INVESTIGATION OF ELECTROMAGNETIC MOMENTS AND CHARGE RADII OF SHORT-LIVED RARE-EARTH NUCLIDES WITH ATOMIC LASER SPECTROSCOPY

G. D. Alkhazov, A. E. Barzakh, V. P. Denisov,
V. S. Ivanov, V. E. Starodubsky, V. S. Letokhov *,
V. I. Mishin *, S. K. Sekatsky *, V. N. Fedoseev *

* Institute of Spectroscopy, USSR Academy of Sciences, Troitsk

The aim of this work is to study the properties of nuclei far from stability by measuring and analysing spins, magnetic dipole, electric quadrupole moments and isotopic changes in nuclear charge radii $\Delta\langle r^2\rangle$. These data are derived from the hyperfine splitting and isotope shifts in the optical transitions for the relevant atoms. The high sensitivity of the laser spectrometer operated on-line with the mass-separator IRIS allows to carry out measurements at isotope beam intensities up to 10^4 ions per second. The nuclei of rare-earth elements ^{146,148,150,152,154,156,158,160}Gd, $^{151,153,155-159}$Eu, $^{147-155,157,159}$Tb have been studied.

The results for Gd and Tb along with the previously obtained data for the other elements lead to the unambiguous conclusion concerning the influence of the subshell closure at Z=64 on the shape transition close to the «critical» neutron number N=90. It has been found that the abrupt change in nuclear deformation at N=88—90 occurs only in the nuclei with Z close to Z=64 ($|Z-64|<5$). Moreover, the nearer the proton number is to Z=64, the stronger is the change in nuclear deformation between the isotopes with N=88 and N=90 (fig. 1). This clear Z-dependence of the shape transition is additional evidence of the magic nature of the proton number Z=64. The mean square charge radius of the «magic» ^{146}Gd has been determined using the charge radii of the stable Gd nuclei measured previously and the $\Delta\langle r^2\rangle$ values for the radioactive Gd nuclei obtained by us. This quantity is of fundamental importance in view of the significance of magic nuclei in the creation of a proper nuclear theory.

The investigations of the neutron-rich Eu isotopes with N>93 were stimulated by the previously discovered inverted odd-even staggering in nuclear charge radii close to $^{154}_{63}Eu_{91}$. While for the majority of the odd-neutron nuclei their charge radii are smaller than the averages of the radii of their even-N neighbours, the radius of ^{154}Eu is found to be greater than the average radius of ^{151}Eu and ^{153}Eu. This inversion was considered as a ground state octupole deformation in a sequence of Eu

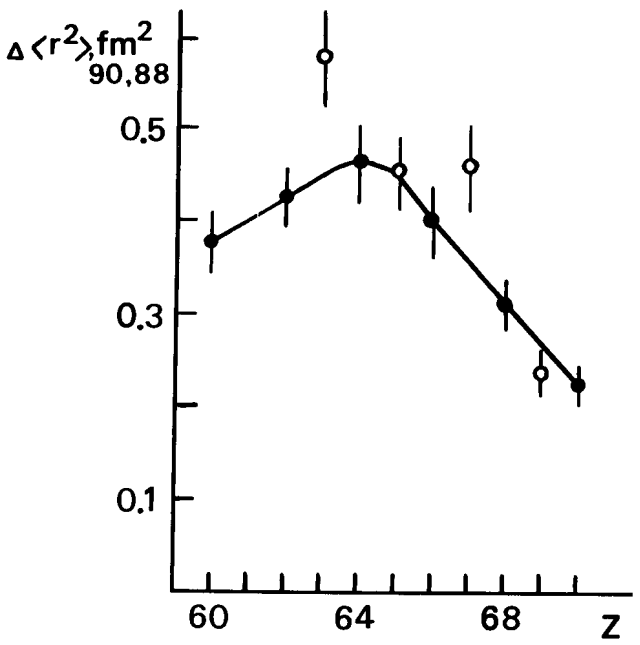

Fig. 1. Z-dependence of $\Delta\langle r^2\rangle_{88,90}$ value

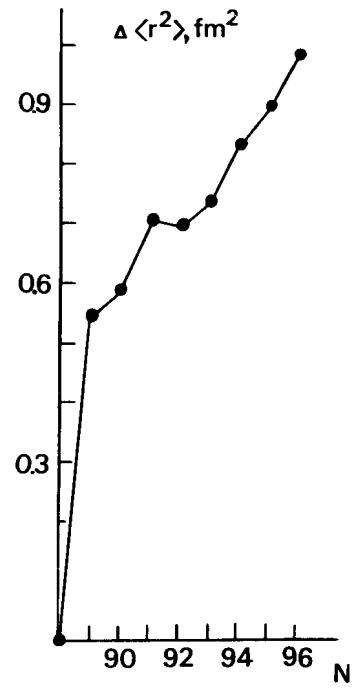

Fig. 2. Isotope changes of mean square charge radii of neutron-rich Eu isotopes

isotopes which include ^{154}Eu. Our measurements confirm the inverted odd-even staggering in the charge radii of Eu isotopes close to A=154. Furthermore, it has been found, that for the Eu isopes with N>92 the normal odd-even staggering is restored (fig. 2). This means that the stable octupole deformation does not display itself in the charge radii of heavier Eu nuclei.

At the same time we have continued to verify the various theoretical approaches comparing their predictions with the experimental data obtained. The Hartree-Fock theory describes fairly well the $\Delta\langle r^2\rangle$ isotopic dependences in the vicinity of N=82 when taking into account zero-point oscilations in the framework of the random phase approximation. The quasiparticle Lagrange method results for strong deformed nuclei are in good agreement with the experiment, being closer to the data than the Hartree-Fock ones.

The main results have been published /1—3/.

REFERENCES

1. *Alkhazov G. D. et al.* Pis'ma Zh. Exsp. Teor. Fiz., 1988. 48. 373.
2. *Alkhazov G. D. et al.* Preprint LNPI-1417, Leningrad, 1988. P. 20.
3. *Barzakh A. E., Starodubsky V. E* Yad. Fiz., 1989. 49. 1588.