Intermediate-energy Coulomb excitation of ^{102}Sn

M. L. Cortés,[*1,*2] F. Browne,[*2] P. Doornenbal,[*2] S. Chen,[*3] A. Corsi,[*4] T. Koiwai,[*5,*2] J. Lee,[*3]
H. Sakurai,[*2,*5] K. Wimmer,[*5] A. Algora,[*6] D. Brugnara,[*1] J. Cederkäll,[*7] J. Gerl,[*8] M. Gorska,[*8]
G. Haefner,[*9] K. Kokubun,[*5] P. Koseoglou,[*10] S. Kubono,[*2] P. Li,[*3] P. Liang,[*3] J. Liu,[*3] Z. Liu,[*11]
T. Lokotko,[*3] J. Park,[*7] L. G. Sarmiento,[*7] R. Taniuchi,[*12] W. Xian,[*3] and I. Zanon[*1]

Being presumably the heaviest, particle-bound, doubly magic $N = Z$ nucleus, ^{100}Sn offers a fundamental testing ground for nuclear theories. Experimental signatures of shell structure can be provided by the 2_1^+ energies as well as by the reduced transition probabilities, $B(E2;\ 0^+_{\mathrm{gs}} \rightarrow 2^+_1)$. In the Sn isotopes between the $N = 50$ and $N = 82$ shell closures, the 2_1^+ energies are well established and show an almost constant value,1) as expected in the generalized seniority scheme. Within the same framework, the $B(E2)\!\uparrow$ values should resemble an inverted parabola peaking at mid-shell. However, measurements in the most proton-rich Sn isotopes,2–4) have shown a clear deviation from the expected behavior.

Different calculations based on the large-scale shell model as well as on the relativistic quasi-particle random-phase approximation have been performed in order to give an account of the measured $B(E2)\!\uparrow$ values.5) Although the calculations tend to agree on the neutron-rich side of the chain, significant differences are observed on the proton-rich side. This is particularly true for ^{102}Sn, where the difference between the predictions amounts to almost a factor of 3, making this isotope a good candidate for the investigation of the effects driving the nuclear structure in the vicinity of ^{100}Sn. In order to elucidate the nuclear structure underlying the measured $B(E2)\!\uparrow$ values, the first Coulomb excitation measurement of ^{102}Sn was performed at the RIBF.6)

A 345 MeV/nucleon beam of ^{124}Xe with an average intensity of 120 pnA was fragmented on a 5 mm thick Be target at the entrance of the BigRIPS separator7) to produce ^{102}Sn. Within the same experimental setting, ^{100}Cd was also transmitted. The isotopes of interest were identified on an event-by-event basis using the $B\rho$-ΔE-$B\rho$ technique. Figure 1a) shows the particle identification obtained in BigRIPS, where ^{102}Sn and ^{100}Cd are clearly visible. A 0.5 mm Au target placed at F8 was used to induce Coulomb excitation. In addition, measurements with a 3 mm C target were performed to obtain the nuclear contribution to the cross section. Outgoing fragments were identified using the ZeroDegree spectrometer, as shown in Fig. 1b). The target was surrounded by the high-efficiency DALI2$^+$ γ-detector array, composed of 226 NaI(Tl) detectors.8,9) The average beam intensities before the secondary target were 90 pps and 4200 pps for ^{102}Sn and ^{100}Cd, respectively, with an energy around 177 MeV/nucleon.

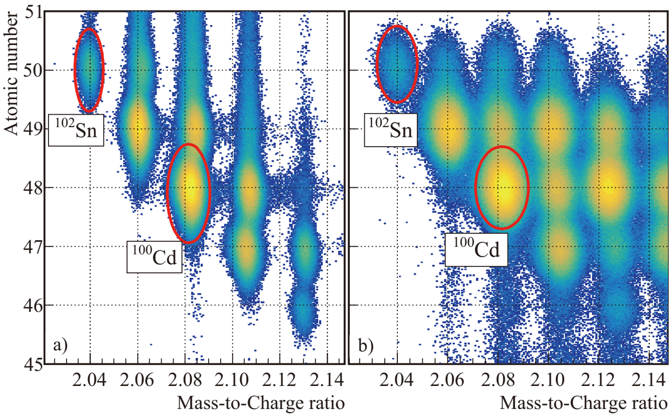

Fig. 1. Particle identification in a) BigRIPS, and b) Zero degree. In both cases ^{102}Sn and ^{100}Cd are clearly identified.

As part of the experiment, the incoming beam was implanted into a plastic target at F7 for 1 h, and data on the γ rays emitted following the decay of the isomer were collected using a HPGe detector. By combining the information on the number of ions implanted and the total γ rays observed, the isomeric ratio of the beam can be obtained. This quantity is fundamental for the correct determination of the cross section from the Coulomb excitation measurement. Finalization of the outgoing particle identification and further analysis on the in-beam γ-ray spectra of ^{102}Sn and ^{100}Cd is ongoing.

References

1) `http://www.nndc.bnl.gov/ensdf/`.
2) G. Guastalla *et al.*, Phys. Rev. Lett. **110**, 172501 (2013).
3) V. M. Bader *et al.*, Phys. Rev. C **88**, 051301(R) (2013).
4) P. Doornenbal *et al.*, Phys. Rev. C **90**, 061302(R) (2014).
5) T. Togashi *et al.*, Phys. Rev. Lett. **121**, 062501 (2018).
6) M. L. Cortés, Experiment NP1612-RIBF153R1.
7) T. Kubo, *et al.*, Prog. Theor. Exp. Phys. **2012** (2012).
8) S. Takeuchi *et al.*, Nucl. Instrum. Methods Phys. Res. A **763**, 596 (2014).
9) I. Murray *et al.*, RIKEN Accel. Prog. Rep. **51**, 158 (2017).

[*1] INFN-Laboratori Nazionali di Legnaro
[*2] RIKEN Nishina Center
[*3] Department of Physics, The University of Hong Kong
[*4] IRFU, CEA, Université Paris-Saclay
[*5] Department of Physics, The University of Tokyo
[*6] IFIC Valencia
[*7] Department of Physics, Lund University
[*8] GSI Helmholtzzentrum für Schwerionenforschung
[*9] Université Paris-Saclay, CNRS/IN2P3, IJCLab
[*10] Institut für Kernphysik, Technische Universität Darmstadt
[*11] Institute of Modern Physics, Chinese Academy of Sciences
[*12] Department of physics, University of York