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Nuclear reactions in the framework of time-dependent density functional theory with pairing correlations

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Superfluidity and superconductivity are remarkable manifestations of quantum coherence at a macroscopic scale. The existence of superfluidity has been experimentally confirmed in many condensed matter systems, in He-3 and He-4 liquids, in nuclear systems including nuclei and neutron stars, in both fermionic and bosonic cold atoms in traps, and it is also predicted to show up in dense quark matter. Pairing correlations in nuclear systems are one of the most important characteristics of non magic atomic nuclei. Various features related to high spin phenomena or to large amplitude collective motion, e.g. fission, indicate that these correlations are crucial for our understanding of nuclear structure and dynamics.

The time dependent density functional theory (TDDFT) is, to date, the only microscopic method which allow to investigate fermionic superfluidity far from equilibrium. In nuclear physics it offers a microscopic description of low energy nuclear reactions, where fermionic degrees of freedom and pairing field dynamics are explicitly taken into account. The local version of TDDFT is particularly well suited for leadership class computers of hybrid (CPU+GPU) architecture. Using the most powerful supercomputers we are currently able to study a real-time 3D dynamics without any symmetry restrictions evolving up to hundred of thousands of superfluid fermions. It represents a true qualitative leap in quantum simulations of nonequilibrium systems, allowing to make quantitative predictions and to reach limits inaccessible in laboratories.

During the talk I will review several applications and results concerning nuclear collisions and induced fission, discussing advantages of this approach.

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