High spin states in ^{205}At

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Introduction

The nuclei near the doubly magic ^{208}Pb ($Z > 82$, $N \leq 126$ mass region) are predicted to exhibit various interesting structural phenomena, from core excited single particle states to the existence of shears band in these extreme proton rich heavy nuclei along with abundance of isomeric levels, super deformation, shape coexistence etc. A systematic study of these nuclei will possibly reveal many other interesting structural features. Structure of such nuclei can be interpreted in terms of the single particle configurations arising from the $(1h_{9/2}, 2f_{7/2}, 1i_{13/2})$ protons and $(3p_{1/2}, 2f_{5/2}, 3p_{3/2}, 1i_{13/2})$ neutrons. But little experimental data is available on the structure of these nuclei, especially doubly-odd isotopes. The main challenge for producing such nuclei is due to low production ($\sim$ 10 mb or less) of evaporation residue (ER) in presence of very high fission background. The resulting background of γ-rays emitted from the fission products makes γ-ray spectroscopy of ER products much more difficult, particularly for short-lived high-spin states. However, use of asymmetric beam-projectile combination, X-ray gating and clean up by tight gating on the time window, have been found to be effective in getting around this problem in our earlier work on ^{208,210}Fr [1, 2] using INGA facility.

Neutron deficient isotopes of Astatine nuclei ($Z = 85$, $N = 119 - 121$) have been found to be relatively less explored, as far as the nuclear structure of the high spin states are concerned and in most cases, there are ambiguities on level energies, spins and parities. Recent studies on these isotopes have been rather incomplete in establishing their level scheme extending to high spin states [3]. An isolated $\Delta I = 1$ band was observed, but the linking transition(s) and the yrast sequence of transitions were not observed. Several isomeric states including $\sim$ μ s were identified in ^{205}At[4]. Attempts for a complete study of the high spin states and isomer decays in ^{205}At will be undertaken in this work.

Experiment

The experiment was done at the recent campaign of the Indian National Gamma Array (INGA), stationed at the Pelletron Linac facility in Tata Institute of Fundamental Research (TIFR), Mumbai. The excited proton rich Astatine nuclei were produced by bombarding a 5.0 mg.cm^{-2} self-supporting Gold (99.95 % purity) target with ^{12}C beam at 65 MeV and 75 MeV beam energies. Mainly $^{204-206}$At have been produced as evaporation residues. Estimation of cross sections, angular distributions of the evaporation residues (ER) and the fission yield were done using the code PACE. Two fold Clover coincidence events with time stamps were collected in a fast digital data acquisition system based on Pixie-16 modules of XIA LLC [5]. All other relevant details are given elsewhere [6]. The data were analysed using RADWARE and INGASORT software.

Results and discussion

According to shell model with ^{208}Pb as a doubly magic nucleus, ^{205}At involves three proton and six neutron-hole configuration. The ground state of ^{205}At has spin-

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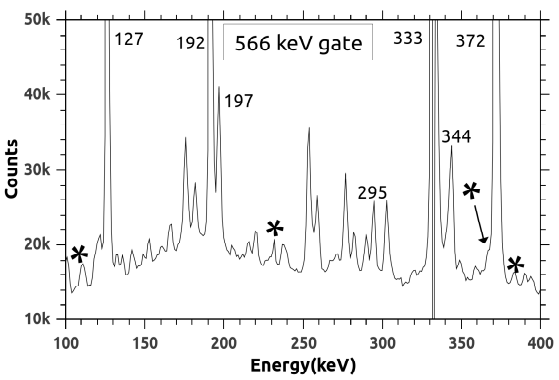

FIG. 1: Zoomed plots of the spectra with 100-400 keV range is shown to bring out the weak transitions noted in the experiment. A few strong transitions linked to the μs feeding isomer reported earlier [4], are marked. New γ-transitions observed in this experiment are indicated by '$*$'.

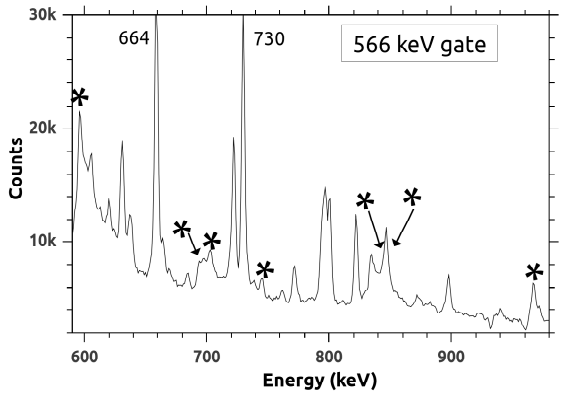

FIG. 2: Zoomed plots of the above spectra within 590-990 keV range. Some of the strong transitions are indexed and the new γ-rays are indicated by '$*$'.

parity of $9/2^-$, and the low lying states were interpreted as weak coupling involving $(1h_{9/2}, 2f_{7/2}, 1i_{13/2})$ orbitals coupled to appropriate Pb core. Previously, the high-spin states in ^{205}At were investigated up to $J \geq 37/2$ and an excitation energy of $>$ 4.0 MeV [4]. All the gamma-rays resulting from transitions between the high spin states reported there, along with those above the 11 μs isomer, are strongly populated in the present work. Gates on the 566 and 468 keV gamma rays feeding the ground state, reveal a significant number of transitions ($>$ 10) which are new, for example 110-, 232-, 367-, 595-, 745-, 967-keV etc. Two representative spectra (566-keV gated) are shown in Fig.1 and Fig.2. Some of the transitions observed possibly for the first time, are indicated in the figures by asterisk ($*$). Reverse gating on these transitions produces spectra of Astatine X-rays and all the known ^{205}At yrast gamma rays. Placement of these transitions into the level scheme is currently going on after investigating various cross-correlation of the transitions. DCO ratio measurements of the transitions are in progress to establish the nature of the spin-difference / multipolarity of the transitions. Matrices generated by gating on the suitable time window will reveal the possible presence of new isomers (ns to ms) along with the linking pathway. More details of the analysis of coincidence data and their interpretation is in progress.

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