High-spin level structure of ^{209}Rn

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The excited states of ^{209}Rn ($Z = 86$, $N = 123$) have been populated by the heavy-ion induced fusion evaporation reaction ^{198}Pt(^{16}O, $5n$)^{209}Rn at a beam energy of 102 MeV. The de-excited γ rays were detected with the Compton suppressed clover HPGe detectors of the Indian National Gamma Array (INGA) set-up. The high spin spectroscopic study of ^{209}Rn has been carried out up to an excitation energy of 7.9 MeV and spin $(55/2)\hbar$. Spin-parity assignments of the excited levels have been determined and are confirmed on the basis of the ratio of directional correlation and polarization asymmetry measurement. The possible presence of new isomeric states has been observed and the half-lives have been estimated. A negative parity sequence of $M1$ transitions has been observed which exhibits the property of magnetic rotation and is interpreted in the framework of semiclassical model calculation. The large basis shell-model calculation has been performed for all the nuclear levels and is found to be in well agreement with the experimental results.

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I. INTRODUCTION

The nuclei in the vicinity of the doubly magic shell closure of $^{208}_{82}$Pb have been the topic of significant physics interest in the recent years. These nuclei exhibit a variety of nuclear structural phenomena, such as, shears band, neutron core excitation across $N = 126$ shell closure, and presence of several short-lived and long-lived isomers. With few proton particles above $Z = 82$ and few neutron holes in the $N = 126$ shell closure, the nuclear structure in these nuclei are mainly dominated by the single particle excitations. As the number of the valence nucleons are increased, the single particle configurations evolve towards the mixture of multinucleon configurations. Hence, the nuclei in this region provide a fertile ground to test the validity of the large basis shell-model calculations. Moreover, several shell-model calculations have been performed in this near Pb region by considering ^{208}Pb as a stable core [1,2]. Further, the presence of the large spin differences between the close lying high-j neutron and proton orbitals give rise to several high-spin isomers in this region [3]. The $13/2^+$ isomeric state has been observed to be present systematically for all odd-A isotopes of the nuclei above $Z = 82$ [4]. The study of these isomeric states in this region provides further understanding in level structure of these nuclei.

The occupation of the high-j orbitals, e.g., $\pi h_{9/2}$, $\pi i_{13/2}$, $\nu i_{13/2}$, etc., by the valence proton particles and the neutron holes gives rise to the magnetic rotation (MR) band in this region. In this case, the higher spin states are mainly generated by the closing of the two blades of shears formed by the aligned proton and neutron angular momentum vectors. The rotational band resulting from this mechanism possesses increasing $B(M1)/B(E2)$ ratio, and decreasing $B(M1)$ value with increasing rotational frequency. While the presence of the MR band is a very common phenomenon around the neutron-deficient Pb region [5–7], the observation of the MR band [8–11] in the above Pb region ($Z = 82$) around $N = 126$ neutron shell closure is rare due to insufficient experimental data at the high spin. The presence of the MR band in this region has already been reported for ^{203,204}At ($Z = 85$) [12,13], ^{202}Bi ($Z = 83$) [14], ^{201,202}Pb ($Z = 82$) [15], and ^{206}Fr ($Z = 87$) [16]. For, Rn ($Z = 86$) isotopes, only the high spin spectroscopic study of ^{205}Rn indicates the presence of a MR band, based on the observation of a cascade of magnetic

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