THE MEAN SQUARE RADII AND QUADRUPOLE MOMENTS OF EVEN-EVEN ISOTOPES WITH 38≤Z≤74, N≤74.

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A wealth of experimental results on the nuclei far from β stability line has been recently obtained thanks to the advances in the laser spectroscopic methods [1,2] and in the mass spectroscopy [3,4]. We have calculated sizes and shapes for the even-even isotopes with 38≤Z≤74 and Z≤N≤74, i.e. for the Sr–W nuclei. Although these mainly unstable nuclei have been already investigated theoretically [5], there still remain open problems, which could be resolved when further experimental data as well as microscopic dynamic description become available. In our calculations we have used the single particle Nilsson potential with the Seo parameters [6] for average mass number A $\sim$ 100. These calculations were based on the generator coordinate method (GCM) with the quadrupole ε_2 and hexadecapole ε_4 deformations taken as the collective variables, $\{q\}=\{\varepsilon_2, \varepsilon_4\}$. The long range two body correlations in local approximation and the pairing forces were included into the mean field hamiltonian $\widehat{H}$. The eigenfunctions χ of this hamiltonian H are obtained within the BCS approximation. The nuclei under investigation, excluding those which are close to the magic ones, show quite stable quadrupole and hexadecapole equilibrium deformations and axial symmetry but they are soft against the change of the nonaxial deformation γ and do not have any significant barrier between the oblate and prolate minimum of the potential energy surface. In Fig. 1 we can see the deformation energies obtained by GCM and Strutinsky shell correction for both prolate (points joined by solid lines) and oblate (open circles joined by dashed

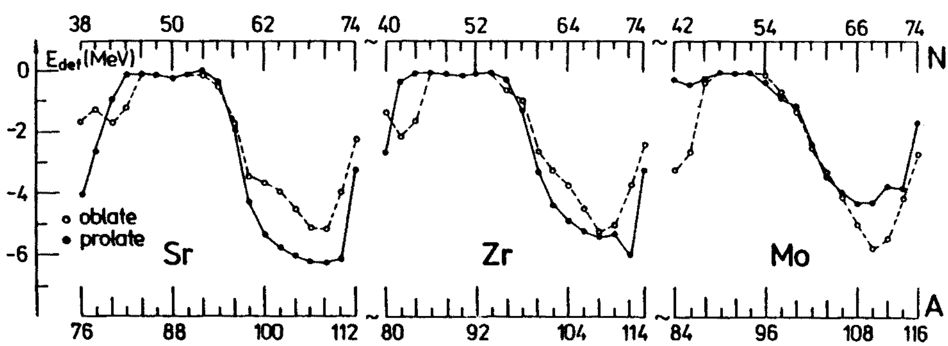

Fig. 1

lines) minima. In the whole region the prolate deformation is usually favoured in spite of the almost spherical nuclei with Z or N close to the magic number 50. It is seen in Fig. 1 that the light Sr isotopes change their equilibrium shape from the prolate to oblate one between A=78 and A=80. Around N=50 nuclei became spherical with very flat energy minimum. It is not only the minimum of the potential energy that decides about the sizes and shapes of nuclei. The average values of the moments feel the whole potential energy surface and also mass parameter dependence of deformation. Up to now, in spite of the detailed microscopic treatment which included even the dynamical aspects of the pairing variables as well as the quadrupole forces [7], we had difficulties with the good reproduction of the experimental isotopic shifts $\delta\langle r^2\rangle^{A,A'}$.

In Fig. 2 the differences between the mean square radius for A $\in$ (108,228) and A'=120 of Xe isotopes $\delta\langle r^2\rangle^{A,120}$ (fm^2) are shown. They are calculated in two ways, by taking the oscillator frequency $\hbar\omega_0$ of Nilsson potential with the isotopic factor (crosses joined by dashed line) suggested in [8]: $\hbar\omega_0 = 41 \cdot (1 \pm \frac{N-Z}{3A})A^{-1/3}$ and without it (points joined by solid line) $\hbar\omega_0 = 41 \cdot A^{-1/3}$.

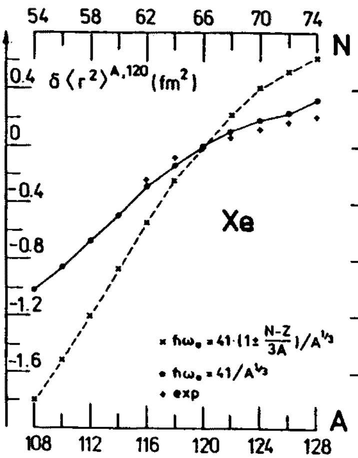

Fig. 2

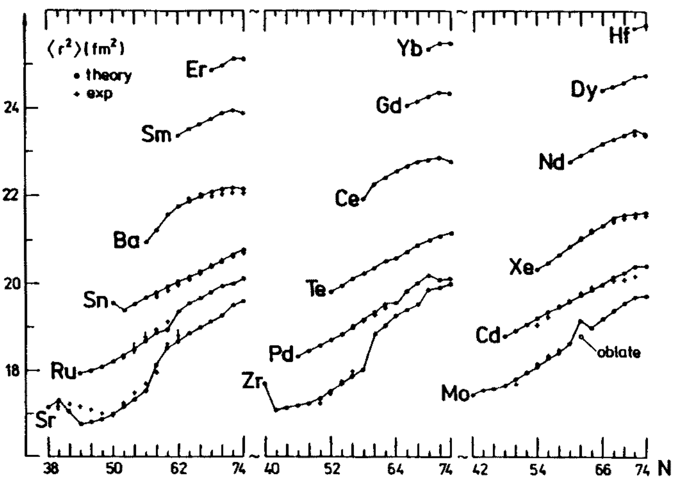

Fig. 3

The experimental data [1,2] (crosses) lie near to the second line for all the elements of the investigated region. It seems that the isotopic factor in $\hbar\omega_0$ should not be considered since it spoils the theoretical values of $\langle r^2\rangle$. Therefore the results presented below are obtained without this factor.

Fig. 3 presents the mean square radii $\langle r^2\rangle$ (fm^2) calculated for the whole region. The agreement with the experimental data is pretty good excluding perhaps a few light, i.e. Sr, isotopes which $\langle r^2 \rangle$ become smaller with growing N number. The latter discrepancy is probably due to some shell effects not described by our single particle potential. Anyhow beginning with N=50 the quick increase of the $\langle r^2 \rangle$ value given in experiment is well reproduced.

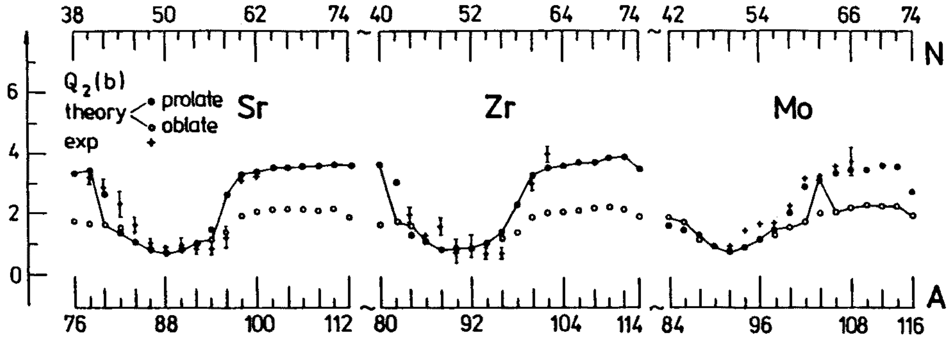

Fig. 4

The quadrupole moments Q_2 (b) for Sr–W isotopes are shown in Fig. 4. The experimental quadrupole moment Q_2^{exp} is obtained from the reduced E2 transition probabilities B between the 2^+ and 0^+ states. These transitions fulfil the sum rule $\sum_i B(E2, 2_i^+ \rightarrow 0^+) \simeq \frac{5}{16\pi}(Q_\lambda^{exp})^2$ where the sum includes all possible 2_i^+ states, although usually only the first term $(2_1^+ \rightarrow 0_1^+)$ dominates the sum [9]. In order to be consistent with this approximation we calculate the quadrupole moments as [10]: $Q_2 = [\int \phi_o^* \langle \chi \mid \widehat{Q}_2^2 \mid \chi \rangle \phi_o dq]^{1/2}$. As seen in Fig. 4, the experimental data are well reproduced by the teoretical estimates, which correspond to the prolate shapes of nuclei. For the heavier elements the inclusion of the nonaxial γ degree of freedom and equality of the protons and neutrons distribution in nucleus are required. As the next step we are going to check the influence of the Woods-Saxon single particle level scheme on our results.

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