

Spin and Parity assignment in ^{206}At based on Polarization Asymmetry and DCO Measurements

P. S. Rawat^{1,*}, S. Kumar¹, Ksh. Rojeeta Devi¹, Neelam¹, Neeraj Kumar¹, Naveen Kumar¹, A. Banerjee¹, C. V. Ahmad¹, S. K. Mandal¹, Unnati^{1,2}, A. Sharma³, S. K. Dhiman³, Pragati⁴, A. Y. Deo⁴, Praveen C. Srivastava⁴, C. Majumder^{5,6}, H. P. Sharma⁶, S. Bhattacharya^{2,7}, T. Trivedi^{7,8}, R. Garg⁹, S. S. Bhattacharjee⁹, Indu Bala⁹, R. Kumar⁹, R. P. Singh⁹, and S. Muralithar⁹

¹Department of Physics and Astrophysics,

University of Delhi, New Delhi-110007, INDIA

²Amity Institute of Nuclear Science and Technology,

Amity University, Noida, Uttar Pradesh-201313, INDIA

³Department of Physics, Himachal Pradesh University, Shimla-171005, INDIA

⁴Department of Physics, Indian Institute of Technology, Roorkee, Roorkee-247667, INDIA

⁵Department of Physics, Indian Institute of Technology Bombay, Mumbai-400076, INDIA

⁶Department of Physics, Banaras Hindu University, Varanasi-221005, INDIA

⁷Department of Pure and Applied Physics,

Guru Ghasidas Vishwavidyalaya, Bilaspur-495009, INDIA

⁸Department of Physics, University of Allahabad, Allahabad-21102, INDIA and

⁹Inter University Accelerator Centre, Aruna Asaf Ali Marg, New Delhi - 110067, INDIA

Introduction

The odd-odd isotopes of *At* have few valence proton particles, and neutron holes outside the doubly magic ^{208}Pb core exhibit a quite similarity in their level structure. Most of these nuclei have negative parity level sequence build over a 10^- isomeric state [1]. Using $^{197}\text{Au}(^{12}\text{C}, 3n)$ reaction, X.C. Feng *et al.* [2] proposed a similar level structure in ^{206}At . Seven HPGe detectors and one intrinsic-Ge planar detector were used to detect the de-exciting γ -rays. The spin and parity of the levels were proposed based on systematics among odd-odd isotopes of *At*. The half-life of 10^- isomer was measured to be 410(80) ns [2]. In the year 2009, G. D. Dracoulis *et al.* [3] re-measured the half-life of 10^- isomer and reported a value 813(21) ns. Later, another measurement on half-life has reported a value of 377(44) ns [4] which was found to be consistent with the first measurement [2].

In this work, we measured the energy, intensity, R_{dco} and polarization asymmetry for the

γ -rays reported in ref. [2], in order to determine multipole nature of γ -rays and spin-parity of the levels.

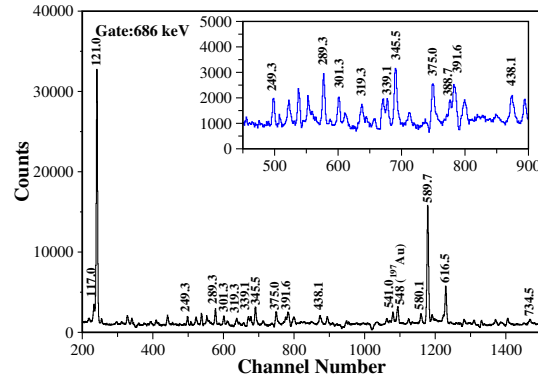


FIG. 1: The coincidence spectrum of 685.9 keV showing the γ -rays observed in present work. In inset figure, the region of 200 to 500 keV is shown to mark the presence of observed γ -rays.

Experimental Details

The experiment was performed at the Inter University Accelerator Centre (IUAC), New Delhi using a 66 MeV ^{12}C beam. The ^{121}Sb

*Electronic address: prernasinghrawat4@gmail.com

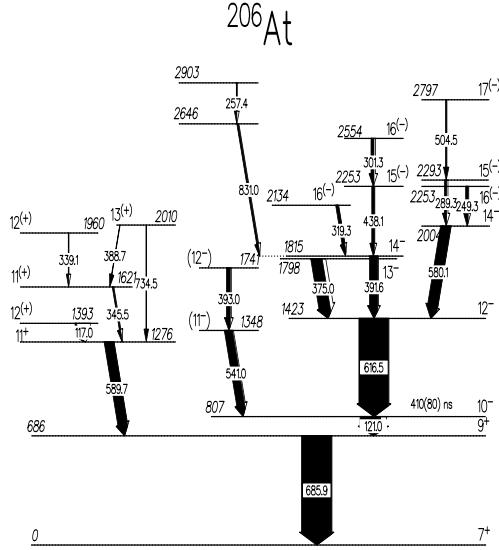


FIG. 2: Partial level scheme of ^{206}At (The half-life for 10^- isomer is taken from ref. [2].)

target having $\sim 1.2 \text{ mg/cm}^2$ with a backing of 10 mg/cm^2 ^{197}Au was used. ^{206}At was populated in the $^{197}\text{Au}(^{12}\text{C}, 3n)$ reaction. The de-exciting γ -rays were detected using the Indian National Gamma Array (INGA) having 18 Compton suppressed clover and two LEPS detectors. The coincidence symmetric and asymmetric matrices were generated using the CANDLER software, and the data analysis was carried out using RADWARE [5] software.

Results & Discussion

The de-exciting γ -rays of ^{206}At in the gated spectrum of 685.9 keV are shown in Fig. 1. In Fig. 2, the partial level scheme for ^{206}At is shown which was reported by X.C. Feng *et al.* [2] and observed in the present work also. The intensity of γ -rays for band at left (above 9^+ state) is obtained from the spectrum gated at 685.9 keV and that of above 10^- isomer is obtained from the gate at 616.5 keV. The intensity below the 10^- isomeric state is normalised w.r.t. 685.9 keV whereas above the isomer it is done w.r.t 616.5 keV.

The spin-parities of the levels are assigned based on polarization asymmetry (Δ) and

R_{dco} values. The R_{dco} values of 1.10(5) and 0.99(5) for 589.7 keV and 685.9 keV γ -rays suggest stretched quadrupole γ -ray transition. The 11^+ and 9^+ for 1276 keV and 686 keV levels are supported by Δ of 0.12(3) and 0.16(3) for 589.7 keV and 685.9 keV γ -rays with E2 character. For isomeric state at 807 keV, 10^- spin is taken based on systematics of odd-odd isotopes of At [3]. For 616.5 keV transition, $R_{dco} = 1.64(9)$ in 375.0 keV-gate confirms E2 multipolarity with 0.098(51) value for Δ . The energy level at 1423 keV is populated by three γ -rays- 375.0-, 391.6-, and 580.1 keV with $\Delta = -0.034(43)$, 0.031(56) and 0.017(60) along with $R_{dco} = 0.60(7)$, 1.08(6) and 0.86(5) respectively. The M1, E2 and E2 nature is confirmed for these γ -rays. The R_{dco} values for 438.1 and 301.3 keV transitions are consistent with the dipole character. The parities for energy levels above 2.1 MeV are tentatively assigned. Analysis is in progress and final results will be presented during the symposium.

Acknowledgments

One of the authors (P. S. Rawat) acknowledges the financial assistance from UGG-DAE-KC with project CRS/19/NP07/0918/0960. The research grant (IOE/FRP/PCMS/2020/27 or IOE/FRP/PCMS/2022/199) under Faculty Research Programme (FRP) of Institute of Eminence (IOP), University of Delhi is acknowledged. The funding for Project No. CRG/2021/002653 from SERB, DST (Govt. of India) is also acknowledged.

References

- [1] M. R. Schmorak, Nuclear Data Sheets **31**, 283 (1980).
- [2] X. C. Feng *et al.*, Eur. Phys. J. A **6**, 235 (1999).
- [3] G. D. Dracoulis *et al.*, Eur. Phys. J. A **40**, 127 (2009).
- [4] D. Kanjilal *et al.*, Nucl. Phys. A **842**, 1 (2010).
- [5] D. C. Radford, Nucl. Instrum. Methods Phys. Res. A **361**, 297 (1995).