Triaxiality of neutron-rich ^{84,86,88}Ge from low-energy spectra

M. Lettmann,[*1] V. Werner,[*1] N. Pietralla,[*1] P. Doornenbal,[*2] A. Obertelli,[*3,*2,*1] T. R. Rodríguez,[*4] K. Sieja,[*5] and the SEASTAR 15 collaboration

Spectroscopic measurements of ^{84,86,88}Ge were performed within the SEASTAR campaign in 2015.[1)] The spectroscopic results and theoretical predictions inspired intensive discussions of triaxial features for the Ge isotopic chain. Two elementary models, which describe the nucleus as a rigid triaxial rotor or as softly shaped, are competing in this region. Both models describe the breaking of the axial symmetry of the Bohr Hamiltonian[2)] by introducing the triaxial deformation parameter γ, which ranges from 0° (prolate shape) to 60° (oblate shape), and the axial elongation β. The maximum of triaxiality is reflected by $\gamma = 30°$. The rigid triaxial rotor model by Davydov and co-workers[3)] considers a well-defined minimum for the potential energy surface while the model by Wilets and Jean[4)] treats the potential independent of γ, introducing γ-softness. The difference between the soft and rigid cases is manifested in the energy spacing between the odd and even members of the γ band. In the case of a rigid triaxial rotor, the odd-spin levels are located closer to the lower-lying even spin levels, whereas the odd spin levels are located closer to the higher-lying even spin levels in the case of a γ-soft nucleus. This energy difference is referred to as staggering.[5,6)]

At the RIBF, a ^{238}U beam with an energy of 345 MeV/u was impinged on a 3-mm-thick ^{9}Be target at the entrance of BigRIPS.[7)] The isotopes of interest were identified by BigRIPS and ZeroDegree spectrometer in two different settings. The Ge isotopes were produced by knockout reactions inside the MINOS[8)] LH_2 target and the emitted γ radiation was detected with DALI2.[9)] The TPC of MINOS[8)] was used to improve the Doppler correction.

In total, 16 transitions in ^{84,86,88}Ge have been observed, ten of which were so far unknown. For ^{86}Ge and ^{88}Ge, new level schemes are proposed, which are shown in Fig. 1 in red. The experimental results are compared to a shell model calculation and a symmetry-conserving configuration mixing Gogny (SCCM) calculation in Fig. 1. The predicted sequences of states are in good agreement with the experimental results, although both theories overestimate the level energies in all cases. Nevertheless, the predicted $R_{4/2} \approx 2.5$ agrees with the data. Both calculations suggest a low-lying γ band, which indicates some amount of triaxiality in both isotopes. Furthermore, both theories predict a

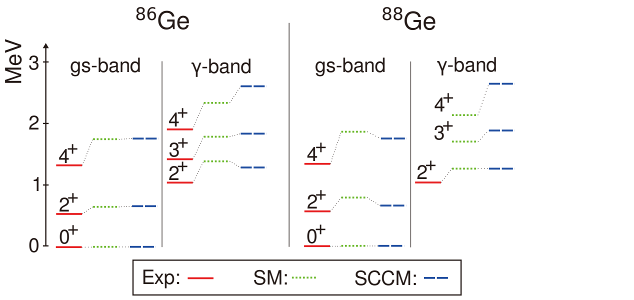

Fig. 1. Systematics of the ^{86,88}Ge level energies from experiment compared to theoretical predictions from shell model (SM) and symmetry-conserving configuration mixing Gogny (SCCM) calculations.

3_1^+ state of ^{86}Ge that is closer to the 2_2^+ state than to the 4_2^+ state of the γ band. A promising candidate for this state is observed through a 380(8)-keV transition of ^{86}Ge, because the strongest decay of the 3_1^+ state is expected to the 2_2^+ state. As highlighted before, the staggering[5,6)] in the γ band should take a positive value for a rigid triaxial rotor. This would be the case for a well-deformed rotor with $E(J) \sim J(J+1)$ as well, though in such a case, the γ-band head is at much higher values. So far only one nucleus in the medium-heavy mass region $A < 100$ is known with rigid triaxial features. This nucleus is ^{76}Ge, where a staggering $S(4) = 0.091(2)$ was found.[10)] With the level assignments presented in Fig. 1, a value of $S(4) = 0.20(4)$ results for ^{86}Ge, pointing to an even larger degree of triaxiality in the ground state than assigned to ^{76}Ge. This results agrees with the predictions of both theories.

References

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*1 Institut für Kernphysik, Technische Universität Darmstadt
*2 RIKEN Nishina Center
*3 CEA, Centre de Saclay
*4 Departamento de Física Teórica, Universidad Autónoma de Madrid
*5 IPHC, CNRS/IN2P3 et Université de Strasbourg