RESONANCE SCATTERING OF GAMMA QUANTA BY Ce^{140} *NUCLEI*

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WE have investigated resonance scattering of 1597-keV γ quanta emitted during the decay La^{140} ($T_{1/2}$ = 40.3 hours) → Ce^{140} by the Ce^{140} nuclei.

The resonant conditions were ensured by the Doppler broadening of the 1597 keV line, due to recoil from the preceding β and γ transitions. The source was used in solid (lanthanum oxide) and liquid form (solution of $LaCl_3$ in hydrochloric acid).

The experimental setup is shown in Fig. 1. The scatterers were plates of CeO_2 and BaO measuring 20 × 20 × 0.8 cm. The average scattering angle was ~ 120°. The experimental procedure is analogous to that described by us earlier [1].

Figure 2 shows the resonance-scattering curve obtained in one of the series with the liquid source, plotted with the aid of an AI-100 100-channel analyzer. The peak near 58 V (curve 1) obtained using a cerium scatterer is due to the resonance effect. The magnitude of the effect amounted to approximately 22% of the total counting rate.

The value of the resonance scattering due to the liquid source with the cerium scatterer was compared with the value obtained using a solid source. This ratio turned out to be 1.40 ± 0.20.

The average resonance-scattering cross section $\bar{\sigma}$, with allowance for the self absorption of the gamma quanta in the scatterer and their angular distribution, was found to be $(3.7 \pm 0.4) \times 10^{-26}$ cm^2. However, the use of a source in solid or liquid form entails considerable difficulties in the determination of the lifetime of the excited state from the measured intensity of the resonance scattering, since an exact calculation of the microspectrum is so far impossible; in any cascade of the type $\beta-\gamma$, $\beta-\gamma-\gamma$, or $\beta-\gamma-\gamma-\gamma$, at one of the stages the intermediate excited state can have a lifetime such that the microspectrum becomes distorted by collisions. We have therefore used the self-absorption method, which gives the width of the nuclear level independently of the details of the microspectrum. The expressions necessary for the analysis are given in the paper by Ofer and Schwarzschild [2]

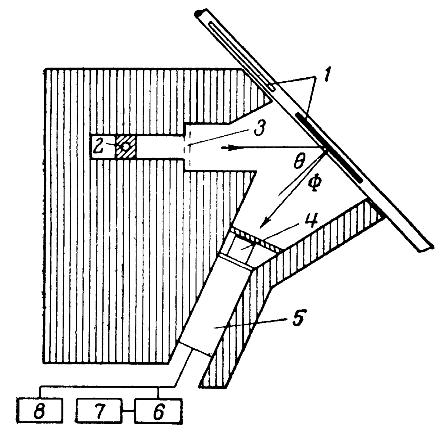

FIG. 1. Diagram of experimental setup: 1—scatterer on moving runners, 2—source in aluminum can, 3—position of absorber (in the experiment with self absorption), 4—NaI(Tl) crystal, 5—FÉU-12B photomultiplier, 6—single-channel pulse analyzer, 7—counting unit, 8—100-channel pulse analyzer AI-100.

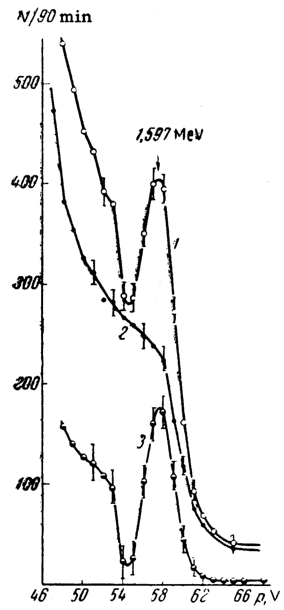

FIG. 2. Resonance scattering of gamma quanta by Ce^{140} nuclei: 1—spectrum of scattered radiation from CeO_2 scatterer, 2—spectrum of scattered radiation from BaO scatterer, 3—difference between 1 and 2.

The experiment was carried out in the following manner. The thicknesses of absorbers of CeO_2 and Te were chosen such that the attenuation of a beam of gamma rays with energy 1597 keV from a solid source with activity ~ 10 mCi was the same, accurate to 99.7 ± 0.2. The attenuation of the resonance effect by the absorbers of Ce_2O and Te was then measured. The initial activity of the source was approximately 200 mCi. The resonance absorption in the absorber of CeO_2 was found to be $(13.0 \pm 4.8)\%$.

Assuming a Debye temperature of 125°K for the CeO_2, taking into account the effective temperatures for the absorber and scatterer of CeO_2 (300°K), we find that $\Delta = 1.004$ eV. The width of the 1597-keV level was found to be $(3.07 \pm 1.14) \times 10^{-3}$ eV, which corresponds to $\tau_\gamma = (2.15 \pm 0.80) \times 10^{-13}$ sec for the lifetime of the excited state of the Ce^{140} with energy 1597 keV. Our value of τ_γ is in good agreement with the data on Coulomb excitation[3].

The resonance fluorescence method[2,4] yielded two contradictory values for τ_γ, owing to the fact that the effect of collisions on the resonant scattering cross section was neglected in [4].

The calculations by the Weisskopf-Moszkowski formula, based on the single-particle model, gives $\tau_\gamma = 17.8 \times 10^{-13}$ sec. Thus, the 1597-keV quadrupole E2 transition in the C^{140} nucleus turns out to be accelerated, with an acceleration factor of 8, pointing to the collective character of the excitation.

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