Investigation of the neutron-rich astatine isotopes by in-source spectroscopy at ISOLDE (CERN) facility: sell-effect and inverse odd-even staggering

A.E. Barzakh, D.V. Fedorov, P.L. Molkanov, M.D. Seliverstov — High Energy Physics Division, NRC "KurchatovInstitute" — PNPI

Hyperfine-structure parameters and isotope shifts for the 795-nm atomic transitions in ^{217,218,219}At have been measured at CERN-ISOLDE, using the in-source resonance-ionization spectroscopy technique. Magnetic dipole and electric quadrupole moments, and changes in the nuclear mean-square charge radii ($\delta\langle r^2\rangle$) have been deduced [1].

In Fig. 1 the changes in the mean-square charge radii for astatine isotopes near the shell closure at N = 126 are presented. A characteristic increase in the slope of the $\delta\langle r^2\rangle$ isotopic dependency when crossing the neutron magic number N = 126 is known as the shell effect in radii. The possibility of description of shell-effect in mean-square charge radii is regarded now as one of the main evidences of the nuclear model quality. Further accumulation of the experimental data of this effect is of great importance.

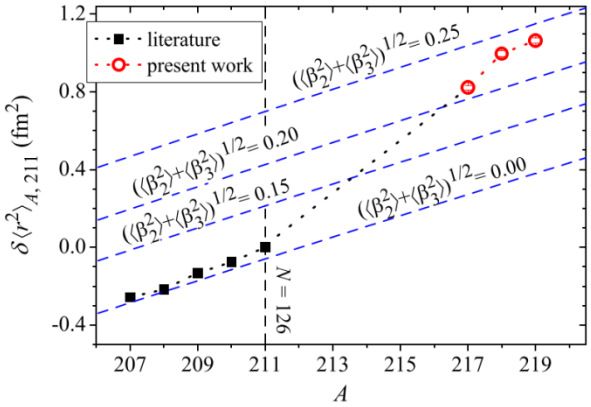

Fig 1. Changes in the mean-square charge radii for astatine isotopes near the shell closure at N = 126.

The odd-even staggering (OES) in radii, when radius of odd-N nucleus differs from the mean value of its even-N neighbors, is quantified by the parameter γ_N:

$$\gamma_N = \frac{2\delta\langle r^2\rangle_{N-1,\,N}}{\langle r^2\rangle_{N-1,\,N+1}},$$

where ***N*** — odd number of neutrons. If γ_N = 1, there is no OES, whereas γ < 1 and γ > 1 correspond to normal and inverse OES, respectively. As can be seen on Fig. 2, at 133 < N < 137 there is inverse OES in Fr, Ra and Rn isotopes (γ_N > 1). Our new data for $^{217-219}$At testify to the retention of this effect for Z = 85 and N = 132–134. It was found previously that inverse OES strongly correlates with the presence of octupole deformation in the corresponding nuclei. Thus, our new data for At isotopes indicate the possible octupole deformation in $^{217-219}$At. This conclusion is supported by the analysis of magnetic dipole moments of $^{217-219}$At measured in our experiment. Earlier the $_{85}$At isotopes were expected to lie outside the region of the quadrupole-octupole collectivity, where inverse OES was previously established. Investigation of the octupole deformed nuclei is the one of topical direction of contemporary nuclear physics. These nuclei prove to be a good benchmark to search for T- and P-violation effects beyond Standard model.

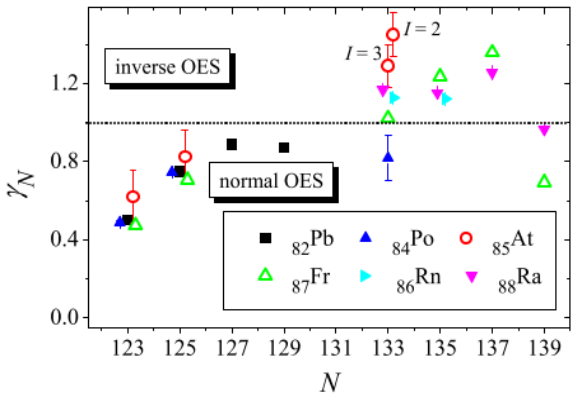

Fig 2. The odd-even staggering parameter in the lead region near the N = 126.

[1] A. E. Barzakh *et al.*, Phys. Rev. C **99**, 054317 (2019).