Transition rates in the negative parity structure of ^{49}V

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Introduction

The $f_{7/2}$-shell nuclei, with neutron and proton numbers between the magic numbers 20 and 28, exhibit a wide range of phenomena. Several experimental and theoretical investigations were carried out earlier to study the interplay between single-particle and collective structures in these nuclei. The middle of the $f_{7/2}$ shell is characterized by large deformations near the ground state; but, as one moves toward the end of the shell, the collective behavior is replaced by the single particle effects. Information on lifetimes and the derived electromagnetic transition strengths of the levels can give a clear picture of the underlying phenomena, since the $B(M1)$ rates are sensitive to the single particle features, while the $B(E2)$ values are sensitive to rotational collectivity.

The ^{49}V nucleus, with three protons and six neutrons in the $f_{7/2}$ shell, is close to a small region of collectivity that exists at the middle of the $f_{7/2}$ shell. The yrast negative parity states are connected by strong E2 transitions up to I^{π}=23/2^{-}. Side bands of positive parities in this nucleus were suggested to stem out of excitations from the *sd* shell. It is to be noted that considerable amount of evidence has been gathered for rotational structure in *sd*-shell nuclei. High-spin states in ^{49}V nucleus were studied earlier by Cameron *et al.* employing ^{12}C(^{40}Ca,3p)^{49}V reaction at a ^{40}Ca beam energy of 160 MeV and POLYTESSA array of sixteen escape-suppressed spectrometers [1]. A much detailed work on this nucleus employing ^{28}Si(^{28}Si,α3p) reaction and EUROBALL IV + Recoil Filter Detector (RFD) has been reported recently where the ^{49}V level scheme was extended up to 13.1 MeV with the observation of 21 new states [2]. However, the experimental data on mean lifetimes and reduced transition probabilities of the excited states in ^{49}V remain rather sparse. Therefore, a dedicated measurement employing Doppler Shift Attenuation Method (DSAM) has been undertaken to deduce the aforesaid experimental observables. The results out of this measurement, coupled with Large Scale Shell-Model (LSSM) calculations, will be important to further explore the extent of collective and single-particle natures of states in nuclei near mid-$f_{7/2}$ shell.

Experimental details

High-spin states in ^{49}V were populated using the ^{27}Al(^{28}Si,α2p)^{49}V reaction at the Pelletron-Linac facility, TIFR, Mumbai. The ^{28}Si beam impinging on the target was of energy 100 MeV. The target consisted of a ∼750 μg/cm^2 thick Al foil with a 14.8 mg/cm^2-thick layer of Au backing. Deexciting γ rays were detected by the Indian National Gamma Array (INGA) spectrometer which consisted of twenty Compton-suppressed clover Ge detectors. The data, acquired employing Pixie-16 based digital acquisition system [3], are being analyzed offline using RADWARE and LINESHAPE software packages.

Results and discussions

The partial level scheme of ^{49}V as obtained and relevant to the present study is shown

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in Fig. 1. The yrast negative parity states were observed up to the I^{π}=27/2$^-$ band-termination state (E$_x$=7797 keV). Most of the

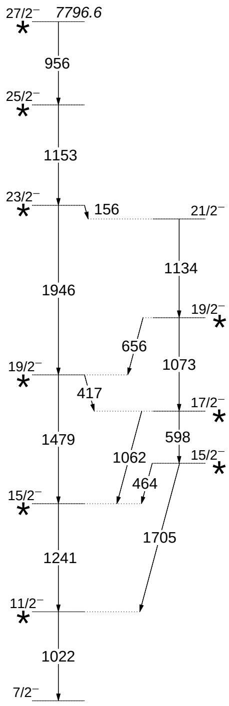

FIG. 1: Partial level scheme of ^{49}V. Lifetimes and reduced transition rates are being deduced for the states which are marked with "$*$".

transitions deexciting the negative and positive parity states as reported by Rodrigues *et al.* [2] were observed in the analysis of the triple-γ coincidence data. In addition, distinct lineshapes were observed at forward and backward angles for almost all the transitions leading up to the I^{π}=27/2$^-$ band-termination state (Figs. 1, 2). Doppler broadened lineshape analysis is being carried out for these transitions to deduce the lifetimes of the levels (marked with "$*$" in Fig. 1). It is to be noted that lifetimes of states, only up to excitation energy of E$_x$ < 3.2 MeV, were measured earlier using α- and p-induced reactions [4]. Further, lifetimes of I^{π}=11/2$^-$ (E$_x$=1022 keV), I^{π}=15/2$^-$ (E$_x$=2263 keV) and I^{π}=15/2$^-$ (E$_x$=2727 keV) states remain ambiguous with large uncertainties. Large

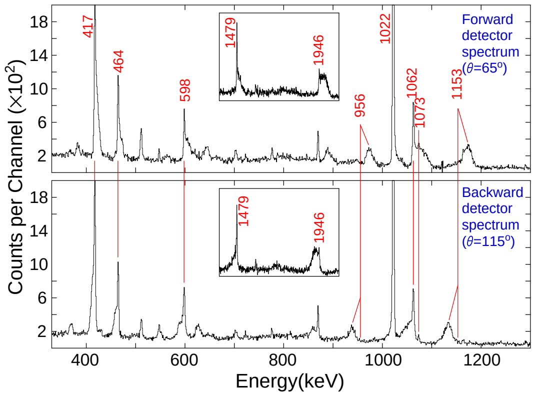

FIG. 2: Representative gated spectrum of ^{49}V as obtained at one set of complementary forward and backward angles ($\theta = 65^o$ and 115^o). The energy gate is 1241 keV.

Scale Shell Model calculations with ^{40}Ca core and a valence space in the full fp-shell (with no restriction on occupancy of available orbits for valence nucleons) are being performed to understand the underlying configuration of the single particle states. The calculated reduced transition rates and quadrupole moments will be compared with the experimental values. Calculations for the positive parity levels will also be performed including the sd shell using the SDPF interaction. The analysis and calculations are in progress. Results will be presented in detail during the symposium.

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