Few-Body Calculations and their Application to Direct Nuclear Reactions

A. Deltuva and A. C. Fonseca

Centro de Física Nuclear da Universidade de Lisboa, P-1649-003 Lisboa, Portugal

Contact email: fonseca@cii.fc.ul.pt

The present work recaptures the three-body concept of direct nuclear reactions that is common to Continuum Discretized Coupled Channels (CDCC) calculations [1] and shows the results for fully converged Faddeev/Alt, Grassberger and Sandhas (AGS) [2] equations for elastic, inelastic, transfer and breakup reactions where three-body dynamics plays an important role. In this work we attempt to calculate all observables using a dynamical model based on energy independent or energy dependent optical potentials for the nucleon-nucleus interaction and realistic $n-p$ potentials such as CD-Bonn. The Coulomb interaction between the proton and nuclear core is treated exactly by the screening and renormalization method [3]. Some examples are shown for reactions initiated by deuterons on ^{10}Be, ^{12}C and ^{16}O, as well as protons on ^{13}C and ^{17}O, and ^{11}Be on protons. Although the use of energy dependent potentials in three-body calculations is, by no means, free of theoretical problems, the results we show demonstrate the possibilities and the shortcomings of these models which may provide a doorway for new ideas that may bring advances in nuclear reaction theory.

Finally state of the art *ab initio* calculations for four-nucleon (4N) scattering are shown [4–7] for all possible reactions initiated by $n-{}^3$H, $p-{}^3$He, $n-{}^3$He, $p-{}^3$H and $d-d$ below three-body breakup threshold. Realistic two-nucleon (2N) interactions based on meson theory or chiral effective field theory are used between pairs together with the Coulomb repulsion between the protons. Effective three-nucleon and four-nucleon force effects are included by using a coupled channel extension of the CD-Bonn potential that allows a single virtual Δ - isobar excitation.

[1] N. Austern, Y. Iseri, M. Kamimura, M. Kawai, G. Rawitscher, and M. Yahiro, Phys. Rep. **154**, 125 (1987).

[2] E. O. Alt, P. Grassberger and W. Sandhas. Nucl. Phys. **B2**, 167 (1967).

[3] A. Deltuva, A. C. Fonseca and P. U. Sauer, Annual Reviews of Nuclear and Particle Science, **98**, November 2008.

[4] A. Deltuva and A. C. Fonseca, Phys. Rev. C **75**, 014005 (2007).

[5] A. Deltuva and A. C. Fonseca, Phys. Rev. Lett. **98**, 162502 (2007).

[6] A. Deltuva and A. C. Fonseca, Phys. Rev. C **76**, 021001(R) (2007).

[7] A. Deltuva, A. C. Fonseca and P. U. Sauer, Phys. Lett. B **660**, 471-477 (2008).