intensity. The first 9 of the new γ-resonances from 619.5 to 980 kev can be attributed to the reaction $Si^{30}(p,\gamma)P^{31}$, since they are not connected with appreciable positron activity. We note that the effectiveness of detection of charged particles is many times greater than the effectiveness of detection of γ-quanta.

The identification of the reactions for the remaining 17 γ-resonances that we have discovered will be carried out at a later time.

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Isotopic Invariance and "Strange" Particles

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THE basic peculiarity of "strange" particles—heavy mesons and hyperons— is that two different types of interaction connect them with the usual strongly interacting particles (π-mesons and nucleons) : strong and weak. The formation of strange particles from ordinary is a fast process (characteristic time $\sim 10^{-23}$ to 10^{-24} sec); decay of "strange" particles to ordinary is a slow process (characteristic time $\sim 10^{-8}$ to 10^{-11} sec). This, and a whole series of other peculiarities of "strange" particles can be explained if, following Gell-Mann,[1] we consider the concept of isotopic spin for these particles and assume that the fast processes with some of these particles is isotopically invariant, and in the slow processes, not only the isotopic spin T changes, but also its projection T_3.

The charge of the particles Q is shown to be connected with the projection of the isotopic spin T_3 by the relation

$$Q = T_3 + (n/2) + (s/2),$$

where n is the number of baryons minus the number of antibaryons, and s is the quantum number "strangeness," introduced by Gell-Mann. A consistent explanation of the properties of elementary particles demands that the following isotopic spin and "strangeness" s be assigned to them:

	π	K	$\tilde{K}$	N	$\tilde{N}$	Λ	$\tilde{\Lambda}$	Σ	$\tilde{\Sigma}$	Ξ	$\tilde{\Xi}$
s	0	-1	1	0	0	$+1$	-1	$+1$	-1	2	-2
T	1	$1/2$	$1/2$	$1/2$	$1/2$	0	0	1	1	$1/2$	$1/2$

(Along with particles, we have considered the corresponding antiparticles, which are designated by the tilde). One of the most direct ways of verifying the correctness of the hypothesis on the isotopic invariance of fast processes with some of the "strange" particles is the experimental test of the relation (arising from this hypothesis) between the cross sections of reactions which differ only in the charge states of the participating particles. We consider three types of such reactions.

a) *Reactions in which* 4 *particles with* $T = 1/2$ *take part.* For example, the scattering of K-mesons by nucleons $K + N \to K + N$ or, in more detail,

1) $K^+ + p \to K^+ + p$,
2) $K^+ + n \to K^+ + n$,
3) $K^+ + n \to K^0 + p$,
4) $K^0 + n \to K^0 + n$.
5) $K^0 + p \to K^0 + p$
6) $K^0 + p \to K^+ + n$.

From charge symmetry it follows that

$$\sigma_1 = \sigma_4, \ \sigma_2 = \sigma_5, \ \sigma_3 = \sigma_6.$$

Consideration of charge invariance in this case does not give additional equations; however, if we consider that there is a relation among the amplitudes a ($\sigma = |a|^2$: $a_1 = a_2 + a_3$, then the inequality $\sigma_1^{1/2} \leqq \sigma_2^{1/2} + \sigma_3^{1/2}$ and its cyclic permutations can easily be established.

b) *Reactions in which one particle with* $T = 1$ *and two particles with* $T = 1/2$ *take part.* (The presence in the reaction of any number of particles with $T = 0$ is not important for us.) For example, formation of a Λ-particle and a K-meson in the reaction $\pi + N \to \Lambda + k$, or, more generally:

$$1)\ \pi^+ + n \to \Lambda^0 + K^+, \quad 3)\ \pi^- + p \to \Lambda^0 + K^0,$$
$$2)\ \pi^0 + n \to \Lambda^0 + K^0, \quad 4)\ \pi^0 + p \to \Lambda^0 + K^+.$$

It follows from charge symmetry that $\sigma_1 = \sigma_3$, $\sigma_2 = \sigma_4$. A relation which is determined by the charge invariance can easily be obtained by the method assumed by Shmushkevich.[2,3] We imagine a nucleonic target which contains an equal number of protons and neutrons, on which falls a beam of pions which contains equal numbers of π^+, π^- and π^0 -mesons. Since the interaction in this reaction is isotopically invariant, but the target and the beam are not isotopically polarized, then the number of π^+ (π^-) -mesons which are knocked out of the beam must be equal to the number of π^+– mesons. The π^+ mesons are absorbed in reaction 1, π^0 in reactions 2 and 4. This gives, at once, $\sigma_1 = \sigma_2 + \sigma_4$ or $\sigma_1 = 2\sigma_2$.

c) *Reactions in which two particles with $T=1$ and two particles with $T=2$ take part.* For example, formation of a Σ-particle and a K-meson in the reaction $\pi + N \to \Sigma + K$:

$$1)\ \pi^+ + p \to \Sigma^+ + K^+, \quad 6)\ \pi^- + n \to \Sigma^- + K^0,$$
$$2)\ \pi^0 + p \to \Sigma^0 + K^+, \quad 7)\ \pi^0 + n \to \Sigma^0 + K^+,$$
$$3)\ \pi^0 + p \to \Sigma^+ + K^0, \quad 8)\ \pi^0 + n \to \Sigma^- + K^+,$$
$$4)\ \pi^- + p \to \Sigma^- + K^+, \quad 9)\ \pi^+ + n \to \Sigma^+ + K^0,$$
$$5)\ \pi^- + p \to \Sigma^0 + K^0, \quad 10)\ \pi^+ + n \to \Sigma^0 + K^+.$$

It follows from charge symmetry that

$$\sigma_1 = \sigma_6, \quad \sigma_2 = \sigma_7, \quad \sigma_3 = \sigma_8, \quad \sigma_4 = \sigma_9, \quad \sigma_5 = \sigma_{10}.$$

Again let us consider an isotopically nonpolarized K-meson beam and a nucleonic target. As in the previous case, the number knocked from the beam of $\pi^+(\pi^-)$ – mesons and π^0–mesons ought to be equal:

$$\sigma_1 + \sigma_4 + \sigma_5 = 2(\sigma_2 + \sigma_3).$$

Moreover, the number of Σ^+ and Σ^0 -particles that are formed ought to be equal: $\sigma_1 + \sigma_3 + \sigma_4 = 2(\sigma_2 + \sigma_5)$. From the latter two equations, we obtain

$$\sigma_3 = \sigma_5, \quad \sigma_1 + \sigma_4 = 2\sigma_2 + \sigma_5.$$

Similar relations are obtained for the following reactions, each of which pertains to one of the types: a), b) or c):

REACTION OF FORMATION OF HEAVY MESONS AND HYPERONS:

$$1)\ \pi + N \to \Lambda + \pi + K\ \text{(c)},$$
$$2)\ \pi + d \to \Lambda + N + K\ \text{(b)},$$
$$3)\ \pi + d \to \Sigma + N + K\ \text{(c)},$$
$$4)\ \pi + d \to \Lambda + \pi + N + K\ \text{(c)}.$$

REACTIONS OF CAPTURE OF K-MESONS:

$$5)\ \tilde{K} + N \to \Lambda + \pi\ \text{(b)},$$
$$6)\ \tilde{K} + N \to \Sigma + \pi\ \text{(c)},$$
$$7)\ \tilde{K} + d \to \Sigma + N\ \text{(b)},$$
$$8)\ \tilde{K} + d \to \Lambda + N + \pi\ \text{(b)},$$
$$9)\ \tilde{K} + d \to \Sigma + N + \pi\ \text{(c)},$$

REACTIONS OF INTERACTION OF Σ-HYPERONS WITH NUCLEONS.

$$10)\ \Sigma + N \to \Sigma + N\ \text{(c)},$$
$$11)\ \Sigma + N \to \Lambda + N\ \text{(b)},$$
$$12)\ \Sigma + N \to \Lambda + N + \pi\ \text{(c)}.$$

REACTIONS OF CREATION OF ANTIHYPERONS AND K-MESONS:

$$13)\ \pi + N \to N + \Lambda + \tilde{\Lambda}\ \text{(b)},$$
$$14)\ \pi + N \to N + \Lambda + \tilde{\Sigma}\ \text{(c)},$$
$$15)\ N + N \to d + \Lambda + \tilde{\Sigma}\ \text{(c)},$$
$$16)\ N + N \to d + \Sigma + \tilde{\Sigma}\ \text{(b)},$$
$$17)\ N + N \to d + K + \tilde{K}\ \text{(a)}.$$

REACTIONS OF ANNIHILATION OF ANTIHYPERONS:

$$18)\ \tilde{\Lambda} + N \to K + \pi\ \text{(b)},$$
$$19)\ \tilde{\Sigma} + N \to K + \pi\ \text{(c)},$$
$$20)\ \tilde{\Xi} + N \to K + K\ \text{(a)},$$

Some of these relations were obtained earlier.[1,4] It should be emphasized that all the relations considered connect the differential cross sections of the corresponding reactions.

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