Enhanced $\mathbf{0^+_{g.s.} \rightarrow 2^+_1}$ E2 transition strength in $^{\mathbf{112,114}}$Sn

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The poorly known B(E2;$0^+ \rightarrow 2^+$) values of ^{112}Sn and ^{114}Sn have been measured to high precision. Two Coulomb excitation experiments were performed to determine the reduced transition probabilities relative to ^{116}Sn in order to minimize the systematic errors. The obtained B(E2↑) values of 0.242(8) e^2b^2 for ^{112}Sn and 0.232(8) e^2b^2 for ^{114}Sn confirm the tendency of large B(E2↑) values for the lighter tin isotopes below the midshell ^{116}Sn that has been observed recently in various radioactive ion beam experiments.

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1. Introduction

In recent years the tin isotopes which is the longest shell-to-shell chain of semi-magic nuclei, have been intensively investigated both from experimental and theoretical perspectives. In particular, the excitation energies and the reduced transition probabilities across the Z=50 chain have been examined in detail. Radioactive ion beams yield new experimental results close to the doubly-magic ^{100}Sn and ^{132}Sn, but very accurate data of the stable mid-shell nuclei are also of great relevance for our understanding. The experimental B(E2;$0^+ \rightarrow 2^+$) values on the neutron-rich side of the Sn chain drop considerably with increasing neutron number and are well described by the seniority scheme. On the proton-rich side an almost constant plateau of high B(E2) values emerges. These unexpected high B(E2) values caused a persistent discrepancy between the results of the new large-scale shell model (LSSM) calculations and experiment findings.

2. Experiments

Two Coulomb excitation experiments [1, 2] were performed at GSI- Helmholtz zentrum, Darmstadt and Inter University Accelerator Centre IUAC, New Delhi. At GSI we performed two consecutive measurements using ^{114}Sn and ^{116}Sn beams at an energy of 3.4A MeV on a ^{58}Ni target. The tin beams were provided by the UNILAC accelarator at GSI. Beam particles were incident on a 0.7mg/cm^2 ^{58}Ni target with a purity of 99.9%. In the experiment carried out at IUAC, targets of ^{112}Sn and ^{116}Sn were bombarded with a ^{58}Ni beam at 175 MeV using a tandem Van de Graaf accelerator. Both targets were of thickness 0.53mg/cm^2 with an enrichment of 99.5% and 98%, respectively. The scattered beam particles and recoils were detected in an annular gas-filled parallel plate avalance counter PPAC. The PPAC was position-sensitive in both the azimuthal φ and the polar ϑ angles. In both experiments Clover Germanium (Ge) detectors were used to measure the de-excited gamma rays. At GSI two Super-Clover Ge-detectors were mounted at angles of $\vartheta_\gamma = 25^\circ$ relative to the beam axis in the forward direction at a distance of 20 cm from the target. At IUAC four Clover detectors (distance to target 22±2cm) were mounted at $\vartheta_\gamma \sim 135^\circ$ with respect to the beam direction.

3. Analysis and Results

The data analysis was very similar for both experiments, it will be described in the following only for the measurement performed at IUAC. The particle identification and the particle position measurement allowed a precise Doppler correction of the measured γ-ray energies. A Doppler shift correction was performed for each Clover detector (ϑ_γ,φ_γ) event-by-event. Figure 1 shows the Doppler corrected spectra for ^{112}Sn excitation (top) and ^{58}Ni excitation (bottom) with the dominating $2_1^+ \rightarrow 0_{g.s.}^+$ transitions. From the observation of the Doppler corrected γ-ray lines corresponding to the $2_1^+ \rightarrow 0_{g.s.}^+$ transitions, the target and projectile excitation can be extracted. The $B(E2\uparrow)$ value of ^{112}Sn was obtained from the experimental γ-ray intensity double ratio $[I_\gamma(^{112}\mathrm{Sn})/I_\gamma(^{58}\mathrm{Ni})]$ / $[I_\gamma(^{116}\mathrm{Sn})/I_\gamma(^{58}\mathrm{Ni})]$ of the $2_1^+ \rightarrow 0_{g.s.}^+$

decays. The experimental data were compared with Coulomb excitation calculations which were performed with the Winther-de Boer COULEX code [3]. The slowing down of the projectiles in the target, the uncertainty of the PPAC boundaries and the adopted ^{116}Sn $B(E2\uparrow)$ value (3 %) were considered for the error calculation in both the cases. The resulting $B(E2\uparrow)$ values in ^{112}Sn and ^{114}Sn are 0.242(8) e^2b^2 and 0.232(8) e^2b^2, respectively.

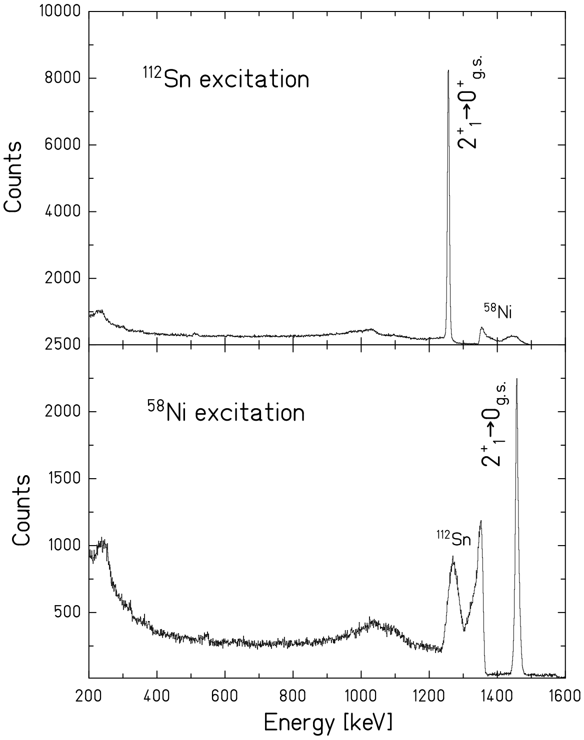

Fig. 1. Doppler corrected γ-ray spectra emitted from the ^{112}Sn target nuclei (top) and the ^{58}Ni projectiles (bottom) .

4. Discussion

The deduced B(E2;$0^+\rightarrow2^+$) values of ^{112}Sn and ^{114}Sn are compared with theoritical models i.e Large-Scale Shell-Model (LSSM) and Relativistic-Quasiparticle-Random-Phase Approximation (RQRPA). In figure 2 (left) the experimental B(E2) values are compared to LSSM calculations for an increasing number t = n of proton np-nh excitations. The evolution of the B(E2) systematics is presented here from the pure neutron space (t=0) to t = 4 proton excitations. The t = 0 curve shows a slight asymmetric maximum at N = 70, which is shifted to N = 68 (t = 2) and N = 66 (t = 4) with increasing number of ph excitations. These calculations demonstrate the important role of core-polarization effects when one breaks the ^{100}Sn core and allows for proton excitations.

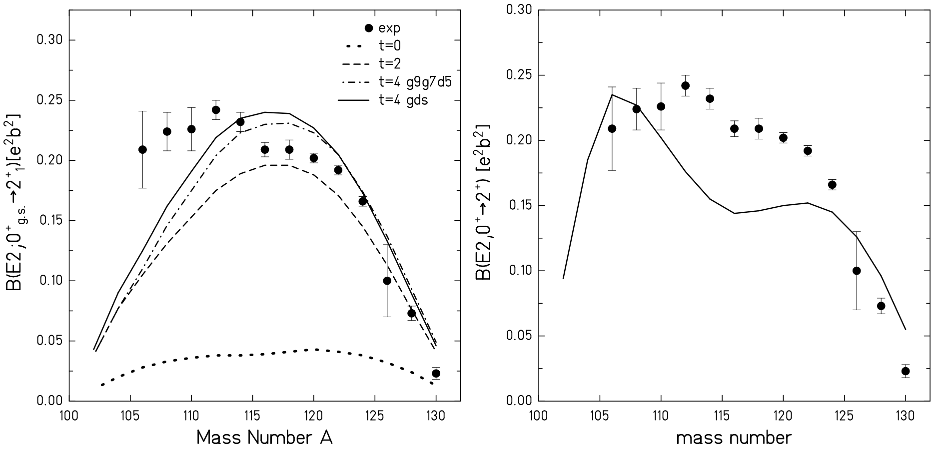

Fig. 2. Experimental B(E2) values are compared to LSSM calculations (left) and RQRPA calculations (right). For the LSSM calculations a ^{90}Zr core was considered which allows for different proton core excitations (t = 0, 2, 4)

The experimental data are also compared with RQRPA calculations [4]. The RQRPA calculations are independent of effective charges for protons and neutrons and do not require any inert core for the $B(E2\uparrow)$ values. It is interesting to note that the same RQRPA calculations yield quite satisfactory agreement also for the Ni and Pb isotopes [5]. In view of there being no free adjustment of parameters, the agreement with experimental data is quite good. The most important feature is the asymmetric behaviour of the B(E2↑) data with respect to the midshell nucleus ^{116}Sn.

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