Shape evolution and isomerism in neutron-rich Pt nuclei

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The study of shapes and of the interplay between independent-particle and collective degrees of freedom play an important role in describing the structure of the nuclei. The nature of collectivity and the extent of deformation can be understood in terms of the occupation of specific quantum states by valence nucleons and the nature of the interactions between them. Prolate deformed rotors are common across the entire nuclear chart and a relatively small number of nuclei with oblate deformation near the ground state are known, usually just below shell closure. At large angular momenta, moment-of-inertia considerations do not favor oblate shapes compared to prolate ones. However, collective oblate states have been predicted and observed [4, 5] at high spin in the $A \approx 180 - 190$ region. In this region, rotation alignment plays an important role in driving the nuclei toward an oblate shape. This process involves pairs of nucleons decoupling under the stress of the Coriolis force and aligning their spin along the rotation axis. In this work, high spin states in neutron-rich Pt isotopes are systematically studied to understand the shape evolution with increasing neutron number. Limited information is available for neutron-rich Pt isotopes, populated through fragmentation of a ^{208}Pb projectile [6], compared to proton-rich Pt isotopes which are relatively easily accessible through fusion-evaporation reactions. Techniques like inelastic excitation or multi-nucleon transfer reactions are more suited to populate neutron-rich nuclei near the line of stability. These techniques give improved spectroscopic information at higher spins compared to fragmentation reactions.

The experiment was performed at Argonne National Laboratory, with a 1450-MeV ^{209}Bi beam from the ATLAS accelerator being incident on a 50 mg/cm^2 ^{197}Au target. Data on excited states in various neutron-rich Pt isotopes, populated through ($1p$,xn) transfer from ^{197}Au, were recorded using the Gammasphere detector array. Three- and four-fold gamma-ray coincidence data were analyzed using the Radware suite of programs for establishing the level schemes. The DCO method is used for spin assignments. Energy-gated time difference spectra are analyzed for isomers having $T_{1/2} \leq 10$ ns. The usual method, where time distribution of individual γ-ray transition is compared with prompt transitions of similar energy, is not feasible due to large contamination from many other reaction channels. For $T_{1/2} \geq 10$ ns, data from delayed cubes, with successively increasing cuts in time, were analyzed and fitted to exponential growth.

A new rotational sequence with apparent oblate character, built on a rotation-aligned isomer ($I^\pi = 12^+$) with $T_{1/2} = 7.7(7)$ ns, is identified for the first time in ^{196}Pt [1, 2]. Two new sequences up to high spins in ^{195}Pt are also established for the first time along with an isomer of $T_{1/2} = 5.2(6)$ ns in the negative-parity sequence [3].The yrast sequences in $^{192-198}$Pt are extended up to high spin ($\approx 26\hbar$ in even and $\approx 53/2\hbar$ in odd-A Pt isotopes), and several new transitions in the negative-parity sequences are also identified [1–3]. The nucleus ^{196}Pt is the most neutron-rich Pt isotope for which high-spin states have been es-

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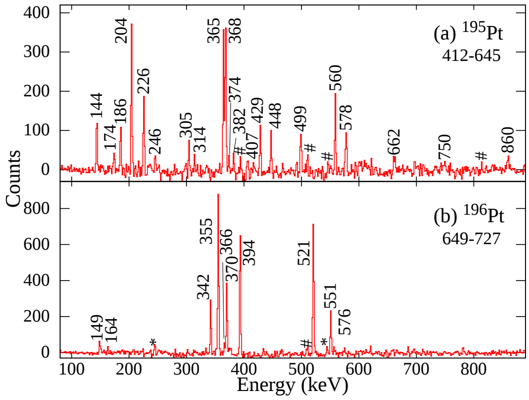

FIG. 1: (a), (b): Triple-coincidence γ-ray spectra (with gating energies indicated), displaying transitions in ^{195,196}Pt.

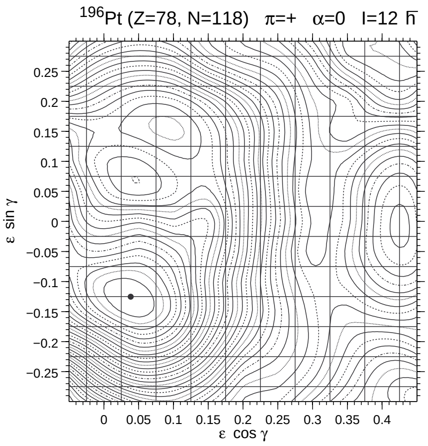

FIG. 2: Total energy surface plot illustrating energy minimum in the positive-parity, yrast structure in ^{196}Pt at $I^{\pi} = 12\hbar$, with the lowest energy minimum for oblate shape ($\gamma \approx -75^{\circ}$)

tablished.

Shape evolution from prolate through triaxial to oblate at high spins in neutron-rich Pt isotopes is studied through the observation of isomeric states and of rotation-induced nucleon alignments. A significant decrease in the $B(E2)$ values is evident while going from ^{194}Pt to ^{196}Pt, followed by an abrupt drop in ^{198}Pt [1], suggestive of a rapid quenching of oblate collectivity at high spin in the neutron-rich region compared to near the respective ground states, where the decrease in deformation is more gradual. Nucleon alignments play an important role in the structure at high spins. The contribution from rotation-aligned angular momentum to the total angular momentum at high spin increases moving towards neutron-rich Pt isotopes. These observations are confirmed by cranking calculations which are in good agreement with data. This work, which is focused on the competition between prolate and oblate potential wells, and the delineation of the upper bound of oblate collectivity, provides an important input for our understanding of the interplay between independent-particle and collective degrees of freedom in nuclei.

Acknowledgments

SKT would like to thank BRNS and UGC for financial support. SGW acknowledges support from DST-INSPIRE Ph.D. Fellowship program. This work is supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under award numbers DE-FG02-94ER40848 and DE-FG02-94ER40834, and contract number DE-AC02-06CH11357. The research described here utilized resources of the ATLAS facility at ANL, which is a DOE Office of Science user facility.

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