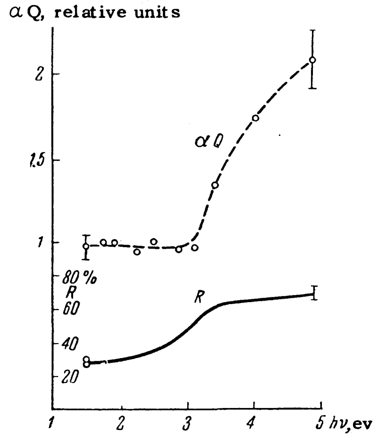


sume that in the photon energy region $E_g < h\nu < 2E_g$, where $E_g \approx 1.1$ ev is the width of the forbidden band for silicon, the quantum yield is unity.

The figure shows the experimental variations of the reflection coefficient R and of the product of the quantum yield Q by the collection coefficient $\alpha$ with the photon energy $h\nu$. A considerable rise in the $\alpha$Q vs. $h\nu$ curve is seen, starting with approximately $h\nu = 3.25$ ev. In view of the fact that $\alpha$ 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).

The authors thank V. M. Malovetskaia, V. M. Patskevich, and L. V. Belova for aid in preparation of crystals with p-n junctions.


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

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Submitted to JETP editor January 15, 1958

J. Exptl. Theoret. Phys. (U.S.S.R.) **34**, 1355-1356 (May, 1958)

An attempt was made in Refs. 1 and 2 to obtain the $\Lambda$-nucleon force and to consider the energy of the $\Lambda$ 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 $\Lambda$-nucleon interaction cannot be considered established at the present time. The introduction of a repulsive wall in the $\Lambda$-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 $\Lambda$-particles with the nucleons in the nucleus has to do with the low-energy region, one might expect that the $\Lambda$-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 $\Lambda$-nucleon potential, starting from a Hamiltonian of the form

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

The Hamiltonian H was obtained from the interactions of baryons with $\pi$- and K-meson fields,[4] after carrying out the transformation of Dyson assuming the baryons to be at rest at the points $x_l$. Only terms linear in the coupling constant were retained in H. It was also assumed that all coupling constants are the same. $T_j^{(\pi)}$ and $T_j^{(K)}$ are eight-row matrices that account for the transformation of baryons into each other upon meson exchange; v(k) is a function which cuts off the momenta of the virtual mesons; $\hat{a}$ is an eight-row diagonal matrix, the elements of which are the inverses of the baryon masses.

Starting from the Hamiltonian (1), we calculated the forces between $\Lambda$ and nucleon, connected with the exchange of a single K, two $\pi$'s, a K and a $\pi$, and two K mesons. The forces were obtained as in Ref. 3, the only difference being that the matrices $\tau$ were replaced by $T_i\hat{a}$. The forces obtained were used to calculate the binding energies of the light hypernuclei $_\Lambda H^3$, $_\Lambda He^4$, and $_\Lambda He^5$. The results of calculation showed that the potential energy of the $\Lambda$-particle in hypernuclei, connected with the $2\pi$- and 2K-meson forces, was almost independent of the spin of the hypernucleus. The potential energy from the 1K-meson force comprised $\sim 1/10$ of the total potential energy, was positive, and was approximately the same for all hypernuclei. The smallness of the energy from the 1K-meson force is connected with the fact that the corresponding potential is nonmonotonic. The energies from the $\pi$K-meson force depend strongly on the spin of the hypernucleus. The lowest potential energy is obtained for the lowest spin of the hypernucleus.

If the cut-off parameter is taken to be $k_m = 6m_\pi c/\hbar$ (Ref. 3) and a coupling constant is chosen so that for $_\Lambda He^5$ the experimental value[5] for the energy of the $\Lambda$-particle, $B_\Lambda \sim 2.6$ Mev, is obtained, then it turns out that $g/\sqrt{\hbar c} = 11.8$ and the energy $B_\Lambda$ of the $He^3$ and $He^4$ hypernuclei is $\sim 2.1$ and $\sim 2.2$ Mev respectively. Here $_\Lambda H^2$ is not bound. Probable experimental values for the energy of the hypernuclei $_\Lambda He^3$ and $_\Lambda He^4$ are $B_\Lambda = 0.3$ Mev and 1.7 Mev, respectively.[5]

Thus, the theory considered gives binding energies too close to each other. Although there is not quantitative agreement, the theory considered correctly reproduces the fact that the force between the $\Lambda$ and nucleons is not of a purely Wigner type. Purely Wigner forces would give a substantially stronger increase in the binding energies of $\Lambda$-particles in light hypernuclei than is actually observed. This tendency for the binding energies of light hypernuclei to be the same is correctly reproduced by the theory considered. Various types of corrections to the forces considered may improve the agreement between experiment and theory.

The author would like to express his gratitude to Prof. D. D. Ivanenko for encouragement in carrying out the present work.

Note added in proof (April 21, 1958). In the calculations described, the effect of the motion of the remaining nucleus in the calculation of the kinetic energy of the $\Lambda$ particle was neglected. If this is taken into account, then for $g^2/4\pi\hbar c = 12.3$, the values 0.48 Mev, 1.53 Mev and 2.30 Mev are obtained for the energies of $_\Lambda H^3$, $_\Lambda He^4$, and $_\Lambda He^5$, respectively, in satisfactory agreement with experiment.

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