Optical potentials in nuclear reactions

- Nuclear reactions are an essential probe to study the structure of the nucleus. They also are extremely relevant to astrophysics and applications.
- For most (except the lightest) nuclei, nuclear reaction theory relies on reducing the many-body problem to a problem with a few degrees of freedom and using few-body techniques to treat those exactly.
- In that reduction, effective interactions, which take into account the effect of those channels not explicitly included in the model space, are introduced: the so-called optical potentials.

- **Results from reaction calculations depend on these effective interactions.**
- **Currently optical potentials used for low-energy reactions are phenomenological, and primarily constrained by elastic scattering.**
- **Existing microscopic optical potentials are developed in an energy regime (≥ 150 MeV) and not applicable for lower energy reactions.**

Optical potentials: Current status

Presently available phenomenological optical potentials for reaction calculations in the FRIB energy range are:

- Local, energy dependent and fitted to different data sets
- Unreliable when extrapolated beyond their fitted range in energy and nuclei

Current nuclear many-body theories are able to include the continuum in their chosen basis, and offer solutions to the single particle scattering that have the correct asymptotic behavior.

Microscopic optical potentials derived in a multiple scattering framework with nuclear force and some nuclear structure information are usually valid only for energies ≥ 100 MeV/nucleon.

Optical potential: Future challenges

Take advantage of state-of-the-art many-body theory in deriving optical potentials, and

- Understand which pieces of the many-body theory are critical in the optical potential for describing scattering data
- Understand if there are crucial quantities in deriving optical potentials for exotic nuclei
- Understand the theoretical prerequisites needed in specific energy regimes for constructing microscopic optical potentials.

In addition:

The concept of fitted effective interactions must be questioned when going off the line of stability, and theoretical error bars need to be assigned.

Requirements:

Avenues for developing strong collaborations between the "traditional" nuclear structure and the nuclear reaction communities