Single-particle states and isomers in ^{202}Tl and ^{203}Pb

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Introduction

Nuclei in the vicinity of magic numbers are near-spherical and excited states therein provide information about the ordering and relative spacing of single-particle levels. Due to the presence of high-j neutron $i_{13/2}$ and proton $h_{11/2}$ orbitals, it is possible to realize high-spin isomers with predominantly intrinsic character. 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 provide valuable inputs for a detailed understanding of nuclear structure and also provide an opportunity to test modern-day shell model calculations.

Several high-spin isomers have been studied in various Hg, Tl and Pb isotopes [1, 2] however many nuclei are yet unexplored and a systematic understanding is lacking. The main difficulty in studying high-spin levels 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. Fusion-evaporation reactions using relatively light ions can be used to study only some of these nuclei.

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Experiment and Analysis

Three data sets have been used in the present analysis, one from the INGA array comprising 14 Compton-suppressed clover Ge detectors and one planar Ge detector at the Inter-University Accelerator Centre, New Delhi, and two from the Gammasphere array at the Argonne National Laboratory. The INGA experiment was carried out using a ^{7}Li beam of 31-36 MeV energy incident on a 10 mg/cm^2 enriched ^{198}Pt target. In the Gammasphere experiments, excited states at high spin were populated through multi-nucleon transfer reactions using heavy-ion ^{207}Pb and ^{209}Bi beams with energies 1430 and 1450 MeV, respectively, incident on a 50 mg/cm^2 ^{197}Au target. More details about the data analysis may be found in our earlier publications [3, 4]. In addition to the DCO and IPDCO analysis from the INGA experiment, intensity balance considerations are also used to determine the spin and parity of the levels, especially for the ones decaying by relatively lower-energy transitions.

Results and Discussion

Previously, experimental information on ^{202}Tl was limited up to $I^\pi = 9^+$ ($E_x = 2340$ keV) using the ^{204}Pb(d,α) reaction. Several other low-lying levels were known from the ^{203}Tl(n,2nγ) neutron-induced reaction [5].

In the present study, excited levels in ^{202}Tl are established upto ≈4 MeV and I ≈20 $\hbar$, with the identification of fifteen 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

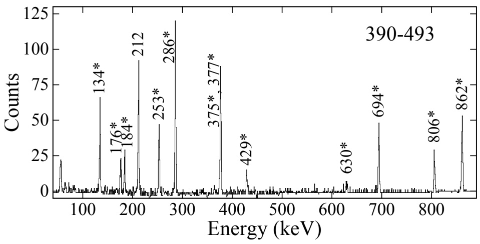

FIG. 1: 390-493 keV double-gated (delayed) coincidence spectrum (Gammasphere data).

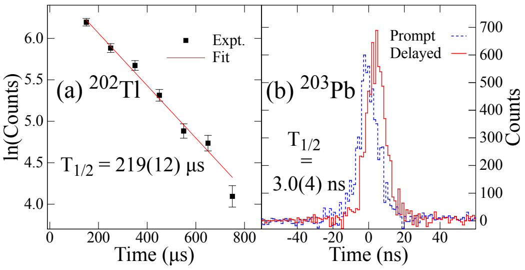

FIG. 2: (a) Decay curve of the $T_{1/2} = 219(12)\mu s$ isomer/s in ^{202}Tl. (b) $T_{1/2} = 3.0(4)ns$ for the isomer in ^{203}Pb determined using the centroid shift method.

the previously known ones deexcited by the 493 keV and 628 keV transitions, are obtained. Figure 1 displays double-gated (Gammasphere data) spectra, clearly showing known γ rays in ^{202}Tl in addition to others which are identified in the present work.

Long-lived feeding with a half-life $T_{1/2} = 219(12)\mu s$ is noted in ^{202}Tl in the Gammasphere data with a pulsed beam and 800 μs beam-off periods. Most of the new transitions can be clearly seen in delayed data (Figure 1) suggesting a significant feeding from the isomer. The observed half-life is possibly attributable to an effective value arising from isomers with $I^\pi = 18^+$ and $I^\pi = 20^+$ in ^{202}Tl. Several new transitions, along with an isomer ($T_{1/2} = 3.0(4)$ns), have also been identified in ^{203}Pb (Figure 2).

The level scheme for ^{202}Tl deduced from the current work suggests that the known and newly identified levels have predominantly intrinsic character. The levels identified below $I^\pi = 20^+$ are fed by the long-lived, high-spin isomer/s. Empirical calculations, using quasiparticle energies and residual interactions obtained from neighbouring nuclei, show good agreement with the data. Shell model calculations using the OXBASH code have also been performed to understand various aspects of the data. Detailed experimental results along with their interpretation will be presented at the symposium.

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References

[1] E. Wilson *et al.*, Phys. Lett. B 747 (2015) 88.
[2] J. Wrzesinski *et al.*, Phys. Rev. C 92, 044327 (2015).
[3] S. K. Tandel *et. al.*, Phys. Lett. B 750 (2015) 225.
[4] S. G. Wahid *et. al.*, Phys. Rev. C 92, 054323 (2015).
[5] N. Fotiades *et al.*, Phys. Rev. C 76, 014302 (2007).