Vol. 29 (1998) *ACTA PHYSICA POLONICA B* No 9

STUDY OF $\bar{p}p \to \phi\eta$ AND $\bar{p}p \to K^+K^-\eta$ CHANNELS OF ANTIPROTON ANNIHILATION AT REST AT THREE HYDROGEN TARGET DENSITIES *

Vassilii Nomokonov

for the OBELIX Collaboration

Joint Institute for Nuclear Research, Dubna, Russia

(Received June 18, 1998)

The Okubo–Zweig–Iizuka (OZI) rule predicts that a ratio between the cross sections or annihilation frequencies of ϕ and ω meson production should be on the level of $4 \cdot 10^{-3}$·. It is known that the predictions of the OZI rule are fulfilled in the hadronic interactions at a level of about 10%. Recently large OZI rule violation has been found in some $\bar{p}p$ annihilation channels in the experiments with stopped antiprotons at LEAR (CERN).

PACS numbers: 13.60.Le, 13.75.Cs

Large apparent violation of the OZI rule [1, 2] was found for the $\bar{p}p \to \phi(\omega)\pi^0$ channel [3,4]. Conservation of P- and C-parities allows the $\bar{p}p \to \phi\pi$ reaction only from the ${}^3S_1$ or ${}^1P_1$ initial states. An interesting dynamical selection rule was found for this channel: ϕ production is at least 15 times more prominent for annihilation from the spin triplet ${}^3S_1$ initial state than from the singlet ${}^1P_1$ one [5].

On the other hand, no OZI rule violation was observed in the reaction $\bar{p}p \to \phi\eta$ ([3, 6]) which proceeds from the same protonium levels as the $\bar{p}p \to \phi\pi^0$ reaction, but from isospin $I = 0$. Therefore it is interesting to find out the $\phi\eta$ spin dependence and compare it with the one of $\phi\pi^0$.

We performed systematic measurements of the channel $\bar{p}p \to K^+K^-\eta$ at rest in a hydrogen target of three densities: liquid, gaseous at NTP and at 5 mbar. Changing the target pressure allowed selection of the $\bar{p}p$ initial state. The fraction of annihilation from the S-wave decreases with decreasing target density. The experiment was performed at LEAR (CERN), using

* Presented at the NATO Advanced Research Workshop, Cracow, Poland, May 26–30, 1998.

the OBELIX spectrometer [7]. The number of events on tapes in the data samples are 10.4, 6.7 and 9.4 millions for liquid target, gas at NTP and gas at low pressure, respectively. The two prong events with both particles identified as kaons by dE/dx measurements were analysed.

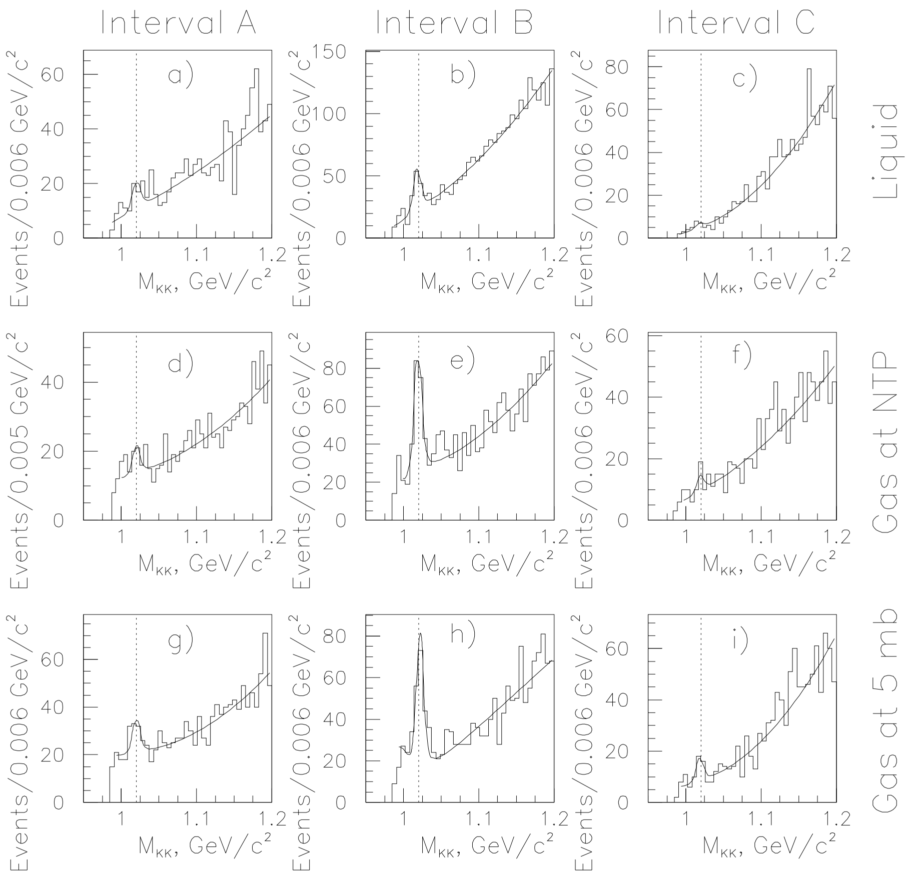

Fig. 1. The distributions on $M_{K^+K^-}$ for three intervals of missing mass for three target densities: (a), (b), (c) for the liquid target, (d), (e), (f) for the gas target at NTP and (g), (h), (i) for the gas target at 5 mbar. The left column corresponds to central interval (see the text), column (b), (e), (h) corresponds to the left one, and column (c), (f), (i) corresponds to the right one. Dashed lines correspond to the ϕ meson mass.

The inclusive measurement of the $K^+K^-\eta$ channel frequency have been carried out by counting number of events in η peak in the missing mass spectra. The yield of the reaction is $Y = (8.17 \pm 0.37) \cdot 10^{-4}$, $(4.68 \pm 0.32) \cdot 10^{-4}$ and $(2.49 \pm 0.30) \cdot 10^{-4}$ for the liquid target, gas target at NTP and for a gas target at low pressure, respectively. To select events from the $\phi\eta$ reaction the invariant mass distribution of two kaons $M_{K^+K^-}$ for events with the missing mass around the mass of η was analysed. It is shown in the middle part of Fig. 1, where events with the missing mass interval $0.26 < M^2_{\rm miss} < 0.34$ GeV$^2/c^4$ (centred around $m^2_\eta = 0.3$ GeV$^2/c^4$) were selected. The left and right parts of Fig. 1 correspond to the $M_{K^+K^-}$ distributions for the missing mass intervals below and above the η mass, where number of events with η is negligible: $0.15 < M^2_{\rm miss} < 0.23$ (left) and $0.37 < M^2_{\rm miss} < 0.45$ GeV$^2/c^4$ (right).

The experimental distributions for the interval "B" (Figs 1(b), (e) and (h)) for events with missing mass around the mass of η show clear peaks in the region of the ϕ meson. The ϕ signal for events from neighbouring missing mass intervals "A" and "C" is far less pronounced. The ϕ signal in the liquid data looks smaller than in 5 mbar data sample.

Counting number of events in ϕ peaks in two latter intervals helped us to estimate number of background events in the ϕ peak in the central interval, which contains most part of $\phi\eta$ events. After that we had number of $\phi\eta$ events in the central interval and could calculate the annihilation frequency $\mathcal{F}$. The registration efficiency $\varepsilon_{\rm reg}$ for annihilation from the $^1P_1$ initial state is less than from the $^3S_1$ one. Thus we could determine only an upper and lower limits for the annihilation frequency corresponding to the initial states $^1P_1$ and $^3S_1$, respectively and the results are (all values are multiplied by 10^{-4}): 0.60 ± 0.20 and 1.01 ± 0.33 for annihilation in liquid; 1.04 ± 0.20 and 1.53 ± 0.29 for annihilation in gas at NTP and 1.05 ± 0.26 and 1.62 ± 0.40 for annihilation at the low pressure.

It is possible to determine the branching ratios B.R. (that is the probability that the $\bar{p}p$ system with the definite quantum numbers J^{PC} of the initial state annihilates into a given final state) of the reaction $\bar{p}p \to \phi\eta$ by using additional information from some models of the protonium atoms.

The procedure is discussed in details in [8].

It turns out that the branching ratio of $\bar{p}p \to \phi\eta$ channel for annihilation from the spin singlet $^1P_1$ state is about 10 times higher than the branching ratio from the spin triplet $^3S_1$ state: B.R.$(^3S_1 \to \phi\eta) = (0.76 \pm 0.31) \cdot 10^{-4}$ and B.R.$(^1P_1 \to \phi\eta) = (7.78 \pm 1.65) \cdot 10^{-4}$. An opposite trend was observed for the $\bar{p}p \to \phi\pi^0$ channel [5].

We would like to thank the technical staff of the LEAR machine group for their support during the runs.

REFERENCES

[1] S. Okubo, *Phys. Lett.* **B5**, 165 (1963); G. Zweig, CERN Rep. No.8419/TH412 (1964); I. Iizuka, *Prog. Theor. Phys. Suppl.* **38**, 21 (1966).

[2] M.G. Sapozhnikov, JINR preprint E15-95-544, (1995).

[3] C. Amsler *et al.,Phys. Lett.* **B346**, 363 (1995).

[4] V.G. Ableev *et al., Nucl. Phys.* **A594**, 375 (1995).

[5] The OBELIX collaboration. A. Bertin *et al.*, Proceedings HADRON'95 Conference, Manchester 1995, p.337.

[6] C. Amsler *et al. Phys. Lett.* **B319**, 373 (1993).

[7] A. Adamo *et al., Sov. J. Nucl. Phys.* **55**, 1732 (1992).

[8] V. Alberico *et al., Phys. Lett.* **B**, in press.