Shell model results of Gamow-Teller transition strengths for ^{48}Ti($^{3}He,t$)^{48}V reaction

Vikas Kumar[1],* Anil Kumar[2], Archana Saxena[2], and Praveen C. Srivastava[2]
[1] *Department of Physics, Central University of Kashmir, Srinagar - 190004, INDIA and*
[2] *Department of Physics, Indian Institute of Technology, Roorkee - 247667, INDIA*

1. Introduction

The study of Gamow-Teller (GT) transition strengths is important tool to study structure of atomic nuclei. The study of astrophysical phenomena like supernovae explosions and nucleosynthesis GT transition strength values used as input. The experimental GT-strength for the transition from $T_Z = +2$ nucleus ^{48}Ti to $T_Z = +1$ nucleus ^{48}V in the ^{48}Ti($^{3}He,t$)^{48}V charge-exchange reaction is available in the Ref. [1]. In the present work we have calculated GT-strengths from ground state of ^{48}Ti to the different excited states of ^{48}V using two different GXPF1A and KB3G effective interactions.

2. Details of the Shell model calculation

The aim of the present study is to present state of the art shell model calculations for the observed transitions in ^{48}Ti nucleus in the fp model space using the KB3G [2] and GXPF1A[3] interactions. The shell model calculations are performed using the code NuShellX@MSU[4]. The KB3G effective interaction is a slightly monopole-corrected version of the well-known KB3 interaction, this is a mass-dependent effective interaction which is able to reproduce the energy spectra, electromagnetic transitions and moments as well as beta decay properties of the fp shell nuclei in the mass range $A = 45 - 65$. This interaction is based on well known effective interaction GXPF1, GXPF1 interaction is derived from the Bonn-C potential and modified 70 well-determined linear combinations of 4 single-particle energies and 195 two-body matrix elements by iterative fitting calculations to about 700 experimental energy data out of 87 nuclei. Further five two-body matrix elements are modified within reasonable amount in GXPF1 interaction to describe the spectroscopic properties of the nuclei in the mass region $A = 47 - 66$. The resulting effective interaction is called GXPF1A interaction.

The Gamow-Teller strength $B(GT)$ is calculated using following expression,

$$B(GT_{\pm}) = \frac{1}{2J_i+1} f_q^2 \,|\langle f|| \sum_k \sigma^k \tau_{\pm}^k ||i\rangle|^2, \tag{1}$$

where $\tau_+|p\rangle = |n\rangle$, $\tau_-|n\rangle = |p\rangle$, f_q is the quenching factor, the index k runs over the single particle orbitals, $|i\rangle$ and $|f\rangle$ describe the state of the parent and daughter nuclei, respectively. In $\beta^{\pm}$-decay, one neutron is converting into one proton and vice-versa and the remaining system will remain same, so it is possible to extract $B(GT_{\pm})$ strength using extreme single particle model (ESPM) [5]. The reported $B(GT)$ and summed $B(GT)$ values are quenched by a quenching factor 0.66 [6]. The qualitative agreement is obtained for the individual $B(GT)$ transitions, while the calculated summed transition strengths closely reproduce the observed ones.

3. Comparison of experimental and theoretical $B(GT)$ strength distributions

Fig. 1 displays a comparison between the shell-model calculations and the experimental $B(GT)$ strength distribution for the transition ^{48}Ti → ^{48}V. Fig. 1(a) presents the experimental data observed through the charge-exchange reaction ^{48}Ti(^{3}He,t)^{48}V up

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*Electronic address: `vikaskumar@cukashmir.ac.in`

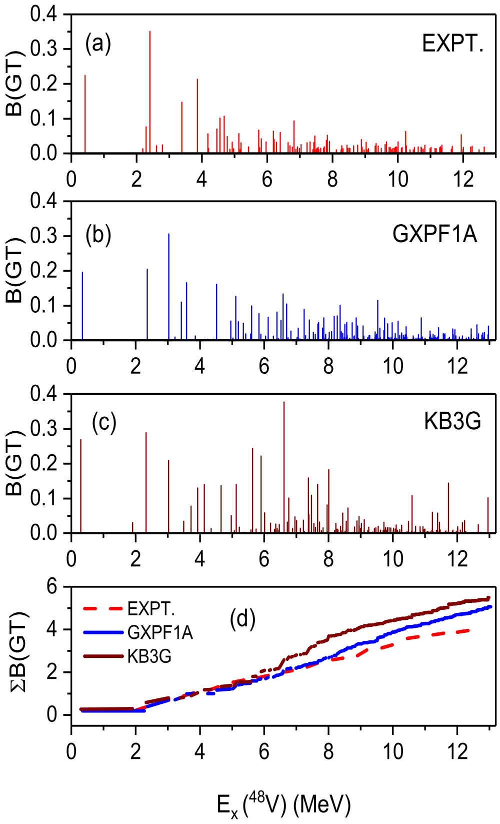

FIG. 1: Comparison of experimental and theoretical B(GT) distributions for ^{48}Ti → ^{48}V.

to the excitation energy $E_x(^{48}\mathrm{V}) = 12.646$ MeV. Fig. 1(b) depicts the shell-model calculation using the GXPF1A interaction up to the excitation energy $E_x(^{48}\mathrm{V}) = 13.048$ MeV, Fig. 1(c), the shell-model calculation using the KB3G interaction up to the excitation energy $E_x(^{48}\mathrm{V}) = 12.983$ MeV, and Fig. 1(d), the running sums of $B(GT)$ as a function of the excitation energy $E_x(^{48}\mathrm{V})$. The experimental GT strength is dominated by the transition $^{48}\mathrm{Ti}(0^+) \rightarrow {}^{48}\mathrm{V}(1^+)$ at excitation energy $E_x = 0.421$, 2.406, 3.864, and 4.554 MeV. The calculated intensities for these transitions are similar to the measured ones at lower excitation energy but at higher excitation energies some more dominated transitions are predicted by both shell model calculations which are not observed in the experiment. It is found that the interaction GXPF1A generated an excitation energy more closer to the experimental one than the energy obtained employing the KB3G interaction. From fig. 1(d) the summed $B(GT)$ strength plot, the summed $B(GT)$ strength by KB3G is in agreement with the experiment at lower excitation energy but not at higher excitation energy, the summed $B(GT)$ strength predicted by GXPF1A interaction matched with observed ones better than KB3G. We have calculated $B(GT)$ values for 350 transitions from ground state of $^{48}\mathrm{Ti}(0^+)$ to $^{48}\mathrm{V}(1^+)$ without any truncation. During the meeting we will present results of rest of recently measured fp shell nuclei.

4. Summary and Conclusion

In the present work we have reported shell model result of recently measured GT-strengths of $^{48}\mathrm{Ti}(^3He,t)^{48}\mathrm{V}$ reaction. The summed $B(GT)$ strength predicted by the GXPF1A interaction is more closer to the experiment than the KB3G interaction.

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