TALENT Course 6: Theory for exploring nuclear reaction experiments
Outline project proposal

Project name:
Time-dependent Hartree-Fock calculations for grazing reactions at intermediate energies

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Project outline and aims:
Outline: Time-dependent Hartree-Fock (TDHF) theory is a microscopic theory for nuclear dynamics, which is capable of describing time-dependent dynamics of colliding nuclei from nucleons' degrees of freedom in a self-consistent manner (for a recent review, see Ref. [1]). The theory of TDHF was first proposed by P.A.M. Dirac in 1930 [2] and its applications to nuclear collision dynamics started in the 1970s [3]. Since then, continuous efforts have been devoted for improving the method and extending applications. However, due to the mean-filed nature of the TDHF theory, the applications are limited to reactions at relatively low incident energies ($\lesssim 10$ MeV/A).
Aims: One of the main aims of this project is to clarify applicability of the TDHF theory to grazing reactions at intermediate energies (~ 100 MeV/A). If there are any difficulties to achieve the TDHF calculations at such relatively high incident energies, I would like to understand what is the main cause of the difficulties and to propose a possible way to overcome those difficulties.

Methodology:
We have developed our own computational code of the TDHF theory for heavy-ion collisions and have applied it to multinucleon transfer reactions [4]. I will use this computational code to calculate grazing reactions at intermediate energies. Starting with calculations at low incident energies (a few MeV/A), I will calculate grazing reactions with increasing the incident energy (up to around 100 MeV/A). The particle number projection method, which was recently proposed by C. Simenel [5], will be used to calculate probabilities for each transfer channel from the TDHF wave function after collision. Physical quantities, e.g. transfer cross sections, angular distributions, total kinetic energy of outgoing fragments, and excitation energies of projectile-like and target-like fragments, will be calculated. To clarify how the TDHF theory works for reactions at relatively high energies, comparisons of observables with measurements will be performed.

Key references:
1. C. Simenel, Eur. Phys. J. A **48**, 152 (2012).
2. P.A.M. Dirac, Proc. Cambridge Philos. Soc. **26**, 376 (1930).
3. J.W. Negele, Rev. Mod. Phys. **54**, 913 (1982).
4. K. Sekizawa and K. Yabana, arXiv:1303.0552 [nucl-th] (to be published in PRC).
5. C. Simenel, Phys. Rev. Lett. **105**, 192701 (2010).