

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 U²³⁸ the fission threshold with the meson present is higher than the excitation energy, while in Pu²³⁹ 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 U²³⁸. From this calculation it is clear that Pu²³⁹ 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 Sn¹¹⁹ 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 Sn¹¹⁹ 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 μ C, obtained by irradiation of metallic tin enriched to 94% Sn¹¹⁸ with thermal neutrons. The content of Sn¹¹⁹ 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% Sn¹¹⁹, while ordinary tin was used for control measurements. The absorber thickness was ~ 0.1 mg/cm². 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 ($< 0.1 \text{ mg/cm}^2$) 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

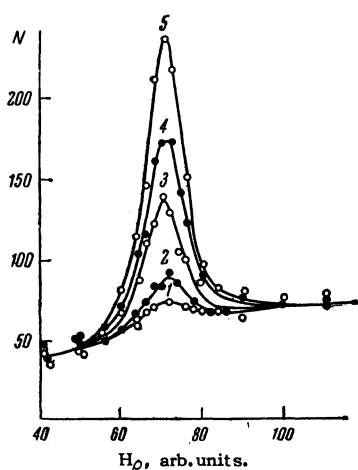


FIG. 1

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 sec-

tion 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 $N_{\text{res}}(T)/N_{\text{res}}(T_0)$ were compared with the theoretical curves for the corresponding value of T_0 . The results of the experiment agreed best with the value $\Theta = 170^\circ \text{K}$, but there is a systematic deviation of the experimental points from the theoretical curves. This can be seen from Fig. 2, which

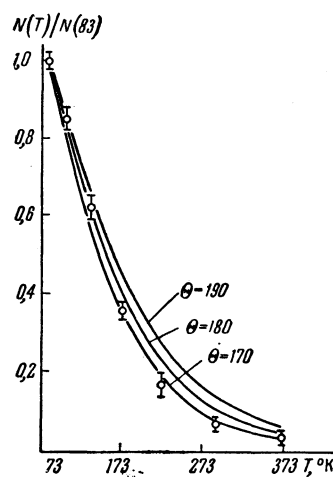


FIG. 2

gives one of the series of curves, corresponding to $\Theta = 170, 180,$ and 190°K , for $T_0 = 83^\circ \text{K}$, as well as the measured data. The observed deviation could be explained by a smooth change of Θ with temperature, with $\Theta \sim 180^\circ$ at temperatures near that of liquid nitrogen, and $\Theta \sim 165^\circ$ for $T > 200^\circ \text{K}$. 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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162

CONTENTS OF COMING ISSUES

SOVIET PHYSICS JETP VOLUME 13, NUMBER 4 OCTOBER, 1961

CONTENTS

Russian
Reference

Experimental Investigation of Electron Capture by Multiply Charged Ions.	40,	989
. V. S. Nikolaev, I. S. Dmitriev, L. N. Fateeva, and Ya. A. Teplova		
Positron Annihilation in Sulphur, Selenium, and Silicon.	40,	1001
. K. A. Baskova, B. S. Dzhelepov, and Z. A. Komissarova		
Neutron Emission from Strongly Excited Nuclei.	40,	1004
. A. S. Karamyan, G. A. Dorofeev, and D. S. Klochkov		
Alpha Decay of the Bi ^{210m} Isomer.	40,	1007
L. I. Rusinov, Yu. N. Andreev, S. V. Golenetskii, M. I. Kislov, and Yu. I. Filimonov		
Electronic Paramagnetic Resonance in the V ³⁺ Ion in Corundum	40,	1016
. G. M. Zverev and A. M. Prokhorov		
Stripping Reactions on the Zr ⁹⁰ and Zr ⁹¹ Nuclei	40,	1019
. N. I. Zaika and O. F. Nemets		
Neutron Diffraction Study of the Crystalline Structure of Solid Hydrogen and Deuterium	40,	1022
. V. S. Kogan, V. G. Lazarev, R. P. Ozerov and G. S. Zhdanov		
Estimate of the Upper Limit of the Charge-Exchange Cross Section for the pn Interac-	40,	1027
tion at 8.5 Bev. V. A. Nikitin and E. N. Tsyganov		
Resonance Scattering of Gamma Rays by Te ¹²⁴ Nuclei.	40,	1031
. A. F. Akkerman, D. K. Kaipov and Yu. K. Shubnyi		
Mass of the Pu ²⁴⁰ Isotope R. A. Demirkhanov and V. V. Dorokhov	40,	1033
Magnetoelectric Effect in Chromium Oxide D. N. Astrov	40,	1035
Investigation of the Spectrum and Asymmetry of Electrons from the π - μ - e Decay in	40,	1042
Nuclear Emulsion. A. O. Vaisenberg, V. A. Smirnit-skii, and E. D. Kolganova		
On the Kinetic Theory of Shock Waves G. Ya. Lyubarskii	40,	1050
Structure of the Transition Layer Between a Plasma and a Magnetic Field.	40,	1058
. V. P. Shabanskii		
Quantum Theory of the Spectrum of Excitations of an Electron Gas in a Magnetic Field	40,	1065
. P. S. Zyryanov		
Commutation Function of a Nonlinear Meson Field.	40,	1072
. D. Ivanenko and D. F. Kurdgelaidze		
On the Use of an Arbitrary Gauge of the Electromagnetic Potentials in the Dispersion	40,	1076
Method. V. D. Mur and V. D. Skarzhinskii		
Resonance Charge Exchange in Hydrogen and Sodium Yu. E. Murakhver	40,	1080
Double Dispersion Relations and Photoproduction of Pions. N. F. Nelipa	40,	1085
Nucleon-Nucleon Interaction at an Energy of 9 Bev.	40,	1093
. I. M. Gramenitskii, I. M. Dremin, V. M. Maksimenko, and D. S. Chernavskii		
Effect of Unresolved Structures on the Line Width in Electronic Paramagnetic Reso-	40,	1101
nance. R. Kh. Timerov		