Transition rates in mirror nuclei ^{35}Ar and ^{35}Cl

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Introduction

Mirror nuclei are a pair of nuclei where the number of protons and neutrons are interchanged. The study of differences between excitation energies of analogue states in mirror pairs (Mirror Energy Differences or MED) has been pursued to test the charge symmetry of nuclear force. A complementary way to test isospin symmetry is based on the investigation of the electromagnetic decay properties in mirror pairs [2].

Anomalous MED in sd shell nuclei, *viz.*, ^{35}Cl and ^{35}Ar has been observed [1]. But so far the electromagnetic decay properties deduced from the level lifetimes in this mirror pair have not been compared. We have already studied ^{35}Cl and have estimated lifetimes of quite a few levels [3]. But for ^{35}Ar, lifetime information for none of the levels is available, except for a theoretical estimation for the first $7/2^-$ state [4]. In the present work, more precise measurements of the lifetimes of excited higher spin levels of ^{35}Cl have been done. Mixing ratios of a few gamma transitions in ^{35}Ar have been determined. These data along with the assumption of isospin symmetry provide estimate of lifetimes of levels in ^{35}Ar necessary for planning future experiment.

The Experiment

High-spin states in ^{35}Cl and ^{35}Ar have been populated through ^{12}C+^{28}Si (110 MeV) reaction in the inverse kinematics. The target was ^{12}C (50 μg/cm^2) evaporated on $\simeq$ 18 mg/cm^2 Au backing. Gamma - gamma coincidence measurement has been done using the multi-detector array of thirteen Compton suppressed Clover detectors (INGA setup) at Inter University Accelerator Centre (IUAC), New Delhi. In the set up, the power supplies, INGA modules, 8 channel 13 bit CAMAC ADC-814 and the Multi CAMAC Crate data acquisition system CANDLE [5] were all developed at IUAC. The detectors were placed at 148^o (4), 123^o (2), 90^o (4), 57^o (2) and 32^o (1).

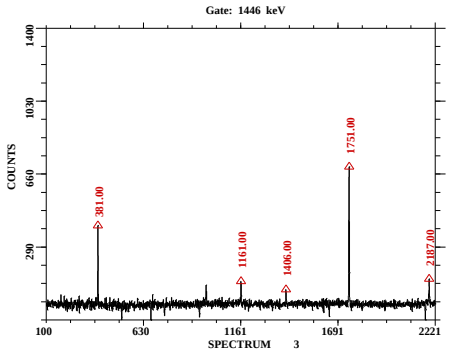

FIG. 1: A typical gated spectrum for the ^{35}Ar.

Results

The data analysis was done using the improved version of the analysis program INGASORT[6]. A typical gated spectrum (Fig. 1) generated by putting gate on the 1446 keV transition in ^{35}Ar shows the quality and quantity of data for this weakly populated channel.

Fig.2 shows lineshapes for a gamma ray

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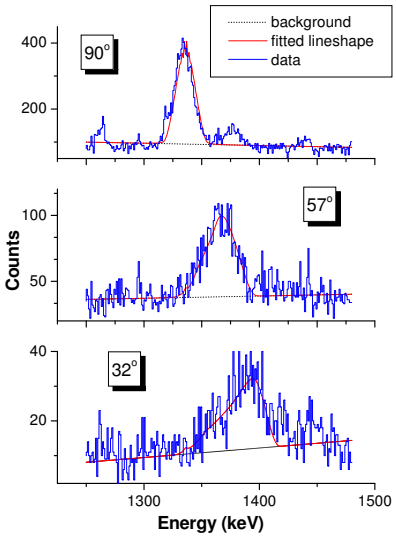

FIG. 2: Lineshapes (both experimental and fitted) are shown in the figure.

(1336 keV) emitted from 10181 keV level (tentative spin is $19/2^+$) in ^{35}Cl at 90^o and other forward angles. The spectra obtained at backward angles are not shown as they contained contaminant peaks. The preliminary estimation of the lifetime using the LINESHAPE [7] code is 0.18 ps. The cross section for ^{35}Ar was one order of magnitude lower than that for ^{35}Cl. The data for ^{35}Ar were inadequate to get proper lineshape spectrum. But the DCO data and the singles data for angular distribution have been used to determine the multipolarities and mixing ratios (δ) of different transitions, which were not known so for. Polarisation measurements have also been done for the first time for ^{35}Ar.

Discussions

Using the experimentally determined level lifetimes for ^{35}Cl (Ref. [3] and references therein, and the present work) along with the mixing ratios and the branching ratios of the de-exciting gamma transitions, corresponding B(ML)s and B(EL)'s have been extracted. Later utilising the relations [2] connecting the strengths of gamma transitions between corresponding states in mirror nuclei which follow charge symmetry, the values of reduced transition probabilities in ^{35}Ar have been calculated. The experimental mixing ratios and branching ratios were used to calculate the expected level lifetimes in ^{35}Ar. The value ($\simeq$10 ps for the first $7/2^-$ state in ^{35}Ar shows order of magnitude deviation from that estimated ($\simeq$ 350 ps) by Prosser and Harris [4].

The new estimates of the ^{35}Ar level lifetimes will serve as important ingredients for planning proper experiment to get reliable lifetime values. This in turn will throw light on the issue of isospin symmetry breaking in nuclear interactions.

Acknowledgments

The authors sincerely thank Mr. Pradipta Das for his technical help during preparation of the experiment. Thanks are due to the target laboratory of VECC, Kolkata for preparation of the target. We thank Anukul, Dinesh and Gayatri, Mr. R.P. Singh and Mr. E.T. Subramaniam for their help and cooperation during the experiment. Special thanks are due to the Pelletron staff for nearly uninterrupted beam.

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