Microscopic effective reaction theory for deuteron-induced reactions

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Projectile-breakup reactions have been utilized for studying the structures of nuclei, in the field of physics of unstable nuclei in particular. In this work, The microscopic effective reaction theory is applied to deuteron-induced reactions based on a $p + n + \mathrm{A}$ three-body model, where A is the target nucleus.

The three-body scattering wave function in the model space is obtained with the continuum-discretized coupled-channels method (CDCC) [1, 2, 3], and the nucleon-target potential is described by a microscopic folding model based on an effective nucleon-nucleon interaction in nuclear medium and a one-body nuclear density of A. The eikonal reaction theory (ERT) [4], an extension of CDCC, is applied to the calculation of neutron removal cross sections. Elastic scattering cross sections of deuteron on ^{58}Ni and ^{208}Pb target nuclei at several energies are compared with experimental data. The total reaction cross sections and the neutron removal cross sections at 56 MeV on 14 target nuclei are calculated and compared with experimental values.

We have carried out CDCC calculation by employing microscopic scattering potentials [3, 5], and showed that the observables obtainable from this method agree fairly well with experimental data in a wide range of energies without the need for artificial normalization or any arbitrary parameters. The Coulomb breakup is explicitly taken into account and its contribution to the total elastic breakup cross section σ_{EB} turned out to be significant at forward angles in the case of 56 MeV incident deuteron energy on ^{208}Pb. Furthermore, its contribution to σ_{EB} was shown to be somewhat large even for light target nuclei. On the other hand, the Coulomb breakup effect on the elastic cross section was found to be negligible in all the cases investigated in the present study. The total reaction cross sections and the inclusive nucleon removal cross sections provided by ERT also agrees fairly well with the experimental data, demonstrating the possible use-case for other nucleon-removal cross section studies in future.

In conclusion, the microscopic CDCC, which is a microscopic effective reaction theory for deuteron-induced reactions, has been shown to be able to describe the existing experimental data for many reaction systems with no free parameters. The success of the microscopic CDCC will be of great importance for proceeding with further studies on deuteron-induced reactions in which unstable nuclei are involved.

References

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