Dark Matter Search in Gravitational-Wave Data

An analysis of gravitational data from the LIGO detector sets new limits on a wave-like form of dark matter called scalar-field dark matter.

By **Michael Schirber**

LIGO and other gravitational-wave observatories detect gravitational waves through miniscule changes—as small as one millionth the width of an atomic nucleus—in the length of the kilometer-long interferometer arms. These detectors might also be sensitive to a specific type of dark matter, called scalar-field dark matter, that is expected to cause size changes to the interferometer equipment. A new analysis of LIGO data finds no size-change signal, implying new constraints on this dark matter model.

Scalar-field dark matter is a wave-like form of dark matter that sometimes goes by the name "fuzzy dark matter" (see **Focus: A Galactic Condensate**). Theory predicts that scalar-field dark matter should cause oscillations in fundamental constants, namely the electron mass and the fine structure constant. Such oscillations could cause matter to shrink and expand at a rate that depends on the mass of the scalar-field particle.

Alexandre Göttel from Cardiff University, UK, and colleagues have looked for oscillation effects in data from LIGO's third observing run (2019–2020). They are not the first to perform such a search, but their analysis accounts for a broader range of effects. "While all matter would be influenced by the scalar field, most of the effects would cancel out in LIGO—except for the signal from the beam splitter," Göttel says. The beam splitter sits at the center of the detector, and any change in its size would shift the laser interference pattern. The researchers find no signal at a frequency of 10 Hz, placing the strongest limits yet on scalar-field dark matter with a mass of 10^{-13} eV/c^2. They plan to keep looking in future datasets from LIGO and next-generation detectors.

Credit: Caltech; MIT; LIGO Lab

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REFERENCES

1. A. S. Göttel *et al.*, "Searching for scalar field dark matter with LIGO," **Phys. Rev. Lett. 133, 101001 (2024).**