Universality of the multi-channel 4-body scattering system

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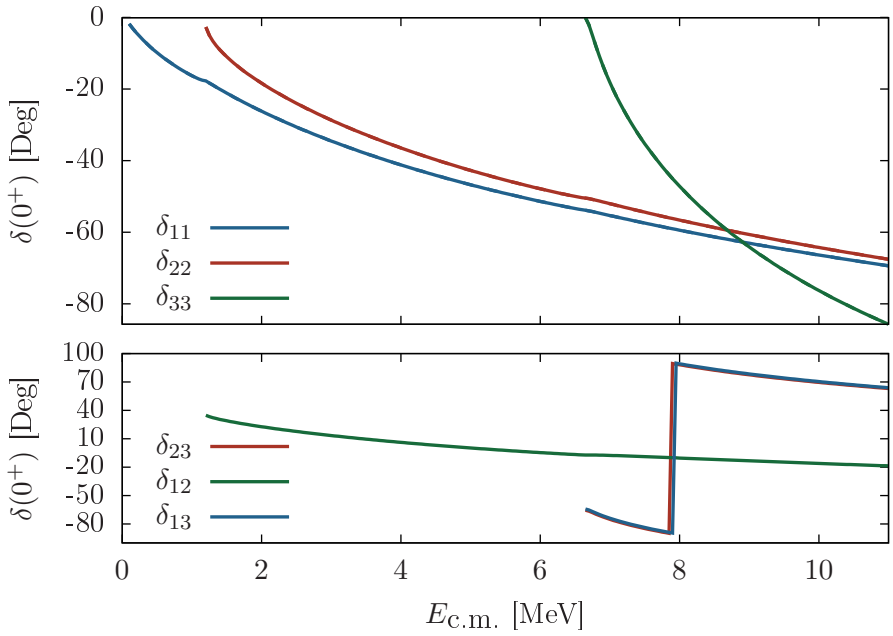

FIG. 1: Energy dependence of phase shifts which parameterize the coupled channel nnpp system in the $^1S_0$ α channel (1).

Abstract

We investigate the scattering system of 4 equal-mass quantum particles at energies where rearrangement channels are open. The interactions are renormalized to capture the essence of the pertinent nuclear 2-neutron, 2-proton system. A full treatment of the Coulomb interaction is included.

The quantity of most practical interest, namely the coupling between the deuteron-deuteron and the ^{3}H-proton/^{3}He-neutron channels, is subjected to a sensitivity analysis with respect to distorted, *i.e.* , screened Coulomb repulsion between the two protons.

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Naïvely, one expects the probability of a neutron (proton) transfer from a projectile deuteron onto a target neutron and the ensuing ejection of a triton (3-helium) plus a proton (neutron) to be strongly correlated with the efficiency of a device which is able to harvest the energy thereby released. Any mechanism which increases this probability is thus of practical interest.

As quantified in fig. 1, the strong nuclear force and the point-Coulomb repulsion between protons do not yield a strong coupling between the deuteron-deuteron and the 3-1 fragment channels (fat red line, bottom panel).

the scattering process is parametrized via a 3-channel S-matrix:

$$S_{ij} = \left\langle \, a\, L_a\, S_a \, \middle| \, \hat{S}^{J^\pi} \, \middle| \, b\, L_b\, S_b \, \right\rangle = \eta_{ij}\, e^{2i\delta} \quad , \tag{1}$$

and the almost decoupled d-d channel is encoded in $\eta_{dd} \approx 1$. Although, the Coulomb repulsion between protons provides a heuristic argument for this weak coupling, the comparison to the relatively strong coupling between the two 3-1 fragmentations seems to defy the argument as an equally strong force keeps the proton out of 3-helium.

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