THE ISOTOPIC SHIFTS OF THE MEAN SQUARE RADII OF ODD NUCLEI* **

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Microscopic calculations of the mean square charge radius of Ag, Rb and Sn isotopes are presented. The model bases on the Nilsson single particle potential and the BCS theory.

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The equilibrium deformations, quadrupole moments and mean square radii (MSR) of even and odd nuclei are calculated within a static microscopic model based on the BCS method using single particle states of the modified Nilsson potential [1], and on the Strutinski [2] shell correction method. The potential energy surfaces are obtained in a two dimensional space (quadrupole ε and hexadecapole ε_4 deformation). For nuclei with odd proton or neutron numbers, the quasiparticle is created in the nearest state to the Fermi surface of the even core.

In Ref. [3], the theoretical equilibrium deformations, deformation energies, mean square radii and quadrupole moments of all the experimentally available even–even nuclei [4, 5] are given. They were calculated within the dynamical microscopic model based on the Nilsson single particle potential with Seo parametrization of the correction term [1] and the generator coordinate method [6]. Now we are going to perform a similar calculation also for odd nuclei, to get the full information about their shapes and sizes. In the present first investigation only the static deformations are taken into account, the dynamical effects are neglected.

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As the first step, using the macroscopic-microscopic method, we have obtained the potential energy surfaces in the two-dimensional deformation space of the quadrupole (ε) and the hexadecapole (ε_4) deformation. To the macroscopic-microscopic formula consisting of the liquid drop energy E_{LD} [7], the Strutinski shell $\delta E_{\rm shell}$ and pairing $\delta E_{\rm pair}$ corrections for the even-even core we have added the energy of the quasiparticle created in that proton (for odd Z) or neutron (for odd N) state $|\nu\rangle$ which is closest to the Fermi surface

$$E_\nu = E_{LD} + \delta E_{\rm shell} + \delta E_{\rm pair} + \sqrt{(e_\nu - \lambda)^2 + \Delta^2}\,. \tag{1}$$

The Fermi level λ and pairing energy gap Δ are obtained by the solution of BCS equations, e_ν is the single particle energy. The equilibrium deformation of the nucleus with $A = Z + N$ nucleons is evaluated by minimizing of the potential energy versus $(\varepsilon, \varepsilon_4)$ deformations. The mean square charge radii are calculated in the equilibrium point using the following formula

$$\langle r^2\rangle^A = \frac{1}{Z}\left[\sum_{\mu\neq\nu}\langle\mu|r^2|\mu\rangle v_\mu^2 + \langle\nu|r^2|\nu\rangle\right] + 0.64{\rm fm}^2\,, \tag{2}$$

where v_μ^2 is the BCS occupation factor and the sum runs over all single particles states different from the state $|\nu\rangle$ occupied by the odd nucleon. The correction 0.64 fm^2 to the MSR is due to the finite range proton charge distribution [8]. The terms with the indexes (ν) in Eqs 1 and 2 describing the odd nucleon are absent for the even-even nuclei.

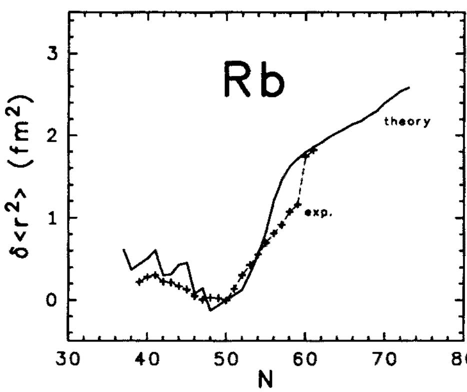

Fig. 1. The isotopic shifts of the charge mean square radius of Ag isotopes related to $A' = 109$ mass. Crosses denote experimental values [4].

The isotopic shifts of mean square radii $\delta\langle r^2\rangle^{A,A'} = \langle r^2\rangle^A - \langle r^2\rangle^{A'}$ of Ag ($A' = 109$) and Rb ($A' = 87$) isotopes are shown in Figs 1 and

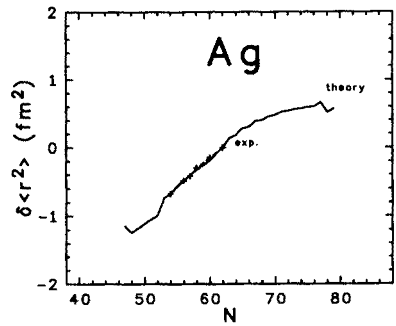

Fig. 2. The isotopic shifts of the charge mean square radius of Rb isotopes related to $A' = 87$ mass. Crosses denote the experimental values [4].

2. A good agreement with experimental data [4] can be achieved only for those isotopes where the theory reproduces the experimental value of the third component of the angular momentum and the parity (K^{π}) of the odd nucleus. Unfortunately this is not always the case and probably one has to revise the parameters of the single particle potential [1] in the future calculations.

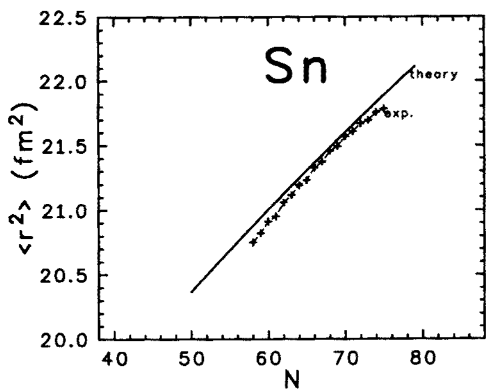

Fig. 3. The mean square radii of Sn isotopes. Crosses denote the experimental values [4, 9].

In Fig. 3, the microscopic estimates of the MSR of Sn isotopes are compared with the experimental data obtained by adding the measured MSR isotopic shifts [4] to the experimental value of MSR for ^{116}Sn [9]. Surprisingly, the "odd–even staggering" effects in the Sn isotopes are almost absent in the theoretical results. We hope that a more careful dynamical description similar to that of Ref. [3] could reproduce the experimental data in a more satisfactory way. A more extended calculation is in progress now.

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