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A stabilization mechanism for excited fermion-boson stars

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Gravitationally bound structures composed by fermions and scalar particles known as fermion-boson stars are regular and static configurations obtained by solving the coupled Einstein-Klein-Gordon-Euler (EKGE) system. As it happens for boson stars, there are different families of solutions labelled by the number of nodes in the radial profile of the scalar field; the ground state solutions have zero nodes in the radial profile, while excited states have 1 or more nodes. We study one possible scenario through which these fermion-boson stars may form by solving numerically the EKGE system under the simplifying assumption of spherical symmetry. Our initial models assume an already existing neutron star surrounded by an accreting cloud of a massive and complex scalar field. We considered an initial Gaussian radial profile for the cloud of scalar field. Our results show that from this generic initial data, we could form both ground and excited fermion-boson stars. Prompted by this finding we construct equilibrium configurations of excited fermion-boson stars and study their stability properties using numerical-relativity simulations. Contrary to purely boson stars in the excited state, which are known to be generically unstable, our study reveals the appearance of a cooperative stabilization mechanism between the fermionic and bosonic constituents of those excited-state mixed stars.

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