Oblate shapes and metastable states of ^{92,94}Se[†]

P. -A. Söderström,[*1,*2,*3,*4] C. Lizarazo,[*1,*2] V. Werner,[*1] N. Pietralla,[*1] P. M. Walker,[*5] G. X. Dong,[*6] F. R. Xu,[*7] T. R. Rodríguez,[*8] F. Browne,[*9] P. Doornenbal,[*3] S. Nishimura,[*3] C. R. Niță,[*10] and A. Obertelli[*1,*3,*11] for the SEASTAR2015 collaboration

The main goal of the second SEASTAR campaign[1)] performed at the RIBF was the exploration of the nuclear structure evolution in the region of a possible onset of deformation and shape transition between the two corner-stone nuclei ^{78}Ni[2)] and ^{110}Zr.[3)] As this region is known for the large abundance of nuclear isomers,[4)] the EURICA decay setup[5,6)] was installed at the end of the ZeroDegree spectrometer in addition to the SEASTAR instrumentation. Thus, complementary to the in-beam spectroscopy data of the Se chain,[7)] it was possible to observe internal isomeric decay using high-resolution γ-ray spectroscopy.[8)]

The type of metastable configurations observed in deformed atomic nuclei, whereby two quasiparticle states are formed by breaking pairs of nucleons close to the Fermi level, significantly changing the angular momentum projection on the symmetry axis is known as K isomers. These typically originate from deformed Nilsson orbitals coming up from lower-lying shells in well deformed prolate nuclei. Analogously, the typical downsloping of these orbitals on the oblate side opens up the possibility for a new region of K isomers at low Z and oblate deformation for exotic nuclei, involving the same orbitals from higher-lying shells as within the prolate deformed $Z \sim 72$ region.

In Ref. 8), we report on the observation of such states for ^{92,94}Se from EURICA during the SEASTAR campaign, see Fig. 1, as well as the impact of their decay pattern on the discussion of shape evolution at $N = 60$. Potential energy surface calculations suggest oblate $K^\pi = 7^-$ ($\nu 11/2^-[505] \otimes \nu 3/2^+[402]$) and $K^\pi = 9^-$ ($\nu 11/2^-[505] \otimes \nu 7/2^+[404]$) configurations for the negative-parity states in ^{92}Se, and $K^\pi = 7^-$ ($\nu 11/2^-[505] \otimes \nu 3/2^+[411]$) for the isomer of ^{94}Se. For ^{94}Se, this leads to a hindrance factor of $F_W = 2.49 \times 10^8$ and a reduced hindrance $f_\nu \sim 25$. Characteristic values for $E1$ K-trap decays with $\nu = 6$ are within $27 \lesssim f_\nu \lesssim 42$.[9,10)]

Also, the observed $J^\pi = 7^-$ states have very different decay paths for the two isotopes. The decay properties can partially be explained considering that the collective wave functions predicted by the SCCM method for ^{92}Se[7)] are relatively soft, implying that K is not a good quantum number due to the lack of well-defined rigid axial symmetry. For ^{94}Se, however, the SCCM method proposes a rigid oblate ground state and a rigid prolate yrare band, increasing the wave-function overlap between an oblate isomer and the oblate ground state relative to the prolate yrare band.

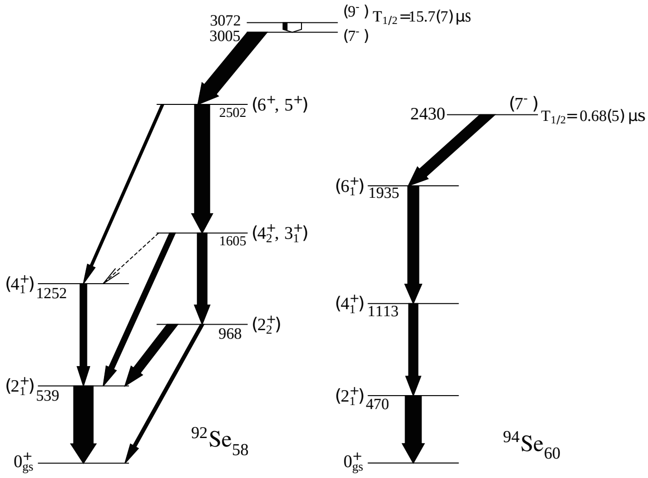

Fig. 1. Level schemes constructed for ^{92,94}Se. The arrow width of each transition indicates its intensity.

This work presents the observation and interpretation of ^{92,94}Se isomeric states. The different isomeric decay paths of each isotope contrast the relatively smooth systematics of the ground-state and $K = 2$ excited bands observed from in-beam spectroscopy.[7)] Also, a similar 32 ns isomer was recently observed for ^{94}Kr at the ALTO facility of the IPN Orsay with the ν-Ball array,[11)] allowing the systematic evaluation of the 7^- and 9^- states along $N = 58$.

† Condensed from the article in Phys. Rev. Lett. **124**, 222501 (2020)

*1 Institut für Kernphysik, Technische Universität Darmstadt
*2 GSI Helmholtzzentrum für Schwerionenforschung GmbH
*3 RIKEN Nishina Center
*4 ELI-NP, IFIN-HH
*5 Department of Physics, University of Surrey
*6 School of Science, Huzhou University
*7 State Key Laboratory of Nuclear Physics and Technology, Peking University
*8 Departamento de Física Teórica, Universidad Autónoma de Madrid
*9 School of Computing Engineering and Mathematics, University of Brighton
*10 DFN, IFIN-HH
*11 IRFU, CEA, Université Paris-Saclay

References

1) P. Doornenbal *et al.*, RIKEN Accel. Prog. Rep. **49**, 35 (2016).
2) R. Taniuchi *et al.*, Nature **569**, 53 (2019).
3) N. Paul *et al.*, Phys. Rev. Lett. **118**, 032501 (2017).
4) D. Kameda *et al.*, Phys. Rev. C **86**, 054319 (2012).
5) S. Nishimura, Prog. Theor. Exp. Phys. **2012**, 03C006 (2012).
6) P. -A. Söderström *et al.*, Nucl. Instrum. Methods Phys. Res. B **317**, 649 (2013).
7) S. Chen *et al.*, Phys. Rev. C **95**, 041302(R) (2017).
8) C. Lizarazo *et al.*, Phys. Rev. Lett. **124**, 222501 (2020).
9) G. D. Dracoulis *et al.*, Rep. Prog. Phys. **79**, 076301 (2016).
10) Z. Patel *et al.*, Phys. Rev. C **96**, 034305 (2017).
11) R. -B. Gerst *et al.*, Phys. Rev. C **102**, 064323 (2020).