special configurations where orbital frequencies become commensurate —leading to distinct imprints on gravitational-wave signals. In this talk, I will summarize the concept of orbital resonances and explore three key aspects: (i) their influence on gravitational-wave emission in EMRIs with Kerr black hole primaries, (ii) the amplified effects of resonances when the primary deviates from the Kerr geometry, exhibiting chaotic behavior, and (iii) the role of resonances in initially spherical EMRIs orbiting both integrable (deformed Kerr) and non-integrable (non-Kerr) rotating primaries. These gravitational-wave features present strong prospects for observational detection and must be modeled with high precision to be reliably identified in future LISA data.

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