Ab initio many-body calculations of *d*-nucleus collision and (d, p) transfer reaction

F. Raimondi[1], P. Navrátil[1], S. Quaglioni[2]

[1] *TRIUMF, 4004 Wesbrook Mall, Vancouver, British Columbia, V6T 2A3, Canada*
[2] *Lawrence Livermore National Laboratory, P.O. Box 808, L-414, Livermore, CA 94551, USA*

Contact email: *fraimondi@triumf.ca*

We perform calculations of binary-cluster nuclear scattering, where both the projectile and target are described in an *ab initio* framework, that is, all the nucleons in the projectile-target system are active degrees of freedom interacting through a realistic nuclear two-body interaction. In particular we consider the specific case of a deuteron (d) projectile impinging on light nuclei with mass number $A > 4$. In this way, we significantly extend the scope and applications of *ab initio* methods to nuclear scattering and reactions.

The adopted formalism is the no-core shell model/resonating-group method (NCSM/RGM) [1], a well-established nuclear many-body approach that allows to treat bound and scattering states of light nuclei within a unified framework, starting from the fundamental internucleon interactions. The actual calculation consists in solving a Schrödinger-like equation in which the relevant aspects of the dynamics of the scattering process are taken into account by adopting accurate nucleon-nucleon (NN) potentials (i.e. those that fit the NN phase shifts with high precision) to describe the interaction between target and projectile nucleons, and by expanding the nuclear wave function over many-body binary-cluster states consistently obtained from the same Hamiltonian.

So far, NCSM/RGM applications concerning collisions and nucleon-transfer reactions with a deuteron projectile have been limited to the description of d-^{4}He (d-α) scattering [2] and both the transfer reactions ^{3}H$(d,n)^4$He and ^{3}He$(d,p)^4$He [3], see Figure. In our work, we push forward the present computational limits of *ab initio* calculations by extending the NCSM/RGM formalism to the treatment of nucleon-transfer reactions with target nuclei heavier than the α particle. This is achieved by introducing a novel algorithm to efficiently handle the large computational scale of the many-body problem under study. Such development will enlarge our ability to test *ab initio* methods against the wealth of data from radioactive-ion beam facilities that are becoming available in the recent years. At the same time, the outcome of such NCSM/RGM calculations has the potential to serve as precious guidance for ongoing experimental investigations of the spectra of exotic nuclei, where the (d, p) reaction is a powerful tool for the study of halo nuclei (see for instance Ref. [4]).

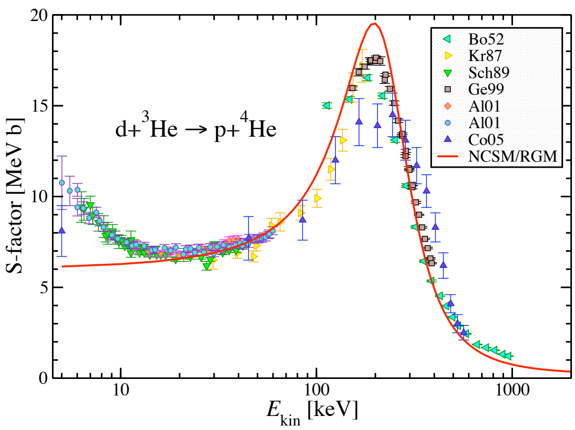

Fig. from Ref. [3]. Calculated S-factors of the ^{3}He$(d, p)^4$He reaction compared to experimental data (see Ref. [3] for details).

[1] S. Quaglioni and P. Navrátil, Phys Rev. Lett. **101**, 092501 (2008);
[2] P. Navrátil and S. Quaglioni, Phys. Rev. C **83**, 044609 (2011);
[3] P. Navrátil and S. Quaglioni, Phys Rev. Lett. **108**, 042503 (2012);
[4] K.T. Schmitt et al., Phys Rev. Lett. **108**, 192701 (2012).