High spin states in ^{204}At

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Introduction

Exploring high spin states of the trans-lead nuclei have attracted much attention in recent years. Very little information is known about the excited states of neutron deficient nuclei in this mass region. High spins states of $^{208-210}$Fr nuclei were investigated in recent times using the INGA facility[1, 2]. Several isomeric states were found, and their spin differences were obtained from the DCO ratio measurement across the isomeric levels. The level schemes, built up for the odd-odd Francium isotopes (^{208,210}Fr) indicate that their nuclear structures can be qualitatively explained from the shell model, though it is difficult to do these calculations at present.

Many isotopes of proton rich Astatine nuclei have not been explored in detail. Recent sudies 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. Somewhat detailed investigation on the high spin states of ^{205}At have been done by the ANU group[4]. Several isomeric states have been identified. Partial level scheme based on systematics of the neighbouring nuclei was established in ^{206}At[5]. A major difficulty in exploring the high spin states of these nuclei is the large fission cross section in this mass region as compared to the evaporation-residue (ER) cross section. The resulting background of γ-rays emitted from the fission products makes γ-ray spectroscopy of ER products very difficult, particularly for short-lived high-spin states. However, use of X-ray gating and clean up by tight gating on the time window have been found to be effective in getting around this problem[1]. Attempts for a complete study of the high spin states and isomer decays in ^{204}At will be undertaken in this work.

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Experiment

The experiment was done at the recent campaign of the Indian National Gamma Array(INGA), stationed at the Pelletron Linac facility in Mumbai. The excited proton rich Astatine nuclei were produced in ^{12}C + ^{197}Au fusion reaction at 65 MeV and 75 MeV ^{12}C beam energies. The de-exciting gamma rays were detected using the Compton suppressed Clover detector array with 15 detectors placed at different angles to enable DCO ratio measurements[6]. Coincidence data with time stamps were collected using a fast DSP data acquisition system based on Pixie-16 modules[7]. Data sorting into coincidence matrices, cubes, angle dependent DCO and crystal orientation dependent polarization matrices were done using the MARCOS sorting program, followed by projected spectral analysis using RADWARE. A few relevant gated spectra are shown in the Figs. 1 and 2.

Results and discussion

The ground state of ^{204}At has spin-parity of 7^+, and is known to be of $\pi(1h_{9/2}) \otimes \nu(2f_{5/2})$ configuration with ^{202}Po as core. 10^- isomeric state, resulting from the $\pi(1h_{9/2}) \otimes \nu(1i_{13/2})$

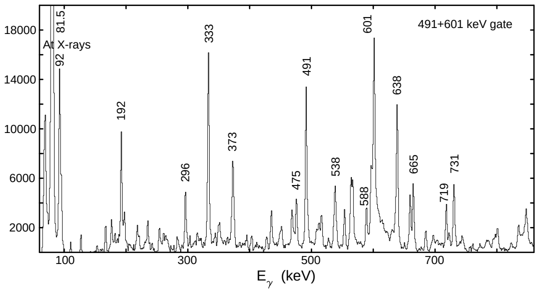

FIG. 1: Gamma ray spectrum gated by the known low lying transitions in ^{204}At.

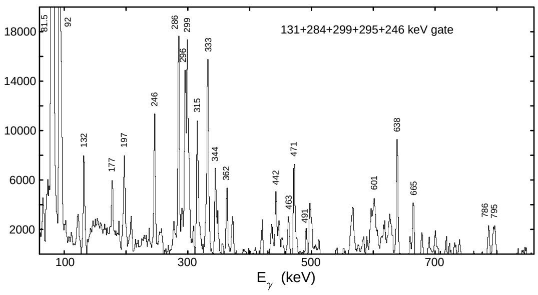

FIG. 2: Gamma ray spectrum gated by the known $\Delta I = 1$ band transitions in ^{204}At.

configuration, with $\sim$ 100 ms life time, was also identified earlier. The main sequence of transitions including 601, 491, 717 and 537 keV gamma rays and the $\Delta I = 1$ sequence of transitions involving 131, 296, 299 and 246 keV gamma rays were identified by the previous workers[3]. Gates on the 601 and 491 keV gamma rays (Fig. 1), and also on the Astatine X-rays reveal a significant number of transitions ($>$ 10) which are new. Further investigations into the cross-correlation of the transitions may reveal the main yrast sequence. A few transitions linking the $\Delta I = 1$ sequence could also be seen in the above spectrum. Cross-correlation studies are presently undertaken. Matrices generated by gating on the time window indicate the possible presence of isomers along the linking pathway to the $\Delta I = 1$ band.

Gamma ray spectrum obtained by gating on the known transitions of the $\Delta I = 1$ band, shown in the Fig. 2, reveal more than 4 new transitions which may belong to the same sequence. DCO ratio measurements of the transitions are in progress to establish the nature of the spin-difference / multipolarity of the transitions. Very preliminary indication of cross-over $E2$ transitions were also found for a few levels belonging to the $\Delta I = 1$ band sequence. Life time measurement of the transitions by DSAM will also be done to confirm its nature. By gating on the 589 keV side-feeding transition and the 491 keV gamma ray, a significant number of new transitions were found. A few more transitions possibly belonging to band-like sequence were observed. Further analysis of the coincidence data are in progress.

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