Systematic Study of the temperature variation of isospin mixing in ^{32}S

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Introduction

The concept of charge symmetry and charge independence is formalized by the concept of isospin quantum number [1]. It is fully preserved by the nuclear interaction; however, the presence of different electromagnetic perturbations causes mixing of good isospin states. The main contribution comes from the isovector part of Coulomb interaction which mixes the states separated by $\Delta T = 1$. The knowledge of this mixing is important in connection with the width of the isobaric analog states [2,3] and the super-allowed 0^+ to 0^+ Fermi β-decays between T = 1 nuclear analog states [4]. It provides an important correction in the ft- values of the super-allowed β-decays thereby giving the most precise determination of weak vector coupling constant and hence the up-down element of the Cabibbo-Kobayashi-Maskawa (CKM) quark-mixing matrix element. Experimentally, isospin mixing can be determined by observing any transition that would have been forbidden if isospin were fully conserved. Interestingly, the high energy γ-decay from Isovector Giant Dipole Resonance (IVGDR) built on the excited states of atomic nuclei is an important tool to study the isospin mixing in self-conjugate (T_z = 0) nuclei populated through T = 0 entrance channel [5]. In such nuclei, the transition between the same T states is forbidden owing to the isovector nature of the photons associated with the decay of IVGDR. The above mentioned selection rule, together with the fact that at moderate excitation energies of the self-conjugate nuclei the density of the T =1 states are much less than that of T = 0 states results in the suppression of high energy γ-yield when the isospin is fully conserved. However, in presence of mixing high energy γ-ray yield increases. There are few measurements of isospin mixing utilizing the γ-decay of IVGDR in self conjugate nuclei [6-9]. However, exclusive systematic measurements for a given system in lower temperatures still remain an open subject.

At Variable Energy Cyclotron Centre (VECC), Kolkata, we have performed an experiment to study systematically the temperature dependence of isospin mixing in ^{32}S for which only one data point exists at E* = 58 MeV [7]. In this paper we report the preliminary results of this experiment.

Experimental Details

The experiments were performed for two systems ^{32}S and ^{31}P populated at same excitation energies but with different entrance channel isospins. ^{31}P was populated to determine the statistical model parameters required for the analysis of ^{32}S. The compound nucleus ^{32}S was formed in T = 0 entrance channel isospin by bombarding ^{28}Si (4.0 mg/cm^2) with 31, 40, and

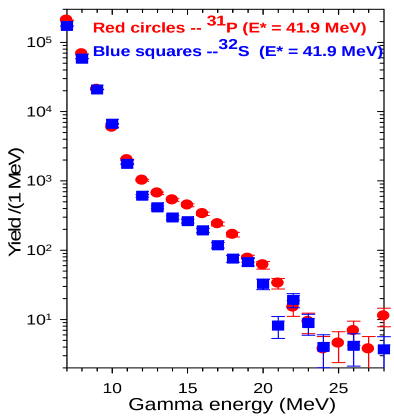

Fig. 1: Experimental high energy gamma spectra for ^{31}P and ^{32}S. The spectra are normalized at 9.0 MeV.

50 MeV ^{4}He beam from the K-130 cyclotron. The initial excitation energies of ^{32}S were 34.1, 41.9, and 50.7 MeV. ^{31}P was populated in T = ½ entrance channel at the same excitation energies by bombarding ^{27}Al (6.8 mg/cm^2) with 28, 37, and 47 MeV ^{4}He beam respectively. The high energy γ-rays were detected with the LAMBDA spectrometer [10] (7X7 array of BaF_2 scintillator each having dimension 3.5 X 3.5 X 35 cm^3) placed at 90° with respect to the

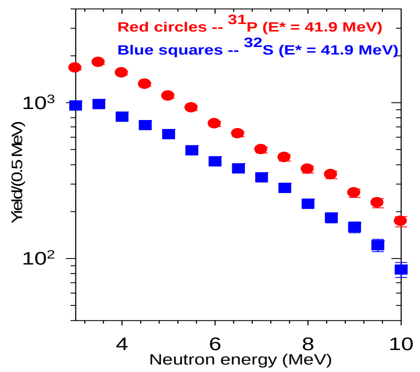

Fig. 2: Experimental neutron energy spectra for ^{31}P and ^{32}S.

beam axis and at a distance of 50 cm from the centre of the target. A 50-element multiplicity filter [11] (divided into two parts of 25 each and placed on top and bottom of the target chamber) was used to measure folds of the low energy multiplicity γ-rays (in coincidence with the high energy γ-rays) as well as to take start trigger for time of flight (TOF) measurements. The evaporated neutron spectrum was measured by BC501A based liquid scintillator to evaluate the inverse level density parameter (k) and hence to determine precisely the nuclear temperature. A clover HPGe detector was also used to identify the evaporation residues thereby ensuring that the beam was not hitting the target frame.

Data Analysis

The high energy γ spectrum was reconstructed using the nearest neighbor cluster summing technique. The neutron contamination and pile-up events were rejected using TOF and pulse shape discrimination (PSD) techniques, respectively. The cosmic events were rejected from the hit pattern of the cosmic events in the LAMBDA spectrometer. The fold distribution measured using the multiplicity filter was converted to the angular momentum distribution using a realistic technique [11]. This angular momentum distribution is very important for the estimation of average angular momentum of the compound nuclei as well as for input population

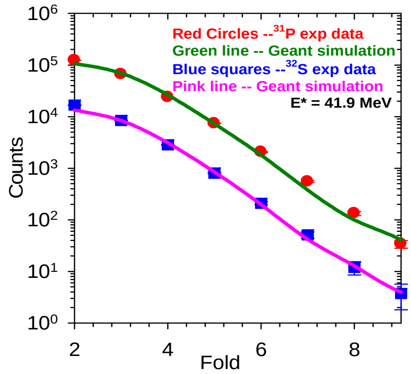

Fig 3: Experimental and simulated fold distribution for ^{31}P and ^{32}S.

in the CASCADE calculations. The neutron TOF spectrum measured with BC501A was converted to neutron energy spectrum using prompt gamma peak as the time reference. The measured high energy gamma spectrum, neutron energy spectrum, and fold distribultion for ^{31}P and ^{32}S at E* = 41.9 MeV are shown in fig 1, fig 2 and fig 3 respectively. The detailed CASCADE calculations are in progress.

Acknowledgement

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