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Constraining critical temperature profiles with r-mode instability in neutron stars

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We constrain the profiles of nucleon critical temperatures with a recently developed model of resonance stabilization of r-modes (Gusakov, Chugunov, Kantor PRL 112, 151101, 2014). To this end, we calculate the finite-temperature r-mode spectrum of a superfluid neutron star under realistic microphysics assumptions. Namely, we, for the first time, account for both muons and entrainment between neutrons and protons, adopting also realistic equation of state and superfluidity model.

Assuming that both rotation and entrainment effects are small, we find a non-analytic behavior of eigenfrequencies and eigenfunctions for superfluid r-modes. This prompts us to develop a specific perturbation scheme to calculate the spectrum. We find that the normal r-mode exhibits avoided-crossings with superfluid r-modes at certain values of temperature and rotation frequency. Near the avoided-crossings the r-mode dissipates strongly, which leads to substantial suppression of the r-mode instability at these resonance parameters. Extreme sensitivity of the positions of avoided-crossings to the superfluidity model allows us to constrain critical temperature profiles by confronting the calculated spectra with observations of neutron stars in low-mass X-ray binaries.

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