Letters to the Editor

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On the Cs^{137} Disintegration Scheme

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THE beta- and gamma-ray spectrum of Cs^{137} (33 yrs.) has been measured by Townsend, Owen, Cleland, and Hughes[1] who find that the beta-ray spectrum is simple with an end point at 0.550 Mev. In addition, there is only one gamma-ray of energy 0.663 Mev which is internally converted. Later, Townsend, Cleland, and Hughes[2] showed that there were no coincidences between the beta- and gamma-rays and proved that the beta-disintegration leads to a metastable state of Ba^{137} which has a half life of 158 ± 5 sec. The gamma-ray is emitted from this metastable state.

In this laboratory various groups have been using the Cs^{137} internal conversion line for calibration purposes and have some additional information to add to this problem.

We have confirmed (with J. L. Meem, Jr. and F. Maienschein) that there are no beta-gamma-coincidences. The half-life of the Ba^{137} metastable state has been measured and a value of 156 ± 3 secs. obtained, in agreement with the earlier work.

The K and L internal conversion lines of the 0.663 Mev gamma-ray have been resolved and the ratio N_K/N_L has been determined by several investigators. The best value for this ratio is 4.8 ± 0.3. In addition, the internal conversion coefficient α_K has been measured and is 11.8 percent.

From this information, the spin change connected with the transition from the metastable state of Ba^{137} to the ground state can be calculated. From the curves of Hebb and Nelson,[3] for the value of Z^2/E associated with this gamma-ray, a value of $N_K/N_L=4.8$ is obtained for a spin change $\Delta l=5$ and 6.6 for a spin change of 4. The experimental value $N_K/N_L=4.8$ indicates that the spin change is $\Delta l=5$.

The internal conversion coefficient can be calculated as a function of spin change from the theory of Dancoff and Morrison. One obtains the following values for $\alpha_K{}^l$, for electric multipole radiation: 2.19, 5.80, 15.15, 39.2 percent for $\Delta l=3$, 4, 5, and 6, respectively. For magnetic multipole radiation one obtains for $\beta_K{}^l$: 7.88 and 20.0 percent for $\Delta l=2$ and 3, respectively. The best agreement is obtained on the assumption that the radiation is electric 2^5 pole. This entails a spin change of 5 and a change of parity.

Finally the spin change can be roughly determined from the life-time of the metastable state. Using the formula given by Bethe[4]

$$\tau=5\times10^{-21}(l!)^2\left(\frac{20}{E_\gamma}\right)^{2l+1}\text{ sec.,}$$

the following values of the half-life, $t_{\frac{1}{2}}$, we obtain: 4×10^{-5}, 0.9, and 2.8×10^4 secs. for $l=4$, 5, and 6, respectively. Here the theory is less exact. The half-life is consistent with $\Delta l=5$.

Since the spins and magnetic moments of Cs^{137} and Ba^{137} (ground state) are known,[5] one is tempted to draw an energy level diagram showing the spins of each level. If this be done, certain difficulties are encountered which we should like to point out. The spin of the ground state of Ba^{137} is 3/2 and magnetic moment 0.235. Three lines of evidence make it appear very probable that there is a spin change of 5 connected with the transition Ba^{137} (excited) to the ground state. This would require that the spin of Ba^{137} (excited) be 13/2. The spin of Cs^{137} is said to be[5] 7/2. We have calculated the (ft.) value for the beta-transition $Cs^{137}\rightarrow Ba^{137}$ (excited) and have found the value 0.3×10^{10}, which would place this transition in the third forbidden group. According to Gamow-Teller selection rules, this requires a parity change and a spin change $\Delta l=\pm3$, ±4. Fermi selection rules require a change of parity and $\Delta l=\pm2$, ±3. A value of $\Delta l=3$, should be chosen if the arguments advanced in this note for the spin of Ba^{137} (excited) are correct. It is very difficult to understand how the beta-transition $Cs^{137}\rightarrow Ba^{137}$ (ground state) can be more highly forbidden than that corresponding to $Cs^{137}\rightarrow Ba^{137}$ (excited) since the arguments advanced here would require a spin change of only 2 and no change of parity.

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[1] J. Townsend, G. E. Owen, M. Cleland, and A. L. Hughes, Phys. Rev. **74**, 99 (1948).
[2] J. Townsend, M. Cleland, and A. L. Hughes, Phys. Rev. **74**, 499 (1948).
[3] M. H. Hebb and E. Nelson, Phys. Rev. **58**, 486 (1940).
[4] H. A. Bethe, Rev. Mod. Phys. **9**, 226 (1947).
[5] H. H. Goldsmith and D. R. Inglis, The Properties of Atomic Nuclei. I. Spins, Magnetic Moments, and Electrical Quadrupole Moments, Brookhaven National Laboratory, October 1, 1948.

Attenuation of Sound in Rarefied Helium*

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THE attenuation of sound at 1 Mc/sec. in helium, at pressures ranging from 30 to 0.4 mm Hg, has been measured in an attempt to elucidate mean-free-path effects. At the lowest pressure reached the wave-length (about 1 mm) was two or three mean free paths.

The complex propagation constant, $K=\alpha+i(\omega/v)$, where α is the amplitude attenuation, ω the circular frequency, and v the phase velocity, is given for a viscous, heat con-