Influence of inclusion of tensor and exchange terms on (^{3}He, t) charge exchange reaction

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Introduction

The charge exchange reactions in intermediate energy range have been investigated widely to examine the spin-isospin excitations modes in nuclei [1,2]. Specifically, during last few decades Fermi (F) and Gamow-Teller (GT) modes of excitation have been exploited to obtain information regarding nuclear structure, electron capture reaction and nucleosynthesis processes [3]. Further, the Fermi (ΔT=1, ΔS=0 and ΔL=0) and Gamow-Teller (ΔT=1, ΔS=1 and ΔJ=1 with ΔL=0, 2) transitions attract the attention of the researcher due to owing an approximate proportionality relation between the differential cross-section at 0° and corresponding transition strength values:

$$\frac{d\sigma}{d\Omega}(q=0) = \hat{\sigma}_{GT}\,B(GT) \quad (1)$$

$$\frac{d\sigma}{d\Omega}(q=0) = \hat{\sigma}_{F}\,B(F) \quad (2)$$

Here $\hat{\sigma}_{GT}$ and $\hat{\sigma}_{F}$ represents the unit cross-sections at 0° for GT and F transitions respectively whereas B(GT) and B(F) are the transition strengths. While, the β-decay gives the reliable information for B(GT) and B(F) but due to weakness of the interaction the high excitation – energy region remains unattended by β-decay. However, the charge exchange reactions fulfill this requirement. Therefore, in this conference contribution we present the calculated results for ^{26}Mg (^{3}He, t)^{26}Al reaction at 140AMeV energy within antisymmetric distorted wave impulse approximation using DCP-2 code.

Further, in charge exchange reactions both central and tensor force components of the NN effective interactions contributes. But due to the difficulty in calculations of tensor knock-on exchange effects, these were treated approximately in most of the earlier work. Fortunately, DCP2 enable us to include knock-on exchange effects precisely and also allow us to estimate the contribution of tensor force in charge exchange cross section calculations.

The Love - Franey interactions for the effective nucleon-nucleon interaction potential at 140 AMeV may be written as [4]:

$$V = \int dx_1 dx_2 dx_1' dx_2' \hat{\rho}_T(x_1, x_1') \hat{\rho}_P(x_1, x_2') \times v_{12}(x_1' x_2', x_1 x_2) \quad (3)$$

The different symbols appeared here in above equation are well explained in Refs. [5-7]. The differential cross-section may be calculated as:

$$\frac{d\sigma}{d\Omega} = \frac{\mu_a \mu_b}{(2\pi\hbar^2)^2} \frac{k_b}{k_a} \times \left| \sum_{i=D,E} \sum_{k,l_1 t_1} \alpha_{j_1 s_1 v_1}^{t_1 s_1 l_1 k l_t} T_i^{t_1 s_1 l_1 k l_t m_{l_t}} \right|^2 \quad (4)$$

here, $\alpha_{j_1 s_1 v_1}^{t_1 s_1 l_1 k l_t}$ is the Racah coefficient and μ_a, μ_b, k_a, k_b depicts the reduced masses and wave numbers corresponding to incident and exit channels, respectively [5-7].

Table 1: The estimated unit cross-section for ^{26}Mg (^{3}He, t)^{26}Al reaction at 140 AMeV with and without tensor term for Fermi and Gamow-teller transitions.

Reaction Mechanism	$^{26}\mathbf{Mg(0^+, g.s.)(^3He, t)^{26}Al(0^+, 0.23)}$ **(IAS)**	$^{26}\mathbf{Mg(0^+, g.s.)(^3He, t)^{26}Al(1^+, 1.06)}$ **(GT)**
$\hat{\sigma}_{exp.fit}$(mb/sr)	2.27	13.112
$\hat{\sigma}_{D}$(mb/sr)	20.25	60.54
$\hat{\sigma}_{D+E}$(mb/sr) w/o tensor	7.50	33.72
$\hat{\sigma}_{D+E}$(mb/sr) with tensor	7.50	24.54

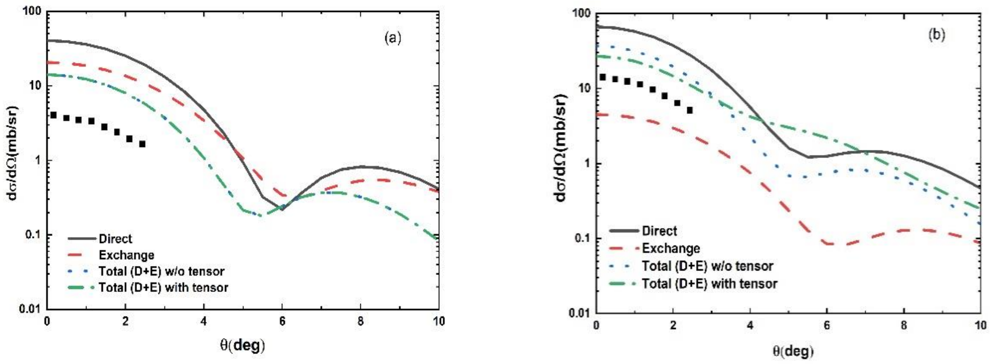

Fig. 1 (color online) The calculated differential cross-section for Fermi (a) and Gamow-Teller transitions (b). Solid (black) and dashed (red) lines indicate the contribution of direct and exchange terms separately. Total (direct plus exchange terms) contribution without and with tensor force are shown by dotted (blue) and dashed-dotted (green) lines. Data points are taken from Ref. [8].

Results and Discussion

The unit-cross section and angular distribution have been calculated for ^{26}Mg (^{3}He, t)^{26}Al reaction corresponding to Fermi and Gamow-Teller transitions and results obtained are shown in fig. 1(a) & 1(b) along with data taken from ref. [8]. During these calculations we include exchange and tensor terms in addition to direct contribution to cross section. It becomes clear from fig. 1(a) & 1(b) that inclusion of exchange terms lowers down the cross section in magnitude (up-to 60% for Fermi and 40% for Gamow-Teller transitions) which eventually enhances the matching between data and calculations [10]. Further the consideration of tensor effect also lowers down it up to 25% for Gamow-Teller transitions and bring the calculation close to data. While in Fermi transitions this effect is negligible. For more clarity in context to influence of inclusion of exchange and tensor terms we have also estimated the total unit cross section and results are presented in table 1. Again, it become clear that the consideration of these effects decreases the magnitude of unit cross section for GT transitions and eventually enhances the matching between data and calculations while for Fermi transitions the effects due to tensor term is not visible. For clear understanding and quantitative analysis of tensor forces further work is required.

In conclusion, we have examined the contribution of tensor forces and of exchange terms in cross section of (^{3}He, t) charge exchange reaction on ^{26}Mg target at 140 AMeV. The results clearly depict the importance of consideration of exchange and tensor forces.

References

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