Nucleus	$(a/b)_0$	$(a/b)_{sp}$	E_{thr}, Mev	ΔE, Mev
U^{238}	1.30	2.24	5.8	0.6
U^{235}	1.25	2.2	5.75	0.6
Pu^{239}	1.30	2.17	5.48	0.5

It is clear from the table that in U^{238} the fission threshold with the meson present is higher than the excitation energy, while in Pu^{239} it is approximately 0.3 Mev below the excitation energy. Nuclear fission induced by μ mesons via the mechanism discussed here has been studied[6,7] in U^{238}. From this calculation it is clear that Pu^{239} is more suitable for an investigation of this effect.

In conclusion, the authors express their profound gratitude to D. P. Grechukhin for his advice and counsel, and also to V. K. Saul'ev for programming and carrying out the calculation on the electronic computer.

*ch = cosh; cth = coth; sh = sinh.

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OBSERVATION OF RESONANCE ABSORPTION OF THE 23.8-kev GAMMA RAYS OF Sn^{119} BY USING THE CONVERSION ELECTRONS

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THE study of resonance absorption of γ rays by nuclei bound in crystals (the Mössbauer effect) is usually done from the attenuation of the beam of γ rays by filters containing nuclei which can be excited resonantly. Thus the resonance absorption effect is observed on a relatively large background of γ radiation transmitted through the absorber. A considerably larger relative effect can be obtained by observing resonant scattering.[1]

It is also of interest to study the resonance by observing the conversion electrons which are emitted in the de-excitation of the resonance level. Such a method has advantages in those cases where the resonance absorption cross section is much greater than the cross section for the photoeffect, and where the internal conversion coefficient is not too small.

We have used this method to investigate the temperature dependence of the resonance absorption of the 23.8-kev γ rays which occur in the decay of the isomeric state of Sn^{119} at an energy of 89 kev ($T_{1/2}$ = 250 days). According to our estimates, the resonance absorption cross section for these γ rays is approximately 30 times greater than that for the photoeffect, while the internal conversion coefficient is 6.3. The recording of the conversion electrons emitted in the deexcitation of the nuclei was done in a double lens β spectrometer whose luminosity with fully open entrance and exit diaphragms was 7%. We used a source which was 0.02 mm thick, with an activity of 30 μC, obtained by irradiation of metallic tin enriched to 94% Sn^{118} with thermal neutrons. The content of Sn^{119} in the source did not exceed 2.3%.

The absorbers were prepared by depositing a thin layer of tin on an aluminum foil by evaporation in vacuum, where we used tin enriched to 75% Sn^{119}, while ordinary tin was used for control measurements. The absorber thickness was ~ 0.1 mg/cm^2. Between the source and absorber we placed a 6 mm thick plate of beryllium to absorb the β radiation

from the source, which contains radioactive impurities, and a palladium filter 0.03 mm thick to reduce the x ray intensity. The source and absorber (together with the filters) were placed in an aluminum box which was tied to a cooling rod. The measurements were made over the temperature range from 83 to 373° K.

A chromel-aluminum thermocouple was used for the temperature measurements, with its junction connected directly to the source box. The high sensitivity of the thermocouple (0.01°) enabled us to maintain the temperature to an accuracy of 1 — 2°. The size of the effect for each temperature was determined from the counting rate of conversion electrons in measurements with the enriched absorber. Since the effective depth from which electrons emerge giving a contribution to the conversion line is very small (< 0.1 mg/cm^2) the counting rate is proportional to the Sn^{119} content of the absorber. Therefore to determine the background we made measurements with an absorber of unenriched tin. In this case, at a temperature of 373° K the "resonance" electrons constituted less than 1% of the total counting rate.

To find the dependence of the effect on temperature, we made several series of measurements, in each of which we measured the counting rate of conversion electrons for definite values of T. The data from one such measurement are shown in Fig. 1, where we show the conversion lines measured with enriched absorber for temperatures of

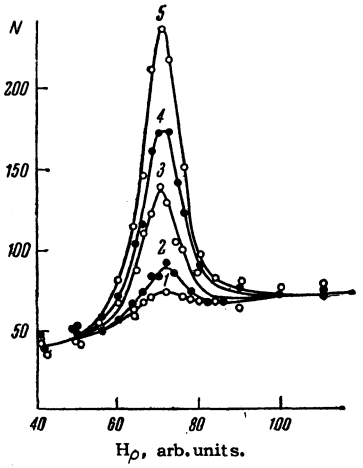

FIG. 1

273, 173, 133, and 83° K (the curves 2, 3, 4, and 5), and, for comparison, we show the curve measured at 383° K with an unenriched absorber (curve 1). The counting rate at the maximum of curve 5 reached 60 counts/min, while at the maximum of curve 1 it did not exceed 16 counts/min.

The temperature dependence of the cross section σ_{res} for resonance absorption is determined by the Debye-Waller factor f. For a source of crystalline material, characterized by a Debye temperature Θ, at temperature T this quantity is given by the expression

$$f = \exp\left\{-\frac{6R}{k\Theta}\left[\frac{1}{4} + \left(\frac{T}{\Theta}\right)^2 \int_0^{\Theta/T} \frac{t\,dt}{e^t - 1}\right]\right\},$$

where R is the recoil energy of the nucleus. If the source and absorber are prepared from the same material, then $\sigma \sim f^2$. Since our measurements did not permit us to determine the absolute value of σ_{res}, because of the large uncertainty in the determination of the effective thickness of the absorber layer which contributes to the conversion line, we tried to determine Θ from the temperature dependence of σ_{res}.

Curves of $f^2(\Theta, T)/f^2(\Theta, T_0)$ were computed for different values of Θ, for T varying over the interval 83 — 383° K. The points T_0 corresponded to temperatures at which measurements were made. After correcting for self-absorption in the source, the relative values of the effect $N_{res}(T)/N_{res}(T_0)$ were compared with the theoretical curves for the corresponding value of T_0. The results of the experiment agreed best with the value Θ = 170° K, but there is a systematic deviation of the experimental points from the theoretical curves. This can be seen from Fig. 2, which

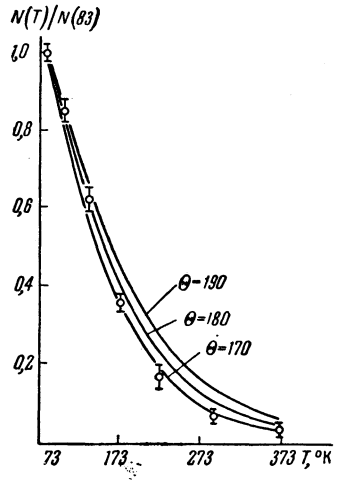

FIG. 2

gives one of the series of curves, corresponding to Θ = 170, 180, and 190° K, for T_0 = 83° K, as well as the measured data. The observed deviation could be explained by a smooth change of Θ with temperature, with Θ ~ 180° at temperatures near that of liquid nitrogen, and Θ ~ 165° for T > 200° K. The computed value f = 0.6 corresponding to Θ

= 180° is in good agreement with the measurements of other authors.[2,3]

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