High spin isomer in ^{202}Tl

S.G. Wahid[1],* S.K. Tandel[1],† A. Patel[1], S. Suman[1], P. Roy[1], M. Hemalatha[1], A.Y. Deo[2], Pragati[2], S. Rai[3], A. Sharma[4], S.S. Bhattacharjee[5], R.P. Singh[5], and S. Muralithar[5]
[1] *UM-DAE Centre for Excellence in Basic Sciences, Mumbai 400098, INDIA*
[2] *Department of Physics, Indian Institute of Technology Roorkee, Roorkee 247667, INDIA*
[3] *Department of Physics, Visva-Bharati, Santiniketan 731235, INDIA*
[4] *Himachal Pradesh University, Summer Hill Shimla, Shimla 171005, INDIA and*
[5] *Inter University Accelerator Center, Aruna Asaf Ali Marg, New Delhi 110067, INDIA*

Introduction

Nuclei in the vicinity of magic numbers are close to spherical and excited states therein provide valuable insight into the ordering and relative spacing of single-particle energy levels. In the vicinity of the doubly-magic ^{208}Pb, the high-j valence orbitals near the Fermi surface are the neutron $i_{13/2}$ and proton $h_{11/2}$, respectively. The presence of high-j orbitals in the vicinity of the Fermi level in these near-spherical nuclei make it possible to realize high-spin isomers with dominant contributions to their wave functions from intrinsic degrees of freedom. Data on high-spin isomers in the vicinity of the heaviest doubly-magic nucleus ^{208}Pb, which are built on configurations involving several valence neutrons and protons, provide essential information regarding single-particle and pairing energies. These constitute critical inputs for a detailed understanding of nuclear structure and also provide an opportunity to test modern day, large-scale shell model calculations and the various interactions used.

High-spin isomers in Hg and Tl isotopes have been studied in the past [1–4], but several nuclei are yet unexplored and a detailed understanding is lacking. One of the difficulties of studying levels at high spin in this region stems from the fact that these nuclei can be reached through reaction mechanisms like multi-nucleon transfer or projectile fragmentation which typically produce a large number of isotopes. Some of the nuclei are accessible through fusion-evaporation reactions using relatively light ions. This experiment was focussed on the study of high-spin levels, specifically multi-quasiparticle states in ^{202}Tl.

Experiment and Analysis

The experiment was performed at the Inter University Accelerator Center (IUAC), New Delhi. A ^{7}Li beam with energy $31 - 36$ MeV from the Pelletron accelerator facility at IUAC was incident on a ≈ 10 mg/cm^2 enriched ^{198}Pt target. Data on γ rays emitted from the decay of excited states in ^{202}Tl, populated through the ^{198}Pt(^{7}Li,3n)^{202}Tl fusion-evaporation reaction, were recorded using the Indian National Gamma Array (INGA) detector array consisting of 14 Compton suppressed clover Ge detectors and 1 planar Ge detector. Two- and higher-fold gamma-ray coincidence data were recorded using CANDLE [5] and sorting of raw data was done utilizing a code developed at IIT Roorkee. The data were further analyzed using the Radware [6] suite of programs for establishing the level scheme of ^{202}Tl. The standard DCO method is used for spin assignments. Electric or magnetic nature of the transitions was determined using the IPDCO technique.

Results and discussion

Previous information on excited states in ^{202}Tl was limited up to $I^{\pi} = 9^{+}$ ($E_x = 2340$ keV) [7] obtained from the ^{204}Pb(d,α) reaction. Other low-lying states were known from the ^{203}Tl(n,2nγ) neutron-induced reaction [8]

*Electronic address: sgwahid@cbs.ac.in
†Electronic address: sujit.tandel@cbs.ac.in

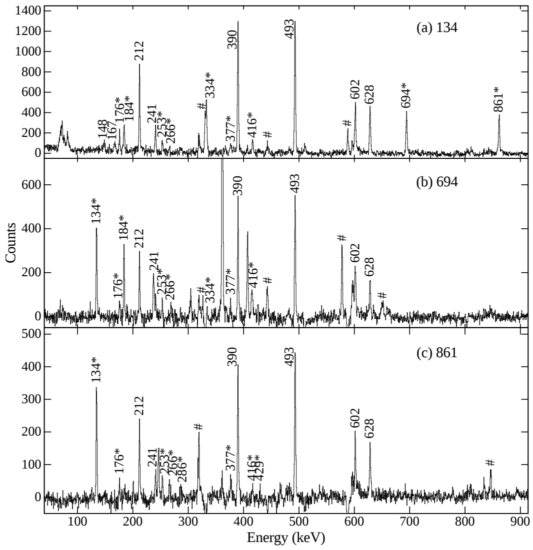

FIG. 1: (a), (b), (c): Coincidence γ-ray spectra (with gates on three newly established γ rays), displaying transitions in ^{202}Tl. New transitions are marked with an asterisk while strong contaminants are labeled with a hash sign.

.

In the present study, excited levels in ^{202}Tl are established up to $E_x \approx 4$ MeV and $I \approx 18$ $\hbar$, with the identification of ten new transitions which are placed above the previously known $E_x = 2045$ keV state. The spin and parity of the newly deduced levels, along with the previously known ones deexcited by the 493 keV and 628 keV transitions, are obtained. Figure 1 displays single-gated spectra with gates on newly-identified transitions which clearly show known γ rays in ^{202}Tl in addition to others which are identified in the present work.

The deduced level scheme for ^{202}Tl suggests that the known and newly identified levels have predominantly intrinsic character. It is of interest to note that the levels identified appear to be fed by a long-lived, high-spin isomer. Preliminary calculations of expected multi-quasiparticle states in this nucleus have been performed which along with other considerations aid in the configuration assignment of the isomer. Detailed experimental results along with their interpretation will be presented at the symposium.

Acknowledgments

SGW acknowledges support from the DST-INSPIRE Ph.D. Fellowship program (IF150098). SKT would like to thank the Board of Research in Nuclear Sciences, Department of Atomic Energy and the University Grants Commission for financial support. The authors would like to thank the accelerator staff at IUAC and the INGA collaboration.

References

[1] E. Wilson *et al.*, Phys. Lett. B 747 (2015) 88.
[2] J. Wrzesinski *et al.*, Phys. Rev. C 92, 044327 (2015).
[3] Zs. Podolyak *et al.*, J. Phys. Conf. Series 580 (2015) 012010 .
[4] M. Pfutzner *et al.*, Phys. Lett. B 444 (1998) 32.
[5] Ajith Kumar B.P. *et al.*, DAE Proceedings 44B, 390 (2001).
[6] D.C. Radford, Nucl. Instrum. Methods Phys. Res., Sect. A 361, 297 (1995).
[7] N. Frascaria *et al.*, Phys. Rev. C 16, 603 (1977).
[8] N. Fotiades *et al.*, Phys. Rev. C 76, 014302 (2007).