ISOTONIC AND ISOBARIC DEPENDENCIES OF NUCLEAR CHARGE RADII

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Two-dimensional picture (regarding proton and neutron numbers) of behaviour of nuclear charge radii was formed in the rare-earth region. It was composed of isotopic changes of nuclear charge radii $\delta\langle r^2\rangle$ obtained by laser spectroscopy, a large contribution being made by the measurements at the IRIS mass separator installation [1, 2]. We normalized these isotopic dependencies of $\delta\langle r^2\rangle$ to the $\langle r^2\rangle$-values from muonic spectroscopy and electron scattering for stable isotopes. The extraction of $\delta\langle r^2\rangle$ from isotope shifts was performed anew using the modern and most reliable approaches. As a result not only isotopic but also isotonic and isobaric dependencies of nuclear charge radii are now available in the rare-earth region. Some examples are shown in Figs.1,2. The most remarkable feature of the isotonic chain for $N = 82$ (Fig.1) is the lack of some noticeable discontinuity at $Z = 64$ (i.e. for ^{146}Gd considered to have magic nucleus properties) unlike the case of the real magic number as $Z = 50$ [1]. The absence of a clear shell effect at $Z = 64$ may be regarded as an evidence for a weak manifestation of magic properties of ^{146}Gd.

The isobaric sequence of nuclear charge radii for $A = 146$ proved to be the longest of the known isobaric chains of nuclear radii. After the correction for the deformation contribution the corresponding $\langle r^2\rangle$-values lay on a straight line (Fig.2). A least squares fit gives for the slope α of this line: $\alpha = 11.6(1.9) \cdot 10^{-2}$ fm^2/proton. Theoretical predictions for α prove to be very sensitive to the choice of an effective force in the framework of the Hartree-Fock (HF) method. As can be seen from Table, only the SkM', G_σ, T3 and T9 forces provide α-values in a reasonable agreement with the experiment. At the same time T3 and T9 forces should be rejected in view of their failure to describe isotopic shifts. The capacity for discrimination between different theoretical models with the aid of the isobaric $\langle r^2\rangle$ dependencies is critically influenced by the uncertainties in α, which is determined by the length of the isobaric series and by the individual errors of the corresponding $\langle r^2\rangle$-values. For example, similar data for medium heavy nuclei ($A = 118$) prove to be insufficient for the choice of the "best" effective force, for the $A = 118$ series from [1] is shorter than the $A = 146$ series in our analysis.

Thus, taking into account our previous results on isotope shifts [2], one can conclude that the SkM' and G_σ forces are the preferable ones for the description of the global $\langle r^2\rangle$ behaviour in the framework of the Skyrme-HF approach. The work is published in [3].

Table

Slope of the isobaric dependency of $\langle r^2\rangle$ as a function of Z at $A = 146$: $d\langle r^2\rangle/dZ(10^{-2}$ fm^2/proton)

Experiment	SkM'	G2	S3	Ska	T3	T5	T9	S6	G_σ
11.6(1.9)	12.6	7.9	8.6	8.7	12.1	13.8	12.1	9.5	11.0

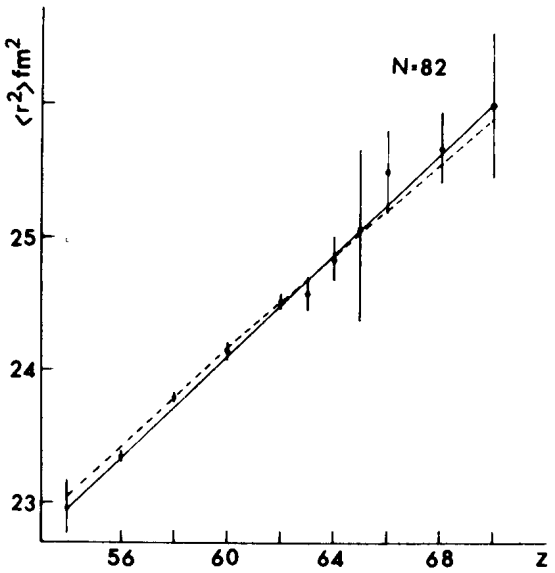

Fig.1. $\langle r^2 \rangle$ in isotonic series $N = 82$. Full line — Droplet Model predictions, broken line — HF(SkM') predictions

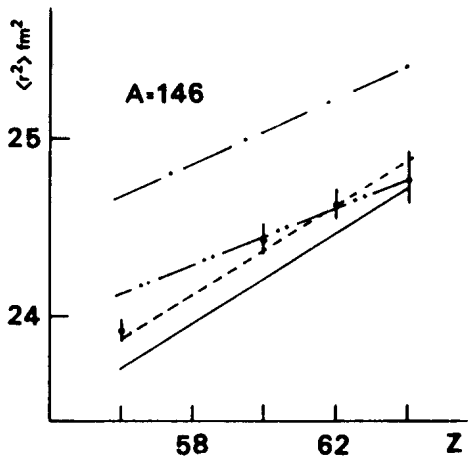

Fig.2. $\langle r^2 \rangle$ in isobaric series $A = 146$. Full line — Droplet Model predictions, broken line — HF(SkM'), dot-dashed line — HF(S6), double dot-dashed line — HF(S3) predictions

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