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1.94 Study of the Difference between the Spin-Orbit Potentials of ^{3}He and t by the Resonating Group Method

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Systematic scattering experiments of ^{3}He and t have been performed by using the polarized beams and the analyses of these data by the optical potentials have given us rich information on the spin-orbit (l·s) potentials of these 3N (three-nucleon) particles. However the derived parameters of the l·s potentials for ^{3}He and for t have been found to be fairly different from each other: Namely the l·s potentials for ^{3}He obtained by Birmingham group[1] have very small diffuseness parameter ($a_{so} \approx 0.2$ fm) while the l·s potential for t obtained by Los Alamos group[2] are deeper at least by two times than are expected by the folding model. It is therefore quite interesting to study by a microscopic theory how difference can be derived between the l·s potentials of ^{3}He and t. We report here the results of the study of the difference between the l·s potentials of ^{3}He and t on the target ^{40}Ca which are obtained by the resonating group method (RGM). The explanation of the procedure to derive the l·s potentials for composite projectiles by RGM is given in another contributed paper[3] by us.

Since the nuclear force between two nucleons are isospin-invariant, the difference between the l·s potentials of ^{3}He and t arises only from the difference between the Coulomb forces. The difference in Coulomb forces makes the local momentum for ^{3}He+^{40}Ca different from that for t+^{40}Ca and the difference in the local momenta creates the difference in the contributions from the Wigner transforms of the non-local RGM potentials between ^{3}He+^{40}Ca and t+^{40}Ca. As is explained in Ref.3, the l·s force of a 3N particle comes not only from the two-nucleon spin-orbit interaction v_{LS}^{NN} but also from the renormalization effect of the two-nucleon central force. Therefore both the central part and l·s part of the non-local RGM potentials contribute to the appearance of the difference between the l·s potentials of ^{3}He and t.

We show in Fig.1 the difference $\delta(r)$ between the calculated l·s potentials for ^{3}He and t, $\delta(r)=(V_{ls}(r))(^3\mathrm{He})-(V_{ls}(r))(t)$ at the incident energy E= 5 MeV/u. The oscillator parameter and the effective two-nucleon force used in the calculation are the same as those in Ref.3. Next, in Table 1, we display the values of the r^2-weighted radial integral J_4 of $V_{ls}(r)$ divided by f_{so}=43/120=(40+3)/(40*3) for several incident energies;

$$J_4 = (1/40)\int_0^\infty r^2 V_{ls}(r)\, r^2 dr \, . \tag{1}$$

When we compare $J_4(^3\mathrm{He})$ and $J_4(t)$ at the same incident energy we see $J_4(^3\mathrm{He})$ is larger than $J_4(t)$. However at present the available data for ^{3}He are near E= 10 MeV/u and those for t are near E= 5 MeV/u. When we compare $J_4(^3\mathrm{He})$ at E= 10 MeV/u with $J_4(t)$ at E=

5 MeV/u, we see that $J_4(^3He)$ is smaller than $J_4(t)$, which is in accordance with the experimental data given in Table 1 which is taken from Ref.4. This shows that, in comparing the l·s potentials for ^3He and t, due consideration of the energy-dependence of the l·s potential is quite important.

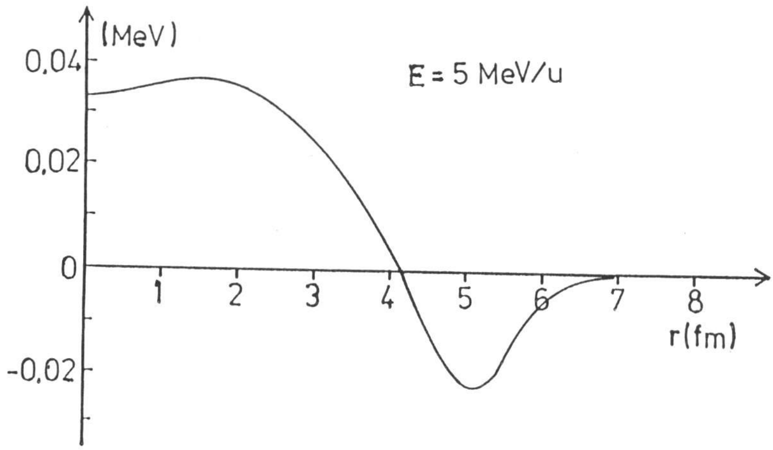

Fig.1 Difference between the calculated l·s potentials for ^3He and t, $\delta(r) = (V_{ls}(r))(^3He) - (V_{ls}(r))(t)$.

Table 1 The r^2-weighted radial integral J_4 of $V_{ls}(r)$ divided by f_{so}=43/120 for several incident energies and the observed values of J_4/f_{so} taken from Ref.4.

Projectile	E (MeV/u) 5	10	15	20	Exp.
^3He	26.9	24.2	22.8	22.0	3(16±6)
t	25.7	23.6	22.5	21.8	3(20±5)

References

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