are the wave vectors of the produced photons. Let us note that in the non-relativistic case $\alpha \rightarrow \pi$ and therefore (9) yields, after integration over $d\Omega$, the well known formula

$$\sigma_{\text{n.r.}} = \pi r_0^2 \frac{c}{v_+} (1 - s_+ \cos \psi), \tag{10}$$

with the consequence that two-photon annihilation is forbidden in this approximation if the electron and positron spins are parallel, i.e., $s_+ \cos \psi = 1$.

One sees from (9) that there is polar (ψ is replaced by $\pi - \psi$) and azimuthal (φ is replaced by $\pi - \varphi$) asymmetry. This fact allows the use of two-photon annihilation of positrons by oriented electrons for experimental determination of the degree of longitudinal polarization of the positrons.

It is known[6] that the asymmetry in the scattering of positrons by oriented electrons is small at low energies and becomes appreciable only at relatively high energies.

On the other hand, two photon annihilation of oriented positrons and electrons gives a noticeable asymmetry in the produced photons only at comparatively low energies. In the high-energy region observation of the asymmetry will apparently be difficult, owing to the decrease in the absolute value of the cross section.

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QUANTUM YIELD OF PHOTOIONIZATION IN SILICON

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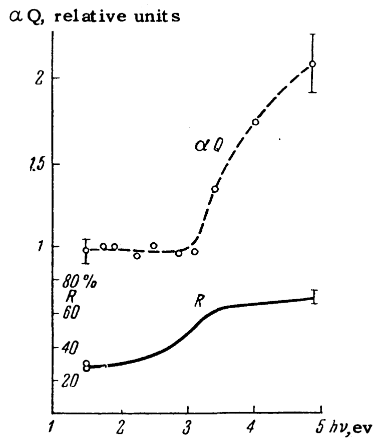
It was shown in earlier works[1,2] that, if the photon energies are high enough, the quantum yield of the internal photoeffect in germanium crystals increases to values much above unity. As was already indicated,[2] the increased quantum yield must be ascribed to impact ionization by primary electrons or holes liberated upon absorption of a photon and having the necessary excess energy.

One would expect a similar phenomenon to take place in silicon. To study the photoeffect in silicon we have used crystals with p-n junctions obtained by thermal diffusion of phosphorus into type-p silicon.[3,4]

Since the diffusion length of the nonequilibrium carriers in the silicon employed was relatively low, we prepared crystals in which the depth of the p-n junction under the illuminated surface did not exceed 2 microns, in order to obtain the necessary sensitivity in the short-wave region. To measure the short-circuit current between the p and n regions of the crystal, and to determine the light flux and the reflection coefficients, we employed a setup similar to that used in the germanium experiments.[2] The interpretation of the results obtained was more difficult in our case than in the determination of the quantum yield in germanium, owing to the following circumstance: The expression for the carrier-collection coefficient α contains the carrier mobility and the diffusion length of the nonequilibrium carriers. However, in the case of a p-n junction obtained by diffusion of impurities from the surface, the mobility changes greatly with depth, increasing inward from the surface where the concentration of the impurity (phosphorus) is high. The carrier diffusion length also undoubtedly varies with depth. In view of this, the formula for the quantum yield Q

$$Q = I_{\text{sc}} / N_{h\nu} q \alpha (1 - R),$$

derived for germanium, cannot be used here (I_{sc} is the short circuit current between the p and n regions, q the electron charge, R the reflection coefficient, and $N_{h\nu}$ the number of photons incident per second. It is therefore necessary to as-



sume that in the photon energy region $E_g < h\nu < 2E_g$, where $E_g \approx 1.1$ ev is the width of the forbidden band for silicon, the quantum yield is unity.

The figure shows the experimental variations of the reflection coefficient R and of the product of the quantum yield Q by the collection coefficient α with the photon energy $h\nu$. A considerable rise in the αQ vs. $h\nu$ curve is seen, starting with approximately $h\nu = 3.25$ ev. In view of the fact that α cannot increase with diminishing wavelength (and consequently with increasing absorption coefficient[5]) the course of the curve indicates an increase in quantum yield and consequently the presence of impact ionization by the carriers liberated upon absorption of the photons.

It would be interesting to compare the photon energies at which this increase is observed (3.2 to 3.3 ev) with the limiting energy of impact ionization in silicon, recently determined by McKay,[6] who studied the multiplication of carriers in strong electric fields. According to his data $E_{i\,min} \approx 2.25$ ev. The value we obtained is quite close to it $(3.25 - 1.1 = 2.15$ ev$)$.

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LAMBDA-NUCLEON POTENTIAL FROM MESON THEORY AND THE ENERGIES OF LAMBDA-PARTICLES IN LIGHT HYPERNUCLEI

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An attempt was made in Refs. 1 and 2 to obtain the Λ-nucleon force and to consider the energy of the Λ particles in hypernuclei from the point of view of quantum field theory. In order to eliminate the divergences at small distances, a repulsive wall was introduced, in analogy to the nucleon-nucleon interaction. The existence of such a wall in the nucleon-nucleon interaction follows from the scattering of high-energy nucleons; however, the existence of such a repulsion for the Λ-nucleon interaction cannot be considered established at the present time. The introduction of a repulsive wall in the Λ-nucleon force causes considerable difficulty in the calculations. However, the nucleon-nucleon forces obtained[3] from meson theory by introducing a cutoff in the momenta of virtual mesons, agree well with the experimental data having to do with the low-energy interaction of nucleons. Since the interaction of Λ-particles with the nucleons in the nucleus has to do with the low-energy region, one might expect that the Λ-nucleon potential obtained from the theory by cutting off the momenta of virtual mesons will give sensible results.

On the basis of these considerations, we calculated the Λ-nucleon potential, starting from a Hamiltonian of the form

$$H = \frac{g\hbar}{2V^{1/2}} \sum_{l=1}^{N} \sum_{k} v(k)\,(\sigma_l k)\,\hat{a}^l \Big\{ \sqrt{\frac{\hbar}{2\omega^{(\pi)}}} \sum_{j=1}^{3} iT_j^{(\pi)(l)} (a_{jk} + a^{*}_{j,-k}) \times \exp\{ikx_l\} + \sqrt{\frac{\hbar}{2\omega^{(K)}}} \Big[\sum_{j=1}^{2} iT_j^{(K)(l)} (c_{jk} + b^{*}_{jk}) \times \exp\{ikx_l\} + \text{Hermitian conj.} \Big] \Big\}. \quad (1)$$