Time dependent density functional theory and supercomputing – new prospects for modelling superfluidity in neutron stars

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Superfluidity is a generic feature of various quantum systems at low temperatures. It has been experimentally confirmed in many condensed matter systems, in ^{3}He and ^{4}He liquids, in nuclear systems including nuclei and neutron stars, in both fermionic and bosonic cold atoms in traps. The superfluid time dependent density functional theory (TDDFT) is, to date, the only microscopic method which allow to investigate dynamics of fermionic superfluids far from equilibrium. However, in order to apply TDDFT method an accurate energy density functional is required which typically is created based on data provided by terrestrial experiments.

I will briefly review recent applications of the TDDFT related to neutron star glitches [1,2]. These studies were possible due to utilization of a local formulation of the superfluid TDDFT that is particularly well suited for massively parallel implementation for top-tier supercomputers. Finally, I will present a systematic strategy of constructing accurate hydrodynamic model of glitching neutron star starting from microscopic (nuclear) level. I will especially focus on quantities that are required to be delivered by other communities, like low energy nuclear physics or ultra-cold atomic gases.

Bibliography

[1] G. Wlazłowski *et al.*, Phys. Rev. Lett. **117** (2016) 232701.
[2] K. Sekizawa *et al.*, JPS Conf. Proc. 14 (2017) 010807.