Department of Theoretical Physics

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Dense Axion Stars

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Axions can be described by a relativistic field theory with a real scalar field whose self-interaction potential is a periodic function of the field. Low-energy axions, such as those produced in the early universe by the vacuum misalignment mechanism, can be described more simply by a nonrelativistic effective field theory with a complex scalar field. I discuss how to determine the coefficients in the expansion of the effective potential as a power series in complex scalar field and how to systematically improve the effective potential to include term of all orders in the complex scalar field. A simple application of this effective potential is to study about the axion stars. If the dark matter particles are axions, gravity can cause them to coalesce into axion stars, which are stable gravitationally bound systems of axions. In the previously known solutions for axion stars, gravity and the attractive force between pairs of axions are balanced by the kinetic pressure. The mass of these dilute axion stars cannot exceed a critical mass, which is about $10^{-14}\,M_\odot$ if the axion mass is 10^{-4} eV. I discuss about a new branch of dense axion stars in which gravity is balanced by the mean-field pressure of the axion Bose-Einstein condensate. The mass on this branch ranges from about $10^{-20}\,M_\odot$ to about $1\,M_\odot$. If a dilute axion star with the critical mass accretes additional axions and collapses, it could produce a bosenova, leaving a dense axion star as the remnant.