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Nonanalytic relativistic r-mode instability windows

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Detectability of the r-mode gravitational-wave signal depends on the interplay between the mode amplification by the CFS instability and its damping by dissipative mechanisms, operating in the stellar matter. Those stellar parameters - usually, the angular velocity, Ω, and redshifted temperature, T^{∞}, - for which the mode is unstable, define the r-mode instability window. We revisit this problem in nonbarotropic neutron stars, accounting for the previously overlooked relativistic r-mode nonanalytic behavior (in Ω) and enhanced energy dissipation due to diffusion in superconducting stellar matter. We show that, at slow rotation rates, relativistic r-modes are amplified by the CFS instability weaker than Newtonian ones, while their viscous and diffusive dissipation is, instead, significantly more efficient. At realistic rotation rates relativistic and Newtonian r-mode amplification by CFS mechanism and damping by shear viscosity become comparable, while the relativistic mode damping by diffusion and bulk viscosity remain significantly stronger than nonrelativistic ones. As a result, accounting simultaneously for diffusion and relativistic r-mode nonanalyticity drastically changes the r-mode instability window as compared to the Newtonian one. This effect is of paramount importance for the interpretation of the future gravitational-wave observations and understanding of the r-mode physics in general.

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