(d,p), (p,d), and (d,n) Reactions

One of the best probes for nuclear shell evolution is single-nucleon transfer reactions through (d,p), (p,d), or (d,n) transfer. This allows to study occupancies of both particle and hole states in stable as well as in exotic nuclei.

(d,p) reactions are of interest to other areas, such as astrophysics, stewardship science and energy applications, since it can provide information on the (n,g) reaction. Measuring (n,g) on unstable nuclei is currently impossible and therefore one relies on indirect techniques.

- Several facilities have strong experimental programs in transfer reactions. Those will continue to be an important component in the FRIB physics.
- A number of new detectors have been and are being developed with the aim of providing better data (ORRUBA, superORRUBA, HiRA, ATTPC, etc) of (d,p) and (d,n) reactions with exotic nuclei.

For a meaningful interpretation of measurements, an accurate description of the reaction process is necessary.

Reaction theory for (d,p): Current status

(d,p) reactions on all nuclei apart from the lightest nuclei are treated within a few-body framework.

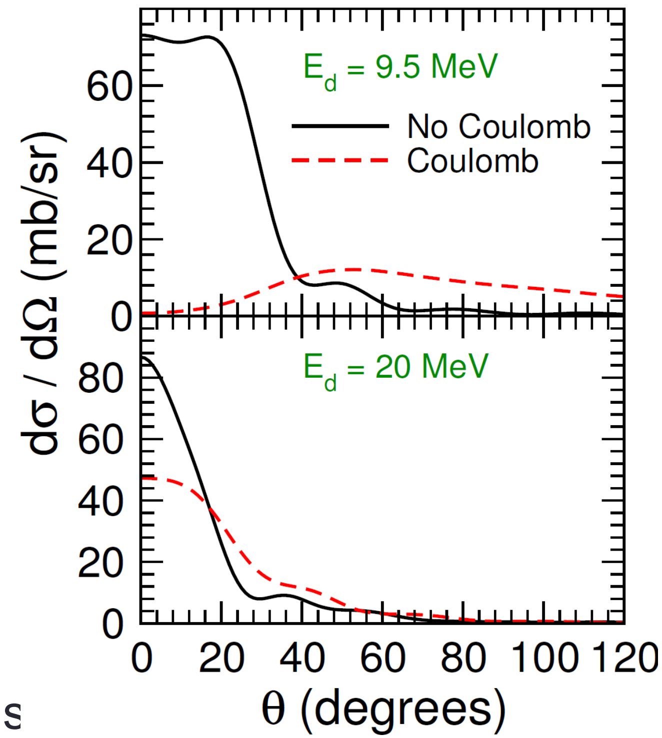
Experimental analysis often rely on approximations known to be inaccurate (such a distorted wave Born approximation).

Benchmarks with three-body methods have shown the limitations of the various approaches.

Currently, exact Faddeev calculations for (d,p) can only be performed for nuclei up to A~40 due to the numerical treatment of the Coulomb force in these calculations

However: Coulomb effects in (d,p) on heavier systems have been shown to be critical to describe cross sections

^{132}Sn(d,p)^{133}Sn



At present a new Faddeev based approach is being pursued that does not rely on screening the Coulomb force and that allows to include target excitations

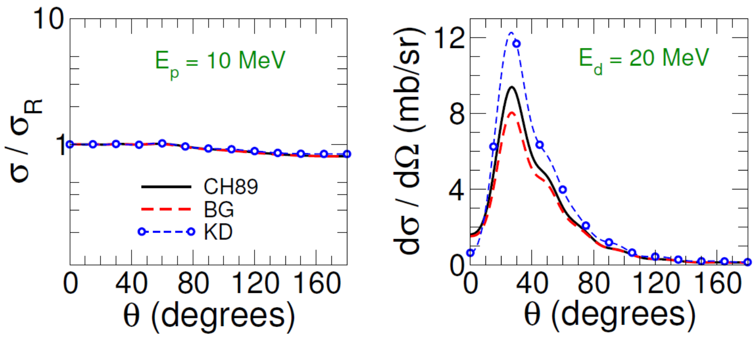
Reaction theory for (d,p): Future challenges

Develop robust computational tool to analyze (d,p) or (d,n) reactions as basis for theory-experimental collaborations

Include core excitations into the formulation and computation

- It has been shown that core degrees of freedom can be important in the reaction mechanism. A suitable framework needs to be developed

Constrain the effective interactions (specifically optical potentials) microscopically, so that extrapolations are better controlled



Understand physics beyond the three-body model and estimate errors

Requirements:

More workforce, particularly more faculty/staff working in this interface between few- and many-body physics.

Collaborations with computational scientists