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Dynamical Friction for Plummer Sphere in Ultralight Dark Matter

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Among popular candidates for dark matter (DM) particles are weakly interacting massive particles (WIMPs) with masses of the order of 100 GeV, sterile right-handed neutrinos with masses of several keV, and axion-like particles with masses of μeV. We consider a model of ultralight dark matter (ULDM) because of its interesting phenomenology. ULDM is composed of bosonic particles with masses from 10^{-23} to 10^{-21} eV, and is hypothesized to form a Bose-Einstein condensate (BEC) on galactic scales. ULDM models could successfully reproduce the large-scale structure of the Universe and are free of some problems which cold dark matter (CDM) models encounter at galactic scales, due to a very large de Broglie wavelength of order kpc.

In the present work, we studied the ground and vortex states of ULDM. We derived an expression for the dynamical friction force for objects of finite size modelled as a Plummer sphere. We also calculated radial and tangential components of the dynamical friction force acting on Plummer spheres traveling in a ULDM medium. Our findings reveal that the frictional force experienced by a Plummer sphere deviates from that of a point mass, particularly when the ratio of the sphere's radius to its orbital radius is more than 10^{-2}. The finite size of a globular cluster introduces a friction correction of up to 10%.

Our study is relevant to the orbital decay of globular clusters moving through the dark matter halos of galaxies. According to standard gravitational theory, some clusters should have experienced significant dynamical friction in CDM, causing them to spiral inward and merge with the galactic center well within the age of the Universe. However, observations show that they remain at relatively large distances from the center. We plan to consider the ULDM model to address the globular cluster timing problem in the future.

1. V.M. Gorkavenko, A.I. Yakimenko, A.O. Zaporozhchenko, E.V. Gorbar, e-Print: 2412.15428 [astro-ph.GA] (2024)
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