Spectroscopic study of ^{40}K

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Introduction

The *sd* - *pf* interface nuclei usually exhibit the characteristic of spherical single-particle excitation spectra and their spectra are well explained by the spherical shell-model [1]. It is now possible to study these nuclei at higher angular momentum and excitation energy using sophisticated detectors and advanced data acquisition systems. As a result, the coexistence of single-particle and collective excitations have been noticed in a few *sd-pf* interface nuclei viz. ^{40}Ca [2], etc. In most of the cases, single-particle nature is dominated at lower excitation energies. In contrast, collective excitations in terms of normal deformed or even superdeformed (SD) bands are observed at relatively higher excitation energies. Shell-model calculations with multi-particle multi-hole excitation have been performed successfully to understand the microscopic origin of these observed SD bands.

^{40}K is the isobaric partner nucleus of ^{40}Ca. So, in ^{40}K, we may also expect generation of collective excitations at higher excitation energy from multi-particle multi-hole excitations. ^{40}K nucleus was previously studied by P.-A. Soderstrom et. al. [3] through heavy-ion reaction. Several states with excitation energy up to 8 MeV and spin up to 10^- have been discovered. They have assigned the spin and parity of these levels tentatively based on the comparison of the branching ratios to the Weisskopf value (Fig. 1). Therefore, our primary motivation is to investigate the high-spin structure of ^{40}K and assign or confirm the spin and parity of these levels in ^{40}K.

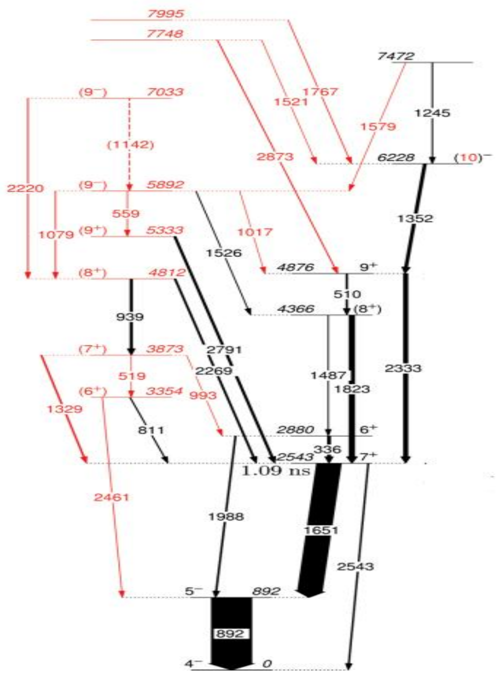

Fig 1: Partial level scheme of ^{40}K taken from ref. [3]. Levels and transitions from their work are indicated with red.

Experimental Details

High-spin states in ^{40}K were populated through the ^{19}F (^{27}Al, αnp) ^{40}K reaction with a 68 MeV ^{19}F beam. The 15UD Pelletron accelerator provided the ^{19}F beam at the Inter-University Accelerator Centre (IUAC), New Delhi. The target ^{27}Al (0.43 mg/cm^2) was evaporated on 11.4 mg/cm^2 Au backing and fabricated at the IUAC target laboratory. Indian National Gamma Array, comprising 12 Compton-suppressed clovers, was used to detect the γ rays. These twelve clovers were mounted at four different angles, i.e., 148^0 (4), 90^0 (4), 57^0 (1), and 32^0 (3) with respect to the beam axis. NiasMARS, the data sorting program developed by IUAC, was used to generate angle-independent symmetric and angle dependent asymmetric E_γ- E_γ matrices, which were further analyzed by sorting program INGASORT [4]. We have used a few online gamma energies ranging from 300 to 4000 keV for energy calibration of the clovers. The relative efficiency calibrations of the clovers were performed using ^{152}Eu, and ^{66}Ga radioactive sources. The ^{66}Ga source having gamma energy 833 to 4806 keV was prepared through ^{19}F (^{51}V, 3np) ^{66}Ga reaction at 68 MeV in the same experimental setup.

Result and Discussion

The level scheme of ^{40}K has been studied based on the coincidence relationship, relative intensities, R_{DCO} and R_{ADO} ratios of gamma rays. The γ rays from nuclei populated from the reaction are marked in Fig. 2.

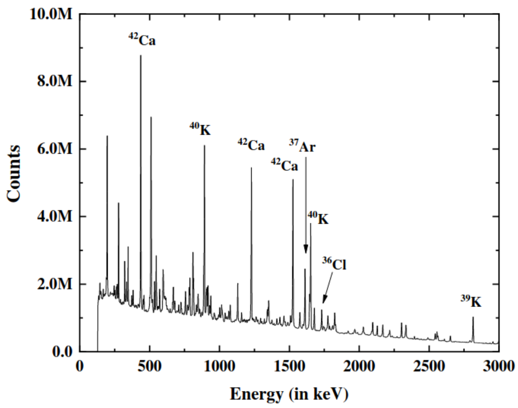

Fig 2: A total projection spectrum of γ rays emitted by different nuclei from the present experiment.

The measurement of the directional correlation of γ rays emitted from excited states (DCO) was carried out to confirm or assign the spins of the levels in ^{40}K (Fig. 3a). The experimental data have been sorted into different angle-dependent asymmetric matrices for DCO measurement. We have measured the R_{DCO} values for a few transitions to confirm the spin of the levels in ^{40}K.

The DCO measurement could not be carried out for few transitions due to their low statistics. Therefore, the angular distribution from oriented nuclei (ADO) measurements have been carried out to determine their multipolarities (Fig. 3b). Based on our results, we have confirmed the spin of the 3354, 3873, 4366, 4812, 5333, 5892, 6228, 7472, 7748, and 7995 keV levels.

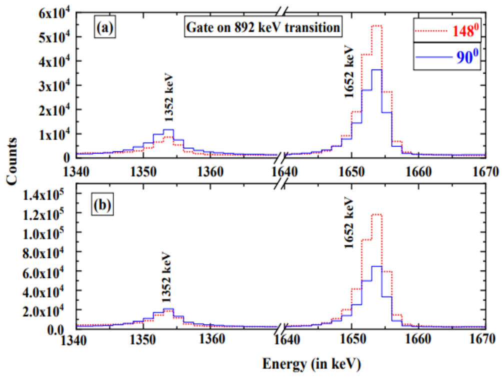

Fig 3: A schematic representation of (a) DCO and (b) ADO spectra in ^{40}K.

In order to assign the parities of these levels, polarization measurements will be carried out. Lineshape analysis will be performed to extract the lifetime of the levels. Large basis shell model calculation with multi particle-multi hole excitations will be carried out to understand the microscopic origin of these levels.

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