acta phys. slov. 24 (1974), No. 4

Letters to the Editor

A SEARCH FOR THE χ^0-MESON IN THE DIMUON DECAYS OF K_L^0 [1]

JAN HLADKÝ,* Praha

One of the possible solutions of the $K_L^0 \to \mu^+\mu^-$ puzzle[2] [1] is given by the model of Alles and Patti [2], which assumes the existence of a new neutral vector meson χ^0.

According to [2], the χ^0—meson would have quantum numbers $I^G(J^P)^C = 0^-(1^-)^-$, a width of about 0.1 MeV and a mass M somewhere in the interval of 350 MeV $\leqq M \leqq$ 425 MeV. The χ^0-meson would be formed in the reaction $K_L^0 \to \chi^0\gamma$ and its basic decay modes are $\chi^0 \to \pi^0\gamma$, e^+e^-, $\mu^+\mu^-$ and $\pi^+\pi^-$, In order to account for the observed suppression of the $K_L^0 \to \mu^+\mu^-$ decay mode (1), the model of Alles and Patti estimates the following branching ratio for χ^0:

$$\frac{\Gamma(K_L^0 \to \chi^0\gamma)}{\Gamma(K_L^0 \to \text{all})} \geqslant 1.2 \times 10^{-2} \tag{1a}$$

where $\chi^0 \to \pi^0\gamma$, e^+e^-, $\mu^+\mu^-$ or $\pi^+\pi^-$. The $\chi^0 \to \mu^+\mu^-$ decay mode should have a branching ratio of $\geqslant 5\%$, i.e.

$$\frac{\Gamma(K_L^0 \to \chi^0\gamma \to \mu^+\mu^-\gamma)}{\Gamma(K_L^0 \to \text{all})} \geqq 6 \times 10^{-4} \tag{1b}$$

These conditions have been checked experimentally. In paper [3] only $\chi^0 \to \pi^0\gamma$ and e^+e^- decay modes have been searched with a negative result. Our preliminary data on the $\chi^0 \to \mu^+\mu^-$ decay are reported in [4]. In paper [5] the decays $\chi^0 \to e^+e^-$ and $\mu^+\mu^-$ have been searched, but the result given for the $\mu^+\mu^-$ decay mode is not inconsistent with the theoretical limit (1b).

This work is devoted to the futher search for the χ^0 meson by means of the decay mode $K_L^0 \to \chi^0\gamma \to \mu^+\mu^-\gamma$.

The experiment was performed with a spark chamber magnetic spectrometer[3] located in a neutral beam of the proton synchrotron in Serpukhov. The apparatus shown sche-

---

[1] Talk given at the Triangle Meeting on Weak Interactions at SMOLENICE, June 4—6, 1973 by J. Hladký. This paper arose in cooperation of the workers in Dubna, Prague, Budapest.

* Fysikální ústav ČSAV, 180 40 PRAHA, Na Slovance 2, Czechoslovakia.

[2] See for instance: Stern H., Gaillard M. K., CEN-DPh-T/72-14.

[3] Basiladze S. G. et al., Dubna P1-5361 (1970).

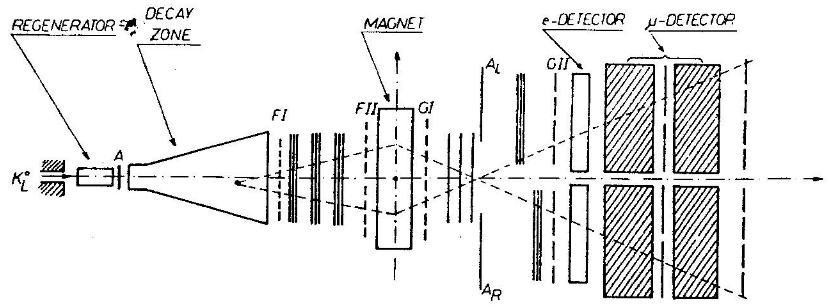

Fig. 1. The spark chamber magnetic spectrometer.

matically in Fig. 1 was originally constructed for $K_L^0 \to K_S^0 \to \pi^+\pi^-$ regeneration experiments. The trigger logic $\bar{A}\,FI\,FII\,GI\,GII$ required to register two coincident charged particles in the spectrometer sides using a crossed geometry behind the magnet. The laboratory momenta of charged particles registered by this apparatus were greater than 4 GeV/c. The muon detector consists of two one meter thick iron blocks and counters between them, which were in coincidence with eight hodoscopic counters, located behind the second block. Using an on-line computer, the information from the magnetostrictive spark chambers as well as the detectors was transferred to a magnetic tape.

The dimuon events have been recorded during the regeneration experiment[4], where about 1.7×10^6 triggers were taken in both regenerator and vacuum runs. The reconstruction of events consists of a vertex and a momenta determination under the following conditions:

a) Two continuous charged tracks registered before the magnet have a well-defined intersection point within a fiducial volume in a K^0 decay zone. The continuation point of tracks in the centre of the magnet was also required.

b) Only one muon counter should give a signal on each side of the muon detector. The trajectory continuity up to the muon detector was required. The Coulomb scattering of muons in the iron was taken into account.

A sample of 1304 events was chosen under the above criteria.

As a background, mainly $K_{\mu 3}$ decays registered also by the apparatus have been assumed. The following processes can give an important contamination to the dimuon sample:

i) Pions decaying in flight ($\pi \to \mu\nu$).

ii) The registration of a halo particle by the muon detector together with a $K_{\mu 3}$ event. The contribution of both processes was calculated and gives one percent of a $K_{\mu 3}$ decay sample [6]. The contaminations from the $K_S^0 \to \pi^+\pi^-$ and $K_L^0 \to \pi^+\pi^-\pi^0$, where both charged pions decayed in flight, from $K_S^0 \to \mu^+\mu^-$ and also from $K_L^0 \to \mu^+\mu^-\gamma$ decays are negligibly small. Thus, using the 125 200 observed $K_{\mu 3}$ decays, we expect the background contamination of about 1250 events to the 1304 dimuon events.

The $\mu^+\mu^-$ effective mass distribution is shown in Fig. 2. The full line represents the distribution of 1304 dimuon events, the dashed line represents the distribution of $K_{\mu 3}$ decays (where the pion has deliberately been misidentified as a muon). The $K_{\mu 3}$ distribution is normalized to 590 dimuon events outside the region of 350 MeV $\leqslant M_{\mu^+\mu^-} \leqslant$ 425 MeV. As one can see, the shape of these distributions is very similar. It gives a rather good proof for the validity of the above mentioned background assumptions. Monte Carlo calculations have proved that the detection efficiencies for $K_L^0 \to \chi^0\gamma \to \mu^+\mu^-\gamma$ and $K_{\mu 3}$ decays in a given interval of $M_{\mu^+\mu^-}$ are equal. The histogram bins width of 5 MeV in Fig. 2 is close to the spectrometer mass resolution (*HWHM*) estimated from the $K_0^S \to \pi^+\pi^-$ peak (se note [3]).

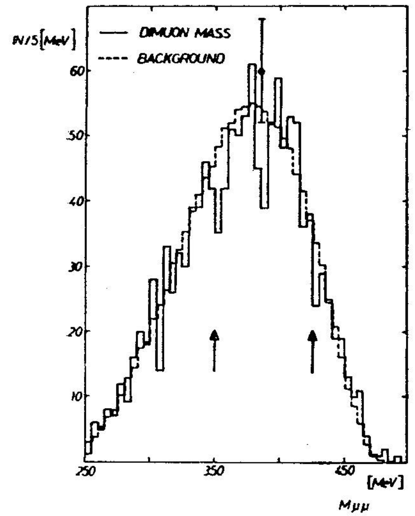

Fig. 2. The $\mu^+\mu^-$ effective mass distribution. The full line represents this distribution for 1304 dimuon events, the dashed line shows the same distribution for $K_{\mu 3}$ decays. The $K_{\mu 3}$ distribution is normalized to the dimuon events outside the region of 350 MeV $\leqslant M_{\mu^+\mu^-} \leqslant$ 425 MeV. The edges of this interval are denoted by arrows.

As one sees in Fig. 2, there is no significant structure of the dimuon invariant mass distribution in the whole interval of a possible χ^0-meson mass. The maximal possible χ^0-meson signal si situated in the interval of 405 MeV $\leqslant M_{\mu^+\mu^-} \leqslant$ 415 MeV, where there are 105 dimuon events and 92.2 background events. On the basis of statistical and normalization uncertainties it was deduced that with 90 % of confidence level the possible χ^0 meson signal is less than 35 events. Using the known $K_{\mu 3}$ branching ratio of 0.27 [7] our final result is

$$\frac{\Gamma(K_L^0 \to \chi^0\gamma \to \mu^+\mu^-\gamma)}{\Gamma(K_L^0 \to all)} \leqslant 8 \times 10^{-5} \qquad (2)$$

Our experiment upper limit (2) lies by a factor of 7 below the theoretical lower limit (1b). This result is of the same order as for the dielectron decay mode of the χ^0-meson [3, 5] and is in accordance with the conclusion of paper [3], i.e., the partial width $\Gamma(K_L^0 \to \chi^0\gamma)$ is by a factor of 50 below the theoretical lower limit (1a).

[4] Birulev V. K. et al., Dubna E1-6851 (1972).

REFERENCES

[1] Dolgov A. D., Okun L. B., Zakharov V. I., *Proc. Neutrino Conf.*, Hungary 1972.
[2] Alles W., Patti J. C., Nuovo Cimento, *10 A* (1972), 325.

[3] Barmin V. V. et al., Sov. Jour. Nucl. Phys., *15* (1972), 1149.
[4] Votruba J., Hladký J., Novák M., Prokeš A., *Proc. II. Intern. Symposium o*
High Energy Physics. Štrbské Pleso 1972.
[5] Clark A. R. et al., Let. Nuovo Cimento, *5* (1972), 665.
[6] Albrecht K. F. et al., Phys. Lett. *48B* (1974), 393.
[7] *Particle Data Group*, Phys. Lett., *39B* (1972), 1.

Received December 4th, 1973