High spin states in ^{33}S

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Introduction

Nuclei in the neighbourhood of doubly closed ^{40}Ca usually exhibit characteristics of single particle excitations. The ground state and low lying excited states of several nuclei in this mass region have been reproduced by using untruncated shell model calculation over the *sd* space [1]. However, for negative parity and high spin positive parity states, contribution from neighboring *fp* shell is important. The nuclei in the *sd–fp* interface are of considerable interest as they provide experimental information relevant to understanding of effective *NN* interaction in this region.

^{33}S nucleus has been extensively studied by using proton, light ions and alpha [2] beams. However, only in a few experiments, heavy ions were used [2]. In the present work, ^{33}S has been populated through heavy-ion fusion evaporation reaction and the level scheme has been extended. Lifetimes of a few levels have been measured using DSAM technique. Cross shell large basis shell model calculation with *sd-fp* effective interaction has been done to interpret the experimental results.

Experimental details

High spin states in ^{33}S have been populated by bombarding 40 MeV ^{12}C beam on ^{27}Al target at the 14-UD pelletron accelerator at Tata Institute of Fundamental Research (TIFR), Mumbai. The target consisted of 0.50 mg/cm^2 ^{27}Al with 10 mg/cm^2 gold backing to stop the recoils. Gamma - gamma coincidence measurement has been done using the multi detector array of fifteen Compton suppressed Clover detectors (INGA setup) [3]. The detectors are placed at 157^o (3), 140^o (2), 115^o (2), 90^o (4), 65^o (2) and 40^o (2).

Results and Discussion

The level scheme of ^{33}S (Fig. 1) has been extended up to 8 MeV by placing 4 new gamma transitions and 3 new excited levels in the existing level scheme [4]. Apart from these, 11 gamma transitions and 6 excited levels which

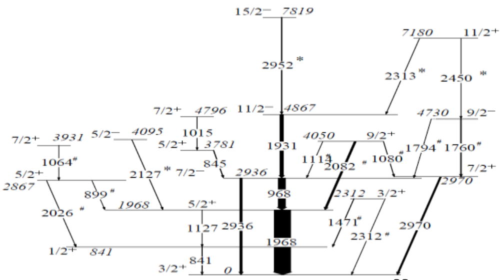

Fig.1 Preliminary level scheme of ^{33}S. Newly assigned gamma transitions and those observed also in light ion induced reactions are indicated by * and #, respectively.

were already reported in light ion experiments were also observed. The spin parities of all levels in the new level scheme have been assigned or confirmed from our DCO and polarization measurements. Present data also exhibit several Doppler shifted gamma peaks of various energies (Fig.2), indicating population of excited states with short half lives. The modified version of computer code LINESHAPE [5] which include corrections for the broad initial recoil momentum distribution produced by α particle evaporation, has been used to extract the level lifetimes (Table 1). The initial recoil momenta distributions of ^{33}S have been obtained from statistical model code PACE4 [6].

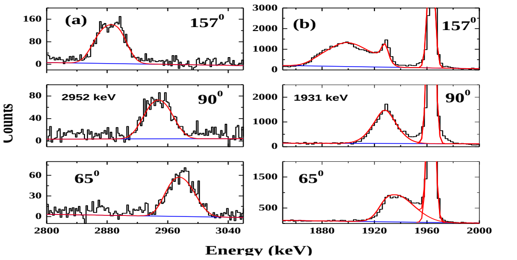

Fig.2 Experimental and simulated lineshape spectra for (a) 2952 and (b) 1931 keV transitions at different angles as mentioned in the figure.

These spectra containing the Doppler shifted gamma peaks have been generated by putting gates below the transitions (GBT). Side feeding corrections have been considered very carefully for each transition.

Table 1: Level lifetime of few levels measured in the present experiment.

E_x(keV)	E_γ (keV)	τ_m(fs)	
		Earlier [2]	Present
7819	2952	-	< 52
7180	2313	-	< 75
4867	1931	-	312±54
4730	1760	82±22	153±26
4050	2082	305±77	< 377

Large basis shell model calculations for ^{33}S have been done using the code OXBASH [7]. The *sdpf* model space and the *sdpfmw* [8] interaction were used for the calculations. The number of valence particles (protons + neutrons) in ^{33}S is 17. To start with, we have considered two truncation schemes to reproduce the experimental level scheme. In Theo-Pos and Theo-Neg, $\hbar\omega$ = 0 and 1 excitations have been considered for the calculations of positive and negative parity states, respectively. In Theo-Pos, the mass normalization factor for *sd* shell interaction has been taken as A=33. In Theo-Neg, A=32 is taken as the mass for normalization of the *sd* shell interaction. The single particle energies (SPE) of *fp* orbitals remain unchanged for these calculations. Results from these calculations (Fig. 3) indicate that all the positive parity states are well reproduced. The calculated ground state binding energy of ^{33}S is -191.139 MeV which matches accurately with the experimental binding energy -191.260 MeV (corrected for coulomb energy) [9]. The energies of the negative parity $5/2^-_1$ and $9/2^-_1$ states are reproduced quite accurately. However, for all other negative parity states, the calculated energies are under-estimated by ~0.5 MeV. So other truncations schemes have been adopted to find the exact configuration of these states.

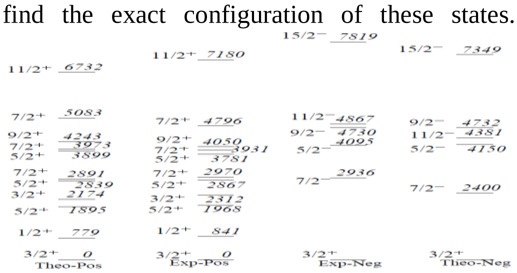

Fig-3: Comparison between experimental and theoretical level schemes. See text for details.

The theoretical transition probabilities have been compared with experimental values to understand the composition of the observed states to a better extent.

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