High spin study of neutron-rich ^{198,200,202}Hg

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Introduction

Nuclei in the $A \approx 200$ region exhibit a variety of structure phenomena. Isotopes with sufficient valence nucleons show evidence of deformation and collective excitations, however closer to neutron and proton shell closures, intrinsic degrees of freedom have a substantial contribution to the excited level structure. The study of Hg isotopes (Z=80), close to doubly magic ^{208}Pb (Z=82), provides an opportunity to study this interplay between collective and intrinsic excitation mechanisms.

High-spin data in neutron-rich Hg nuclei are not as well established as in the proton-rich region. The neutron-rich region can be reached through projectile fragmentation and multi-nucleon transfer reactions. Isotopes like ^{196,198,200}Hg, have been studied using (α, xn) reactions [1–5]. Isotopes like ^{202,204}Hg have been studied using (n,γ) and (d,pn) reactions [6, 7]. To reach high spins, multi-nucleon transfer reactions are quite useful. In this work, transfer products ^{198,200,202}Hg are studied at high spin. With the proton and neutron orbitals almost filled, these Hg isotopes are characterized by moderate oblate deformation near their ground states.

Experiment and Analysis

In the present work, data from two experiments performed at the Argonne National Laboratory using the ATLAS superconducting linear accelerator and Gammasphere detector array, have been analyzed. Excited states in Hg isotopes were populated through multi-nucleon $(1p, xn)$ transfer reactions from ^{209}Bi to ^{197}Au, with a 1450-MeV ^{209}Bi beam incident on a thick (50 mg/cm^2) Au target. The ^{209}Bi beam, with the natural 82.5 ns pulsing from ATLAS, was incident on the ^{197}Au target. Further, using a 1430-MeV ^{207}Pb beam incident on a similar ^{197}Au target, multi-nucleon transfer followed by neutron evaporation also produced a number of Hg isotopes.

High-fold coincidence data with different timing conditions were analyzed for verifying the placement of known transitions, identifying new ones and their location in the level scheme, and exploring the data for the presence of high-spin isomers. Lifetimes of metastable states in the nanosecond region were determined using the centroid shift method. Spin assignments were done using the DCO technique.

Results and Discussion

Previous information on ^{198}Hg was limited to spin 18^+ and 13^- in the yrast positive and negative parity sequences, respectively [1, 2]. In the present work, the decay scheme for ^{198}Hg has been expanded with the inclusion of 11 new transitions at high spin upto $E_x \approx 6$ MeV. The new transitions include two high spin coupled rotational sequences. Based on the excitation energies, spin assignments and observed coincidence relationships between transitions in these two sequences, the new sequence is assigned a 4-quasiparticle configuration. Coincidence analysis also leads to the reassignment of a 1022-keV γ-ray. DCO analysis indicates quadrupole and dipole character for the 334-keV and the 1150-keV γ-rays, respectively. The lifetimes of the metastable 10^+, 12^+ and the 5^-,7^- states have been also measured and are in agreement with previously reported values.

In the previous work on ^{200}Hg, levels upto I=20$\hbar$ have been established through the ^{198}Pt(^{9}Be,α3n) reaction [3]. The metastable nature of the 12^+ state in ^{196,198}Hg and

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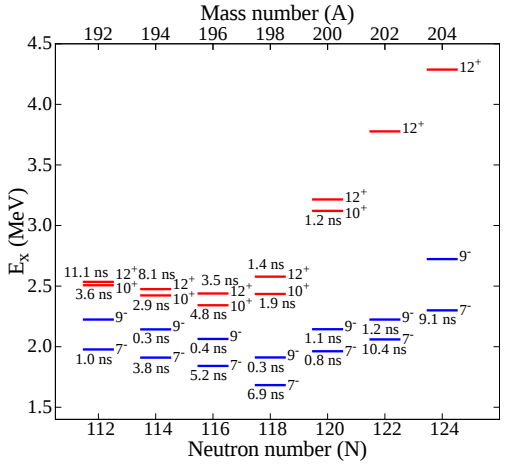

FIG. 1: Excitation energy vs neutron number for Hg isotopes (A=192 to 204) displaying the excitation energy of the 12^+, 10^+, 9^-, and 7^- states along with their respective halflives.

the proximity of the 10^+ and 12^+ levels in ^{196,198,200}Hg motivated inspection of the time difference between the transition feeding the 12^+ state (397 keV) and the one deexciting it (574 keV) in ^{200}Hg. A half-life of 1.2(5) ns was obtained for the 12^+ state in ^{200}Hg.

In previous studies, excited levels in ^{202}Hg had been established upto $E_x \approx 2$ MeV and $I \approx 6\hbar$ [7, 8]. In the present work, the decay scheme for ^{202}Hg has been expanded with the inclusion of 15 new transitions placed above the 5^- state. Two sequences of transitions are found to be feeding the tentatively assigned 11^- state. The analysis of delayed coincidence data indicates the presence of an isomer. The 7^- and 9^- states are observed to be metastable in nature in the neighbouring ^{196,198,200}Hg isotopes. Time difference analysis resulted in a halflife of 10.4(18) ns for the 7^- state and a halflife of 1.2(10) ns for the 9^- state.

Effective g-factor measurements for the 12^+ state in ^{198}Hg suggest a rotation-aligned $(\nu i_{\frac{13}{2}}^{-2})$ configuration [9]. A pronounced alignment in the yrast positive parity sequences in ^{196,198,200}Hg at $\hbar\omega \approx 0.2$ MeV in all three isotopes is attributed to the decoupling of an $i_{13/2}$ pair occupying low-Ω orbitals at oblate deformation. The close lying 5^-, 7^- and 9^- negative-parity states are built from a configuration of aligned $i_{13/2}$ and $p_{3/2}/f_{5/2}$ neutrons.

The trend in the excitation energy of the positive and negative parity sequences in Hg isotopes is illustrated in Fig. 1. With increase in neutron number towards N=126, reduction in collectivity is evident along with an abrupt increase in the excitation energy of the 12^+ state due to sub-shell gaps.

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