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3.44 Faddeev Calculation of d-α Scattering with Absorption Effects

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The Faddeev calculations of the d-α elastic scattering at E_d(Lab)=21 MeV and 56 MeV are performed, and the results are compared with the Tsukuba data[1] and the RCNP data[2]. The improvements over the previous treatment[3] are i) the inclusion of absorption effects due to the coupling to reaction channels, and ii) the exclusion of a Pauli forbidden bound S-state in the p-α subsystem.

In the p-α sector, the elastic channel (#1) with the threshold $E_1=0$ is coupled to a hybrid representative reaction channel (#2) with $E_2=18.4$ MeV. For the coupling interaction, a 2×2 rank-1 separable potential of the form $V=|g>\lambda<g|$ is assumed. Here, $|g>$ is a 1×2 column matrix with components g_1 and g_2 where

$$g_1 = \sqrt{1-\kappa}\, f_1 , \quad g_2 = \sqrt{\kappa}\, f_2 , \quad \text{with } f_i(p) = p^{\ell_i}/(p^2 + \beta_i^2)^{\ell_i+1} .$$

The corresponding t-matrix is given by $t = |g>\tau(E)<g|$ with

$$\tau(E) = \left(\lambda^{-1} - \sum_{i=1}^{2} <g_i|G_0^{(i)}(E)|g_i> \right)^{-1} ,$$

where $G_0^{(i)}(E) = (E-E_i-K_i+i\varepsilon)^{-1}$. In the three-body calculation, we use the elastic component t_{11} only. This amounts to replacing the p-α interaction by its "optical potential"

$$V_{opt} = |g_1> \left(\lambda^{-1} - <g_2|G_0^{(2)}(E)|g_2> \right)^{-1}<g_1| ,$$

which is real below the reaction threshold E_2 while it is complex and absorptive above it. The non-orthogonality effects between the elastic and rearrangement channels are shown to belong to the off-shell part of the coupling interaction. The p-α phase shifts and absorption coefficients for seven partial waves from $\ell_1=0$ to 3 for E_p(Lab)=0 to 55 MeV are reproduced with the values of parameters in Table 1. A typical fit is shown in Fig.1 for the $d_{3/2}$ state. The $s_{1/2}$ potential thus obtained has one bound state at -13.09 MeV. This Pauli-forbidden state is projected away to infinity by the orthogonal projection method of Kukulin.[4] The n-α subsystem is treated in the same manner. For the two-nucleon sector, the $^3S_1+^3D_1$ separable interactions of Phillips and of Doleschall are used. No Coulomb force is considered.

The two-body t-matrices thus obtained are used as the dynamical imputs to the AGS equation, which is reduced to the Amado-Lovelace equation. In Figs.2 and 3, we show the results of d-α elastic scattering at E_d(Lab)=21 and 56 MeV for cross sections and vector and tensor analyzing powers. The solid lines represent the results with both the channel coupling and the Pauli exclusion. The dashed lines are without the channel coupling and the dot-dashed lines are without the Pauli exclusion. The NN interaction used is the YY7 of Phillips. These figures show the importance of the absorption effects and the Pauli effects. As seen from Fig.2, the three-body model of the d-α scattering seems to be a good approximation at E_d=21 MeV, as has been amply proven previously.[3,5] At this energy, we have also performed the calculations with the 2T4 NN potential and the YY0 NN potential.The 2T4 potential is found to yield almost the same results as those with YY7, although there are some differences at large scattering angles. The YY7 potential with 7% deuteron D-state probability is found to be superior to the YY0 potential with no deuteron D-state in reproducing T_{20} and T_{22}.

At E_d(Lab)=56 MeV, the three-body model has failed grossly, as seen from Fig.3. This may be attributed to the possible existence of a nearby resonance in the $^3He+^3H$ or the $n+d+^3He$ systems,which can not be incorporated in our three-body model.

(ℓ_1, j)	ℓ_2	β_1	β_2	κ	λ
S 1/2	2	1.57	1.86	982(-3)	-137(2)
P 3/2	1	1.63	2.57	398(-3)	-420(1)
P 1/2	1	1.32	0.66	606(-6)	-650(0)
D 5/2	2	2.99	1.30	546(-6)	-129(4)
D 3/2	0	2.80	2.42	292(-6)	-559(3)
F 7/2	3	2.23	1.37	376(-6)	-195(4)
F 5/2	3	1.66	1.78	829(-3)	-227(3)

Table 1 The p-α potential parameters. The data for the phase shifts and absorption coefficients are taken from A.Houdayer et al, Phys.Rev.C18(1978) and D.C.Dodder et al, Phys.Rev.C15(1977)518. β_i are in fm^{-1} and λ is in $\mathrm{MeV \cdot fm}^{-(2\ell_1+1)}$.

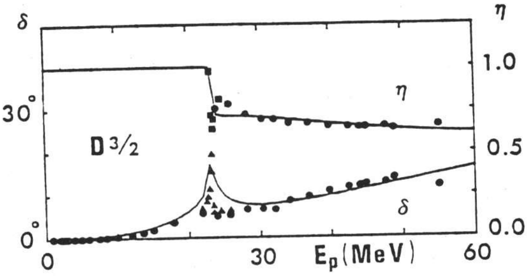

Fig.1 The $d_{3/2}$ p-α phase shifts and absorption coefficients. The triangles and squares are from G.R.Plattner et al, Phys.Rev.C5(1972)1158.

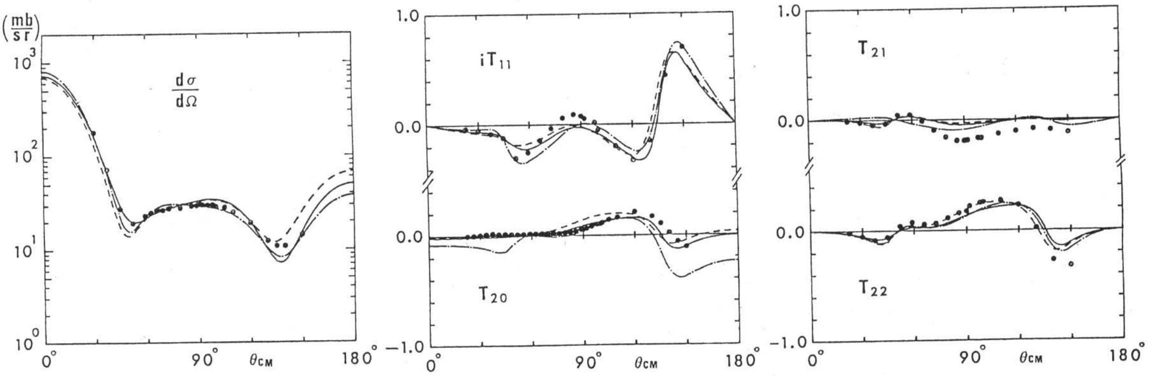

Fig.2 The d-α elastic scattering cross sections and vector and tensor analyzing powers at E_d(Lab)=21 MeV. For details, see the text. The data are from ref.1.

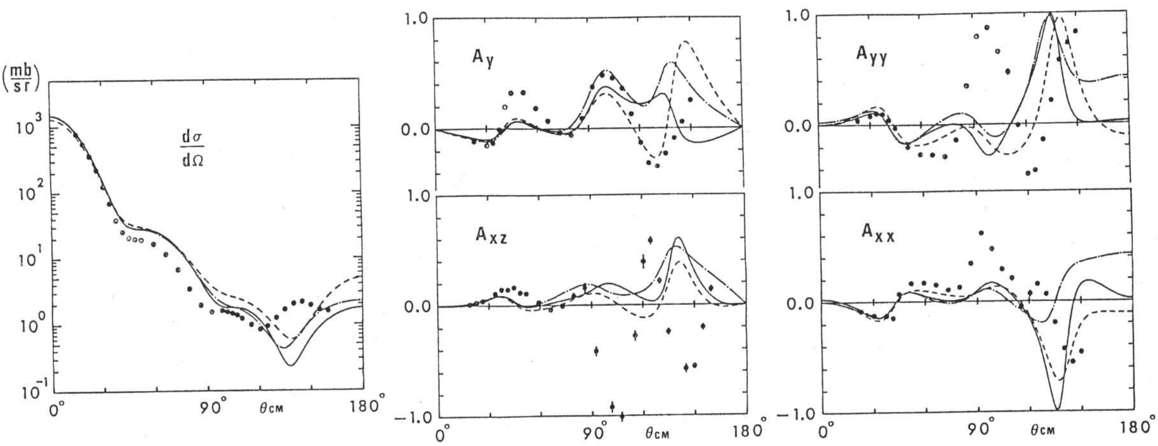

Fig.3 The d-α elastic scattering cross sections and vector and tensor analyzing powers at E_d(Lab)=56 MeV. The data are from ref.2. For details, see the text.

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