Analysis of (^{3}He, t) charge exchange reaction on ^{58}Ni at intermediate energy

[1]Pardeep Singh*, R. G. T. Zegers[2], Pawel Danielewicz[2], S. Noji[2], B. T. Kim[3,4] and H. Sakai[4], [5]Rajiv Kumar and [6]Rajesh Kharab

[1]Department of Physics, Deenbandhu Chhotu Ram University of Science and Technology, Murthal-131039, INDIA
[2]National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing-48824, MI, USA
[3]Department of Physics and Institute of Basic Science, Sungkyunkwan University, Suwon 440-746, Korea
[4]RIKEN Nishina Center, Wako 351-0198, Japan
[5]Department of Physics, D. A. V. University, Jalandhar, INDIA
[6]Department of Physics, Kurukshetra University, Kurukshetra-136119(Haryana)-INDIA.
**email: panghal005@gmail.com*

The (^{3}He, t) charge exchange reaction wherein a proton transforms into a neutron which eventually changes the isospin of the reaction participants indentified as a reliable tool to analyze the spin-isospin excitation in nuclei [1, 8]. Variety of charge-exchange reactions have been also used, to extract the Gamow –Teller strengths with the use of a proportionality relation, between differential cross section at vanishing momentum transfer and the corresponding GT transition strength. The strengths deduced through charge exchange reactions provide stringent tests for nuclear structure calculations and serve as inputs to the modeling of the explosion dynamics of a massive star [3, 4].

In present contribution we analyze the results of (^{3}He,t) charge-exchange reaction at 140 MeV/u on ^{58}Ni within the theoretical framework of distorted wave impulse approximation(DWIA). In this approach the differential cross section for inelastic charge exchange reaction A(a, b)B may be expressed as

$$\frac{d\sigma}{d\Omega}=\frac{\mu_a\mu_b}{(2\pi\hbar^2)^2}\frac{k_b}{k_a}\left|\sum_{i=D,E}\sum_{k,l_1t_1}\alpha^{t_1s_1l_1kl_t}_{j_ts_tv_1}\,T_i^{t_1s_1l_1kl_tm_{l_t}}\right|^2 \qquad (1)$$

Here μ_a , μ_b and k_a , k_b are the reduced masses and wave numbers in the incident and exit channels, respectively. The coefficient, $\alpha^{t_1s_1l_1kl_t}_{j_ts_tv_1}$, contains the Racah coefficients describing the recoupling of various angular momenta. The subscript i appeared in eq. (1) is i =D for direct transitions and i = E for exchange transitions. The transition amplitude may be written in terms of direct and exchange overlap integrals as

$$T^i_{t_1s_1l_1k\,l_tm_{l_t}}=\frac{(4\pi)^{3/2}}{k_a\,k_b}\sum_{l_al_b}i^{l_a-l_b+\pi}\,\hat{l}_a\,(l_a0\,l_t\,m_{l_t}|l_bm_{l_t})\,O^i_{t_1s_1l_1k\,l_t,\,l_al_b}\,Y_{l_bm_{l_t}}(\hat{k}_b)$$

Here O^i represents the direct (i = D) and exchange (i = E) overlap integrals respectively [5,6].

Through the use of eq. (1) we have calculated the differential cross section for the ^{58}Ni(^{3}He, t)^{58}Cu(1^+,g.s) and ^{58}Ni(^{3}He, t)^{58}Cu(0^+,0.203) charge exchange reactions at 140 A MeV energy and the results so obtained are presented in Figs. (1) and (2) respectively. Our calculation contains exactly calculated exchange contribution which approximated in almost earlier work.

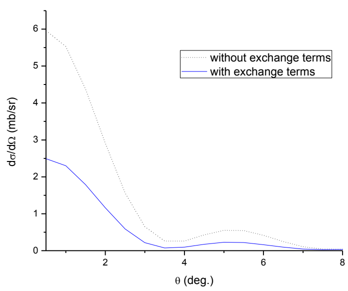

Fig.1 (color online) The calculated angular distribution for the reaction (^{3}He, t) on ^{58}Ni target at 140 A MeV energy. The solid (blue line) line has been obtained with the inclusion of exchange contribution while dashed (black) line represents the result corresponding to direct contributions alone.

In fig. 1 the dashed lines represent the results without exchange terms while the solid line gives the contribution corresponds to direct and exchange terms both.

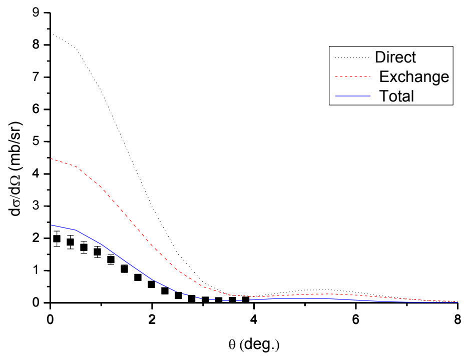

Fig. 2 (color online) Differential cross section for the reaction (^{3}He, t) on ^{58}Ni target at 140 A MeV energy. The doted (black) and dashed (red) lines corresponds to direct and exchange contribution respectively while solid (blue) line represents the results for direct plus exchange terms

It is clearly seen from fig. 1 that the inclusion of exchange contributions in the calculations reduces the differential cross section in magnitude. In fig. 2 the calculated results are presented along with the experimental data. The doted (black) and dashed (red) lines corresponds to direct and exchange contribution alone respectively while solid (blue) line represents the results for direct plus exchange terms.

It becomes clear from the figures that the inclusion of exchange contribution in the calculations reduces the magnitude which in turn bringing it down towards the experimental results.

Conclusively, in the present calculations the exchange effects have been incorporated exactly for (^{3}He, t) reaction on ^{58}Ni target at 140 A MeV. The results obtained clearly illustrate the importance of including correctly calculated exchange terms.

This work was supported by the University Grants Commission of India under Indo-US 21st Century Knowledge Initiative and by the National Science Foundation under Grants PHY-1068571 and PHY-1403906.

REFERENCES

1. M. Fujiwara et al., Nucl. Phys. A**599**, 223c (1996).
2. M. N. Harakeh and A. Vander Woude, Giant Resonances: Fundamental High-Frequency Modes of Nuclear Excitations(Oxford University, New York, 2001).
3. K. Langanke and G Martinez-Pinedo, Rev. Mod. Phys. 75, **819** (2003), and references therein.
4. T. Adachi et al., Phys. Rev. C **73**, 024311 (2006).
5. B. T. Kim et al., Phys. Rev. C 61, 044611 (2000).
6. G.R. Satchler, Direct Nuclear Reactions, Clarendon, Oxford,1983, T. Udagawa, et al., Nucl. Phys. A **474**, 131 (1987).
7. R. G. T. Zegers et al., Phys. Rev. Lett.**99**, 202501 (2007).
8. Pardeep Singh et al., Proc. DAE Symp. Nucl. Phys. **59,** 386 (2014.)