The Effect of Orthogonality and Antisymmetrisation in the Strong - Coupling Model of Nuclear Cluster Reactions

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Abstract

The possibility and feasibility is investigated of including in the modelling of nuclear cluster reactions a unified treatment of the effects both of the non-orthogonalities between transfer channels, and of the antisymmetrisation required by the Pauli Principle. The deuteron - nucleus interaction, the simplest cluster reaction, is considered in detail within the Coupled Channels framework. The Coupled Channels formalism was chosen because it accurately handles inelastic and transfer couplings of arbitary strengths.

The fact that transfer channels are orthogonal to each other only asymptotically is taken into account by reallocating the wave function in the internal region, from the deuteron channels to the transfer channels, taking components from the deuteron channels in ways exactly analogous to the way the antisymmetrisation requirements remove blocked deuteron-core components. Thus a unified treatment of the two effects is facilitated.

It is found further that when all possible transfer channels are included, along with all Pauli blockings from the core nucleons, then under certain conditions at low energies, the wave function in the deuteron channel is small and oscillatory in the internal region, leaving the deuteron as a cluster to have largely asymptotic significance. In this limit, the exact non-local potential governing the deuteron channel simplifies considerably in one approximation to be replaceable by just several orthogonality conditions, and these are easily modelled in solving the coupled equations for the radial wave functions. This simplified and unified model has the advantage, since the deuteron's internal wave form is significant only asymptotically, of allowing automatically for arbitary deuteron polarisation by the core (though not vice-versa). Furthermore, the asymptotic matching is not at a fixed radius as in R-matrix theory, but is a continuous process that depends on the binding energies of the actual proton & neutron bound states in the residual nucleus.

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