Advances in the reaction theory for exotic nuclei

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With the construction and upgradation of various radioactive beam facilities across the globe there has been a resurgence of interest in the study of direct nuclear reactions involving exotic nuclei [1]. Direct nuclear reactions, especially in the low-energy regime (around 10-20 MeV/u), are important tools to probe nuclear structure of exotic nuclei.

Deuteron-induced single nucleon transfer reactions are the preferred choice. This is because:

1. Single-nucleon (d,p) or (d,n) transfer reactions are appropriate to provide indirect information on proton or neutron capture rates on unstable nuclei of astrophysical relevance [3], and

2. deuterons have a relatively small Coulomb barrier, with added benefit of well understood structure.

Traditionally, these reactions are used to study shell structure in stable nuclei, but experimental techniques have been developed to apply same approaches to exotic beams as well [2].

Since the exact solution of a many-body problem is not feasible for targets of mass $A \geq 10$, (d,p) reactions are reduced to three-body problem. This three-body problem can be solved exactly using momentum space Faddeev techniques [4], which includes elastic, breakup and transfer channels to all orders.

Practically, the finite-range adiabatic wave approximation (ADWA) method [5] is used to study (d,p) and (p,d) reactions, which takes into account deuteron breakup to all orders in the transfer channel while making an important simplification of the continuum.

The continuum-discretized coupled channels (CDCC) method [6], is the well established method to study deuteron-induced breakup reactions. This method does not make any approximations in the treatment of the breakup states.

In order to get reliable and accurate information from the theoretical studies of these reactions, it is important that the uncertainties and limitations of the available methods are better understood and quantified.

Further, existing Faddeev calculations are not possible for (d,p) reactions on intermediate mass and heavy nuclei because of repulsive Coulomb. This calls for development of new Faddeev method.

In this talk, limitations of various reaction mechanisms will be quantified with the emphasis on important developments in reaction theories for exotic nuclei.

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