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Extreme Dark Matter Tests with Extreme Mass Ratio Inspirals

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Future space-based laser interferometry experiments such as LISA are expected to detect $\mathcal{O}(100-1000)$ stellar-mass compact objects (e.g., black holes, neutron stars) falling into massive black holes in the centers of galaxies, the so-called extreme-mass-ratio inspirals (EMRIs). If dark matter forms a "spike" due to the growth of the massive black hole, it will induce a gravitational drag on the inspiraling object, changing its orbit and gravitational-wave signal. We show that detection of even a single dark matter spike from the EMRIs will severely constrain several popular dark matter candidates, such as ultralight bosons, keV fermions, MeV–TeV self-annihilating dark matter, and sub-solar mass primordial black holes, as these candidates would flatten the spikes through various mechanisms. Future space gravitational wave experiments could thus have a significant impact on the particle identification of dark matter.

Primary authors: Dr HANNUKSELA, Otto (Nikhef); Dr NG, Kenny (Gravitation Astroparticle Physics Amsterdam (GRAPPA)); Prof. LI, Tjonnie (The Chinese University of Hong Kong)

Presenter: Dr HANNUKSELA, Otto (Nikhef)

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