# Transition rates in $^{49}$Ti

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## Introduction

The *pf*-shell serves as an excellent platform for investigating the interplay between single particle and collective excitation. The collectivity in the ground state of the $1f_{7/2}$ shell increases towards the middle of the shell and starts to disappear rapidly when approaching the doubly magic nucleus $^{56}$Ni as the nuclei evolve towards a spherical shape [1,2]. The nuclei around $^{48}$Cr highlight collective phenomena which are explained well by large-basis shell-model calculations [3].

The spectroscopic information of $^{49}$Ti, one of the neighbouring nuclei of $^{48}$Cr, was very limited. Only a few experiments were performed to investigate the high spin structure of $^{49}$Ti. The level scheme of $^{49}$Ti was extended only up to 7 MeV [4,5]. The lifetime information was available only for a few levels. We have started our investigation on $^{49}$Ti and extended the level scheme above the band terminating $19/2^-$ state (Fig. 1) and confirmed / assigned the spin and parity of most of the levels [6]. In the present work, we have reported the lifetime information of few levels in $^{49}$Ti and compared them with the results obtained from the shell model calculations.

## Experimental Details

The high-spin states of $^{49}$Ti were populated through $^{48}$Ti($^4$He,2pn)$^{49}$Ti fusion evaporation reaction with 48 MeV alpha beam at Variable Energy Cyclotron Centre (VECC), Kolkata. The experiment was carried out on a self-supported 12.4mg/ cm$^2$ thick natural Ti target and the γ-rays were detected using Indian National Gamma Array (INGA). The details of the experimental set up and data analysis can be found in Ref. [7].

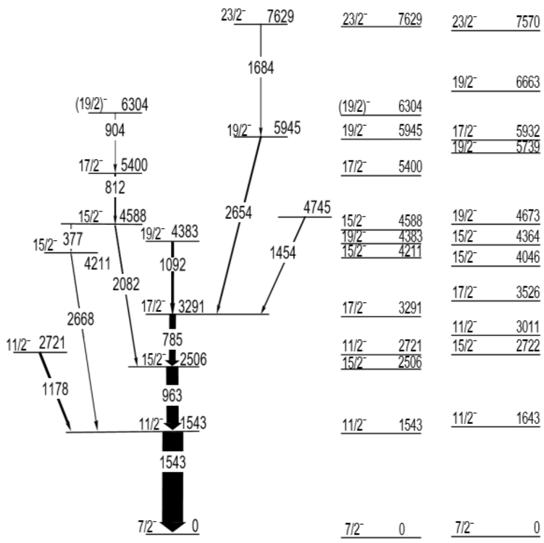

Fig. 1: Partial Level Scheme of $^{49}$Ti (Left). A comparison between the experimental and shell model level energies is shown on the right.

## Results and Discussion

Doppler shifted peaks for a few transitions viz. 785, 812, 904, 1092, 1178 keV etc. have been observed in the present data. We have therefore performed lineshape analysis using the lineshape code [8] based on Doppler Shift Attenuation Method (DSAM) to extract the lifetimes of the corresponding levels. In the present analysis, the lineshape spectra were obtained from the $125^0$, $90^0$ and $40^0$ clovers for strong transitions (Fig. 2(a-c)) and $125^0$ and $90^0$ clovers only for weak transitions (Fig. 2(d-f)). In the present work, the line-shape spectra are generated by putting gates on a transition below the transitions of interest. The effect of side feeding, estimated from the relative intensities of the feeding and decay-out transitions, was therefore properly considered. It was modelled with a cascade or a single-step feeding, depending on the type of transition of interest. During line-shape simulation, the background parameters for each level were kept as free parameters.

We have measured the lifetimes of five levels viz. 4588 keV, 5400 keV, 5945 keV, 6304 keV, and 7629 keV for the first time from the lineshape spectra of the decay out 2082, 812, 2654, 904 and 1684 keV transitions, respectively. The lifetime of 2721, 3291, and 4383 keV levels was previously measured and their reported values are 0.082(39) ps, <0.101 ps and <0.173 ps, respectively [9]. In the present work, we have remeasured them with greater accuracy. Since, we do not have any feeding transitions to the 2721 keV and 4383 keV levels, we only get the upper limit of their lifetimes. Finally, we have extracted the B(M1) and B(E2) strengths of the transitions from their measured lifetimes, branchings and mixing ratios. The measured strengths are then compared with the calculated strengths obtained from shell model calculations performed using the code NUSHELLX [10] and KB3GPN [11] effective interaction. In these calculations, effective charges of $e_p = 1.5e$ and $e_n = 0.5e$ were applied, along with the free values of g-factors. The calculated strengths of these transitions agreed well with their experimental values.

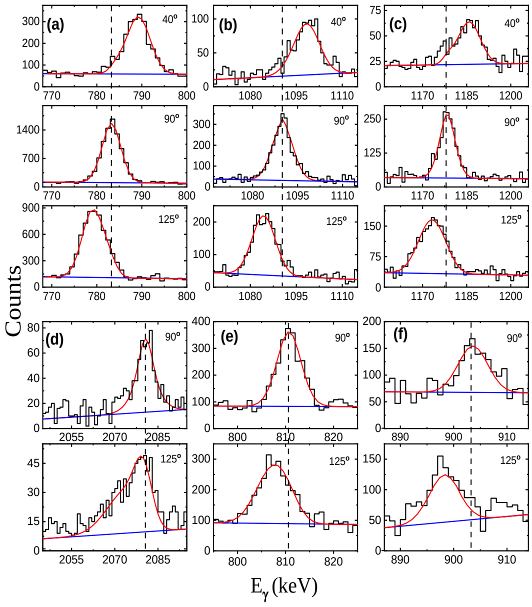


Fig. 2: Experimental (black) and simulated (red) lineshape spectra are shown for the (a) 785, (b) 963, (c) 1178, (d) 2082, (e) 812 and (f) 904 keV transitions.


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