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Probing Graviton Mass Through Strong Lensed Gravitational Waves with Next-Generation Detectors

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Gravitational-wave (GW) astronomy is an established field that is rapidly expanding with increasing detections from merging compact binary systems. The next generation of GW detectors promises a tenfold increase in sensitivity, leading to a thousandfold increase in the observable volume of the Universe and a corresponding rise in detection rates. This growing dataset provides a unique opportunity to investigate fundamental aspects of physics, including probing the properties of gravitons through the study of strongly lensed gravitational waves.

In this work, we explore constraints on the mass of the graviton by analyzing strongly lensed GW signals from typical binary black hole mergers, using different gravitational lens models. Specifically, we use the point mass model for black holes and the singular isothermal sphere (SIS) model for galaxies to determine limits on the graviton mass. Additionally, we simulate the detector response for both next-generation ground-based GW detectors (e.g., Einstein Telescope) and space-based detectors (e.g., LISA) to further assess the capabilities of future observations. We evaluate the potential of future GW observations to provide meaningful constraints on the graviton mass, offering new insights into the nature of gravity at cosmic scales. Our study highlights the importance of gravitational lensing in extending the reach of GW astronomy to address fundamental questions in physics.

Primary author: GENG, Shuaibo (National Centre for Nuclear Research)

Presenter: GENG, Shuaibo (National Centre for Nuclear Research)

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