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Instability windows of relativistic r-modes in hyperonic stars

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R-modes are oscillations of rotating stars, restored primarily by Coriolis force. Of all oscillations, they are the most susceptible to the Chandrasekhar-Friedmann-Schutz instability with respect to emission of gravitational waves. This instability makes them particularly promising targets for current and future gravitational wave searches. In order to develop, the CFS instability should surpass the dissipative processes that accompany oscillations. As a result, r-modes become unstable only for specific combinations of stellar angular velocity Ω and its (redshifted) temperature T^{∞}, which define the so-called instability window on the (Ω, T^{∞}) plane. At high temperatures, bulk viscosity ζ (heat production sourced by out of equilibrium chemical reactions) is the primary dissipative agent that opposes the CFS instability. Dissipation due to ζ can be substantially enhanced by two physically indendent mechanisms: 1) the presence of hyperons (if permitted by the equation of state), which greatly amplifies bulk viscosity ζ, and 2) the recently discovered peculiar properties of relativistic r-modes in nonbarotropic matter, which lead to substantially higher dissipation through ζ compared to predictions from Newtonian theory. In this study, we investigate for the first time the combined effect of these amplification mechanisms on the r-mode instability windows. In our calculations, we take into account that, apart from generating bulk viscosity, chemical reactions also modify adiabatic index of the matter. We also provide the estimates on how the effects of nucleon superconductivity and superfluidity might influence the instability windows. We compare our predictions against the up-to-date observations of neutron stars in Low-Mass X-ray Binaries and find that bulk viscosity could be the long-sought dissipative mechanism capable of stabilizing r-modes in the fastest-spinning and moderately hot stars, even when accounting for nucleon superfluidity and superconductivity. The reported results are particularly important for interpreting observations and improve the overall understanding of relativistic r-mode physics.

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