$$J = {}^1/_2 : I = 1 - 0{,}6 \cos^2\theta + a\,(1 + \cos^2\theta);$$

$$J = {}^3/_2 : I = 1 + 0{,}75 \cos^2\theta$$

$$+ \alpha\,(0{,}4 - 1{,}2\cos^2\theta) + \alpha^2\,(0{,}37 + 0{,}48\cos^2\theta) + b;$$

$$I = {}^5/_2 : I = 1 - 0{,}45\cos^2\theta$$

$$+ \beta\,(0{,}4 - 1{,}2\cos^2\theta) + \beta^2\,(0{,}33 + 0{,}43\cos^2\theta)$$

$$+ c\,[(1 - 0{,}14\cos^2\theta) + \gamma\,(0{,}5 - 1{,}5\cos^2\theta)$$

$$+ \gamma^2\,(0{,}44 - 0{,}1\cos^2\theta)];$$

$$J = {}^7/_2 : I = 1 - 0{,}6\cos^2\theta$$

$$+ \delta\,(0{,}5 - 1{,}36\cos^2\theta) + \delta^2\,(0{,}26 + 0{,}48\cos^2\theta)$$

$$+ d\,[1 + 0{,}23\cos^2\theta + \varepsilon\,(0{,}7 - 2{,}1\cos^2\theta)$$

$$+ \varepsilon^2\,(0{,}5 + 0{,}01\cos^2\theta)]$$

Note added in proof. The problem of the correlations in the decay of a Σ-particle have also been considered in the recent publication of Gatto.[4]

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[2]A. I. Akhiezer and V. B. Berestetskii, *Quantum Electrodynamics*, GTTI, 1953).

[3]Biedenharn, Blatt and Rose, Rev. Mod. Phys. 24, 249 (1952).

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Gamma Resonances in Reactions of Proton Capture by Silicon Isotopes

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THE reactions Si (p , γ) P were first studied[1] by means of the yield of γ-radiation from thick targets for the proton energy interval from 0.3 to 0.55 mev. Somewhat later,[2] Tangen reported the results of more detailed investigations of this reaction in the same proton energy interval. He found resonances for E_p = 326 and 414 kev, which he attributed to the reaction Si^{29} (p, γ) P^{30}, since he observed them by the activity of P^{30}, and also resoances for E_p = 367 and 499 kev, which he attributed to the reaction Si^{30} (p, γ) P^{31}. Recently, Milani, Cooper and Harris observed[3] γ-resonances in the reaction Si^{29} (p, γ) P^{30} at approximately E_p = 696, 727, 917, 956 kev. They carried out their investigations both on thin and thick targets of Si^{29}.

The integral excitation function of the Si (p, γ) P reactions was measured on the 4 mev electrostatic generator of the Physico-technical Institute of the Acadmey of Sciences, USSR, in the proton energy interval from 500 to 2600 kev. A thick target with the natural mixture of the istopes of silicon (Si^{28}, 92.28 %; Si^{29}, 4.67%; Si^{30}, 3.05%) was prepared from a pure (99.98 %) single crystal of silicon, which has been obtained by vacuum distillation. To test the various impurities in the silicon crystal, investigations were carried out on thick and thin targets, prepared from silicon which has served as the initial material in the preparation of the single crystal. The tests showed that Al, Fe and Pb, which appeared as impurities in the original material, had been removed. The energy of the accelerated protons was measured by an electrostatic analyzer with accuracy to within 0.05 %; the imhomogeneity in the energy of the proton beam amounted to 0.8 kev for the entire interval of proton energies, the γ-rays were detected by a copper counter. The current at the target was measured by a current integrator of the Watt type. During the measurements, the target temperature was maintained at the level 300-500° to avoid weakening of the carbon film; vapors of the oil of the diffusion pumps were carefully frozen out with a liquid nitrogen trap. In the measurments of the integral excitation function, the position and width of 26 new γ-resonances were determined. New γ-resonances were found for E_p = 619.5, 717, 753, 775, 800, 831, 895, 940, 980, 1520, 1618, 1635, 1647, 1663, 1680, 1699, 1774, 1810, 1849, 1879, 2520, 2543, 2553, 2557.5, 2570 and 2575 kev. The experimental widths were observed to lie within the limits 0.8 to 8 kev.

For identification of the reactions corresponding to the resonances, the differential excitation function was measured on thin targets by the yield of positron activity of P^{29} and P^{30}. At present, this work has been carried out only to proton energies of E_p = 1000 kev. Not a singleresonance was foundfor P^{29}. Also, no new resonances have been found for P^{30} up to 1000 kev. The positions of the two γ-resonances mentioned earlier[3] for the reaction Si^{29} (p, γ) P^{30} for E_p = 917 and 956 kev were determined more accurately by us; according to our measurements, E_p = 916.5 ± 0.5 and 956 ± 1 kev. The lower accuracy of the determination of the resonance for 956 kev was caused by its weak 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 $K + N \rightarrow K + N$ or, in more detail,

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

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 $\pi + N \rightarrow \Lambda + k$, or, more generally: