Progress in all order breakup reaction theories

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Breakup reactions are one of the most sought after methods to study the structure of nuclei right from stable to nuclei near the driplines. For the latter case it is perhaps the only technique which is reasonably successful in dealing with exotic species - like halo nuclei. It is thus challenging to construct a theoretical model for these reactions which would be applicable over the entire span of nuclei having binding energies ranging from the MeV to the keV scale.

Theoretical approaches to breakup reactions trace their origin to the construction of the exact transition matrix (the T-matrix) which are of the post and the prior form type depending on whether one uses the initial(prior) or the final(post) channel form of the asymptotic Hamiltonian [1]. Although these two forms are equal the prior form has been further subdivided into a class called the alternate prior form, which however is not equal to the post form.

Theories of breakup reactions like the distorted wave Born approximation (DWBA) and the Continuum discretized coupled channels (CDCC) can be constructed by suitable choice of the exact scattering wave function. The CDCC calculation owes allegiance to the alternate prior form of the T-matrix, while the DWBA can be done on both the post and prior form. In the latter case, it was found that the post form of the theory appears to corroborate experimental data in a better way than the prior or the alternate prior form. What is interesting however, is that many of the recent data emanating from different laboratories across the world are reasonably well explained by these methods as also by elaborate models like the dynamical eikonal approximation and the time dependent Schrödinger equation method. This is surprising because these models are based on different approximations. An obvious explanation, though, is that that most of the reaction observables calculated - like the momentum distributions, relative energy spectra, angular distributions- are of an inclusive nature and involves lots of summations or integrations, which suppresses contribution of many partial waves. A case will thus be made to calculate more exclusive observables, like double- and triple-differential cross sections, where the differences within the theories would be more apparent.

Advances and problems in including Coulomb, nuclear and their interference terms consistently within the same post form DWBA theory will be emphasised. Efforts to calculate the breakup amplitude analytically, as far as possible, which can serve as a benchmark test for the theories above will be discussed [2]. Finally, advances in theoretical efforts to calculate Coulomb breakup of one-neutron and one-proton halo nuclei within the all order fully finite ranged post form DWBA, where one need not do any zero-range or local momentum approximation, will be presented.

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[1] G. R. Satchler, *Direct Nuclear Reactions*, Oxford University Press, New York, (1991).
[2] P. Banerjee *et al.*, Phys. Rev. C **65** 064602 (2002); R. Chatterjee, L. Fortunato and A. Vitturi Eur. Phys. J. A **35** 213 (2008).

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