Full 3D nonlinear dynamics of charged and magnetized boson stars

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Gauged boson stars are exotic compact objects that can potentially mimic black holes or magnetized neutron stars in both their gravitational and electromagnetic signatures, offering a compelling new description or even an alternative explanation for various multimessenger phenomena. As a crucial step toward establishing boson stars as viable multimessenger sources, we perform 3D numerical simulations of the fully nonlinear Einstein-Maxwell-Klein-Gordon system, focusing on both spherical and axisymmetric boson star configurations that vary in their electromagnetic coupling between the neutral case up to values close to the critical case, and so their magnetic field content. For spherical configurations, we consistently find stable solutions. In contrast, for axially symmetric, electrically neutral, magnetized configurations, the dynamics are highly sensitive to the electromagnetic coupling. Configurations with stronger coupling develop a one-armed mode instability, which leads to collapse into black holes. Configurations with weaker coupling undergo a two-stage process: an initial bar-mode instability that triggers a one-armed spiral deformation. This eventually also results in black hole formation, accompanied by emissions of both gravitational and electromagnetic radiation. A similar instability and two-stage pattern is observed in all charged rotating boson stars analyzed. However, all of these configurations become stable when self-interactions are introduced.