Four-nucleon scattering

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The four-nucleon ($4N$) scattering problem gives rise to the simplest set of nuclear reactions that shows the complexity of heavier systems. The n-^{3}H and p-^{3}He scattering is dominated by the total isospin $\mathcal{T} = 1$ states while d-d scattering by the $\mathcal{T} = 0$ states; the reactions n-^{3}He and p-^{3}H involve both $\mathcal{T} = 0$ and $\mathcal{T} = 1$ and are coupled to d-d in $\mathcal{T} = 0$. All these complex features make the $4N$ scattering problem the natural theoretical laboratory to test different force models of the nuclear interaction.

Below the three-cluster breakup threshold the n-^{3}H and p-^{3}He elastic scattering has been calculated using three different theoretical frameworks, namely, the hyperspherical harmonics (HH) expansion method, the Faddeev-Yakubovsky (FY) equations for the wave function components in coordinate space, and the Alt, Grassberger and Sandhas (AGS) equations for transition operators that were solved in the momentum space. A good agreement between these methods has been demonstrated in a benchmark [1] using realistic nucleon-nucleon (NN) potentials. In the AGS framework the results have been obtained also for all elastic and transfer reactions initiated by n-^{3}He, p-^{3}H and d-d [2].

Recently we extended our calculations to energies above the four-body breakup threshold where the singularity structure of the AGS equations becomes very complicated. We combined the complex-energy method [3] with the use of special weights for the integration [4]. The use of special weights reduces drastically the number of mesh points needed for convergence thereby making the method much more efficient as compared to the original complex-energy method [3] using standard integration meshes. Results have been obtained for n-^{3}H elastic scattering and breakup [4] and for $n + n + d$ recombination into n+^{3}H [5]. Extension to p-^{3}He scattering and to coupled n-^{3}He, p-^{3}H and d-d reactions is in progress.

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