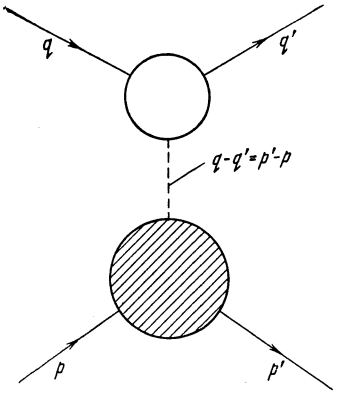
process indicated on the figure.

The shaded area refers to strongly interacting particles. The momentum transfer is $q' - q = p - p'$, and therefore the amplitude depends only upon the squares of the momentum transfer $(p - p')^2$ (relativistic invariance), even though the interaction of scattered particles is non-local.

Thus if the scattering amplitude satisfies the dispersion relations, it still does not generally follow that the causality principle is satisfied.



One can only assert that if the dispersion relations are violated, then so is the principle of causality. A similar example was suggested by Lehmann.[4]

In conclusion I consider it my pleasant duty to thank N. N. Bogoliubov for his guidance and A. A. Logunov for discussion of the subjects presented here.

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Translated by M. A. Melkanoff
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ADHESION OF SLOW ELECTRONS TO SF_6 *AND* CCl_4 *MOLECULES*

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FOX[1] has shown recently that the process $SF_6 + e \rightarrow SF_6^-$ has a resonant character and occurs in an energy range on the order of 0.05 ev at electron energies less than 0.1 ev. Carbon tetrachloride also captures electrons with energies close to zero, dissociating thereby into CCl_3 and Cl^- (Refs. 2 — 4), but in this case the energy and width of the capture region were determined with low accuracy.

We determined the energy and resonant capture cross-section of slow electrons in SF_6 and CCl_4.

The measurements were carried out in a setup similar to that of Lozier.[5] The electron beam was collimated by a cellular diaphragm and a magnetic field (15 — 20 oersted), and was passed through a diaphragm with variable potential and a screening grid into an equipotential region, and then to a collector. The ions produced in the equipotential region were gathered on a cylindrical collector, screened by the grid. Equality of the potential was insured by thorough compensation for the contact potentials.

To obtain monochromatic electrons, use was made of the so-called "quasi-monochromatization,"[6] which consists of passing a beam of electrons through a diaphragm that transmit only electrons with energies exceeding the diaphragm potential. The diaphragm potential was periodically varied by ΔV, and the increment in ion current due to this variation was measured. Obviously this increment is due to electrons with a distribution of width ΔV. It was possible to obtain by this method electrons with an exponential energy distribution 0.2 — 0.3 ev wide (the vertical and the right-hand solid curves of Figs. 1 and 2). The

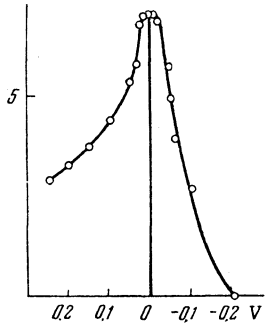

Fig. 1. o — ion current in SF_6.

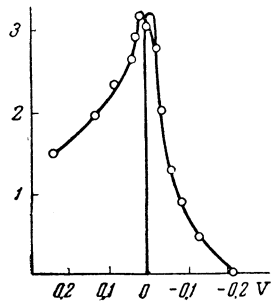

Fig. 2. o — ion current in CCl_4.

sharp boundary of the distribution makes it possible to set the energy scale reliably.

If capture took place in an energy interval that was narrow compared with the width of the electron distribution, the shape of the ion peak duplicates the shape of the distribution, and the shift of the maximum ion current relative to the maximum distribution determines the capture energy. Figures 1 and 2 show the electron distributions in the ion-current curves for SF_6 and CCl_4 (the ion and electron currents are given in arbitrary units, and a common scale is used). The correspondence in the shapes of the ion peaks and of the electron distribution in the region of the maxima is evidence that resonant electron capture in a narrow energy interval takes place for SF_6 and CCl_4. From the shifts of the maxima it was determined that the capture takes place at 0 ± 0.01 ev in SF_6 and 0.02 ± 0.01 ev in CCl_4 (in both cases the values are obtained by averaging eight measurements).

The resonant capture cross-section of SF_6 and CCl_4 was found under the assumption that the capture takes place in an energy interval of 0.05 ev. The cross-section was determined from the maximum ion current and from the electron current in the interval from 0 to 0.05 ev, and calculated from the formula

$$\sigma = (I_{\max}/\eta\xi) / (\Delta I_{el}/\beta)\, 3{,}55 \cdot 10^{16} \cdot 273\,(p/T)\,\lambda L.$$

Here I_{max} is the maximum ion current, ΔI_{el} is the current of the electrons with energies from 0 to 0.05 ev, p the pressure of the investigated gas, T the temperature of the working region, equal to room temperature, L the length of the working region, η the correction for recapture of ions by the grids that screen the ion collector, ξ the correction for the ion escape, β the correction for the recapture of electrons by the grid that screens the collector, and λ the correction for the elongation of the electron path in the magnetic field.

It was determined as a result that $\sigma = (1.2 \pm 0.4) \times 10^{-15}$ cm^2 for SF_6 and $\sigma = (1.7 \pm 0.4) \times 10^{-16}$ cm^2 for CCl_4 (both values were obtained by averaging six measurements).

I thank V. L. Tal'roze for continuous interest in the work and for valuable advice.

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QUANTUM YIELD OF INTERNAL PHOTOEFFECT IN GERMANIUM

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It is known that at photon energies near the threshold of the internal photoeffect, corresponding to approximately 0.7 ev for pure germanium, the quantum yield is constant and equal to unity.[1,2] This is in agreement with the usual concept of the creation of one electron-hole pair upon absorption of a photon.

If the photon has a sufficient excess energy above threshold, additional electrons can be liberated in the crystal as a result of impact ionization. The possibility of a quantum yield of photoluminescence in excess of unity, upon excitation by quanta with energies more than double the energy of the luminescence quantum, was indicated by S. I. Vavilov[3] in 1947. This phenomenon was observed experimentally by Butaeva and Fabrikant[4] in short-wave excitation of luminophors and by Koc in an investigation of the internal photoeffect in germanium. Experimental data on the increase in quantum yield by impact ionization with photo electrons or holes are important from the point of view of the theory of scattering of carriers in a crystal and the theory of impact ionization, developed by Chuenkov[6] and others.

We measured the quantum yield of the internal photoeffect in N-type germanium in the wavelength range from 1.5 to 0.254μ. The quantum yield Q was determined as the ratio of the number of excess free carriers to the number of absorbed photons. Single germanium crystals with a specific resistivity ρ ranging from 10 to 20 ohm-cm and with initial diffusion length L of approximately 1.5 mm were used in the experiments. Crystals in the shape of platelets 0.3 — 0.6 mm thick and approximately 1 cm^2 in area were illuminated on one side by