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Multi-scale modelling of pulsar glitches

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Neutron stars are an exceptional fundamental physics laboratory, and provide us with the only opportunity to study the strong interaction at high densities and low temperatures. These objects are, in fact, not only very dense (with central densities surpassing nuclear saturation density), but also cold, as their thermal energy is generally negligible compared to the Fermi energy of the constituents. This will modify the dynamics of the system considerably, with large scale superfluids expected in the interior.
Observations of radio pulsar glitches offer what is considered to be a probe of the dynamics of the superfluid in NS interiors. Glitches, i.e. sudden jumps in the spin frequency of the pulsar, are generally thought to be due to a large scale superfluid component that is decoupled from the spin-down of the 'normal' component, and then recouples catastrophically, giving rise to the observed signal. This is a fascinating macroscopic effect of small scale, quantum, properties of a superfluid. A superfluid rotates by forming an array of quantised vortices, which can 'pin' to ions in the crust or flux-tubes in the core, preventing the superfluid neutron component from expelling vorticity and spinning down with the rest of the star.
Previous work has been successful in separately modelling vortex motion on microscopic scales and the large scale hydrodynamics of the star.
In this talk I will present recent work that aims to bridge this gap in scales and consistently model the whole glitch process. I will discuss analytical and numerical work to extend the results of small scale quantum mechanical simulations to larger scales, and how these results can be used in hydrodynamical simulations, possibly to explain the recently observed size distribution of glitches in the Crab pulsar.

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