High spin isomer in ^{209}Rn

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Introduction

The nuclei in the vicinity of doubly magic shell closure of ^{208}Pb has been the topic of special interest in the recent years to understand the interplay between collective and single-particle excitations. The presence of large spin differences between the close lying neutron orbitals gives rise to the several isomeric states with lifetimes ranging from micro-second to nanosecond. Recently, the configurations of isomeric states have also been studied in terms of seniority quantum number [1] to understand the transition from single-particle seniority-type mode to collective mode and it has been observed that the collectivity develops differently for low and high-spin states [2]. The interplay between single particle and collective structures at higher excitation energies and the presence of high-spin ns isomers in ^{209}Rn has been investigated with the high resolution and high efficiency HpGe Clover detector array.

Experiment

The high spin states of ^{209}Rn were populated in the reaction ^{198}Pt(^{16}O,5n)^{209}Rn at 102 MeV beam energy from the Pelletron Accelerator, IUAC, New Delhi. The de-exciting γ rays were detected using the INGA setup, consisted of 18 Compton suppressed clover HPGe and 2 LEPS detectors. List-mode data was acquired using CANDLE and offline data analysis was carried out using LAMPS, INGASORT, RADWARE software packages.

Data Analysis and results

To study the coincidence relationship between the γ rays, the γ-γ symmetric matrix and γ-γ-γ cube were generated . From the present analysis, 14 new γ rays have been placed on the basis of coincidence relationship between the γ rays. The level scheme has been extended upto the high spin $J^{\pi} = 55/2^{+}$ and the excitation energy of 7.9 MeV

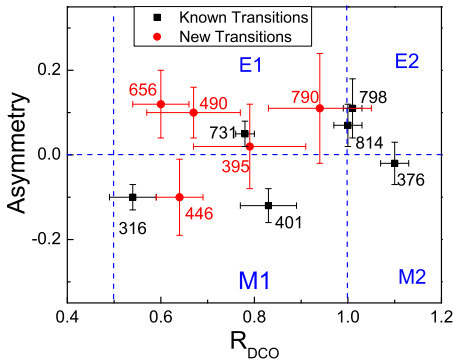

FIG. 1: Plot of R_{DCO} vs. polarization asymmetry. R_{DCO} determined at the gate of streched E2 transition.

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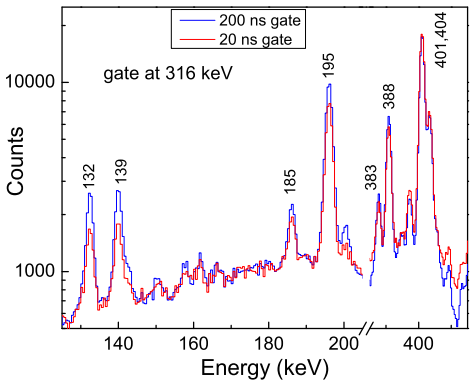

FIG. 2: Gate of 316 keV with coincidence time window of 20 ns and 200 ns.

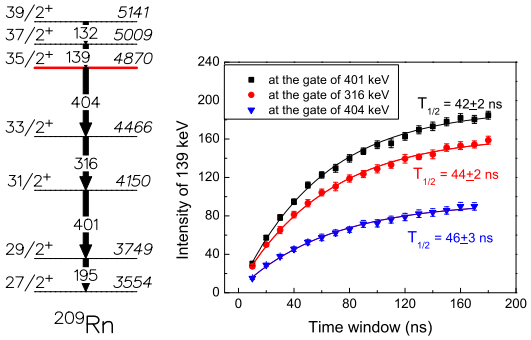

FIG. 3: Left: Cascade of transitions relevant to the present work. Right: Plot of intensity variation of 132 keV at the gates of 316 keV, 401 keV, 404 keV for different time windows.

compared to the earlier one [3]. To assign the spin-parity of the states, the directional correlation of oriented states (DCO) ratio [4] and polarization asymmetry [5] of the decaying γ rays have been determined from the two asymmetric γ-γ matrices. Fig. 1 shows the plot of R_{DCO} vs. polarization asymmetry for the new transitions along with few previously known transitions obtained from the present work.

In order to study the presence of isomers, several γ-γ symmetric matrices were generated by gating at the different coincident time windows of the total aligned TAC. The coincident time window was varied from 10 ns to 200 ns in the interval of 10 ns. The intensity of γ rays above the isomer observed at the gate of the transitions below the isomer, is related with the coincidence-time window by the following formula [6]:

$$N_t = N_0(1 - Ae^{-\frac{ln2}{T_{1/2}}\Delta t})$$

where, N_0 and N_t are the counts initially and at time t respectively, $T_{1/2}$ = half-life of the isomeric state, Δt is the coincidence time window, A is used as a free fitting parameter. Fig 2. shows the variation of intensity of γ rays at the gate of 316 keV transition for 20 ns and 200 ns coincidence time windows, normalized at the γ ray energy of 401 keV, which is in prompt coincidence with 316 keV. It is clearly observed from the fig. 2 that the intensity of 132 and 139 keV γ ray transition increases significantly from 20 ns to 200 ns coincident time window. This is an indication of the existence of an isomeric state. The relevant sequence of transitions of interest is shown in the left panel of the fig. 3. The lifetime of the state at the excitation energy of 4870 keV has been determined by measuring the intensity of 139 keV transition for different time windows at the gates of prompt coincidence transitions of 316 keV, 401 keV, 404 keV which are below the isomeric level and by fitting them with the above equation. This is shown in the right panel of the fig. 3. The half-life obtained for this state at the gates of these three transitions is found to be similar.

Acknowledgments

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