If the decay scheme suggested in Fig. 3 is indeed the correct one, some striking similarities can be noted between the two branches of the decay. The ratio of the energy of the second excited state to that of the first in Os^{192} is 1.98, while the corresponding ratio in Pt^{192} is 1.94. The ratio of intensities of the transitions among the lowest four levels is remarkably similar in the two branches. As in Pt, the parities of the first four Os levels are all positive. The spin of level *b* is 2. The spin of level *c* can be limited to (1, 2, or 3), and that of level *d* to (3 or 4). This is consistent with the spin assignments made in the Pt branch.

The intensities of the gamma rays indicate that $\sim$3.5% of the Ir^{192} decays go by electron capture to Os^{192}. These transitions lead to levels *d* and *e*, with the relative intensities 2:1.5. An upper limit of 10^{-6} positrons per decay can be put on the intensity of positron emission, from a search for a positron spectrum. From this, the energy of the transition of level *d* must be less than 1.3 Mev, with a corresponding upper limit of 2 Mev for the $Ir^{192}-Os^{192}$ mass difference.

ACKNOWLEDGMENTS

We wish to acknowledge the assistance of E. Hatch, S. Raff, and P. Snelgrove in the collection of data, and of F. Humphrey for chemical separations.

PHYSICAL REVIEW VOLUME 100, NUMBER 5 DECEMBER 1, 1955

First Excited State of Mn^{55}†

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(Received July 21, 1955)

The spin of the first excited state of Mn^{55} at 128 kev has been measured in the electric excitation process with 3-Mev alpha particles. Determinations of the K conversion coefficient and the angular distribution of the gamma rays lead to a spin assignment of $7/2^-$ for the excited state and multipolarity $M1$ for the transition to the ground state. The K conversion coefficient ($\alpha_K=0.0144\pm0.003$) was measured by comparison with the known coefficient of the 137-kev transition in Ta^{181}. The spin, parity, and transition probability are consistent with those expected for a rotational state.

INTRODUCTION

The first excited state of Mn^{55} at 128 kev has been observed in the reactions[1–3] $Mn^{55}(p,p')Mn^{55*}$ and $Mn^{55}(n,n')Mn^{55*}$ and in electric excitation.[4] Electric excitation, which has been shown to be $E2$, and multipolarity of the decay, shown below to be $M1$, show that the level has negative parity, since the ground state is $5/2^-$. Since the nature of the level is not known, it is of interest to determine whether the spin, as well as the parity, is consistent with the rotational prediction[5] of 7/2. We have measured the K conversion coefficient and the angular distribution of the gamma rays following electric excitation of this level in order to determine the spin. Alpha particles from the Duke 4-Mev Van de Graaff accelerator were used as the bombarding particles.

CONVERSION COEFFICIENT

In this case, where both $M1$ and $E2$ decay are allowed, the analysis of the angular distribution of the gamma rays is unique only if one can determine the multipolarity of the transition by other means. This can be done, of course, from conversion measurements. For low-energy transitions in light elements, the K conversion coefficient is much more sensitive to multipolarity than the K/L ratio. We have measured the K conversion coefficient by comparing the number of K electrons and gamma rays of the 128-kev transition from a thin Mn target with those of the 137-kev transition from a thin Ta target. Since the K conversion coefficient for the latter transition is known, one can determine the coefficient for the Mn transition. The targets were made by vacuum evaporation. The Mn was evaporated on a thick carbon backing, while the Ta was evaporated on a thick copper backing. The electrons were measured using a wedge-shaped magnetic beta-ray spectrometer.[6] The gamma rays from the same targets were detected with a NaI crystal mounted on a Dumont 6292 phototube. Since the two gamma rays are of essentially the same energy, no correction was necessary for absorption or crystal efficiency.

The results of the conversion measurements are as follows: the ratio of Ta K electrons to Mn K electrons is 4.9 ± 0.5 and the ratio of Ta gamma rays to Mn gamma rays is 0.039 ± 0.004. These individual ratios depend, of course, on the target thicknesses. From these data one concludes that the ratio of α_K(Ta) to α_K(Mn)

† This work was supported in part by the U. S. Atomic Energy Commission.

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is 125±25, where α is the conversion coefficient. The Ta 137-kev transition has been established to be ~90% $M1+10\%$ $E2$.[7,8] Using this mixing ratio and the recent theoretical calculations of internal conversion coefficients by Rose,[9] one finds $\alpha_K(\mathrm{Ta})=1.8$. Then we have $\alpha_K(\mathrm{Mn})=0.0144\pm0.003$. This is in very good agreement with the value of $\alpha_K(\mathrm{Mn})=0.0141$ one obtains from the measurements of the yield of K electrons by Huus and the yield of gamma rays by Temmer and Heydenburg. From the theoretical calculations one finds $\alpha_K^{E2}(\mathrm{Mn})=0.15$ and $\alpha_K^{M1}(\mathrm{Mn})=0.014$. We therefore conclude that the Mn 128-kev transition is all or nearly all $M1$, with an upper limit of 2% $E2$.

ANGULAR DISTRIBUTION

The angular distribution of the Mn gamma rays was measured using the distribution equipment of Goldburg and Williamson.[10] A thin layer of Mn evaporated on 0.005-inch copper was used as the target. The target was placed at 45° to the alpha beam and the gamma rays were observed at 0° and 90° with respect to the beam such that the thickness of copper between the target and the NaI detector was the same at both angles. To check left-right symmetry the target was rotated through 90° and the gamma rays observed at 0° and 270° with respect to the beam. Since the target angle could be set to better than $\frac{1}{4}$° there was less than one percent change in the 0° yield between the two target settings. The left-right anisotropies agree with each other within one percent. The entire spectrum was covered by a 10-channel differential pulse-height analyzer. Total counting rates were 20 000 counts per run. The only background present was machine background which was rather constant. This background, which was about ten percent of the total counting rate, was measured after each run and subtracted out. The distributions were measured at 3-Mev alpha-particle energy. For purposes of comparing with the theory, we define the experimentally observed anisotropy as:

$$C=[I(0°)-I(90°)]/I(90°),$$

where $I(\theta)$ is the gamma intensity corrected for background at an angle θ with respect to the beam.

Although resonances due to compound nucleus formation were observed in the excitation of this level with protons above 1 Mev,[2] the Coulomb penetrability for 3-Mev alpha particles is several orders of magnitude below the value for 1-Mev protons. Appreciable compound nucleus formation at this alpha energy seems unlikely especially in view of the excitation curve of Temmer and Heydenburg.[4] Therefore, the theoretical anisotropies were determined from the calculations of Alder and Winther[11] assuming pure electric quadrupole excitation. Although these calculations do not agree exactly with experiments,[10,12] the agreement is, in general, good enough to assign spins. In the case considered here the disagreement could lead to anisotropies which differ by about ten or fifteen percent from the ones calculated; however, this does not affect the conclusions given below. For pure magnetic dipole decay the theoretical angular distribution function can be written as[11]

$$W(\theta)=1+a_2A_2P_2(\cos\theta), \qquad (1)$$

where A_2 is the angular correlation coefficient for a pure gamma-gamma correlation calculated by Biedenharn and Rose,[13] and a_2 is the energy-dependent parameter given in reference 11. Equation (1) can, of course, be written in the form

$$W(\theta)=1+C_2\cos^2\theta.$$

Then C_2 becomes the theoretical counterpart of the measured anisotropy C.

The calculated values of C_2 for the three possible spins are: $3/2(M1)5/2$, $+0.033$; $5/2(M1)5/2$, -0.073; and $7/2(M1)5/2$, -0.023. The experimentally measured value is $C=-0.012\pm0.015$. This is an average value for six runs. Comparing C with the theoretical anisotropies we conclude that the spin of the 128-kev level in Mn is 7/2. It should be noted that if one allows as much as a 5% admixture of E_2 in the decay of this state, the theoretical anisotropy calculated for a spin of 7/2 still agrees with the experiment if the value of δ is taken to be positive,[14] but the theoretical value for a spin of 5/2, using a negative sign for δ, comes very close to the lower limit of the measured value. However, from the conversion measurement one concludes that it is unlikely that the admixture of $E2$ is over 2%.

CONCLUSION

The spin and parity of this level and the large $E2$ transition probability (~20 times single-particle estimates[2,4]) are consistent with those expected for a rotational state, providing strong evidence for collective excitation. However, particle transitions may be expected to have enhanced $E2$ transition probabilities due to coupling with the nuclear surface.[15] Since the ground state configuration of Mn^{55} is complex, one should not rule out the possibility of a many-particle transition.

We would like to express our appreciation to Dr. Walter I. Goldburg and Dr. Robert M. Williamson for the use of their distribution equipment and their valuable advice concerning the distribution measurements.

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