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The hydrodynamics of superfluid vortex avalances in neutron stars

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Neutron Stars offer a unique opportunity to study the fundamental physics in extreme conditions. Physical properties of Neutron Stars are believed to be affected by the presence of superfluid matter inside that is connected with pulsar glitches. To study the latter the dynamics of quantized vorticity is used in the most models. However, the problem of establishing connection between the properties on the micro and macro scales still remains unsolved.

We took a first step towards developing a mean field prescription to include the dynamics of vortices in large scale hydrodynamical simulations of superfluid neutron stars. It is shown that allowing for vortices to accumulate and induce differential rotation in the neutron superfluid leads to propagating waves, or 'avalanches', as solution for the equations of motion for the superfluid velocities. The additional variable, namely fraction of free vortices, is introduced. It's found that the new terms contribute linearly to the rise of a glitch, and that, in specific setups, they can give rise to glitch precursors and even to decreases in frequency, or anti-glitches.

We have applied our model to the glitches in the Vela and Crab pulsars, considering two separate cases in which glitch originates either in the crust or in the core, and obtained constraints on the values of the mutual friction parameter, that governs the coupling between the superfluid and the normal fluid.

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