Twice Forbidden Beta-Ray Transition of Co^{60}†

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(Received February 27, 1961)

The high-energy beta-ray transition from the ground state of Co^{60} to the first excited state of Ni^{60} was studied in a magnetic spectrometer. The shape of the beta-ray spectrum is found to be consistent with that expected for a "unique" twice forbidden transition from a 5+ to a 2+ level. The relative intensity of this 1.48-Mev transition is found to be 0.12%. The comparative half-life is $\log(\langle S_2^3\rangle f_0t)=11.8$ which is in close agreement with the values found for the other "unique" twice forbidden transitions of Be^{10} and Na^{22}.

TWO conflicting reports exist on the beta decay by the very weak twice forbidden transition from the ground state of Co^{60} to the 2+ first excited state of Ni^{60}. Keister and Schmidt[1] reported that their data on the beta spectrum could not be fitted with the "unique" shape factor characteristic of a $\Delta I=3$, *no* transition, and made what appeared to be a satisfactory fit in terms of a $\Delta I=2$, *no* shape factor implying a spin of 4 for the ground state of Co^{60}. On the basis of their fit, they calculated an intensity for the 1.48-Mev transition of 0.15%. Later, Wolfson[2] claimed that the beta group could be fitted with the "unique" twice forbidden shape factor, consistent with the new evidence[3] that the spin of Co^{60} is indeed 5 rather than 4. However, Wolfson claimed that by comparison with the intensity of the internal conversion line of the 1.33-Mev gamma-ray transition, the intensity of the 1.48-Mev beta group is only 0.01%.

We have studied the beta spectrum of Co^{60} in the 40-cm radius of curvature, shaped magnetic field spectrometer. We used a strong source of about 15 mC in order to obtain data with good statistical accuracy. Although the source was relatively thick ($\sim$3 mg/cm²), the low-energy ($\sim$100% abundant) group yielded a good straight line Fermi-Kurie plot from 0.215 Mev to the end point at 0.314 Mev. The relative intensity of this group was obtained by reconstructing the allowed beta spectrum from the statistical Fermi-Kurie plot. The higher resolution in our instrument permitted us to include in our analysis of the high-energy beta group, the part of the spectrum between the conversion lines of the 1.17- and 1.33-Mev gamma transitions as well as the short stretch of spectrum beyond the lines.

We find that indeed the spectrum can be fitted by a "unique" shape factor implying a $\Delta I=3$, *no* transition, although a $\Delta I=2$, *no* spectrum shape cannot be completely ruled out because of the short energy range of definitive data, the arbitrariness of the parameter, k, and the uncertainty of the end-point energy, W_0, in a $(W^2-1)+k(W_0-W)^2$ shape factor.

On the basis of a "unique" spectrum shape, we find for the relative intensity of the 1.48-Mev beta transition, when compared directly with that of the 0.314-Mev allowed beta group, a value of 0.12% which is to be compared with Wolfson's value of 0.01. As a check on our intensity measurements, we calculated the internal conversion coefficient of the 1.17-Mev gamma-ray transition by comparing the intensity of the K conversion line with that of the 0.314-Mev beta spectrum. We obtain $\alpha=1.65\times10^{-4}$. This is in good agreement with the theoretical value for α as well as with other experimentally determined values.

Our measurements yield a value for the comparative half-life of $\log f_0t=12.97$ as compared with Wolfson's value of 14.0. The quantity which is expected to be a better constant for $\Delta I=3$, *no* transitions is $\log f_2{}^3t=\log(\langle S_2{}^3\rangle f_0t)$, which takes account of the energy dependence of the shape factor, $S_2{}^3$, in the integration over the spectrum. For two other $\Delta I=3$, *no* transitions, Be^{10} and Na^{22}, $\log f_2{}^3t=12.07$ and 11.9, respectively. For Co^{60}, the present investigation yields a value of 11.8 whereas Wolfson would get a value[4] of 12.8, which is almost an order of magnitude higher than the average.

† This work was supported by the joint program of the Office of Naval Research and the U. S. Atomic Energy Commission.

[1] G. L. Keister and F. H. Schmidt, Phys. Rev. **93**, 140 (1954).
[2] J. L. Wolfson, Can. J. Phys. **34**, 256 (1956).
[3] W. Dobrowolski, R. V. Jones, and C. D. Jeffries, Phys. Rev. **101**, 1001 (1956).
[4] Wolfson actually reports an even higher value of 13.6 for $\log f_2{}^3t$, but this appears to be the result of a computational error.