The Absolute Strength of Radioactive Sources

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IT has been the custom to determine the strength of a radioactive material by comparing the counting rate of the material in question with a "standard" source. Usually the energies of the "standard" and test sources are not comparable and, as such, corrections for absorption are required. Thus absolute source strengths usually are not very reliable, thereby sometimes preventing the accurate comparison of work from different laboratories.

In the case of ThC″, Dunworth[1] has pointed out a method for obtaining the β- and γ-efficiencies of counters as well as the strength of a source. The calculations are set up for the modified-level scheme proposed by Oppenheimer.

We have found that the absolute number of disintegrations per second in a source can be found simply from the simultaneous β- and γ-counting rates and from the β–γ-coincidence rate, independently of the solid angle subtended by the counters and of the β- and γ-efficiencies of the counters.

The relationship is

$$\frac{N_\beta N_\gamma}{N_{\beta\gamma}}=N. \tag{1}$$

N_β and N_γ are the respective counting rates of the β- and γ-counters, $N_{\beta\gamma}$ is the β–γ-coincidence rate, and N is the number of disintegrations per second occurring in the source placed between the two counters.

For a nucleus which has a simple β-spectrum followed by γ-radiation, no assumptions need be made. The value obtained is independent of the absorption of the β-radiation in the window of the β-counter as well as the absorption of the γ-rays in the walls of the γ-counter.

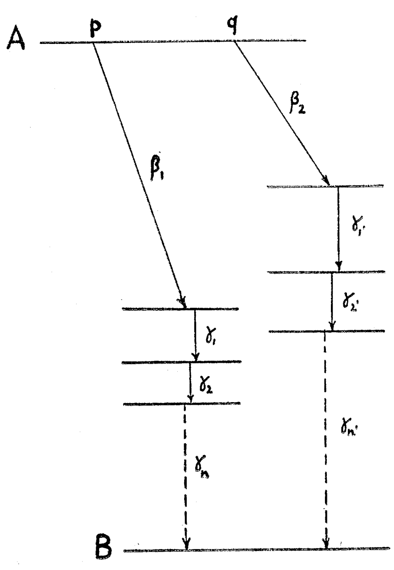

FIG. 1. Decay scheme for a complex β-spectrum.

For complex β-decay (Fig. 1)

$$\frac{N_{\beta\gamma}}{N_\beta}=\frac{[pF_1(\sum_{1'}^{n}\epsilon_n e^{-K_nT})+qF_2(\sum_{1'}^{n'}\epsilon_{n'}e^{-K_{n'}T})]\sigma_\gamma}{(pF_1+qF_2)}, \tag{2}$$

$$N_\gamma=[p(\sum_{1}^{n}\epsilon_n e^{-K_nT})+q(\sum_{1'}^{n'}\epsilon_{n'}e^{-K_{n'}T})]N\sigma_\gamma. \tag{3}$$

p = fraction of disintegrations in which a beta-ray of maximum energy β_1 is emitted ($p+q=1$). F_1 = fraction of β_1 transmitted through absorber. F_2 = fraction of β_2 transmitted through absorber. ϵ_n = efficiency of γ-counter for γ_n. K_n = absorption coefficient for γ_n. T = thickness of γ-absorber (counter wall, etc.).

At zero beta-absorber thickness F_1 and $F_2=1$. Then $N_\gamma N_\beta/N_{\beta\gamma}=N$ as in Eq. 1. That is, the absolute disintegration rate can be obtained for a complex β-decay if the value $N_{\beta\gamma}/N_\beta$ is taken at zero absorber thickness. In practice this would require that an extrapolation be made for the thickness of the counter window. This should introduce little error, however, since counter windows of only a few mg/cm² thickness are in common use.

It would seem that this method would offer a simple, accurate method of measuring long lifetimes, since no special care need be taken in reproducing counter efficiencies or geometries from one measurement to the next.

[1] J. V. Dunworth, Rev. Sci. Inst. 11, 167 (1940).

Further Work on Satellites in the Microwave Spectrum of Ammonia*

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SINCE the publication of our work[1] on hyperfine structure in the microwave spectrum of ammonia, we have observed additional satellites near lines involving J values as high as 10. The intensities of these satellites are apparently in agreement with theoretical predictions; i.e., intensity relative to the main line decreases rapidly as J value increases. In observing line positions, incident power was varied until the satellite intensity relative to the main line was a maximum; i.e., until saturation phenomena had set in. This technique was also used in our published work.[1] The separation of the satellites from the main line is also in apparent agreement with theory. Since as J values increase the satellites appear closer together and experimental measurements of $\Delta\nu/\Delta\nu'$ become less accurate, this type of check of the theory becomes less exact as J values increase. As the results already published are in agreement with and merely extend other published work[2] and give satisfactory values for quadrupole coupling, we shall not pursue the subject further.

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[1] R. J. Watts and Dudley Williams, Phys. Rev. 72, 263 (1947).
[2] Daily, Kyhl, Strandberg, Van Vleck, and Wilson, Phys. Rev. 70, 984 (1946).