Shell model interpretation for recently measured Gamow-Teller strengths for ^{54}Ni, ^{50}Fe, ^{46}Cr, and ^{42}Ti nuclei

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I. INTRODUCTION

The Gamow-Teller(GT) transition plays an important role for the study of nuclear structure. GT transition is the allowed transitions in the β-decay and there are two types of GT transitions, β^+-decay and β^--decay. In β^+-decay a nucleus with $(Z,\ N)$ goes to the final nucleus with $(Z-1,\ N+1)$, while in β^--decay nucleus with $(Z,\ N)$ goes to the final nucleus with $(Z+1,\ N-1)$. Experimentally there are two ways to study the GT transitions. First, through β-decay which is weak interaction processes, while second one is the charge exchange (CE) reactions which is strong interaction processes. The $\sigma\tau$ operator is responsible for the GT transitions among the spin-orbit partners, such as $f_{7/2}$ and $f_{5/2}$ orbits, where σ is the rotation matrix which changes parity of nucleus from 0 to 1 and τ is the isospin matrix which changes proton to neutron and vice-verse.

Recently, F. Molina *et.al.* [1], populated the ^{54}Ni, ^{50}Fe, ^{46}Cr, and ^{42}Ti nuclei by the fragmentation of a ^{58}Ni beam at 680 MeV/nucleon on a 400 mg/cm^2 Be target and studied the β-decay. With the help of experimentally observed half lives of β-decay, excitation energies, and β branching ratios, they reported the Fermi and Gamow-Teller transition strengths. The more precise B(GT) value is reported in [2] with the help of charge-exchange reaction, there is good agreement between the both experimental data.

In the present study we performed the theoretical shell model calculations for newly populated ^{54}Ni, ^{50}Fe, ^{46}Cr, and ^{42}Ti nuclei in full fp model space with KB3G [3] and GXPF1a [4] interactions using NushellX@MSU code[5]. The experimentally observed B(GT) strength distribution results [1, 2] are compared with theoretical calculations.

II. COMPARISON OF EXPERIMENTAL AND THEORETICAL GT STRENGTH DISTRIBUTIONS

The measured GT strength distribution for ^{42}Ti, ^{46}Cr, ^{50}Fe, and ^{54}Ni have been interpreted in terms of shell-model approach. The shell-model calculations have been performed in fp valence space using most appropriate effective interactions KB3G and GXPF1a, due to huge matrix dimensions of ^{54}Ni, we allowed maximum up to four nucleons excitation from the $f_{7/2}$ shell to the rest of the pf orbitals. However we performed full-fledged calculations for ^{42}Ti, ^{46}Cr and ^{50}Fe nuclei. The B(GT) value and sum of B(GT) in shell-model strengths have been scaled by the quenching factor $(0.74)^2$. The theoretical results are compared with the experimental data reported in [1] and [2]. There are good agreement between theoretical values and the experimentally observed B(GT) strength distributions. Comparison between the shell-model calculations and the experimental GT strength distribution for the ^{46}Cr$(0^+) \rightarrow$ ^{46}V(1^+) transitions are shown in the fig.1. In this, fig.1(a), represents the experimental data observe through β-decay [1] i.e.,^{46}Cr(p,n)^{46}V up to the excitation energy $E_x(^{46}\mathrm{V}) = 2.875$ MeV; fig.1(b), represents the experimental data observe through charge-exchange reaction process [2] i.e., ^{46}Ti(^{3}He,t)^{46}V up to the excitation energy $E_x(^{46}\mathrm{V}) = 4.723$ MeV; fig.1(c), the shell-model calculation using the KB3G interaction; fig.1(d), the shell-model calculation using the GXPF1a interaction,

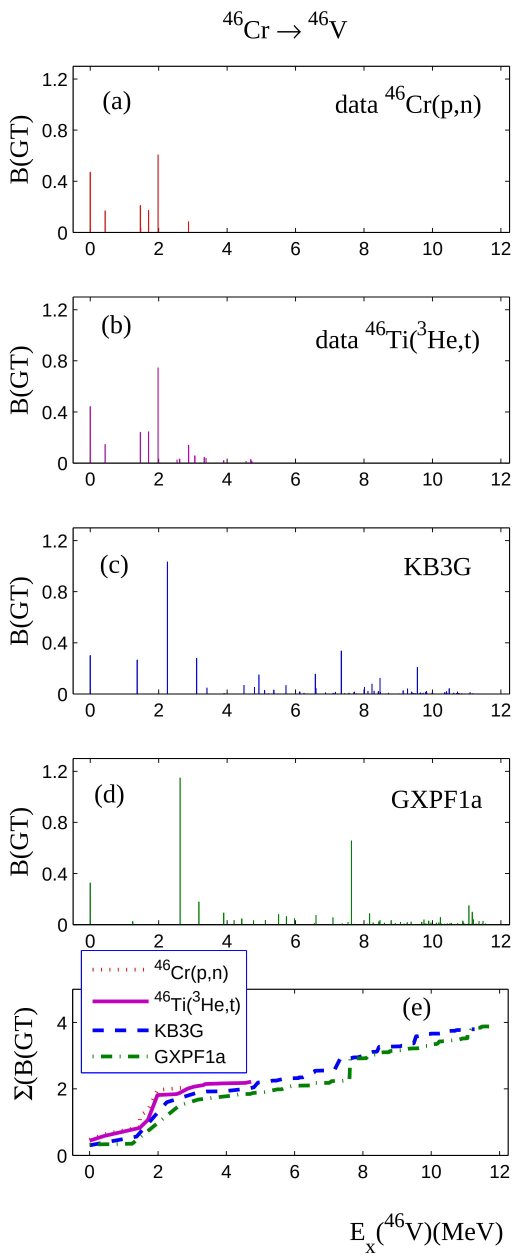

FIG. 1: Comparison of experimental and theoretical $B(GT)$ distributions for ^{46}Cr → ^{46}V.

and fig.1(e), running sums of B(GT) as function of excitation energy. At $E_x(^{46}\text{V}) = 0$, calculated B(GT)value in KB3G interaction is lower by 0.173 and 0.141 than ^{46}Cr(p,n) data and ^{46}Ti(^{3}He, t) data respectively, in GXPF1a interaction it is lower by 0.148 and 0.116 respectively. The next major B(GT) value calculated by KB3G and GXPF1a are 1.031 and 1.147 at $E_x(^{46}\text{V}) = 2.256$ and 2.628 MeV respectively, which is larger than the experiment. The experimentally observed B(GT) value (0.172) at $E_x(^{46}\text{V}) = 1.704$ MeV in β-decay is reported at $E_x(^{46}\text{V}) = 3.175$ MeV with B(GT)=0.177 in GXPF1a interactions. After $E_x(^{46}\text{V}) = 1.985$ MeV, the experimental observed B(GT) value in both the data are not well described by the KB3G or GXPF1a interactions. The shell-model calculations of sums of B(GT) using KB3G and GXPF1a are showing same trends as in the experiment, however KB3G results are closer to the experiment this is because the more strength is predicted at low excitation energy, with the GXPF1a the calculated sums of B(GT) is lower than KB3G up to $E_x(^{46}\text{V}) = 11.162$ MeV but above $E_x(^{46}\text{V}) = 11.197$ MeV it is higher than KB3G results. Finally we will report the results for rest three nuclei during conference [6].

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