Investigation of neutron and proton couplings in ^{202}Po

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Introduction

The nuclei around $A = 190 - 200$ are known to exhibit a wide variety of collective and single-particle features making them spectacular examples of shape coexistence. For nuclei close to the doubly-magic spherical shell closure at Z = 82, N = 126 (^{208}Pb), the near-ground-states excitation spectra are made up of single-particle excitations, whereas higher excitation energies and spins manifest a variety of collective rotational behaviour including superdeformation [1].

For the even-even $^{200-208}$Po isotopes with 2 protons above the $Z = 82$ shell closure, a typical feature is the competition between the two quasi-proton and two quasi-neutron configuration [2]. Since seniority behaves as a nearly good quantum number in Pb isotopes, it is expected to dominate the spectroscopic features in Po as well [3]. Only two measurements are known for ^{198,200}Po (N=114, 116) with seniority=2 isomers forming the yrast 12^+ states. Hence, the investigation of ^{202}Po (N=118) would be interesting to confirm seniority=2 isomer in this nucleus and to explore high-seniority isomers which are not yet known in this mass region. Several other isomeric states are known in this nucleus which are worth exploring to understand the role of neutron and proton couplings giving rise to these isomeric states.

In 1990s, regular structures with oblate deformed states connected by M1 transitions were first observed in ^{198,199,200}Pb [4, 5]. Such bands were then observed in the isotopes of Pb, Hg and Bi nuclei (A = 192 to 201) and were called as shears bands generated by high-K neutron-proton coupling and alignment. The mechanism was well explained with the tilted axis cranking (TAC) and semi-classical models [6]. No such bands are yet reported in neighboring Po isotopes. Analogous to ^{200}Pb, an interesting candidate to investigate the existence of such sequences is ^{202}Po and understand the role of the two protons above the shell closure.

Experimental Details

The excited states in ^{202}Po were populated using the ^{195}Pt($^{12}C, 5n$) reaction at a beam energy of 83 MeV produced by the 15-UD BARC-TIFR Pelletron LINAC facility in Mumbai. The ^{12}C beam was bombarded on a 3.2 mg/cm^2 thick ^{195}Pt target foil with a ^{197}Ag catcher foil to stop the recoil ions produced. The de-exciting γ-rays were detected using a hybrid array of 16 Compton-suppressed HPGe clover detectors arranged in spherical geometry with six rings, viz. $-23°$, $\pm 40°$, $\pm 65°$, and $90°$ with respect to the beam direction, coupled with 14 $LaBr_3$(Ce) scintillators. The crystal of $LaBr_3$(Ce) detectors were in cylindrical shape of $\oslash 2'' \times 2''$. The time-stamped data were collected with two- and higher-fold coincidence condition using an XIA-based digital data-acquisition system (DDAQ) [7, 8]. Two crate synchronization method was used, with one crate for digitizer modules with 100-MHz sampling frequency (for HPGe clovers)

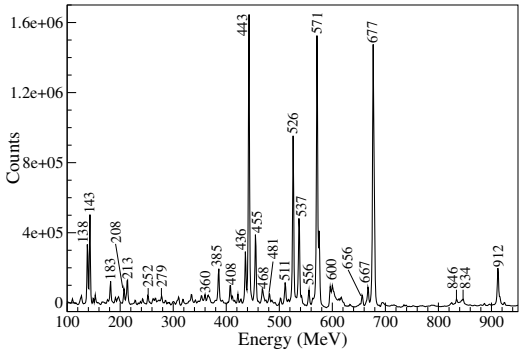

FIG. 1: Sum-gated spectrum with gates on 443-, 572- and 677 keV transitions, showing the $\gamma-$ray transitions belonging to ^{202}Po.

and other for one for modules with 250 MHz sampling frequency (for $LaBr_3$(Ce) detectors).

Data Analysis and Results

After the energy calibration of all the HPGe detectors, the time-stamped coincidence data were sorted by Multi-pARameter time-stamped based COincidence Search (MARCOS) code, developed at TIFR, Mumbai [7]. The $\gamma-\gamma$ matrices and $\gamma-\gamma-\gamma$ cubes were formed with 100-, 300- and 500 ns time windows and analyzed by RADWARE software packages [9]. The full width at half maximum (FWHM) of $\gamma-$rays at 1.33 MeV for the HPGe clover and $LaBr_3$(Ce) detectors were found to be $\approx$ 2.4 and 30 keV, respectively. Multipolarity of the γ transitions were confirmed were determined using Directional Correlation of $\gamma-$ray de-exciting Oriented states (DCO ratio method) [10] and integrated polarization directional correlation from the oriented nuclei (IPDCO) method [11].

Previously known level scheme [2] has been confirmed and about 30 new transitions have been identified. A sum gated coincidence spectrum is displayed in Fig. 1 showing the known and several of the new transitions. A regular sequence of dipole transitions has been identified similar to band 2 in ^{201}Bi (suggesting a similar neutron-proton configuration), having dynamic moment of inertia between 10-30 $\hbar^2 MeV^{-1}$ as found in the shears bands in the neighboring Pb and Bi isotopes. Such bands observed in Pb and Bi isotopes were interpreted in terms of a high-K two-quasiproton $(h_{9/2} \otimes i_{13/2})$, $(h_{9/2})^2$, $(i_{13/2})^2$ configuration, coupled to an aligned pair of $i_{13/2}$ quasineutrons in the even-A nuclei, and either one or three $i_{13/2}$ quasineutrons in the odd-A nuclei. A similar configuration is suggested for the newly observed band in ^{202}Po isotope which further needs to be confirmed. Analysis is in progress and the detailed results of the spectrocopic studies and lifetime measurements will be presented in the conference.

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