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Constraining dark matter candidates with gravitational wave observations

The nature of dark matter continues to elude us after decades of pointed efforts to detect various dark matter candidates. We know of its existence because dark matter gravitates, making gravitational waves (GW) a unique avenue for its detection. Compact object binaries forming in dark matter rich environments are detectable by the current generation of Earth-based GW detectors, giving us a window to detect exotic formation channels separate from stellar evolution. Especially, the detection of a sub-solar mass black hole will provide decisive evidence for new physics, possibly formation channels involving dark matter. To that effect, searches for GW signals from sub-solar mass compact objects have been conducted in data from LIGO-Virgo detectors with no detections so far. However, these searches provide limits on the merger rates of subsolar-mass binaries which in turn have been used to constrain dark matter candidates like primordial black holes. Here, I will also expand upon scenarios where GW observations can constrain properties of dark matter described by specific models. GW signals from black hole binaries that form from the cooling and gravitational collapse of dissipative dark matter halos constrain the mass spectrum of such objects. On the other hand, asymmetric dark matter accumulation in the cores of neutron stars can cause their implosion to form solar-mass black holes which if present in binary systems, will produce detectable GW signals. Therefore, GW observations from current and next generation detectors can complement direct detection efforts for dark matter in constraining the parameter space of dark matter candidates.

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