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V–6 Magnetic Moments of ^{183}Re, ^{184}Re and ^{184m}Re Measured by Nuclear Orientation

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In the odd-odd nucleus ^{184}Re the ground state with $I^\pi = 3^-$ and an isomeric state with $I^\pi = 8^+$ are known to decay by electron capture (E. C.) with half lives of 38d and 169d, respectively to ^{184}W.[1] The magnetic moments of these states allow a determination of the Nilsson assignments of the odd nucleons involved and provide a check of the additivity theorem for magnetic moments in the region of deformed nuclei. We have measured the magnetic moments of these states as well as that of the $I^\pi = 5/2^+$ ground state of ^{183}Re ($T_{1/2} = 71$d) by the method of nuclear orientation.

The Re activities were obtained by deuteron bombardment of natural tungsten. Sources of $\ll 1$ at % of Re in iron were prepared in the following way.[2] The Re fraction was extracted from the irradiated material by ion exchange chemical separation. The activity was electroplated into iron foils which were subsequently molten.

The Re(Fe) foils were polarized at low temperatures by an external magnetic field. The magnetic hyperfine interaction $\mu \cdot H$ was determined from measurements of the temperature dependence of the anisotropies of gamma rays in the ^{183,184}W daughter nuclei. For all three states more than one gamma ray was analyzed for the determination of $\mu \cdot H$. Two examples of our results are shown in Figs. 1 and 2.

The analysis was performed by fitting the theoretical ratio $W(0)/W(90)$ with[3]

$$W(\theta) = \sum_k B_k U_k F_k P_k(\cos\theta)$$

to the experimental data. In the fits the hyperfine interaction and in some cases one further quantity (multipolarity of gamma or E. C. transitions) was varied.

A few cases deserve a comment. For the 292 keV transition in ^{183}W we fitted in addition to the hyperfine interaction the multipolarity of the proceeding $\Delta K = 1$, $5/2^+ \rightarrow 5/2^-$ E.C. transition and obtained

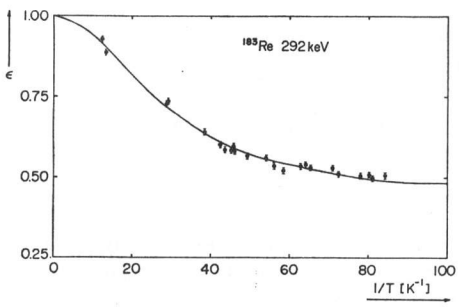

Fig. 1. Temperature dependence of the anisotropy $W(0)/W(90)$ for the 292 keV γ-ray fed by the decay of ^{183}Re.

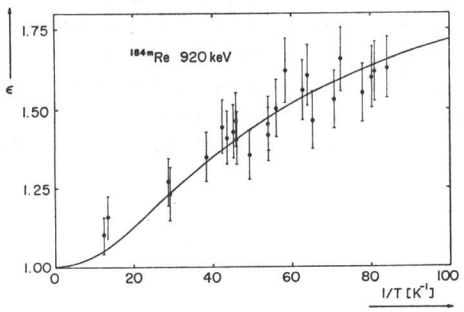

Fig. 2. The anisotropy of the 920 keV transition fed by the decay of ^{184m}Re.

almost pure $L = 1$. This result is consistent with the K selection rule which inhibits the $L = 0$ part. In cases where the multipolarity of the γ-transition itself was not established or not accurately enough known, it could be determined also from the fits. Using the value of $-(760 \pm 15)$ kG for the magnetic hyperfine field for Re in iron,[4] we obtain the magnetic moments given in Table I. For the $5/2^+$ [402] ground state in ^{183}Re one expects from the Nilsson model[5] the same magnetic moment as for the analogous state in ^{185}Re. For comparison the experimental value for ^{185}Re is given in the fourth column of the table (listed as μ_{th}).

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Table I. Comparison of experimental and theoretical magnetic moments.

Isotope	I	μ_{exp}	μ_{th}	Nilsson assignment
^{183}Re	$5/2^+$	2.88(12)	3.173(2)	$5/2^+[402]_p$
^{184}Re	3^-	2.67(16)	2.48(9)	$\{5/2^+[402]_p + 1/2^-[510]_n\}$
^{184m}Re	8^+	2.77(14)	2.53(12)	$\{5/2^-[402]_p + 11/2^+[615]_n\}$
			4.20(12)	$\{9/2^-[514]_p + 7/2^-[503]_n\}$

The theoretical values for ^{184}Re were calculated using the expression

$$\mu_{pn} = \frac{I}{I+1}(g_{Kp} + g_{Kn}K_n + g_R) \text{ with}$$
$$g_K K = g_l\langle l_3\rangle + g_s\langle s_3\rangle.$$

The quantities g_K and g_R used for the calculation of μ_{th} were derived in the following way: (i) For the $5/2^+[402]$ proton and the $1/2^-[510]$ neutron levels g_K and g_R were deduced from known magnetic properties of the ground state bands in ^{185}Re and ^{183}W, respectively. (ii) For the other states the g_K values were calculated with Nilsson wave functions using effective g_s factors of 0.685(17) for the proton states and 0.828(34) for the neutron states, respectively, derived from the experimental magnetic properties of the ^{185}Re and ^{183}W states mentioned above. For g_R a value of 0.4(1) was adopted. For the 8^+ isomeric state in ^{184}Re the configuration $\{9/2^-[514]_p + 7/2^-[503]_n\}$ is definitely excluded. For the other configurations the agreement between experimental and calculated moments is very good. The additivity is fulfilled within approximately 10%.

References

1) A. H. Kucoč, B. Singh, J. D. King and H. W. Taylor: Nuclear Phys. **A143** (1970) 545.
2) E. Gerdau, W. K. Müller and H. J. Wolf: Z. Phys. **235** (1970) 124.
3) S. R. De Groot, A. H. Tolhoek and W. J. Huiskamp: in *Alpha-, Beta- and Gamma-Ray Spectroscopy*, ed. K. Siegbahn (North Holland Publ. Co., Amsterdam 1965) chap. XIX B.
4) D. A. Shirley: in *Hyperfine Structure and Nuclear Radiation*, ed. E. Matthias and D. A. Shirley (North Holland Publ. Co., Amsterdam 1968) app. B.
5) I. L. Lamm: Nuclear Phys. **A125** (1969) 504.