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Detection and characterization of strongly-lensed gravitational waves

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Like light, gravitational waves can be deflected by massive objects along their travel path from source to observer. Depending on the mass of the lens, the wave can get distorted, magnified, or split into multiple potentially detectable images. The latter case is called strong lensing and happens when the characteristic size of the lens is much larger than the gravitational-wave wavelength. In this case, one would observe several images with the same frequency evolution but magnified, time-shifted, and with a possible overall phase shift. This phenomenon is expected to be observed in the coming years and could lead to new tests of general relativity, the identification of the host galaxy for binary black hole mergers, and tests of cosmology. However, because of the growing number of events over the year, the detection of strongly-lensed images represents a major challenge. Indeed, for O(1000) unlensed events, one has to analyze all the possible pairs, making for O($5x10^5$) pairs to analyze. This requires the development of fast and precise tools for their identification. In addition, the presence of the extended unlensed background leads to a high probability of false alarms, making it difficult to identify genuinely lensed events. Here, we present GOLUM, a framework able to do fast and precise parameter estimation for lensed events, reducing significantly the background compared to other fast methods. We also show how the inclusion of lens models can help in the identification of lensed events in an unlensed background for a realistic observation scenario.

Primary author: JANQUART, Justin

Co-authors: Prof. VAN DEN BROECK (Utrecht University and Nikhef); Dr MOORE , Anupreeta (The Inter-University Centre for Astronomy and Astrophysics (IUCAA),); Dr HARIS, K. (Utrecht University); Dr HANNUKSELA, Otto A. (The Chinese University of Hong Kong)

Presenter: JANQUART, Justin

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