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Axisymmetric Bosonic Stars: bifurcations with spherical bosonic stars

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We study the bifurcation phenomena between spherical and axisymmetric bosonic stars. By numerically solving for the zero-modes of spherical bosonic stars under specific axially symmetric perturbations, we discover that excited state spherical bosonic stars bifurcate into two types of axisymmetric bosonic stars under $\ell = 2$ perturbations, with matter distributions resembling chains and rings, respectively. Meanwhile, $\ell = 4$ axisymmetric perturbations lead spherical scalar bosonic stars to bifurcate into a new type of axisymmetric bosonic stars, exhibiting a mixed chain-like and ring-like matter distribution, which we refer to as gyroscope-like. Additionally, for the first time, we have constructed chains of scalar bosonic stars with 7 constituents and their corresponding ring-like scalar bosonic stars. Our results provide an explanation for the bifurcations in bosonic stars from the perspective of perturbations, and by analyzing physical quantities such as quadrupoles and energy densities, we systematically discuss the impact of axisymmetric perturbations on spherical bosonic stars.

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