This equation was first obtained by Silin[2] with a somewhat different numerical coefficient on the last term.

The method here described is generalized by indicating a general way of finding the quantity $(\overline{\nabla_p \epsilon})^2$, which enters into the dispersion equation (5). Since this quantity is given in terms of quantities characterizing the ground state, it is sufficient to write the energy $\epsilon = (1/2)m(\nabla_p \epsilon)^2$ of a single particle for this state as a function of the momentum, accounting for all possible interactions by single-particle wave functions (which are plane waves in the constant-density state).

We take this opportunity to thank V. P. Silin for correcting a serious error in the first version of this communication.

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NEW FORM OF ISOMERISM IN EU^{152}

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EXPERIMENTAL data on the β-decay of Eu^{152} indicates that the β and γ spectra of its ground state (T = 13 years) and isomeric state (T = 9.2 hr) are very complex.[1-4] Certain details of the decay schemes, however, are quite well established and can be used to determine the spin of the isomer. These are shown in Fig. 1. The log τf value of 7.6 for the 9.2 hr β^- transition of Eu^{152} to the ground state 0+ of Gd^{152} is characteristic for singly forbidden β^- transitions and indicates that the spin of the Eu^{152} isomer is 1—.

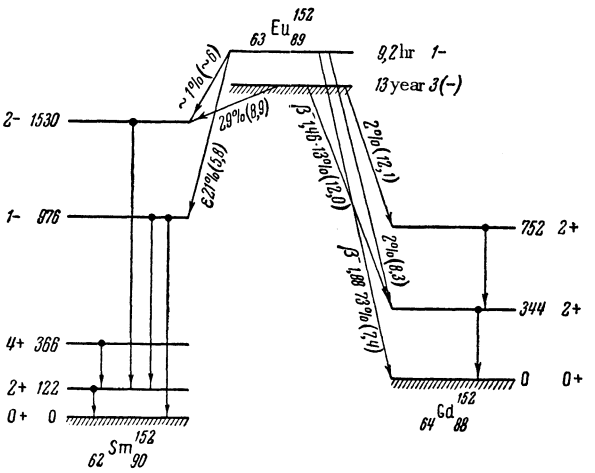

FIG. 1

The value 0— is excluded, since K-capture is observed to the 1537 kev 2— level of Sm^{152}. The value 2— is less likely, since in this case the β^- transition would be "unique" and one would expect to have log $\tau f \geq 7.6$.

The spin of 13-year Eu^{152} was directly measured by the paramagnetic resonance method,[5] and was found to be 3. These experimental values of 3 (—) and 1— for the spins of the ground state and isomeric state of Eu^{152} lead to several serious difficulties:

1. The spin difference of these two states is 2. Therefore the γ-transition between the isomeric and ground states of Eu^{152} must be* E2. Nevertheless, this transition is never observed. If it does exist, it is retarded by a factor of more than 10^{12} compared to the usual E2 transitions. One is not able[6,8] to explain this in terms of the selection rules for any of the known quantum numbers (for deformed nuclei) I, K, N, n_z, Λ, or Σ. The isomerism of Eu^{152}

*From a more detailed analysis of the decay scheme it follows that the parity of 13-year Eu^{152} would seem to be the same as that of 9.2-hour Eu^{152}. It is, however, impossible to eliminate completely the possibility that 13-year Eu^{152} has positive parity.

must thus be of a new type which cannot be explained in terms of the previously known ones (which are easily explainable in terms of selection rules for the above quantum numbers).

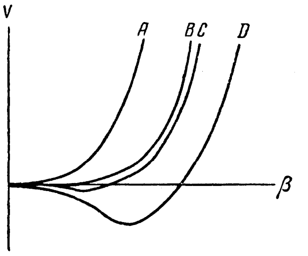

FIG. 2. Dependence of the nuclear potential energy V on the deformation β. Curve A represents nuclei with almost filled shells and with a spherical equilibrium shape ($\beta = 0$). Curve D represents nuclei with ellipsoidal equilibrium shapes ($\beta \neq 0$). Curves B and C represent nuclei close to the transition point between spherical and ellipsoidal equilibrium shapes. Curve B refers to the spherically symmetric 9.2-hr isomer of Eu^{152}, and C refers to the 13-year ground state (ellipsoidal equilibrium shape).

2. The singly forbidden β^- decay of 13-year Eu^{152} to the first and second 2+ levels of Gd^{152} has a log τf value of 12, which means that it is slower than ordinary transitions by a factor of about 10^5. K-transitions to the Sm^{152} level are about equally slowed down (log $\tau f \approx 10$). No K-capture is observed[2,3] to the 123 kev (2+) and 366 kev (4+) levels, which belong to a rotational band of the ground state.

3. Comparison of the probabilities for β^- and K-transitions of the same type, as well as the values for the total ratios K/β^- for the ground state plus isomeric state of Eu^{152} show that 9.2-hr Eu^{152} decays primarily to Gd^{152} levels, and that 13-year Eu^{152} decays to Sm^{152} levels.

In order to understand the properties of Eu^{152} decay, let us consider the question of the equilibrium shape of the nucleus. It is known that all nuclei with 88 neutrons are spherical, whereas those with 90 neutrons have an ellipsoidal equilibrium shape. It is natural to assume that nuclei with N = 89 are in "neutral" equilibrium and can be either spherical or ellipsoidal depending on the number of protons. Analysis shows that nuclei with N = 89 and Z = 60 or 62 are spherical, whereas that with Z = 64 is ellipsoidal.[6]

Thus the nucleus with N = 89 and Z = 63 is in "neutral" equilibrium with respect both to the neutrons and protons. Such a nucleus should have unique properties. The potential vs. deformation plot in Fig. 2 shows that for this nucleus (curves B and C) the states with $\beta = 0$ and $\beta \neq 0$ are almost equally stable, and transitions between them may be caused even by weak excitation of the nucleus.

The nucleus with Z = 63 and N = 89 is Eu^{152}. In agreement with the above, let us assume that its ground state (T = 13 years) has an ellipsoidal equilibrium shape, and that the isomer is spherical in equilibrium. In this case the isomeric transition in Eu^{152} is related to the change of the equilibrium shape, and therefore to a realignment of the nuclear levels. Such a realignment can explain the factor $F > 10^{12}$ in slowing down the γ transitions. It is natural to assume that the equilibrium deformation parameter β for Eu^{152} is minimal and therefore[9] equal to about 0.2. In $_{64}G^{152}_{88}$ the deformation parameter $\beta = 0$, and in $_{62}Sm^{152}_{90}$ it has the value $\beta = 0.3$. The β-transitions to the Gd^{152} levels and the K-transitions to the Sm^{152} levels are accompanied by a large change in the deformation parameter (the β^--decay causes a change in the equilibrium shape). The significant realignment of nuclear levels which takes place in these transitions may strongly decrease the decay probability, thus explaining the fact that $F \approx 10^3 - 10^5$.

In these processes, the β^--decay is accompanied by a larger change in the deformation parameter ($\Delta\beta = 0.2$) than the K-capture ($\Delta\beta = 0.1$). Thus in the 13-year Eu^{152} we have $K/\beta^- > 1$, and $\log \tau f_K < \log \tau f_{\beta^-}$. The possibility of K-transitions to the 122 kev and 366 kev rotational levels of Sm^{152} is reduced not only by the change in the deformation parameter, but also by forbiddenness with respect to the quantum number K, which decreases the probability[6] by a factor of 10^4 when $\Delta\nu = \Delta K - L = 2$. Such K transitions should be practically unobserved.

These conclusions, as we have seen, are in agreement with the experimental data. No change in the equilibrium shape takes place in the β^--decay of the spherical nucleus Eu^{152} (T = 9.2 hr), since Gd^{152} is also a spherical nucleus. In complete agreement with this, $\log \tau f_{\beta^-}$ has the usual value for singly forbidden β-transitions, as already mentioned above.

The probability for K-capture should be much lower, since it is accompanied by a change of the equilibrium shape. This is in agreement with the general features of the experimental data, since $K/\beta^- < 1$ in 9.2-hr Eu^{152}. The observed probability for β^+ and K-transitions, however, is more than could be expected. It should be noted that the existing experimental data on the intensity of β^+-transitions is contradictory,[3,10] so that further study of these transitions is necessary.

It is interesting to note that the hypothesis that the equilibrium shape of Eu^{152} (T = 13 years) is ellipsoidal is supported by data on its spin and magnetic moment. They agree exactly with the data for the

Eu^{154} nucleus ($I = 3$, $\mu = 2.0$ nuclear magnetons), which is known to be ellipsoidal.[5,11] The spin of the Eu^{152} isomer, namely 1—, is in agreement with the hypothesis that the nucleus is spherical.

Thus Eu^{152} is a rare (if not the only) example of a nucleus located intermediately between states with known spherical and ellipsoidal equilibrium shapes, and must thus have several unique properties (other than those considered above). Therefore further experimental study of this nucleus and the establishment of its complete decay scheme is very important for the development of concepts on its structure.

I offer my deep gratitude to L. A. Sliv for detailed discussion of the work.

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SMALL-ANGLE SCATTERING OF FAST NEUTRONS BY HEAVY NUCLEI

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We have studied the angular distribution of fast neutrons elastically scattered from Pu, U, Pb, Bi, Sn, and Cu nuclei in the interval of angles* from 4 to 25°. This work may be considered an attempt at the experimental investigation of the possible "polarizability" of the neutron in the strong Coulomb field of the nucleus, which is of interest from the point of view of studying the internal structure of the neutron. As has previously been noted,[1,2] the "polarizability" of the neutron would be observed in the anomalous behavior of the differential elastic scattering cross section at small angles.

A fast neutron beam is extracted from the reactor with the aid of a collimator previously described.[1] The detector was a cylindrical chamber filled with He^4 to a pressure of 15 atmos. In order to improve the characteristics of the chamber, as well as to determine the energy scale, 5% of N_2 was added to the

*The angular distribution of fast neutrons in the interval of angles from 0.7 to 5° will be published later.