cally covering the γ-beam by a lead absorber, was placed before the collimator situated in a 4 meter thick shielding wall 13 meters from the spectrometer. A lead plate in the form of a half-disc, mounted on the reductor axis of an electric motor, periodically covered the γ-beam making 12 r.p.m. The counting of the γ-quanta registered by the spectrometer was done separately for the cases of the completely covered and completely uncovered beam.

For the purpose of the determination of the absorption coefficients of γ-quanta in Cu and Al by means of the same revolving device, the lead absorber was periodically changed by a copper and an aluminum absorber. A frequent change of the absorbers made it possible to carry out the measurements without a monitor and, besides, removed errors due to the time variation of the sensitivity of the spectrometer. The γ-beam, after traversing the collimator, was purified from electrons and positrons by a special magnet.

The values of the absorption coefficients (in cm^2/g) of γ-quanta of the energy $E_\gamma = 500 \pm 50$ mev, obtained in our work, are:

$$\text{Pb}: 0.1115 \pm 0.0025; \quad \text{Cu}: 0{,}0510 \pm 0{,}0025;$$

$$\text{Al}: 0.0295 \pm 0.0017.$$

The absorption of γ-quanta of $E_\gamma = 500$ mev is due basically to electron-positron pair production. The calculation shows that the absorption due to the photoeffect and the Compton effect amounts for Pb to ~ 0.5%, for Cu to ~ 1.2% and for Al to ~ 2% of the total absorption cross-section.

The γ-absorption cross-sections obtained by us are in a good agreement with the results of calculations by Davies et al[1].

It should be noted that the results for γ-quanta of 500 mev, which are in agreement with the calculations, were obtained with a lead filter of the thickness 5.55 g/cm^2 permanently placed in the beam. The values of cross-sections obtained without this filter were 10% higher. No influence of such a filter was observed in measurements of the cross-section for 280 mev γ-quanta. The obtained value of the cross-section for 280 mev γ-quanta is in good agreement with Ref. 2. It has not been possible to explain the cause for the higher result for the absorption cross-section of 500 mev γ-quanta in the absence of the additional lead filter.

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Translated by H. Kasha
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A Physical Model of the Hyperon

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IN recent times a number of attempts have been made to reduce the number of particles that are regarded as "elementary" by regarding some of them as compound structures.[1–5] Some proposals of this sort are not in agreement with experiment and with the very successful phenomenological scheme of Gell–Mann, since they lead to charge states that most probably do not exist in nature.[3,5] The one that seems most natural is an early proposal of Goldhaber,[2] which, being applied in the light of our present knowledge, provides the correct charge multiplet of the hyperon and a very attractive picture of the interaction of baryons and heavy mesons.

We assume that hyperons are bound systems* of nucleons and $\bar{K}$–mesons, which, according to Gell–Mann, form a charge doublet $\bar{K}(\bar{K}^0, \bar{K}^-)$. The nucleon and the $\bar{K}$–meson can form singlet and triplet charge states. The singlet state can be identified with Λ°, the triplet with $\Sigma^+, \Sigma^0, \Sigma^-$. The qualitative features of the proposed interaction between K–mesons and nucleons are such that, in agreement with experiment, the binding forces are independent of the charge and depend only on the isotopic spin, the forces being larger for the antiparallel orientation of the isotopic spins. As a model for the Ξ–particle (which we assume to be a doublet) one can take the bound system of a Λ° or a Σ–particle and a $\bar{K}$-meson (doublet of the $N\bar{K}\bar{K}$ system). According to the idea being developed here there must exist a hyperon with isotopic spin $T = 3/2$ and with a mass greater than the mass of the Ξ, if the interaction between the Σ and $\bar{K}$–particles is sufficiently strong to form a bound system with parallel isotopic spins. If there is no degeneracy, then there can exist other states with $T = 1/2$ besides the Ξ. For the state with $T = 1/2$ higher than the Ξ and for the components $T_3 = \pm 1/2$ of the state $T = 3/2$

there is possible rapid decay to Ξ with emission of a γ–quantum, If the mass difference is large enough, the components $T_3 = \pm 3/2$ can also decay, via a strong interaction, to Ξ and a charged pion.

In connection with our considerations, the question can arise as to why bound systems are not formed of nucleons and $\bar{K}(K^+, K^\circ)$ particles in analogy with the systems $N\bar{K}$. To account for this, we assume that the interaction energy of the K–meson field and the field of the given nucleon changes its sign on charge conjugation applied to the K–meson variables

$$(K^+ \leftrightarrow \bar{K}^-,\ K^0 \leftrightarrow \bar{K}^0).$$

A similar situation is well known in quantum electrodynamics: the interaction energy of the Dirac field and a given electromagnetic field changes its sign on charge conjugation applied to the variables of the Dirac (for example, electron) field $(e^+ \leftrightarrow e^-)$.

Then if the NK forces correspond to attraction, the forces between nucleon and $\bar{K}$–particle correpond to repulsion and have the same magnitude.

If the principle of invariance under the parity transformation holds as formulated by Lee and Yang,[6] then the properties of the ϑ and τ particles are identical, except for the intrinsic spatial parity, and we can assume the existence of two-parity –conjugate states of types $(N\vartheta)$ and $(N\tau)$. The existence of such states has been predicted by Lee and Yang.

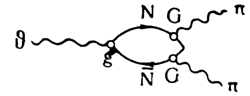
The operator of (strong) interaction between $\bar{K}$ and K mesons and nucleons is taken in the form

$$U = G_1 (\bar{\psi}\Omega_N\psi)(\bar{\chi}\Omega_K\chi) + G_2 (\bar{\psi}\tau\Omega_N\psi)(\bar{\chi}\tau\Omega_K\chi). \quad (1)$$

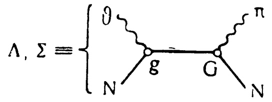
Here ψ is the operator of the nucleon field and χ is that of the K–meson field. Both functions are taken to be isotopic spinors of the first kind in accordance with the proposal of d'Espagnat and Prentki[7] (χ corresponds to the destruction of K° and K^+ particles and the creation of $\bar{K}^\circ$ and $\bar{K}^{-}\vartheta$); $\bar{\chi}$ has the reverse effect); Ω_N and Ω_K are operators acting on the space and spin coordinates.

The bilinear form of the interaction energy (1) in the operators $\bar{\chi}$ and χ, which is a consequence of the isotopic spinor nature of the K–particles and the postulate of charge invariance,[7] provides for the joint creation of K and $\bar{K}$ particles. If a $\bar{K}$–particle (or more than one of such particles) is created in a bound state with a nucleon, then we have to do with associated productions of types $\rightarrow K\Lambda, K\Sigma,\ KK\Xi$, predicted by Gell–Mann's theory.

According to our hypothesis the decay $\vartheta \rightarrow 2\pi$ occurs because of a direct weak boson–fermion interaction of the type diccussed by Oneda:[8]



The same coupling with the constant g leads to the decay of the hyperon:



It is easily seen that if our considerations are correct, they provide a physical basis for the phenomenological classification of particles and types of interactions given by Gell–Mann. The "strangeness" quantum number receives a simple interpretation: in our model it is identical with the difference N_k between the number of K–particles and the number of $\bar{K}$ (anti–K) particles. N_K is a constant of the motion for strong interactions. For strong interactions there is conservation of the number ϑ of elementary isotopic fermions, given by the sum of N_K and N_N (number of nucleons minus number of antinucleons). But N_N itself is separately conserved since, according to our conception, all nucleons are elementary baryons, and thus the number of heavy particles (a constant of the motion) is just N_N . Therefore $S = N_K$. is conserved in all fast reactions. The weak interaction of K–mesons with nucleons destroys the conservation of N_K .

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* The situation here is analogous to that occurring in the interaction of electrons. The number of electrons minus the number of antielectrons is conserved as long as only the electromagnetic interaction is considered. But the weak (β-decay) interaction of electrons with nucleons destroys this conservation law.

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Translated by W. H. Furry
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On the Structure of Nucleons

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COMPARISON of the results of the measurements of the scattering of fast electrons (with energy up to 550 mev) by protons, carried out by Chambers and Hofstadter.[1] with measurements of the interaction of electrons with neutrons[2,3] has led a number of physicists to the conclusion that these data as a whole are in contradiction either with the charge independence of the interaction of π–mesons with nucleons, or else with the foundations of quantum electrodynamics. The purpose of this note is to present arguments against the legitimacy of this sort of conclusions.

The most direct argument in favor of the conclusion mentioned has been formulated by Yennie, Lévy and Revenhall[4]; it reduces to the following. Chambers and Hofstadter have shown that the root–mean-square radius of the electric charge distribution of the proton is close to the value

$$r_p = 0.77\cdot 10^{-13}\text{cm} = 0{,}55\, h/\mu c. \qquad (1)$$

On the other hand, if the interaction of π–mesos with nucleons is charge invariant, then the meson clouds of proton and neutron must be mirror–symmetric (identical charge distributions, but with opposite signs). Therefore if, following Saks, one superposes the charge densities of proton and neutron, their meson charges cancel mutually and we obtain the charge density of the so–called "core" of the nucleus , i.e., the charge density due to the distribution of just the single nucleons and of nucleon pairs:

$$\rho_c(r) = \rho_p(r) + \rho_n(r).$$

Using the above–mentioned experimental data, Yennie et al, found that the root mean square radius of the charge of the core is practically equal to r_p :

$$r_c \sim r_p \sim 0.77\cdot 10^{-13}\text{cm} \sim 3.7\, h/Mc. \qquad (2)$$

It is just this result that is regarded as paradoxical, and for the following reason. If we confine ourselves to the consideration of mesons with energies less than μc^2, then the recoil in the emission of a meson by a "bare" nucleon can be neglected, so that the nucleon must be in the center of the physical nucleon ($r_c \sim 0$), while the radius of the distribution of mesons must be of the order $h/\mu c$, which does not contradict Eq. (1), but does contradict Eq. (2). But in the case of emission of mesons with energies of the order of μc^2, it is necessary to take into account the recoil experienced by the nucleons, and owing to the recoil, the nucleons will be displaced by about the same distance as the mesons; but this distance must be of the order of h/Mc. According to Eq. (2), however, r_c is considerably greater than this value.

In my opinion, the argument that has been presented is based, though not obviously, on the idea of weak interaction of mesons with nucleons.

Since in reality this interaction is strong, each meson must be dissociated for an appreciable fraction of the time into a ϑ nucleon–antinucleon pair. Therefore, the distribution of these pairs (which by definition forms part of the core of the nucleon) must be just about the same as the meson distribution itself

$$(r \sim h/\mu c),$$

in accordance with Eq. (2).

It is true that if we confine ourselves to consideration of processes of the type $\pi \to N + \tilde{N} \to \pi$ (where $\tilde{N}$ denotes an antinucleon), then the charge of the nucleon pairs will be distributed in just the same way as the charge of the mesons, and consequently cancels out in the calculation of the quantities p_c and r_c . But measurements by Segre′ and others have shown that the cross–section for annihilation of antiprotons on nucleons is very large* (which is quite understandable from the point of view of meson theory). Therefore the antinucleons produced at the mesonic periphery of the physical nucleon will have a large probability of being annihilated with the nucleon located at its center, being created again, and so on. The result is that the charges of all the nucleons and antinucleons (i.e., the charge of the core) is distributed more or less uniformly over the whole