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Fuzzy dark matter oscillations in perturbed soliton cores

Bosons of sufficiently low mass—termed 'ultralight' bosons—exhibit wavelike behaviour with wavelengths of the order of kpc, and can be described by a single coherent wavefunction. For this reason, this dark matter candidate is named 'fuzzy dark matter' (FDM). The presence of oscillations in the soliton cores within FDM simulations has been noted previously [1-3]; studies have been published on the effects of core oscillations on the structure and dynamics of galaxies [2,3], and possible limits on the constituent boson mass [1].

We analytically investigate the properties of these FDM oscillations in perturbed ground state soliton solutions to the Gross-Pitaevskii—Poisson equations using the empirical fitting formula from [4], by means of an approach presented in [5]. We find results in good quantitative agreement with those in [5], though our approach bypasses the requirement of refitting the initial density profile by enforcement of the virial condition. Our results confirm that both the soliton empirical formula and the numerically calculated ground state are virialised, and our analytically derived expression for the oscillation frequency is found to be in strong agreement with our results from simulations.

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