Nuclear orientation of ^{103}Ru: Reanalysis

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Previous low-temperature nuclear orientation and angular correlation data from the decay of ^{103}Ru are reanalyzed in order to determine more precise values for the ^{103}Ru magnetic moment and the ^{103}Rh gamma-ray mixing ratios.

[NUCLEAR STRUCTURE ^{103}Ru; reanalyzed $\gamma(\theta)$, $\beta\gamma(\theta)$, $\gamma\gamma(\theta)$; ^{103}Ru, deduced μ; ^{103}Rh deduced $E2/M1$ δ.]

In a previous publication,[1] the decay of ^{103}Ru oriented at low temperature was investigated in order to extract the ^{103}Ru magnetic moment and properties of levels and transitions in ^{103}Rh. Since that publication, the ^{103}Ru-^{103}Rh decay has been revised considerably[2]; in particular, the ^{103}Ru ground state is now assigned spin $\frac{3}{2}$, rather than $\frac{5}{2}$ as was assumed in Ref. 1. In this Brief Report the data of Ref. 1 are reanalyzed in accordance with the presently accepted decay scheme and the results are compared with more recent nuclear orientation (NO) studies. Some comments are made regarding the presently available set of ^{103}Ru decay data.

The ^{103}Ru decay scheme is shown in Fig. 1.

From the gamma-ray angular distributions from oriented nuclei, it is, in general, not possible to deduce both the magnetic moment of the decaying state and the multipole mixing ratio of the gamma ray; in general, one or the other must be known or independently determined in order to complete the analysis. The angular distribution of the intense 497-keV gamma ray was previously determined[1] to be $B_2U_2A_2 = -0.020(1)$ at the temperature $T = 5.5(1)$ mK. The 497-keV mixing ratio can be deduced from the previously measured beta-gamma circular polarization correlation,[3,4] $A = -0.107(11)$; with the present decay scheme, the beta decay is $\frac{3}{2}^+$-$\frac{5}{2}^+$ (pure Gamow-Teller), and the beta-gamma correlation can then be analyzed for the 497-keV $E2/M1$ multipole mixing ratio:

$$\delta(497) = -0.368(11) \ .$$

(An analysis of this sort was not possible with the previous level scheme, since the beta decay was taken to be mixed Fermi and Gamow-Teller.) This value is in reasonably good agreement with those determined from recent NO work, $-0.42(4)$ by Murray *et al.*[5] and $-0.34(5)$ by Hagn *et al.*[6] With the above deduced value for $\delta(497)$, our previous NO data for the 497-keV anisotropy can be analyzed for the ^{103}Ru magnetic moment:

$$|\mu| = 0.200(7)\mu_N \ .$$

This value is in agreement with the result $0.18(2)\mu_N$ of Murray *et al.*,[5] deduced from NMR on oriented nuclei, and also with the result $0.225(60)\mu_N$ of Hagn *et al.*,[6] deduced from the 497-keV angular distribution (using a less precise value of the 497-keV mixing ratio).

Thus using the more precise value of $\delta(497)$ from the beta-gamma correlation permits a precise deduction of μ from the NO data, free from the ambiguities that arise in the analysis owing to correlations of δ and μ in the high-temperature region (as discussed by Hagn *et al.*[6]).

From our previous 610-keV angular distribution,

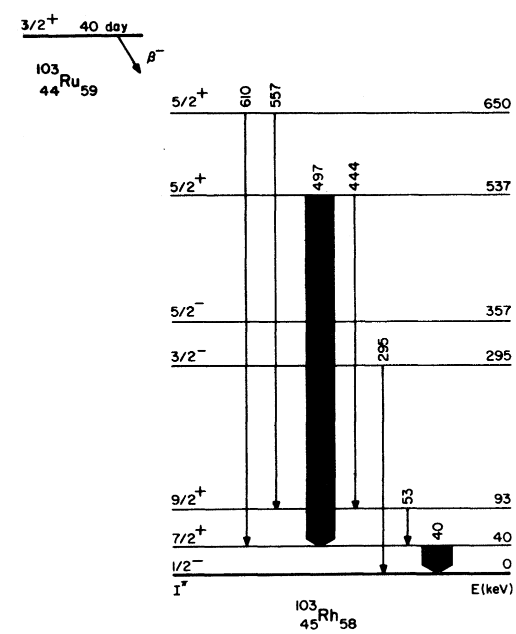

FIG. 1. Decay of ^{103}Ru.

$B_2U_2A_2 = 0.018(13)$, it is now possible to recalculate the $E2/M1$ mixing ratio; two ranges are permitted:

$$\delta(610) = +0.09 \pm 0.14 \ ,$$

or

$$\delta(610) > +11 \ , \quad < -6 \ ,$$

in agreement with the values of Murray *et al.*[5] $+0.15(3)$, $> +20$, < -80. Internal conversion measurements[7,8] are of no hope in deciding between $M1$ and $E2$ multipolarity for this transition, since the K-conversion coefficients are virtually identical for $M1$ and $E2$, and the L-conversion lines are too weak to be measured. The beta-gamma correlation involving this transition has been measured,[4] with the result $A \simeq +0.3$ to $+0.5$. With a pure $\frac{3}{2}^+$-$\frac{5}{2}^+$ Gamow-Teller beta decay, the smaller value of $\delta(610)$ gives $A = -0.58(12)$ and the larger value gives $A = 0.00(13)$; neither is in particularly good agreement with the measured value, although only the latter permits positive values of A. The question of the 610-keV multipole mixing ratio must therefore remain unresolved.

Additionally, it should be noted that according to the presently accepted decay scheme, the 444-53 and 557-53 angular correlations should be identical, since in both cases the first transition is pure $E2$ $\frac{5}{2}^+$-$\frac{9}{2}^+$. The expected angular correlation coefficient is $A_{22} = -0.131(40)$, where the uncertainty allows for the range of possible 53-keV mixing ratios ($|\delta| < 0.05$, from internal conversion measurements[7,8]). The previous angular correlation data have been summarized[9] (although the 557-53 analysis was done using the old spin assignments) and, in general, the results for the A_{22} values of the two cascades are in very poor agreement, even differing in sign. Although this difference has previously been the basis for arguing in favor of different spin assignments for the 650- and 537-keV levels, the most recent gamma-gamma measurement done by Bargholtz *et al.*[10] shows good agreement between the two cascades. (In fairness to the previous investigators, it should be pointed out that all reported measurements of the 557-53 correlation give the expected magnitude and sign; only in the case of the 444-53 correlation do discrepancies occur, and in this case the cause may be interdetector scattering of the intense 497-keV transition, as discussed by Bargholtz *et al.*[10]) A recently reported beta-gamma-gamma correlation[11] also shows this discrepancy in sign.

Finally, the previous beta-decay branching to the 40-keV, $\frac{7}{2}^+$ state (which would not be consistent with the $\frac{3}{2}^+$ assignment to ^{103}Ru) has recently been shown to be erroneous,[12] thus removing yet another objection to the $\frac{3}{2}^+$ assignment. It is thus concluded that the previous NO data can be precisely, directly, and consistently analyzed with the presently accepted spin assignments, and that those assignments are consistent with the presently available angular correlation data.

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