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Primordial black holes and gravitational waves from long-range scalar forces

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Most of the elementary particles discovered in the past century have Compton wavelengths that are much smaller than the size of the atom, and, therefore, they cannot mediate any long-range forces between atoms. This changes in the early Universe, when the horizon size is small. The forces that mediate attractive interactions between particles, such as Yukawa forces, are of particular interest in this early era. These attractive forces exhibit an instability similar to the gravitational instability, but are generally stronger. The effect of this instability is the formation of structure, even in a radiation dominated era. Simultaneously, this same attractive interaction enables the removal of energy and angular momentum through the emission of scalar radiation which facilitates collapse. The process of early structure formation and collapse, has a rich phenomenology and has been utilized to address numerous open questions in physics. In this talk, I will demonstrate how long-range forces and scalar radiation lead to the formation of primordial black holes (PBHs) as dark matter. Furthermore, we will explore the observational consequences of early structure formation, particularly possible contributions to the stochastic gravitational wave background. Lastly, I will talk about the implications of PBHs as dark matter, with a particular focus on the interactions between PBHs and neutron stars.

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