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Fundamental Physics with Gravitational Waves: Probing the Dark Side

WILLIAM EAST, Perimeter Inst for Theo Phys

The era of gravitational wave astronomy will not only shed new light on the astrophysics of black hole and neutron star binaries, but also promises unique probes of fundamental physics. I will discuss some exciting ways that multimessenger observations of black holes and neutron stars can be used to look for new types of matter that are inaccessible to terrestrial labs. The phenomenon of superradiance enables a rotating black hole to grow an oscillating cloud of ultralight bosons, spinning down in the process. Gravitational waves from such a source would be a distinct signature of axions or dark photons. With its high densities and gravitational compactness, a neutron star can become a collection site for dark matter, eventually forming a tiny black hole at its center that devours the star from the inside. I will discuss recent theoretical work to model such sources and understand the rich, strong-field dynamics involved.