Measurement of the Relative Intensities of γ-lines by a Two-Meter Crystal Diffraction γ-Spectrometer

O. I. SUMBAEV
The National Scientific Research Institute of Metrology

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Results of measurements of the relative intensities of a number of lines in the γ-spectra of Ir^{192}, Ta^{182} and Ta^{183} are presented. In those cases when the relative intensities have been measured by different methods, the data for the Ir^{192} spectrum obtained by a crystal diffraction spectrometer agree satsifactorily with the results derived from photo-electron and recoil electron measurements.

THE relative intensities of the lines in the spectra of γ-radiation from Ir^{192}, Ta^{182} and Ta^{183} are measured on the two-meter crystal diffraction γ-spectrometer.[1] The high resolving power of the spectrometer (0.1 percent for γ-quanta with energies less than 1 mev, together with the exceptional simplicity of the spectra (each line is represented by a single peak in the spectrum on an almost constant background), permits the study of complicated spectra with closely spaced lines. In calculating the spectral sensitivity of the apparatus one must take into account self-absorption in the source, the reflection coefficient of the γ-radiation from the curved quartz crystal and the efficiency of the scintillation spectrometer, used as detector of the γ-radiation. The only specific dependence is the dependence of the reflection coefficient from the curved crystal (a quartz crystal with effective planes 3140 was used) on the wavelength. The investigations of DuMond and others[2] have shown that this relation is nearly quadratic. Detailed investigations carried out by us for energies of 191 (In^{114}), 279 (Hg^{203}), 412 (Au^{198}) and 1190 kev (the average energy of the group of hard lines in the spectrum of Ta^{182}) have confirmed DuMond's results and have led to the relation

$$\Gamma_i = k \cdot E^{-n},$$

where Γ_i is the reflection coefficient, E is the γ-ray energy and $n = 1.85 \pm 0.04$.

THE SPECTRUM OF Ir^{192}

A source of 1 curie activity, in the form of a foil of dimensions 30 × 5 × 0.2 mm, was used in investigating the spectrum of $Ir.^{192}$ The resolving power of the spectrometer

$$\delta = (1.5 \div 1.7) \cdot 10^{-3} E,$$

where δ is the relative line width at half maximum in percent and E is the γ-ray energy in kev.

Table I shows the relative intensities of the γ-lines in the spectrum of Ir^{192} from the results of Refs. 3–7.

TABLE I

Relative intensities of the lines in the spectrum of $Ir.^{192}$

E(kev)[5]	Intensities: our data	Σ	[3]	Σ	[4]	Σ	[5]	Σ	[6]	[7]	Σ
205,75	0,30		0,27		0,25		0.23		—	4.35	
295.94	2,26		3.0		1,88		2,12			22.0	
308,45	2.31	10.7	3.1	13,8	2.02	9.45	2.06	10.1	9.09	21.4	101.1
316.46	6.10		7,7		5.55		5.90			57.5	
467,98	3.72		4.1		4,1		3.78		4.58	17.4	
484,75	0.34		—		0.37		0.23		—	0.64	
588,4	0,40		0.33		0,46		0.418			0.64	
604,5	0.77	1.74	1.0	1,74	0.72	1.74	0.825	1.74	1.74	0.81	1,74
612,9	0,56		0.41		0,55		0.495			0.29	

The results of Refs. 4 and 5, obtained from photo-electrons in magnetic spectrometers, and of Ref. 6, using recoil electrons in a magnetic spectrometer ("ritron"), in good accord with each other, are strongly in disagreement with the results obtained by DuMond on a crystal diffraction spectrometer.[7] As is apparent from the Table, our results, obtained with a crystal diffraction spectrometer of the DuMond type, agree with those of Refs. 3–6, carried out with magnetic spectrometers.

THE SPECTRA OF Ta^{182} AND Ta^{183}

The source used was in the form of a foil of dimensions 30 × 5 × 0.1 mm irradiated with neutrons. The overall activity of the source before the start of the measurements was 1.4 curies. The investigation has shown that besides the spectrum of Ta^{182}, the spectrum of Ta^{183}, obtained as the result of two consecutive neutron captures, Ta^{181} $(n\gamma)$ Ta^{182} $(n\gamma)$ Ta^{183}, is present.

Relative intensities for a number of lines, from the results of DuMond's group[7,8] and from our results, are shown in Table II. The ratio of the intensities of the soft and hard groups of lines from the results of Refs. 7 and 8 differ from each other markedly (approximately 3 times). Our results are closer to

TABLE II
Relative intensities of lines in the Spectrum of Ta^{182}

E (kev) [8]	Intensities: our data	[7]	[8]
152.41	13.9	12.5	35
156.37	5.85	3.98	11.5
179.36	6.91	5.40	16
198.31	3.45	2.56	7.5
222.05	18.6	12.8	35
229.27	7.9	6.82	20
264.09	7.1	7.68	22
1122	100	100	100
1155	9.0	—	6.5
1189	59.5	44.6	45
1222 } 1231 }	136	95	145

those of the earlier work.[7] In evaluating the reliability of the results, one should take into account the fact that our results were obtained using the same spectral sensitivity curve as was used in the investigation of the Ir^{192} spectrum (with the exception of a somewhat different value for the self-absorption) and also a much better ratio of signal to background for the group of hard lines than in the (previous) investigations[7,8] (Fig. 1).

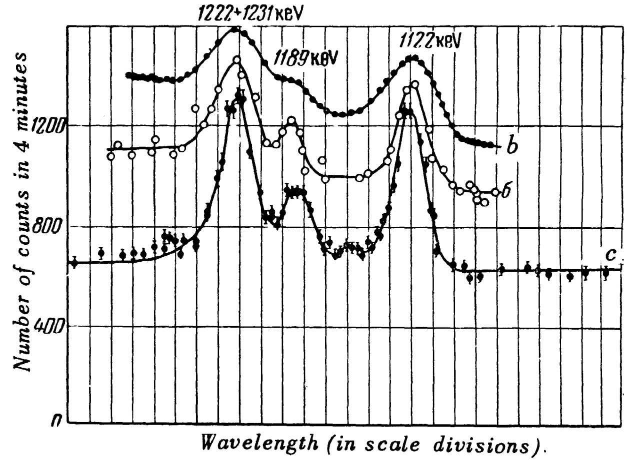

FIG. 1. Hard lines in the spectrum of Ta^{182} : *a*—from the results of the author; *b* and *c*—obtained on the DuMond spectrometer.[10]

TABLE III
Relative intensities of lines in the Spectrum of Ta^{183}

E (kev) [8]	Intensities: our data	[8]
144.12	10.7	8.5
160.53	11.9	10.5
161.36	33.6	31
162.33	16.5	16.5
208.81	1.8	2.6
209.87	16.0	16.5
244.26	29.7	34
246.05	100	100
291.71	14.8	20
313.03	24.8	30
354.04	39.1	40

Relative intensities of a number of lines in the spectrum of Ta^{183} from the results of Ref. 8 and from our results are displayed in Table III. Our results were obtained by using the same spectral sensitivity curves as in the cases of Ir^{192} and Ta^{182}. The resolving power of the spectrometer in the work of DuMond's group[8] was approximately twice as poor as in our work ($\delta = 3.10^{-3} E$). This last circumstance is important since groups of closely spaced lines appear in the spectrum (Fig. 2) and it would be necessary to use decomposition into components with a lower resolving power. The half

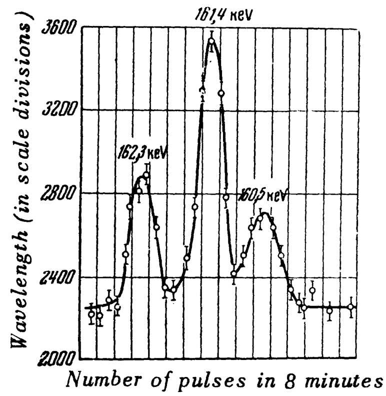

FIG. 2. Group of closely spaced lines in the spectrum of Ta^{183}

life of Ta^{183} was measured by us from the decrease in intensity of the most intense line in the spectrum with 246 -kev energy. The value of 5.0 ± 0.4 days found by us is in good agreement with earlier published results (5.2 days [8] and 5.3 days[9]).

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Structure of the Periphery of Extensive Atmospheric Cosmic Ray Showers

IU. N. ANTONOV, IU. N. VAVILOV, G. T. ZATSEPIN, A. A. KUTUZOV, IU. V. SKVORTSOV, G. B. KHRISTIANSEN

P. N. Lebedev Physical Institute, Academy of Sciences, USSR

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An investigation of the lateral distribution of various components of extensive showers at their periphery (200–800 *m* from the axis) has been carried out. The data on the lateral distribution indicate that the contribution of the shower periphery to the total shower particle flux is significant.

The lateral distribution of the electron component at the periphery can be explained by means of the theory of multiple Coulomb scattering. Coulomb scattering also plays an important role in the divergence of the penetrating particles (μ-mesons); however the angles of emission in the elementary events of nuclear cascade processes of $\pi^{\pm}$-mesons which give rise to μ-mesons can apparently also lead to this type of divergence of μ-mesons.

An investigation of the intensity of the primary cosmic radiation at very high energies (10^{16} – 10^{17} ev) was also carried out.

A DETAILED investigation of the peripheral regions of extensive atmospheric showers is of considerable interest from the point of view of elucidating the qualitative characteristic features of the nuclear-cascade process which forms the foundation of the development of the shower. At the same time such an investigation also turns out to be necessary for the determination both of the total number of particles in the shower and of the ratios of the various components of the shower at any given depth of the atmosphere.

For the investigation of the periphery of showers, experimental arrangements are used involving counter systems situated at large distances D from each other which lead to a very large effective area of the recording system (of order D^2). This enables us to investigate the intensity of the primary cosmic radiation for ultra-high energies.