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Instability windows of relativistic r-modes in neutron stars with hyperonic cores

R-modes are quasitoroidal oscillations of rotating stars, primarily restored by the Coriolis force. The fact that, among the variety of stellar oscillations, r-modes are the most susceptible to the Chandrasekhar-Friedman-Schutz (CFS) instability (i.e., instability with respect to gravitational wave emission) makes them promising targets for current and future gravitational wave searches. An r-mode becomes unstable if the energy supply to the mode by the CFS mechanism surpasses the energy losses caused by various dissipative mechanisms operating in the stellar matter. The corresponding stellar parameters - typically, rotation rate Ω and (red-shifted) temperature T^{∞} - determine the so-called r-mode instability window on the (Ω, T^{∞}) plane. At high temperatures, bulk viscosity ζ, arising from out-of-equilibrium chemical reactions, is the dominant dissipative mechanism that opposes the CFS instability. Dissipation through ζ can be substantially enhanced by two independent mechanisms: (1) the presence of hyperons, which significantly increases the bulk viscosity coefficient, and (2) peculiar properties of relativistic r-modes in nonbarotropic matter, which strongly amplify their dissipation through bulk viscosity compared to that in Newtonian theory. In this study, we present the first investigation of the combined impact of these two mechanisms on the r-mode instability windows. Our calculations also estimate the effect of nucleon pairing on the instability windows and investigate the importance of accounting for chemical reactions in the adiabatic index of the matter. We find that hyperonic bulk viscosity is a much more efficient dissipative mechanism than previously thought and that it may provide the dissipation required to stabilize r-modes in the fastest-spinning and moderately hot neutron stars in low-mass X-ray binaries, even when nucleon pairing effects are taken into account. These results have important implications for the interpretation of observations and for the broader understanding of relativistic r-mode physics.

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