High spin structure in ^{208,209}Rn

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Introduction

The Rn (Z=86) isotopes with four protons and few neutron holes with respect to ^{208}Pb doubly magic (Z=82, N=126) core can yield valuable information about the interaction between neutron holes and proton particles. The unique parity orbital $i_{13/2}$ plays an important role for generation of the level structure of nuclei in this region. Lower spin states in these nuclei are dominated by the aligned configurations with the four valence protons occupying the $h_{9/2}$, $i_{13/2}$ and $f_{7/2}$ orbitals, while at higher spins neutron core excitations play a significant role. Low lying states in these nuclei are dominated by the single particle configurations involving four valence proton particles and few neutron holes in the available orbitals of $\pi f_{7/2}$, $\pi h_{9/2}$, $\pi i_{13/2}$ and $\nu p_{1/2}$, $\nu f_{5/2}$, $\nu p_{3/2,}\nu i_{13/2}$. The involvement of high-j orbitals generates a possibility of presence of high multipolarity transitions (M2 and E3) and thus to form high spin isomer and band structure built on it. Various other interesting phenomena have also been observed in this region, such as, shears bands in several Pb [1,2] and Bi isotopes [3] and also an indication of such band structure in ^{205}Rn [4].Similar band structure can also be expected in other Rn isotopes. Another characteristic feature of nuclei near ^{208}Pb is the occurrence of strong E3 transitions which arise as a result of particle-vibration coupling, which have been observed in several odd-A Rn isotopes. Thus, information concerning the high spin states in both odd-A and even-A Rn isotopes would be valuable to understand the collectivity and deformation due to particle alignments and their coupling to the core.

Single particle structures have been reported for ^{208,209}Rn [5,6] with the observation of transitions above the high spin isomers. A band like structure bypassing the isomer has also been reported in ^{209}Rn but the spin and parity of it and connecting transitions between the main structure and the side band are yet to be established. Neutron core excitation states at high spin are expected in these nuclei like nearby nuclei which are not well studied. The aim of the present work is to study the high spin structures above isomers of ^{208,209}Rn.

Experiment and Analysis:

The high spin states above the long lived isomers of ^{208,209}Rn are produced following fusion evaporation reaction ^{198}Pt (^{16}O,5n)^{209}Rn at 102 MeV beam energy using the 15UD Pelletron facility at IUAC Delhi. A self supported 9.3mg/cm^2 thick enriched ^{198}Pt foil was used as target. The γ-rays, coming from the excited levels were detected using INGA setup at IUAC, New Delhi, which consists of 18 Compton Suppressed Clover HPGe detectors and 2 LEPS detectors. The list mode data were collected with two-fold coincidence trigger condition and the corresponding time was also measured with TDC using CANDLE [7] data acquisition system. The data were sorted using LAMPS and Radware packages. Standard ^{152}Eu and ^{133}Ba source were used for calibration and efficiency. A γ–γ matrix has been formed with the addbacks of all Clover detectors for coincidence analysis.

Results:

Fig. 1 shows a representative coincidence spectrum corresponding to the gate on ground state transition of ^{208}Rn from the γ–γ coincidence matrix.

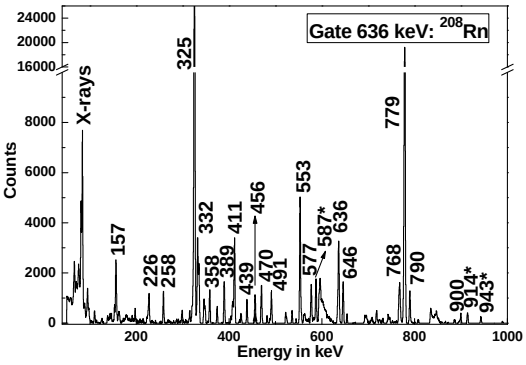

Fig.1 *Coincidence spectrum with the gate of 636 keV ground state transition of ^{208}Rn. New transition are marked with '*'.*

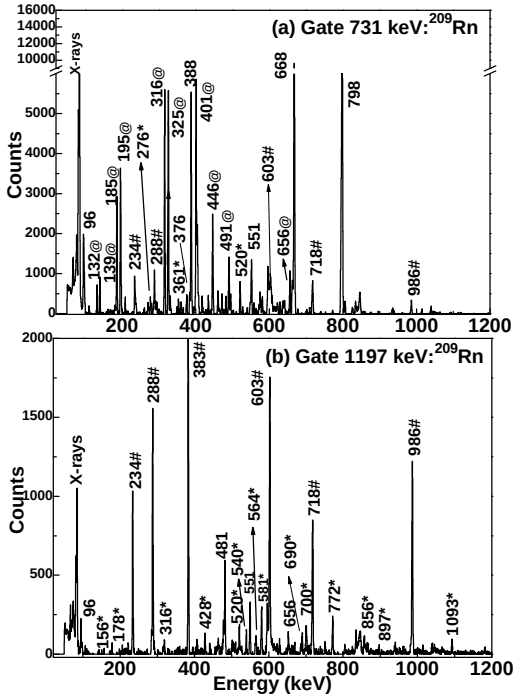

Fig.*2* *Coincidence spectra: corresponding to ^{209}Rn (a) gate of 731keV transition connecting the side band with main structure. (b) gate of 1197keV transition just above 4μs isomeric state. '*', '#', '@' marked transitions are new, placed above the 35/2$^+$ isomer and placed in side-band respectively.*

As the 636 and 637keV doublet is present below and above 735ns isomer in ^{208}Rn, almost all the γ-rays of ^{208}Rn can be identified from Fig.1. New transitions have also been observed in the present work (marked '*' in Fig. 1) and are expected to be decaying from states above the isomer. Fig.2 corresponds to the coincidence gates of ^{209}Rn. The gate of 731 kev shows all the transitions which are already assigned to the side band as well as few new transitions marked as '*'. The presence of the transitions placed above the isomer, such as, 234, 718 keV etc., (marked #) in coincidence with 731 keV gate (Fig.2(a)) indicates connections between the side band and the excited states above isomer. The 1197 keV gate does not show any transitions in coincidence from side band. The presence of 480 and 551 keV in coincidence with 1197 keV (Fig.2(b)) may be explained either as due to random coincidence of transitions below the 4 μs isomer or can have new placements above the isomer. In 1197keV gate presence of new transitions, such as, 428, 520, 540 keV etc., indicates the possible extension of the high spin level structure of ^{209}Rn.

Summary:

Preliminary coincidence analysis of ^{208,209}Rn indicates an extension of level structure beyond 21, 51/2 spin states respectively. New transitions have been identified in ^{208,209}Rn. The γ–γ coincidence analysis to place the new transitions observed in the present work in the level scheme is in progress. Analysis of DCO and IPDCO matrices to assign the Spin and Parity of the excited states in both ^{208,209}Rn are in progress.

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