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Multimessenger and Cosmological Probes of Axions and Axion-Like Particles

Abstract

The axion, and more generally any pseudoscalar boson, is a well-motivated dark matter candidate because of its natural agreement with the misalignment mechanism of dark matter production and its late-time redshift being equivalent to that of cold dark matter. Theoretically, axions generate and modulate coherent radio emissions in extreme environments, particularly strong magnetism and superradiant black holes. Fast radio burst emissions could consequently provide signatures that point to the existence of axions. Beyond multimessenger signals, extensions of the conventional Lagrangian with axion-electromagnetic coupling can also produce significant signatures; in the case of this work, a Lagrangian with additional axion-dark energy coupling terms can produce these signatures from superradiance. In this way, superradiance provides a powerful mechanism for probing the microphysics of dark energy and axion dark matter simultaneously.

In this talk, I will consider an extension of the conventional axion-photonmodel in which the Lagrangian includes a dynamical dark energy scalar fieldcoupled to the axion. Using magnetars as a benchmark study, I will show that this interaction modifies the physical mass scales and couplings, thereby altering axion-photon conversion probabilities and the resultant astrophysical FRB signatures. In turn, these modified signatures can provide a novel probe of the dark energy sound speed.