Spectroscopic study of ^{32}S

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Introduction

Nuclei in the arena of mass~40 generally exhibit single particle types of excitations and Shell Model calculation successfully explained the single particle nature of these nuclei [1]. In recent years, several nuclei exhibited deformed, even super deformed states at higher excitation energy [2]. The microscopic origin of these states was also explained well in shell model calculation [2]. We have already reported the presence of collective excitation in even-odd ^{33}S [3]. The neighboring isotope ^{32}S (N=Z=16) is also an interesting candidate for such study. Several theoretical studies have already predicted the coexistence of cluster configuration [4], superdeformed bands [5], vibrational states [6],etc in ^{32}S. However, all these are not well studied experimentally.

^{32}S was investigated extensively using light ions. But no such heavy-ion data for this nucleus is reported in the literature [1]. In the present work, ^{32}S populated through heavy-ion induced reaction, has been studied. The analysis was initiated based on the level scheme reported in ref. [6]. We have studied the level scheme up to 9.46 MeV. Spin and parity of the levels have been confirmed from R_{DCO}, R_{ADO} and polarization asymmetry measurements. Large basis shell model (LBSM) calculation has been carried out to understand the microscopic origin of these levels.

Experimental Details

Excited states of ^{32}S have been populated through ^{28}Si(^{12}C,2α)^{32}S inverse kinematics reaction with 110 MeV ^{28}Si beam at Inter University Accelerator Centre (IUAC), New Delhi. The ^{12}C target of thickness 50 μg/cm^2 was evaporated on 18 mg/cm^2 Au backing. A multi-detector array (INGA Array) of thirteen Compton suppressed Clover detectors were used to detect the gamma rays. These detectorswere mounted at five different angles i.e. 148°(4), 123°(2), 90°(4), 57°(2) and 32°(1) with respect to the beam line.The data have been analyzed using the analyzing program INGASORT [7].

Result and Discussion

The experimental data have been sorted into angle independent and -dependent (90° vs 90°) symmetric γ–γ matrices to build up the level scheme.

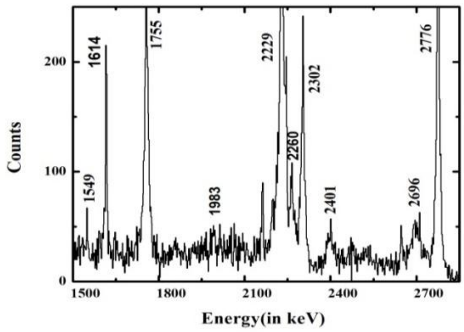

Fig 1: Background subtracted coincidence spectra obtained by putting a gate on 2232 keV transition.

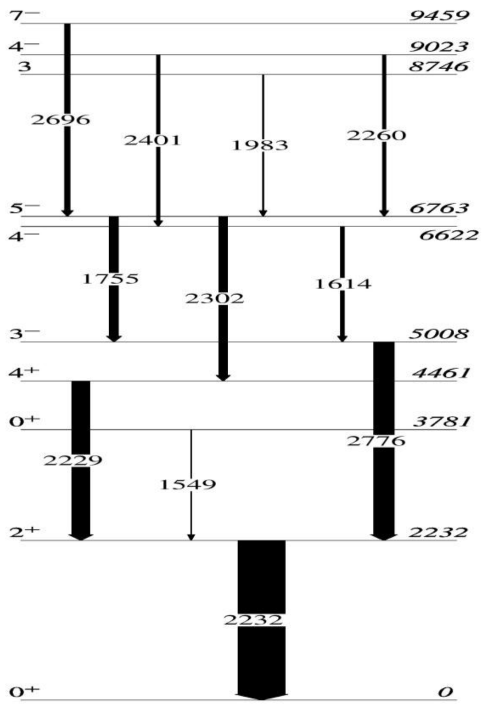

Fig 2: Partial level scheme of ^{32}S. Width of the lines indicates their relative intensity.

The PACE4 [8] predicted cross section of ^{32}S for this reaction is only 13.1% of the total cross section. In the present data, we have identified only 10 gammas in the 2232 keV gated spectrum (Fig-1).

These gammas were already observed in light ions experiments [1]. We have confirmed their placement in the existing level scheme based on their coincidence relations and relative intensities (Fig-2). We have confirmed the spin and parity of the levels up to 6.7 MeV from R_{DCO}, R_{ADO} and polarization measurements. For the levels above 6.7 MeV, we could not perform R_{DCO} and polarization measurements due to the low statistics of the decay out 1983, 2260, 2401 and 2696 keV transitions. We have only measured the R_{ADO} of these transitions. Mixing ratios for a few transitions have also been extracted by using computer code ANGCOR and compared with values enlisted in ref [1].

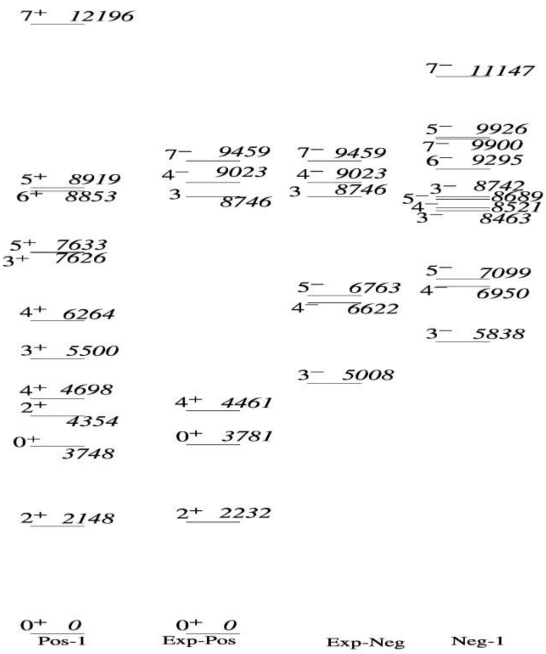

Fig 3: Comparison between theoretical and experimental levels in ^{32}S.

To understand the microscopic origin of ^{32}S, LBSM calculations have been performed in *sd-fp* model space using the OXBASH [9] code. The valance space consists of $1d_{5/2}$, $1d_{3/2}$, $2s_{1/2}$, $1f_{7/2}$, $1f_{5/2}$, $2p_{3/2}$, and $2p_{1/2}$ for both protons and neutrons above ^{16}O inert core. 0p-0h (Pos-1) and 1p-1h (Neg-1) calculations have been carried out using *SDPFMW* interaction [10] to reproduce the positive and negative parity states, respectively. The low lying positive parity states (up to 4_1^+) reproduced well in this calculation. However, the low lying negative parity states are over predicted by 300-800 keV (Fig-3). A detailed investigation on their calculated wave functions will be presented to show the microscopic structure of the levels.

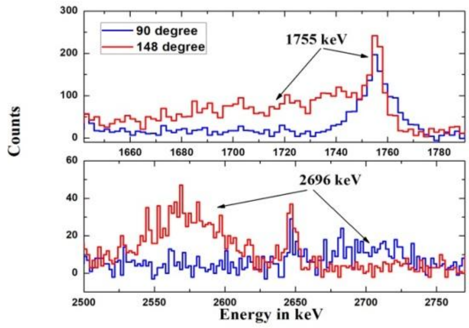

Fig 4: The shifted and un-shifted positions (marked by arrows) of (a) 1755 and (b) 2696 keV transitions of ^{32}S.

The energy spectra for most of the γ transitions in ^{32}S have large Doppler-shifted component along with a stopped component (Fig-4). Most of the lifetimes of these levels were measured in late 90s using light ion experiments. These lifetimes are being re-measured from our heavy ion data using DSAM technique.

Conclusion

The high spin structure of ^{32}S, populated through heavy ion reaction, has been studied up to 9.5 MeV. The spin and parity of the levels up to 6.7 MeV have been confirmed from DCO and polarization measurements. LBSM calculations have been performed to understand the microscopic structure of these levels.

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