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Probing the nature of dark matter using gravitational-wave strong lensing

Third generation gravitational wave (GW) detectors are expected to detect millions of binary black hole (BBH) mergers during their operation period. A small fraction of them (~1%) will be strongly lensed by intervening galaxies and clusters, producing multiple observable copies of the GW signals. The expected number of lensed events and the distribution of the time delay between lensed images strongly depend on the mass distribution of dark matter halos. Warm dark matter (WDM) or fuzzy dark matter (FDM) models predict lower abundances of small mass halos as compared to the standard cold dark matter. This will result in a reduction in the number of strongly lensed GW events, especially at small time delays. Using the total number of lensed events and the time delay distribution, we can put a lower bound on the mass of the WDM/FDM particle from a catalog of lensed GW events. The expected bounds from GW strong lensing from third-generation GW detectors are better than the existing constraints.

Email

souvik.jana@icts.res.in

Affiliation

ICTS-TIFR

Author: JANA, Souvik (ICTS-TIFR)

Co-authors: Dr J. KAPADIA, Shasvath (IUCAA); Dr VENUMADHAV, Tejaswi (UCSB); Prof. PARAMESWARAN, Ajith (ICTS-TIFR)

Presenter: JANA, Souvik (ICTS-TIFR)

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