GRAVITATIONAL WAVES

Neutron stars under aLIGO's lens

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The improved sensitivity of Advanced LIGO–Virgo has opened up fundamentally new avenues to study the properties of compact objects. Young neutron stars — up to a few thousand years old — are expected to emit continuous gravitational waves (GWs) during their initial spin-down phase. The LIGO Collaboration performs a targeted search for such signals in the dataset of the first Advanced LIGO observing run (aLIGO O1) and places the tightest constraints yet on the properties of 16 putative young neutron stars.

Unlike the all-sky searches performed by aLIGO–Virgo, targeted searches for continuous GWs are computationally much more intensive but less time-critical. Up to 10^{14} waveform templates are used per source to cover the full parameter space that might be relevant to that target, owing to the large uncertainties in the masses, ages and other properties of the neutron stars. As a result, up to 10^{6} supercomputer core hours are needed per target. Each search results in a potential signal or upper limit per GW frequency bin investigated.

Through a rigorous screening process for systematics, noise and injected test signals, the LIGO team conclude that there is no astrophysical signal in their data. Instead, the authors use their analysis to place the tightest upper limits yet on two key properties of their targets, their ellipticity and their Rossby modes (oscillations dominated by the Coriolis force). In addition, these upper limits can constrain other neutron-star properties, including their internal magnetic field strength and other extreme matter microphysics. In the upcoming O3 run, a further improved aLIGO–Virgo and the GEO600 detector are joining forces, improving our chances of detecting these continuous GWs.

Marios Karouzos

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