THE g-FACTORS FOR COLLECTIVE AND INTERNAL MOTION IN Tb^{159} AND Yb^{173} NUCLEI

É. E. BERLOVICH, M. P. BONITZ,* and M. K. NIKITIN

Leningrad Physico-Technical Institute, Academy of Sciences, U.S.S.R.

Submitted to JETP editor October 11, 1960

J. Exptl. Theoret. Phys. (U.S.S.R.) 40, 749-751 (March, 1961)

The transition probabilities for magnetic dipole transitions from the first excited states in Tb^{159} and Yb^{173} nuclei have been measured with a multi-channel time analyzer. The gyromagnetic ratios calculated on the basis of the unified model are compared with results of experiments on Coulomb excitation. The experimental results show that the g-factors for collective motion are close to those estimated on the basis of the unified model according to the formula $g_R \approx Z/A$.

THE knowledge of the lifetimes of magnetic dipole transitions and in addition the magnetic moments μ of the nuclei allows one to determine separately the g-factors of collective motion (g_R) and internal particle motion (g_K) on the basis of the unified model.[1]

In the method of Coulomb excitation the reduced probability of E2 transitions B(E2) is determined directly from experiment, and the reduced probability of M1 transitions B(M1) is calculated from the ratio of the intensities of the two components $\delta^2 = \lambda(E2)/\lambda(M1)$, where λ is the transition probability. However, in those cases in which the M1 component makes up the preponderant fraction of the radiation, the determination of g-factors by the method of Coulomb excitation becomes very unreliable, since it is based on the accuracy of the knowledge of the small amount of E2 admixture.

It is clear that in such cases, which are frequent, it is expedient to make a direct measurement of the lifetime of the level by the method of delayed coincidences.

In Figs. 1 and 2 are shown the results of measuring the half-lives of the 58-kev level in Tb^{159} and the 78.7-kev level in Yb^{173}, obtained with a multichannel time analyzer which has been described earlier.[2]

In the case of Yb^{173}, coincidences of the 272-kev gamma ray with conversion electrons from the 78.7 kev transition were counted. A compound of Co^{60} was used as a comparison source (for β-γ coincidences). In the case of Tb^{159} coincidences of the characteristic x-rays with conversion electrons from the 58-kev level were counted, and the comparison source used was Hg^{203} (for β-γ coincidences). This comparison source exhibits the accurately known lifetime of the 279-kev level of Tl^{203}, and the weighted average value from many measurements[2,3] of the half-life is $T_{1/2} = (2.90 \pm 0.12) \times 10^{-10}$ sec. In this case, the use of Co^{60} as a comparison standard was inconvenient because of the excessive difference in the energies of the two radiations.

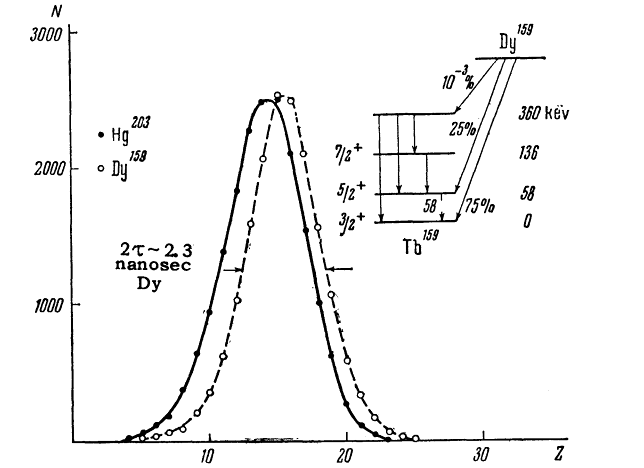

FIG. 1. Determination of the lifetime of the 58 kev level in Tb^{159}. N is the number of coincidences; Z is the channel number in the time analyzer. The channel width is 1.92×10^{-10} sec.

Having as a goal the complete removal of instrumental shifts in coincidence time (which become very significant in the measurement of such short times), we applied the method of "control of single pulses," which has been described in detail previously.[2]

The experimental values for the half-lives are:

$T_{1/2} = (1.3 \pm 0.4) \cdot 10^{-10}$ sec for the 58-kev level of Tb^{159},
$T_{1/2} = (3.8 \pm 0.5) \cdot 10^{-11}$ sec for the 78.7-kev level of Yb^{173}.

*Dresden Polytechnic Institute, German Democratic Republic.

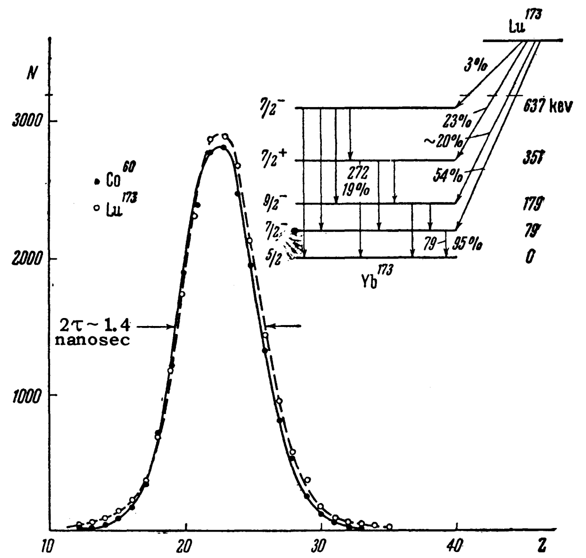

FIG. 2. Determination of the lifetime of the 78.7-kev level in Yb^{173}. The channel width is 2.16×10^{-10} sec.

The values for the g-factors are:

$$g_R = 0{,}44 \pm 0.10,\ g_K = 1{,}37 \pm 0{,}08 \quad \text{for } Tb^{159},$$
$$g_R = 0.35 \pm 0{,}04,\ g_K = -0{,}52 \pm 0{,}02 \quad \text{for } Yb^{173}.$$

The magnetic moments of Tb^{159} and Yb^{173} have been taken equal to 1.5 nuclear magnetons[4] and − 0.67 nuclear magnetons[5] respectively. The sign of the ratio $(g_K - g_R)/Q_0$ is known from work on angular correlation;[6,7] this permitted the choice of one of two possible sets of values for g_K and g_R.

In the case of Tb^{159}, our values for the g-factors differ markedly from the results of investigations by Coulomb excitation[8,6] (however, the results of the two works referred to also differ significantly from each other). We think that all the disagreement arises predominantly from the inaccurate knowledge of the E2 admixture, an account of which is important in the calculation of the g-factors from the results of experiments by Coulomb excitation.

In the case of Yb^{173} the g-factors obtained agree satisfactorily with the results of de Boer et al.[7] by Coulomb excitation. With the amount of admixture (4.5%) of the E2 component (this was well determined in the work of Romanov et al.[9]), the magnitude of the internal quadrupole moment of the nucleus Yb^{173} can be determined. $Q_0 = 8.4 \times 10^{-24}\ cm^2$, in agreement with the results of other work,[8,10] and also with the magnitudes of quadrupole moments in this region of nuclei.

Finally, the values for the g-factors for collective motion which we determined are close to the value $g_R = Z/A$ which corresponds to the unified model value for a homogeneous charge distribution. The latter values are 0.41 for Tb^{159} and ~ 0.4 for Yb^{173}. However, the Coulomb excitation results for Tb^{159} give for this quantity 0.1 (reference 8) and 0.25 (reference 6), and 0.31 for (reference 7) Yb^{173}.

[1] A. Bohr and B. Mottelson, Kgl. Dan. Vid. Selsk., Mat.-Fys. Medd. **27**, 16 (1953). A. Bohr, Rotational States of Atomic Nuclei, Copenhagen, Munksgaard 1954.

[2] M. Bonitz and E. J. Berlovich, Nucl. Instr. Meth. **9**, 13 (1960).

[3] Bashandy, Gerholm, and Lindskog, Ark. för Fys. **17**, 24, 421 (1960).

[4] J. M. Baker and B. Bleaney, Proc. Phys. Soc. **68A**, 257 (1955).

[5] K. Krebs and H. Nelkowski, Z. Physik **145**, 543 (1956).

[6] Martin, Marmier, and de Boer, Helv. Phys. Acta **31**, 435 (1958).

[7] de Boer, Martin, and Marmier, Helv. Phys. Acta **32**, 377 (1959).

[8] Huus, Bjerregaard, and Elbek, Kgl. Dan. Vid. Selsk., Mat.-Fys. Medd. **30**, 17 (1956).

[9] Romanov, Iodko, and Tuchkevich, JETP **38**, 1019 (1960), Soviet Phys. JETP **11**, 733 (1960).

[10] Elbek, Nielsen, and Olesen, Phys. Rev. **108**, 406 (1957).

Translated by C. S. Littlejohn
121