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Vadym Khomenko - Hydrodynamical instabilities in superfluid neutron stars with background flows between the components

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The interiors of mature neutron stars are expected to be superfluid. Superfluidity of matter on the microscopic scale can have a number of large scale, potentially observable consequences, as the superfluid component of the star can now flow relative to the 'normal'component that is tracked by electromagnetic emission.
The most spectacular of such phenomena are pulsar glitches, sudden spin-ups of the neutron star, observed in many pulsars. A background flow of the normal-fluid part of the star with respect to the superfluid is also known to lead to a number of instabilities in laboratory superfluids, possibly leading to turbulence and modifying the nature of the mutual friction coupling between the two fluids.
We consider modes of oscillation in the crust and core of a superfluid neutron star, by conducting a plane-wave analysis. We explicitly account for a background flow between the two components (as would be expected in the presence of pinning) and perturbations of the entrainment, and we consider both standard (Hall-Vinen) and isotropic (Gorter-Mellink) forms of the mutual friction. We find that for standard mutual friction there are families of unstable inertial and sound waves both in the case of a counter-flow along the superfluid vortex axis and for counterflow perpendicular to the vortex axis and find that entrainment leads to a quantitative difference between instabilities in the crust and core of the star. For isotropic mutual friction we find no unstable modes, and speculate that instabilities in a straight vortex array may be linked to glitching behaviour, which then ceases until the turbulence has decayed.

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