DETERMINATION OF THE SPIN OF Eu^{152m}

V. M. LOBASHOV, V. A. NAZARENKO, and L. F. SAENKO

A. F. Ioffe Physico-technical Institute, Academy of Sciences, U.S.S.R.

Submitted to JETP editor April 28, 1962

J. Exptl. Theoret. Phys. (U.S.S.R.) **43**, 1579-1581 (November, 1962)

The $\beta\gamma$ correlation between the β-electron momentum and γ-quantum circular polarization in the allowed branch of the Eu^{152m} β decay with an end point β-electron energy of 560 keV and relative intensity 1.2% is measured. The correlation coefficient $A_1 = +(0.40 \pm 0.10)$ indicates that a spin and parity 1^- should be assigned to the Eu^{152m} isomeric state instead of the previously accepted value 0^-.

THE spin of the isomeric state of Eu^{152m} has assumed great significance in connection with the experiment of Goldhaber et al[1] in which the neutrino polarization in K capture was measured. As is well known, the spin and parity that can be ascribed to the isomeric state of Eu^{152m} is either 0^- or 1^-. In many of the later investigations it is shown that 0^- is more probable. The basis for this are the following facts:

1) According to Cohen et al[2], the magnetic moment of Eu^{152m} is either zero or at any rate very close to it.

2) The β transition to the first excited level of Ge^{152}, judging from the form of the β spectrum and the value of the angular $\beta\gamma$ correlation coefficient[3], is interpreted as unique and first-forbidden (see the figure).

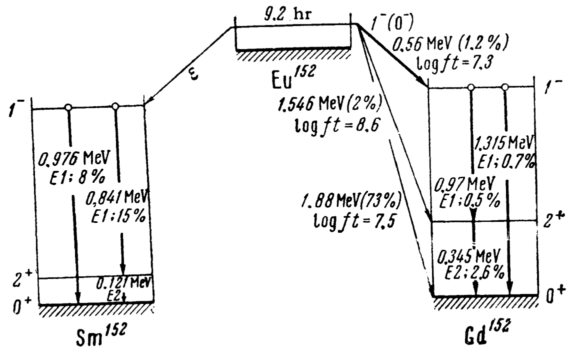
3) No γ transition from the isomeric state Eu^{152m} to the ground state has been observed[4], and the hindrance factor is very large ($\sim 10^{12}$).

Nonetheless, it is indicated in the foregoing investigations that one can not exclude a unity spin value on the basis of these data.

To obtain an unambiguous answer we measured the correlation between the momentum of the β-electron transition with end-point energy 560 keV and the circular polarization of the γ quantum with energy 1327 keV.

The investigated β transition is allowed, so that the interpretation of the results of the experiment can be carried out with great certainty. As can be seen from the decay scheme (see the figure), its intensity is $\sim 1.2\%$ of the total number of Eu^{152m} decays, so that an investigation of the polarization correlation entailed considerable difficulties in view of the low transmission of the correlation apparatus.

The measurements were carried out with apparatus previously described[5]. In view of the fact that the decay of Eu^{152m} is very similar to the Pr^{144}, decay dealt with in that paper, the experimental procedure used is analogous.



The Eu^{152m} sources were prepared by depositing Eu oxide on aluminum foil with subsequent irradiation in the reactor of the Institute. The surface density of the sources was $\sim 100\ \mu g/cm^2$.

The measurements yielded

$$\Delta = 2(I_1 - I_2)/(I_1 + I_2) = +(1.6 \pm 0.4)\%,$$

where $I_{1,2} = R_{coinc}/R_\gamma \theta_\beta$; R_{coinc} and R_γ are the counting rates of the coincidences and of the single pulses of the γ channel, θ_β is the correction for the influence of the magnetic field in the β channel (0.03%), and the indices 1 and 2 pertain to different directions of the polarimeter magnetization. The calculated correlation coefficient with account of the random-coincidence background, the geometry, and the efficiency of the γ polarimeter is $A_1 = +(0.40 \pm 0.10)$.

Assuming universal VA interaction, the correlation coefficient for the transitions $0^- \xrightarrow{\beta} 1^- \xrightarrow{\gamma} 0^+$ should be +1.00. For the case $1^- \xrightarrow{\beta} 1^- \xrightarrow{\gamma} 0^+$ the correlation coefficient depends on the interference between the Fermi and the Gamow-Teller nuclear matrix elements and is equal to

$$+\tfrac{1}{2}(1 \pm 2\sqrt{2}\lambda)(1+\lambda^2)^{-1};$$

here

$$\lambda = C_V\,|M_F|/C_A\,|M_{GT}|.$$

It is obvious that our result can be reconciled only with the second case, i.e., $1^- \xrightarrow{\beta} 1^- \xrightarrow{\gamma} 0^+$, with $0 < |\lambda| < 0.15$.

A thorough check was made of the role of different factors that could decrease the correlation coefficient. The greatest attention was paid among them to the admixture of the 975-keV γ line, which has opposite circular polarization (see the figure), and to the dead time of various parts of the radio circuitry. The latter is very important since the β-channel count was $\sim 5 \times 10^5$ counts per second. It was established that the 975-keV γ-line admixture was less than 5%, so that the maximum reduction in the correlation coefficient does not exceed 7% of the effect. The role of the dead time of the radio circuitry and of the photomultiplier turned out to be small.

It should be mentioned that the same apparatus was used previously to measure $\beta\gamma$ correlations in β decays of Co^{60} and Au^{198},[6] the results of which are in good agreement with the data by others. In view of this, the influence of the apparatus factors which reduce the correlation seems to be of low probability.

Of course, the foregoing is valid only if the Eu^{152m} β-decay scheme shown in the figure is correct. There are apparently no grounds for doubting this scheme at present.

We already mentioned that the data of [2-4] cannot exclude absolutely 1^- spin and parity values for Eu^{152m}, so that our result does not contradict these data, although it does make their interpretation more difficult.

As regards the experiment of Goldhaber[1], the change in the Eu^{152m} spin does not change the main conclusion regarding the neutrino helicity, but merely limits the possibility of further refinement of the neutrino polarization in experiments with Eu^{152m}, inasmuch as for a transition of the $1^- \xrightarrow{\epsilon} 1^-$ type it is necessary to know the ratio of the Fermi and the Gamow-Teller nuclear matrix elements.

In conclusion the authors express their gratitude to Professor D. M. Kaminker for continuous interest in the work, and also to G. D. Chuklin and V. B. Belyakov for participating in the construction of the apparatus and in the measurements. The authors are deeply indebted to A. I. Egorov for preparing the Eu^{152m} sources.

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Translated by J. G. Adashko
273