Lifetime measurement for the high spin states of ^{88}Sr nucleus

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Introduction

Core excitations across the N=50 major shell gap as well as Z=40 semi shell gap play a crucial role for the high spin states of Sr, Zr and Mo isotopes in A∼90 region. Due to the relatively small difference in these two shell gaps, excited states in these nuclei can experience a competition between protons and neutrons excitations across the core. Though the neutron core excitation has been reported in some of these nuclei [1], little is known about the simultaneous neutron and proton core excitations, which can give rise to band structures at high spin for nuclei in this mass region. In this context, the high spin states of ^{88}Sr were studied in the present work. Two band structures have been reported in the previously established level-scheme of ^{88}Sr by E. A. Stefanova *et al.* [2]. However, the spin and parity of the bands were not confirmed and no conclusion can be drawn on the origin of band formation. The present work attempts to establish the band structures by measuring spin, parity and mean lifetime of the levels using gamma spectroscopic techniques.

Experiment and Analysis

The high spin states of ^{88}Sr were populated by bombarding ^{13}C nuclei at 60 MeV on 1 mg/cm^2 thick ^{82}Se target with 4.26 mg/cm^2 thick Au backing. The ^{13}C beam was provided

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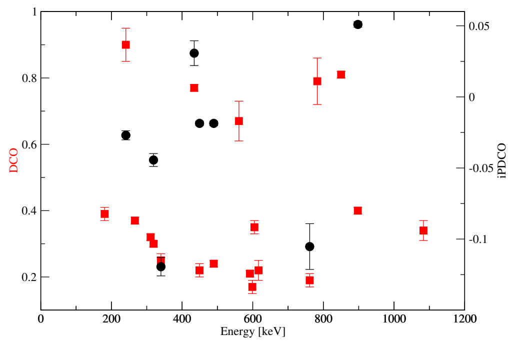

FIG. 1: The plot of experimentally measured DCO and iPDCO ratios with energy, where, the square (circle) symbol denotes DCO (iPDCO) values. The DCO ratios have been calculated using stretched $\Delta = 2$ gating transition.

by the Pelletron-Linac facility at TIFR, Mumbai. The γ-rays from the de-exciting nuclei were detected using 11 Compton suppressed Clover detectors of Indian National Gamma Array (INGA), TIFR [3].

In order to establish the level scheme, the spin difference between the excited levels were confirmed by measuring the directional correlation of oriented states (DCO) ratios [4]. A two fold coincidence matrix was constructed with 90^0 detectors along one axis and 157^0 detectors along the other axis for this measurement.

Parities of the excited levels were fixed by measuring the integrated polarisation from directional correlation of oriented states (iPDCO) ratios [5]. To evaluate the iPDCO

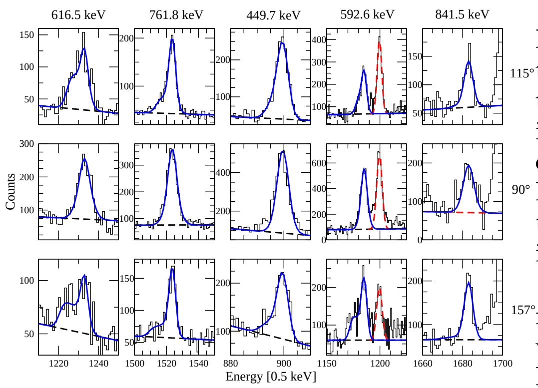

FIG. 2: Lineshapes of the γ transitions decaying from the high spin positive parity states of ^{88}Sr. The lineshapes of the transitions decaying from 13^+ and 14^+ levels have been extracted using the $341(11^+ \rightarrow 10^+)$ keV gate and for other transitions the $1287(8^+ \rightarrow 7^-)$ keV gate has been used.

ratios, the asymmetry between the parallel and perpendicular scattering probability of γ-rays with respect to the reaction plane had to be calculated. This calculation was performed using the counts detected in the four Ge crystals of 90^0 detectors. The present measurement confirms the previously established level scheme by E. A. Stefanova *et al.* and also fixes the spin and parities of the high spin bands uniquely. The experimentally measured DCO and iPDCO ratios have been plotted with γ-energy in FIG. 1.

The sub-picosecond lifetime for the high-spin states of ^{88}Sr were measured by Doppler Shift Attenuation Method (DSAM) using LINESHAPE code by Wells and Johnson [6]. This code was used to generate the velocity profile of the nuclei recoiling into the backing as seen by the detectors at 90^0, 115^0, 140^0 and 157^0 angles using Monte Carlo technique. The velocity profile contains 10000 histories with a time step of 0.001 ps. The line shapes were extracted using the coincidence spectra from the angle dependent asymmetric matrices.

For the positive parity band, the 616.5 keV$(17^+ \rightarrow 16^+)$ transition lineshape was fitted assuming a 100% side feed. Considering the lifetime of 17^+ level as effective lower lying transitions were fitted into a cascade to evaluate the mean lifetime of the levels. The lineshape fits for the γ-transitions belonging to the positive parity band have been depicted in FIG. 2.

The same procedure was followed for the negative parity band, where the cascade fit was performed using the mean lifetime of 13^- level as effective. The lineshape of $605(8^- \rightarrow 7^-)$ keV transition was extracted using the top gate, where the fitting involves a four level cascade with the lifetime of 11^- level as effective.

The measured lifetimes are used to calculate the M1 transition rates, which can be used to assign the neutron and proton configurations involved in the band formations of ^{88}Sr. A theoretical model calculation using the shell model basis states is under progress, where we try to explain the angular momentum generation mechanism behind the band structures in ^{88}Sr.

Acknowledgments

We thank all the staff and members of the TIFR-BARC Pelletron-Linac facility for their active co-operation during the experiment.

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