Level-lifetime measurements using inelastic scattering reactions: addressing the $B(E2)$ disparity in Sn isotopes

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Nuclear level lifetimes have often been used as a probe for investigating the underlying nuclear structure. The Sn ($Z = 50$) isotopes constitute the longest chain of semi-magic even-even nuclei between the ^{100}Sn ($N = 50$) and ^{132}Sn ($N = 82$) double-shell closures, seven of which, ^{112,114,116,118,120,122,124}Sn, are stable. These nuclei have become a prototypical benchmark of extensive microscopic theory and experiment, as reflected in the considerable interest focused over several years on the study of enhancement or suppression in low-lying quadrupole collectivity in the even-even Sn isotopes. Multiple independent studies have investigated the collective nature of the 2_1^+ state through experiments on Coulomb excitation [1, 2], heavy-ion scattering [3, 4] and lifetime measurements for the 2_1^+ level [5]. In particular, the existing lifetime estimates for the stable Sn isotopes indicate significantly reduced collectivity, with different trends in the regions prior to and post the midshell (^{116}Sn). A re-examination of the same has been carried out via a series of fresh experiments, on two of the stable isotopes – one prior to and one post the midshell – ^{112,120}Sn, as reported here.

Low-lying levels in the ^{112,120}Sn isotopes have been populated by inelastic scattering with heavy-ion beams at the Pelletron-Linac facility in Mumbai. New lifetime values are extracted with the Doppler shift attenuation method (DSAM), implemented using updated methodologies [6], wherein the Doppler-broadened γ-decay peaks in each isotope have been detected with the INGA [7, 8] array of HPGe clovers. The transition characteristics are inferred through the $B(E2;\ 0^+_{\mathrm{g.s.}} \rightarrow 2^+_1)$

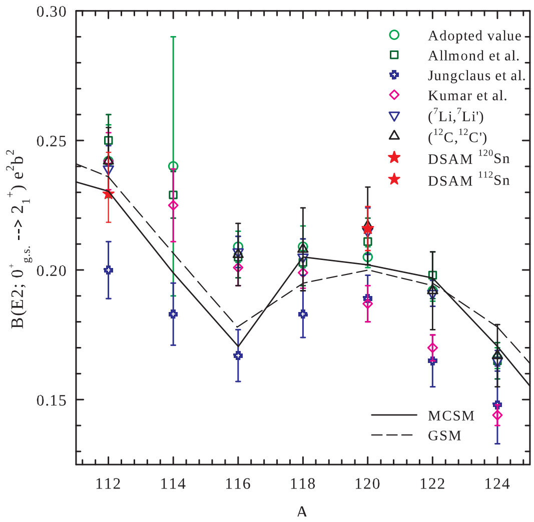

FIG. 1: Systematic plot of $B(E2;\ 0^+_{\mathrm{g.s.}} \rightarrow 2^+_1)$ values for the stable even-even Sn isotopes from existing measurements, compared with the ones from the present set of DSAM measurements.

values, which are contingent on the lifetime of the 2_1^+ level, and are the most direct and unambiguous test of the collective nature of the transition. The present results [9, 10] confirm the presence of signatures of enhanced quadrupole collectivity, and are in compliance with systematic Coulomb excitation measurements on the Sn isotopes, thereby addressing the long-standing discrepancy (shown in Fig. 1). Good agreement is also seen with generalized seniority model [11] as well as state-of-the-art Monte Carlo shell model [12] calculations. The latter predicts strong core-proton excitations from the $1g_{9/2}$ orbit accompanied with the neutron deformation via enhanced proton-neutron interaction. In particular for ^{112}Sn [9], both the $0^+_{\mathrm{g.s.}}$ and 2^+_1 states are seen

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to have oblate deformations, leading to the highest $B(E2; 0^+_{\text{g.s.}} \rightarrow 2^+_1)$ value across the Sn chain. The results will be presented and discussed. To expand the scope of this work, similar attempts are underway to implement DSAM in other avenues such as transfer reactions, to probe the 2^+_1 lifetime for the unstable ^{110}Sn nucleus, populated by $2n$-transfer from ^{112}Sn.

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