Letters to the Editor

EFFECT OF COLLISIONS OF RECOIL NUCLEI ON THE CROSS SECTION FOR RESONANCE SCATTERING OF GAMMA RAYS BY Ni^{60} *NUCLEI*

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THE cross section for resonance scattering of γ rays by nuclei is very sensitive to the density of the source medium and to the lifetime of the level. To reduce the effect of collisions of recoil nuclei with surrounding molecules one usually uses sources in the gaseous state.[1,2] If the lifetime τ_γ of the level is less than $10^{-12} - 10^{-13}$ sec, investigation of the resonance effect with a liquid source can give some information concerning the nature of the interaction of the recoil nuclei with the surrounding atoms, and, in particular, concerning the mean free path of the recoil atom in the medium.

We have investigated the resonance scattering of γ rays with an energy of 1330 kev by Ni^{60} nuclei, using gaseous and liquid sources of Co^{60} in the compound $CoCl_2$. Earlier,[3] for a gaseous source, a value of $(17.1 \pm 3)\cdot 10^{-27}$ cm^2 was obtained for the average cross section for the resonance scattering.

A strong effect was also observed in using a liquid source (solution of $CoCl_2$ in HCl) with an activity ~ 40 mC. This enabled us to determine τ_γ by self-absorption to be $(1.14 \pm 0.37) \times 10^{-12}$ sec, which is in good agreement with the data of other authors.[4,5] The cross section for resonance scattering for the liquid source was found to be $(1.73 \pm 0.2) \times 10^{-27}$ cm^2.

The lifetime of the level τ_γ and the average cross section for resonance scattering $\bar{\sigma}$ are connected by the well-known relation

$$\bar{\sigma} = \frac{1}{2\tau_\gamma} \sigma_0 \pi h P(E_p). \qquad (1)$$

Here σ_0 is the cross section at resonance and $P(E_p)$ is the energy distribution of the γ quanta.

The slowing down of the recoil nuclei can be taken into account by introducing in (1) a factor $1 - \exp(-l/v\tau_\gamma)$, where v is the velocity of the recoil nucleus and l the mean free path of the recoil nucleus before collision. For a gaseous source $t_{coll} \gg \tau_\gamma$, and the factor is equal to 1. Using (1), we write the ratio of the cross section $\bar{\sigma}_1$ for the gaseous source to the cross section $\bar{\sigma}_2$ for the liquid source:

$$\bar{\sigma}_1 / \bar{\sigma}_2 = [1 - \exp(-l / v\tau_\gamma)]^{-1}. \qquad (2)$$

The value of τ_γ has been determined by various authors with sufficient accuracy to be $(1.1 \pm 0.1) \times 10^{-12}$ sec. Using for v the value 7.2×10^5 cm/sec, which is the velocity of the recoil nucleus for exact resonance, and noting that $\bar{\sigma}_1/\bar{\sigma}_2 = 9.9$, we obtain for l the value 8×10^{-8} cm. It should be mentioned that the width of the resonance line is very small (~ 1 ev), and the change in l because of the spread in recoil velocity is extremely small.

The value of l is determined both by the distance between molecules in the source and by the nature of the interaction of the recoil nucleus with the surrounding molecules. To get a picture of the effect of interaction, it is necessary to carry out similar experiments for different isotopes of Co. It should be mentioned that the contradiction in the determination of the lifetime of the 1.60-Mev level of Ce^{140} in references 6 and 7 is due to the neglect in reference 6 of the effect of collisions on the resonance scattering cross section.

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