High Spin Spectroscopy of ^{34}Cl

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Introduction

The low lying positive parity energy levels of nuclei below the doubly closed ^{40}Ca have been fairly successfully explained using untruncated *sd* shell model calculations [1]. However, for negative parity and higher spin positive parity states, intruder configurations from the neighbouring fp shell become relevant. Even after the availability of improved computational facilities, untruncated calculation involving full $sd-fp$ shells is not feasable. The nuclei in the $sd-fp$ interface are of considerable recent interest to study the effects of several options of truncation in this model space.

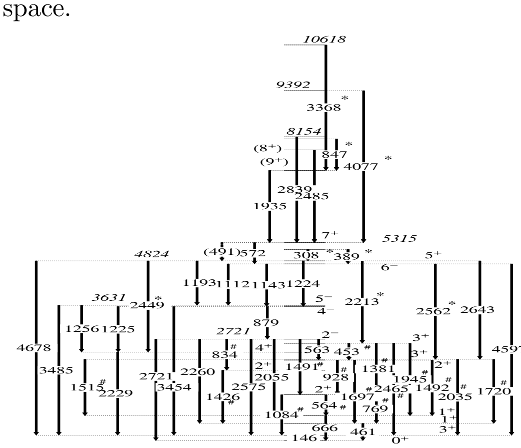

FIG. 1: Preliminary level scheme of ^{34}Cl. Newly assigned gamma transitions and those observed also in light ion induced reactions are indicated by * and #, respectively.

^{34}Cl, an odd-odd nucleus in the *sd* shell (Z=N=17) has properties similar to ^{26}Al [2], but on a much shorter time scale. Spectroscopic information for ^{34}Cl is of interest for understanding the large ^{33}S abundance observed in nova [2]. This nucleus has been extensively studied [3] using proton, light ions and alpha beams but there are few experiments where heavy ions were used. In the present work, heavy ion beams are used to extract spectroscopic data for high spin states above $\simeq$ 5 MeV, important for astrophysical scenario. Spherical shell model calculations have been done to interpret the experimental data. Several options of truncation adopted have provided useful insight into the $sd-fp$ cross-shell calculations.

Experimental details

High spin states in ^{34}Cl have been populated by bombarding 40 MeV ^{12}C beam on ^{27}Al target at 14-UD Pelletron accelerator at Tata Institute of Fundamental Research (TIFR), Mumbai. The target consisted of 0.50 mg/cm^2 ^{27}Al with $\simeq$ 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)[4]. 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 ^{34}Cl (Fig. 1) has been extended by placing 9 new gamma transitions and 5 new excited levels in the existing level scheme [3]. Apart from that 16 gamma transitions and 4 excited levels which were al-

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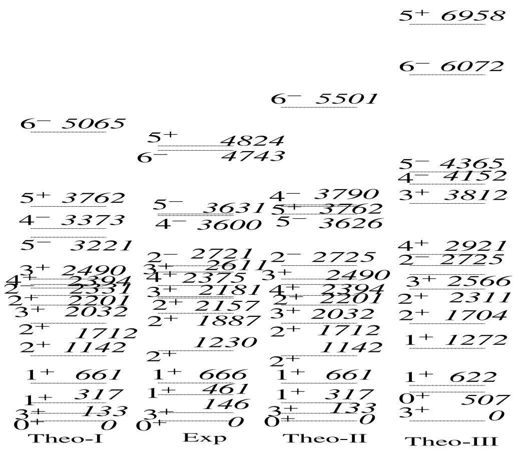

FIG. 2: Comparison between experimental and theoretical level schemes. See text for details.

ready detected in light ion experiments, were also observed. The data from linear polarization measurement and angular correlation measurements are being analyzed to assign the spins and parities of the new excited levels. Present data also exhibit several Doppler shifted gamma peaks of various energies from 1850 to 4100 keV, indicating population of excited states with very short half lives.

Large basis shell model calculations for ^{34}Cl have been performed using the code OXBASH [5]. The valence space consists of ($1d_{5/2}$, $1d_{3/2}$, $2s_{1/2}$, $1f_{7/2}$, $1f_{5/2}$, $2p_{3/2}$ and $2p_{1/2}$)-orbitals for both protons and neutrons above the ^{16}O inert core using the *sdpfmw* [6] interaction. The number of valence particles (protons + neutrons) in ^{34}Cl is 18. As unrestricted calculation is not possible due to computational limitations, different truncation schemes have been adopted to get the best fit to the experimental data. Fig. 2 shows the comparison of the theoretical results with experimental data. In Theo-I and II, $\hbar\omega = 0$ and 1 excitations have been considered for calculations of positive parity and negative parity states, respectively. In Theo. I, for negative parity states the mass normalisation factor for *sd* shell interaction has been taken as A=33. In Theo-II, $\hbar\omega = 1$ calculations, A=34 is taken as the mass for normalisation of the *sd* shell interaction. In the third truncation method (Theo-III), 12 nucleons have been kept inert in the $1d_{5/2}$ orbital, the remaining 6 nucleons have been allowed to move within ($1d_{3/2}$, $2s_{1/2}$, $1f_{7/2}$, and $2p_{3/2}$) orbitals. In both Theo II and III, the energies of $1f_{7/2}$ and $2p_{3/2}$ have been depressed to reproduce the energy of the first 2^- excited state.

Results from these calculations (Fig.2) indicate that although the low lying positive parity (Theo-I and II) and negative parity (Theo-II) states are (up to 3631 keV) well reproduced, there are large deviations for high spin positive and negative parity states. In Theo-III, the sequences of excited states are exactly same as the experimental spectra, except the ground state and this is mainly due to the inertness of the $1d_{5/2}$ orbital. 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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