Galactic discs embedded in fuzzy dark matter haloes

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Abstract

The ΛCDM cosmological model encounters difficulties in explaining observations on the ”small” scales that are galactic scales (for example, the problem of dark matter “cusps” deduced from numerical simulations using this model, which are not very compatible with observations that indicate dark matter “cores” instead). In an attempt to solve these problems, the possibility of replacing standard Cold Dark Matter (CDM) with Fuzzy Dark Matter (FDM) has been raised for some time (see e.g. Hu et al, 2000). FDM is made up of extremely light particles, axions (bosons), which do not form the smallest structures of CDM while behaving like it on large scales (where the ΛCDM model has been very successful in explaining observations). It is important to understand whether this FDM can indeed solve the problems of small dark matter structures while not disturbing baryonic matter too much, i.e. in such a way that its effects are not incompatible with observations of the baryonic components of galaxies. We thus simulate the evolution of stellar galactic discs in FDM haloes in order to study the impact of FDM on the dynamics of these discs. Using the analytical formalism of El Zant et al 2016, adapted to FDM in our paper El Zant et al 2020, we include perturbative forces due to FDM in N-body simulations of a Milky Way type galaxy, and quantify stellar disc heating, thickening, bending modes, and bar formation and evolution. The effects of FDM are stronger for a lower mass of the FDM axion. Our work provides a lower bound on this mass similar to what has been determined either by studies of other types of systems or by more analytical studies of discs, including our own study by El Zant et al 2020.