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Translated by E. S. Troubetzkoy
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Simultaneous Creation of Λ and θ-Particles

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(Submitted to JETP editor January 10, 1956)
J. Exptl. Theoret. Phys. (U.S.S.R.) 32, 933-934
(April, 1957)

THE ANALYSIS OF ANGULAR and energy distributions of π-mesons from the decay $\tau^+ \to 2\pi^+ + \pi^-$ leads to the conclusion that the spin and parity of the τ-meson are 0^-. Such a meson cannot decay into two π-mesons, therefore there must be two kinds of K-mesons: τ^+ and θ^+. The experimental masses and lifetimes of the K^+-mesons coincide. The equality of the masses can be explained by the hypothesis of Lee and Yang[1] according to which the Hamiltonian of strong interactions is invariant with respect to the operation C_p which changes the parity. The equality of the lifetimes of the τ and θ-mesons remains, however, unexplained.

Another possible assumption is the hypothesis that the K-meson decay interaction does not conserve parity and that there exists only one K-meson.

We want to point out that the experiments on the pair production of Λ^0, K^0 can be used to answer the question on the number of K-mesons. Steinberger *et al.*,[2-4] observed the decays of Λ^0 and θ^0 particles, $\Lambda^0 \to p + \pi^-$, $\theta^0 \to \pi^+ + \pi^-$ produced in the process

$$\pi^- + p \to \Lambda^0 + \theta^0.$$

The lifetimes of these decays are $\tau \sim 10^{-10}$ sec. They determined the probabilities R_θ and R_Λ that the observed decay $\Lambda \to p + \pi^-$ will be followed by the fast decay $\theta \to \pi^+ + \pi^-$, and vice versa. The experiment gives $R_\theta \sim R_\Lambda \sim 0.3 - 0.4$.

Let us assume that there exists only the K-meson and that parity is not conserved. In order to explain the existence of the long-lived K^0-meson observed in the experiments of Lande *et al.*,[5] one has to assume that the Hamiltonian of the decay interaction is invariant with respect to C or CI, where C is the charge conjugation and I is the inversion[6]. The K-meson is the mixture

$$K^0 = (K_s^0 + K_a^0)/\sqrt{2},$$

where the wave function of K_s^0 is symmetric and the wave function of K_a^0 is antisymettric with respect to C or CI respectively K_s^0 decaying into two π-mesons with a lifetime of 10^{-10} sec and K_a^0 being long-lived. We then get for R_θ and R_Λ: $R_\theta = 0.5\, p_\theta$, $R_\Lambda = p_\Lambda$, where p_θ, p_Λ are the probability ratio

$$p_\theta = w(\theta^0 \to \pi^+ + \pi^-)/[w(\theta^0 \to \pi^+ + \pi^-) + w(\theta^0 \to \pi^0 + \pi^0)] < 1,$$

$$p_\Lambda = w(\Lambda \to p + \pi^-)/[w(\Lambda \to p + \pi^-) + w(\Lambda \to n + \pi^0)] < 1.$$

Comparing with experiment: $p_\theta = 0.6 - 0.8$, $p_\Lambda = 0.3 - 0.4$.

Experimentally, only the order of magnitude of these quantities is known at the present time. Osher and Mojer give p_Λ and $p_\theta \sim 0.5$ which, in view of the inaccuracy of these values, should be considered as not being in contradiction with the hypothesis of a single K-meson.

In the Lee and Yang scheme the τ and θ-mesons are produced in equal numbers and, taking into account that θ^0 is a mixture of symmetric and assymmetric components, we get

$$R_\theta = 0{,}25\, p_\theta < 0{,}25; \quad R_\Lambda = p_\Lambda.$$

We come to a contradiction, as the experiment gives $R_\theta \sim 0.3 - 0.4$.

The contradiction can be avoided by taking into account the fact that, in the Lee and Yang scheme, even and odd Λ-particles should exist simultaneously with even and odd K-mesons, and by assuming that one of the Λ-particles is long-lived with a lifetime of $10^{-8} - 10^{-9}$ and that the θ-meson is produced only (or most of the time) with a short-lived Λ-particle. Such an assumption means that the θ and τ do not transform one into the other in strong interactions.

We then get, as in the case of a single K-meson:

$$R_\theta \sim 0{,}5\, p_\theta, \quad R_\Lambda \sim p_\Lambda.$$

The assumption on the existence of a long-lived Λ-particle can be verified directly. In particular, such a long-lived particle should have been observed in experiments[5]. The fact that it has not actually been observed is in contradiction with such an assumption.

Therefore, the values R_Λ and R_θ agree most easily with the single K-meson hypothesis, the values of p_θ and p_Λ being $p_\theta = 0.3 - 0.4$, $p_\Lambda = 0.6 - 0.8$.

Let us now investigate the theoretical values of p_θ and p_Λ. In the Gell-Mann scheme, it is assumed that the decay interaction satisfies the selection rule $\Delta T_3 = 1/2$ (T is the isotopic spin). One can assume that the decay interaction satisfies a more restricted selection rule $\Delta T = 1/2$, which explains by a natural way the longer lifetime of θ^+ with respect to that of θ^0, because, for an interaction with $\Delta T = 1/2$, the decay $\theta^+ \rightarrow \pi^+ + \pi^0$ is forbidden. For $\Delta T = 1/2$, $p_\theta = p_\Lambda = 2/3 = 0.67$. These values are actually quite indeterminate because a small admixture of interaction with $\Delta T = 3/2$ strongly influences p_Λ and p_θ.

In order to explain the decay $\theta^+ \rightarrow \pi^+ + \pi^0$, one has to introduce an impurity with $\Delta T = 3/2$, the amplitude a_3 of which being $a_3 = 0.07\, a_1$, where a_1 is the amplitude of the transitions with $\Delta T = 1/2$. The ratios

$$w\,(\theta^0 \rightarrow \pi^0 + \pi^0)/w\,(\theta^0 \rightarrow \pi^+ + \pi^-)$$

$$\text{and}\quad w\,(\Lambda \rightarrow n + \pi^0)/w\,(\Lambda \rightarrow p + \pi^-)$$

vary between the limits

$$\frac{1}{2}\left|\frac{1 \pm \sqrt{2}\,a_3/a_1}{1 \mp a_3/a_1\sqrt{2}}\right|^2,$$

which, for $a_3/a_1 = 0.07$, give $0.62 < p_\Lambda < 0.72$; $0.62 < p_\theta < 0.72$.

In order to obtain $p_\Lambda \sim 0.3 - 0.4$, it is necessary that $a_3/a_1 \approx 0.3$ for the decay interaction of Λ-particles.

Finally, let us emphasize the existing experimental values of p_θ, p_Λ and of R_θ, R_Λ contain large errors which do not allow to draw a unique conclusion. We think therefore that an accurate measurement of these quantities would be very desirable.

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Translated by E. S. Troubetzkoy
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Absorption of Sound in a Phase Change in Rochelle Salt

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(Submitted to JETP editor January 7, 1957)
J. Exptl. Theoret. Phys. (U.S.S.R.) **32**, 935-936
(April, 1957)

SOME TIME AGO Landau and Khalatnikov[1] looked into the problem of the relaxation time necessary for establishing thermodynamical equilibrium in the asymmetric phase of a body undergoing a second-order phase transition. From their calculations it turned out that the relaxation time increases as the temperature of the ordered phase approaches the λ-point. Applying M. A. Leontovich's and L. I. Mandel'shtam's relaxation theory of sound absorption to this problem, Landau and Khalatnikov predicted an increase in the absorption of sound in the absorption of sound in the low-temperature phase near the λ-point.

With the object of observing this phenomenon, we set up an experiment for investigating the absorption of sound in Rochelle salt near its upper Curie point. We used a pulse method for measuring the attenuation of sound in a single crystal of Rochelle salt. Transverse pulses at a frequency of 5 Mcs, 1 to 5 microseconds in length, occurring every 0.002 seconds were introduced into a lamina of Rochelle salt placed in a thermostat. The waves were propagated along the crystallographic z-axis. The oscillations received at the opposite side of the lamina were amplified and fed into cathode-ray oscillograph with a delayed sweep. The attenuation of the sound could be determined from oscillograms of pulses which had passed through different thicknesses of Rochelle salt.