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Electromagnetic properties of atomic nuclei: the path to collectivity and the nature of pre-collective nuclei

Content

The emergence of nuclear collectivity will be discussed, beginning with the tellurium isotopes, which have 52 protons and show a transition from vibrator-like structures near midshell (^{118}Te) to seniority structures near $N = 82$ (^{134}Te). We report measurements of excited-state g factors and $E2$-transition strengths following Coulomb excitation, as well as lifetimes from Doppler-broadened line shapes, for the stable isotopes from ^{124}Te to ^{130}Te. These measurements, performed at Australia's Heavy Ion Accelerator Facility, allow us to map the pathway from the $\pi 0g_{7/2}^2$ seniority structure in ^{134}Te toward collective excitations near midshell as successive pairs of neutrons are removed.

The experimental results, which give a novel perspective on the nature of pre-collective nuclei, will be presented. It is found that collectivity does not emerge suddenly, with the nucleus becoming collective as a whole, as might be inferred by examining energy patterns such as $R_{4/2} = E_x(4_1^+)/E_x(2_1^+)$ ratios, alone. The $E2$ transition strengths and g factors show that collectivity develops in subsets of nuclear excitation: the 2_1^+ state becomes collective first while the 4_1^+ and 6_1^+ states retain a significant $\pi 0g_{7/2}^2$ component. The 4_1^+ state becomes collective next, while the seniority structure persists in the 6_1^+ states. For example, it appears that, despite approaching midshell, ^{124}Te retains a seniority structure for the 6_1^+ level, i.e. a significant $\pi 0g_{7/2}^2$ contribution.
This persistence of the shell structure at the 6_1^+ state is in contrast to the $B(E2)$ values of the lower-excitation 2_1^+ and 4_1^+ states in ^{124}Te, and neighboring ^{120}Te and ^{122}Te, for which the collectivity becomes enhanced. Large-basis shell-model calculations can describe the trends, although $E2$ strengths progressively fall short away from $N = 82$. It is evident that g-factor ratios such as $g(4_1^+)/g(2_1^+)$ and $g(6_1^+)/g(2_1^+)$ are an important indicator of emerging nuclear collectivity versus the persistence of seniority structure.

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