Experimental bound on the probability of the decay $K_L \to \eta_2$ (480) $+ \gamma$

V. V. Barmin, G. V. Davidenko, V. S. Demidov, A. G. Dolgolenko, V. A. Shebanov, and N. N. Shishov

Institute of Theoretical and Experimental Physics

(Submitted February 13, 1974)
ZhETF Pis. Red. **19**, 398–400 (March 20, 1974)

We report the results of a search for the decay $K_L \to \eta_2$ (480) $+ \gamma$ among the photographs of a 180-liter xenon bubble chamber. We find that at a 90% confidence level the probability of the decay is $\Gamma[K_L \to \eta_2(480)+\gamma]/\Gamma_L < 1 \times 10^{-4}$. This contradicts the probability obtained for this decay from the hypothesis of A. L. Lyubimov.

Lyubimov[1] has advanced a hypothesis that makes it possible to eliminate the disparity between the experimental value of the decay probability $W_e = K_L \to 2\mu/K_L \to \text{all} \leqslant 1.8 \times 10^{-9}$ obtained in the experiment of Clark *et al.*, [2] and the lower theoretical bound of this quantity, $W_T = K_L \to 2\mu/K_L \to \text{all}$. 1) Lyubimov's hypothesis states that what was really observed in the experiments aimed at determining the probability of the $K_L \to 2\gamma$ decay was another K_L-meson decay, namely $K_L \to \eta_2(480) + \gamma_3(\eta_2 \to \gamma_1 + \gamma_2)$, which is difficult to distinguish from decay into two γ quanta, owing to the low probability of registration of γ_3, while the insufficient accuracy in the determination of the effective mass of the two γ quanta does not permit the decays $\eta_2(480) \to 2\gamma$ and $K_L \to 2\gamma$ to be distinguished from each other. Proposing then that the $K_L \to 2\gamma$ decay probability is much lower than the experimentally observed value 5×10^{-4}, [5] and that the probability of the decay $K_L \to \eta_2 + \gamma/K_L \to \text{all}$ is $\approx 10^{-3}$, the aforementioned singularity can be eliminated.

We report here on a search for the decay $K_L \to \eta_2(480) + \gamma$ in photographs from a 180-liter xenon bubble chamber exposed in a neutral beam. The experimental setup was described earlier in the report on the $K_L \to 2\pi^0$ decay. [6]

Preliminary simulation of the $K_L \to \eta_2 + \gamma$ decay under the conditions of this experiment has shown that the probabilities of registering such a decay in the chamber at an η_2-meson mass 480 MeV is 0.65, and 0.51 at 485 MeV. (The minimum energy of the γ quanta registered in the chamber is 20 MeV.)

To search for the $K_L \to \eta_2 + \gamma$ decay, we took the previously selected 65 cases with three observable γ quanta. Out of these, it was possible to measure the γ-quantum energies and their emission angles relative to the direction of motion of the K_L mesons in 48 cases. All the measured cases were calculated in accordance with a program in which we verified their agreement with the hypothetical decay $K_L \to \eta_2(480) + \gamma(4c\text{-fit})$. The efficiency of the program for the selection of cases with $P(\chi^2) > 1\%$ was close to 100%.

It turned out that only one case satisfied the hypothesis $K_L \to \eta_2(480) + \gamma$ with $P(\chi^2) > 1\%$. This case can be due either to the sought decay, or to the background of the $K_L \to 3\pi^0$ and $K_L \to 2\pi^0$ decays, when three or one γ quantum were registered in the chamber, respectively.

If we assume that this one case is due to the $K_L \to \eta_2 + \gamma$ decay, then the probability of this decay at the 90% confidence level is

$$\Gamma[K_L \to \eta_2(480) + \gamma]/K_L \to \text{all} \leqslant \frac{3.9 \cdot 0.215}{18060 \cdot 0.65 \cdot 0.74} = 1 \cdot 10^{-4},$$

where 3.9 is the number of events corresponding to the 90% confidence level, 0.215 is the fraction of the $K_L \to 3\pi^0$ decay relative to the total number, 18060 is the number of $K_L \to 3\pi^0$ decays, 0.65 is the efficiency of registration of the decay $K_L \to \eta_2 + \gamma$, and 0.74 is the coefficient of measurability of the 3γ cases.

It is seen from the estimate obtained by us for the probability of the $K_L \to \eta_2(480) + \gamma$ decay, that the hypothesis of A. L. Lyubimov is not confirmed by experiment.

In conclusion, we are deeply grateful to A. G. Meshkovskii and Yu. V. Terekhov for useful discussions.

---

1)The recently published results, in which a value $W_e = 11^{+10}_{-5} \times 10^{-9}$ agreeing with W_T, was obtained on the basis of only six cases of $K_L \to \mu^+\mu^-$, contradicts the data of [2] and obviously calls for new additional experiments.

---

[1]A. L. Lyubimov, JINR Preprint R1-6650, Dubna, 1972.

[2]A.R. Clark, T. Elioff, R.C. Field, H.J. Frisch, R.P. Johnson, L.T. Kerth, and W.A. Wenzel, Phys. Rev. Lett. **26**, 1667 (1971).

[3]L.M. Sehgal, Nuovo Cimento **45A**, 785 (1966).

[4]W.C. Carithers, T. Modis, D.R. Nygren, T.P. Pun, E.L. Schwartz, H. Sticker, J. Steinberger, P. Weilhammer, and H.J. Christenson, Phys. Rev. Lett. **30**, 1336 (1973).

[5]Particle Data Group. Review of Particle Properties. Phys. Lett. **39B**, April 1972.

[6]V.V. Barmin, V.G. Barylov, V.S. Borisov, G.K. Bysheva, G.S. Veselovsky, V.M. Golubchikov, L.L. Goldin, G.V. Davidenko, A.G. Dolgolenko, V.S. Demidov, N.K. Zombkovskaya, T.A. Chistyakova, I.V. Chuvilo, V.A. Shebanov, E.M. Bogdanowicz, V.B. Vinogradov, I.A. Ivanovskaya, T.I. Kanarek, V.A. Maximenko, Z.I. Ogrzevalski, L.S. Okhrimenko, and Z.S. Strugalski, Phys. Lett. **33B**, 377 (1971).