Three ways to describe nuclear dynamics with energy density functional

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In the last few years, describing the dynamics of nuclei ongoing large collective motion (e.g. quasi-fission, collective vibrations) received a surge of interest with the progress of time-dependent approaches. Typically, with the help of sufficient computational power and sophisticated numerical methods, the state of the art time-dependent mean field codes are now able to deal with collisions involving more than 400 nucleons while including the pairing residual interaction and without assuming built-in symmetries. These technical developments lead for instance to a successful explanation of the role of quasi-fission in the collisions ^{40,48}Ca+^{238}U [1], central reactions in our quest to the super-heavy elements. Despite great success, the time dependent mean field approach has intrinsic limitations which translate typically in the its failure to predict properly the fission yields or the dissipation of collective vibrations. To overcome these shortcomings, several strategies are now being investigated ranging from a semi-classical treatment of an ensemble of time dependent mean-field trajectories to a full quantum time dependent multi-configuration mixing. This presentation aims at overviewing the current status of the time dependent approaches to nuclear dynamics. I will emphasize the strengths and weaknesses of different theories and stress how it translates in terms of predictions for some nuclear processes. To illustrate the discussion, I will mostly focus on two specific examples: the fission dynamics [2] and the transfer reactions in collisions between two superfluid nuclei [3].

[1] V. E. Oberacker, A. S. Umar, C. Simenel, Phys. Rev. C **90**, 054605 (2014)
[2] D. Regnier, N. Dubray, N. Schunck, Phys. Rev. C **99**, 024611 (2019)
[3] D. Regnier, D. Lacroix, arXiv:1902.06491 (2019)