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Collective and intrinsic excitations in Hg and Tl isotopes explored through nanosecond to microsecond isomers

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Isotopes of Hg and Tl in the $A \approx 200$ region exhibit competition between collective and intrinsic modes of angular momentum generation. The neutron number $N = 120$ appears to constitute a boundary, with lighter isotopes exhibiting collective behavior, and heavier ones displaying primarily single-particle excitations. Most of these isotopes lie close to the line of stability and are difficult to access through fusion-evaporation reactions involving heavy-ion beams. Therefore, multi-nucleon transfer reactions using $\approx$ 1.4 GeV ^{207}Pb and ^{209}Bi beams, with above-barrier energies, incident on a ^{197}Au target, were used to populate highly-excited levels. The deexciting γ rays were recorded by the Gammasphere detector array. The beams were pulsed in different intervals ranging from < 1 μs to several seconds, to study isomers with a wide range of half-lives.

The evolution of collectivity in ^{198,200,202}Hg has been studied through a measurement of the half-lives of the 7^-, 9^- and 12^+ states, and inferring the associated $B(E2)$ values. The half-lives of the 7^- and 9^- states in ^{202}Hg are measured to be $T_{1/2}$ = 10.4(4) ns and $1.4(3)$ ns, respectively, while that of the 12^+ state in ^{200}Hg is $T_{1/2}$ = 1.0(3) ns. For even Hg isotopes, near the ground state, the extent of collective behavior is found to decrease from $N = 112$ to $N = 124$, while it increases for the 12^+ and 9^- states up to $N = 118$, and then reduces for higher neutron numbers [1]. Several new isomers were identified in the isotopes ^{200,202,203}Tl. These include a six-nucleon-hole isomer with $T_{1/2} = 57(2)$ ns in ^{200}Tl [2]. The level structure of ^{202}Tl has been studied up to the new I^π = 20^+ state, with $T_{1/2}$ = 215(10) μs, arising from a four-nucleon-hole excitation [3]. In ^{203}Tl, isomeric states with $I^\pi = 15/2^-, 35/2^-, 39/2^-$ and $49/2^+$ have been identified, with $T_{1/2} = 7.9(5)$ ns, $4.0(5)$ ns, $1.9(2)$ ns, and $3.4(4)$ ns, respectively [4]. For the previously identified long-lived decay, the spin is reassigned as $29/2^+$ from the earlier suggested value of $25/2^+$. These new isomers provide a host of nuclear structure insights, including the magnitude of residual interactions for different configurations. Shell-model calculations, using the OXBASH code and the KHH7B interaction, have been performed for these nuclei.

References

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