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Testing ultralight scalar field dark matter in high-redshift universe

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Scalar field dark matter (SFDM) comprised of ultralight (m ~ 10^{-22} eV) bosonic particles has received significant attention as a viable alternative to Cold Dark Matter (CDM), as it approximates CDM on large scales (⊠ 1 Mpc) while potentially resolving some of its small-scale problems via kpc-scale quantum interference. However, the basic SFDM model described by a free real field, a.k.a. fuzzy dark matter (FDM), is recently challenged by a catch-22 problem: small boson masses yield the desired cores of dwarf galaxies but underpredict structure in the Lyman-α forest, whereas large boson masses render FDM effectively identical to CDM. Therefore, we propose to study the complex SFDM model with a possible self-interaction. A complex scalar field with U(1) symmetry results in the conservation of the associated Noether current, a new degree of freedom. We examine the dynamical implications of the Noether charge for large-scale structure and the Cosmic Microwave Background. We also discuss potential tests of SFDM by the 21cm line from the Cosmic Dawn and by the gravitational-wave (GW) signal from spinning black holes. Furthermore, we demonstrate that the kination phase resulted from complex SFDM can amplify the primordial GW background and thus explain the recent pulsar timing array results.

Paper info

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