JOINT INSTITUTE FOR NUCLEAR RESEARCH

Laboratory of High Energies

P-298

E.O. Okonov

ON SOME FEATURES

OF ANTIPROTON ANNIHILATION ON A DEUTERON

ЖЭТФ, 1959, т36, в5, с1597-1598

D u b n a 1959.

P-298

E.O. Okonov

ON SOME FEATURES OF ANTIPROTON ANNIHILATION ON A DEUTERON

As it was already pointed out[1] the so called "one meson annihilation" may occur besides a usual antiproton annihilation on one of the nucleons of the deuterium nucleus. In the annihilation process of such a kind a part of the energy released in the annihilation is directly transferred to the remained nucleon

$$\tilde{p} + d \to p + \pi^- \tag{1}$$

$$\tilde{p} + d \to n + \pi^0 \tag{2}$$

A relative probability of such reactions depends, evidently, not only upon statistical factors but also upon the character of the annihilation interaction which is so far known very little.

Without going into details of the available models of the annihilation interaction it would be reasonable to suppose that the relative probability of the mentioned processes will be not less (the statistical corrections are not taken into account) than the relative probability of the reaction

$$\pi^+ + d \to p + p \tag{3}$$

the cross section of which for π^+-mesons of the momentum ~130 MeV/c is ~10% of the total cross of π^+d-interaction [2]. When the momentum of an incident particle decreases /with the increase of the de Broglie wave length/the contribution due to similar processes involving both nucleons of the deuterium nucleus is very likely to be even more.

It is possible that in some cases of annihilation observed in the emulsion the annihilation energy is directly transferred to the nucleons that results in a noticable number of the "mesonless" annihilation stars (~5%)*. To make more grounded conclusions more complete experimental data are necessary as well as the analysis of the energy distribution of the nucleons emitted in the annihilation process.

It is easy to make sure that charge invariance predicts quite a definite relation between the cross sections of reactions (1) and (2), namely

$$\frac{d\sigma\ (\tilde{p}+d) \to p+\pi^-)}{d\sigma\ (\tilde{p}+d \to n+\pi^0)} = 2 \tag{4}$$

It should be noted, however, that the violation of this relation may be due not only to the violation of isotopic invariance but also to the emission in the annihilation of a hypothetical ρ^0-meson with an isotopic spin 0

$$\tilde{p} + d \to n + \rho^0 \tag{5}$$

---

* When estimating this magnitude by the available data [3] the corrections for the $\pi^\pm$ selfabsorption in emulsion nuclei were made. The cases of only neutral meson emission (by the data about $\tilde{p}$ annihilation on hydrogen) [4] are also excluded.

Moreover, if π^0 and ρ^0-mesons have the same structure as, e.g., in Fermi-Yang model, according to which π^0 and ρ^0 may be described by the symmetrical and antisymmetrical functions of the type

$$\pi^0 = 2^{-1/2}(p\tilde{p} + n\tilde{n})$$
$$\rho^0 = 2^{1/2}(p\tilde{p} - n\tilde{n})$$

then the relation between the cross sections of reactions (1),(2), and (5) will be as follows:

$$d\sigma(p\pi^-) : d\sigma(n\pi^0) : d\sigma(n\rho^0) = 2 : 1 : 3$$

(with an accuracy up to a relative mass difference between π^0 and ρ^0-mesons). If π^0 and ρ^0-mesons cannot be distinguished experimentally then the neutral annihilations (2) (5) would be found to be twice as great as the "charged" (1)*.

It is worth noting that in the annihilation capture of an antiproton by a deuteron a pair production of strange particles

$$\tilde{p} + d \rightarrow \Sigma^- + K^+ \qquad (6)$$
$$\tilde{p} + d \rightarrow \Sigma^0 + K^0 \qquad (7)$$
$$\tilde{p} + d \rightarrow \Lambda^0 + K^0 \qquad (8)$$

may occur besides the reactions (1), (2) and (5). The study of the relative probability of these processes makes it possible to verify the isotopic invariance as well as the validity of grouping the strange particles into charge multiplets. The charge independence requires that the ratio of the cross sections for the reactions (6) and (7) would be

$$d\sigma(\Sigma^- K^+) : d\sigma(\Sigma^0 K^0) = 2 : 1$$

If one accepts the Gell-Mann-Pais hypothesis about the symmetry in strong interactions within the frame of which all the baryons including hyperons are treated as isotopic doublets $N_1 = \begin{vmatrix} \Sigma^+ \\ Y^0 \end{vmatrix}$ where $Y^0 = 2^{-1/2}(\Lambda^0 - \Sigma^0)$ and $N_2 = \begin{vmatrix} Z^0 \\ \Sigma^- \end{vmatrix}$ where $Z^0 = 2^{-1/2}(\Lambda^0 + \Sigma^0)$

then in this case appears an additional relation

$$d\sigma(\Sigma^0 K^0) = d\sigma(\Lambda^0 K^0)$$

(with an accuracy up to $\delta = \frac{m_\Sigma - m_\Lambda}{m_\Lambda} \sim 0.07$)

---

* The available experimental data[4] still, (statistically very poor) do not allow to assume yet that in the antiproton annihilation on a proton besides π^0-meson a considerable number of hypothetical ρ^0-mesons[5] is emitted.

Reactions (6),(7),(8) are easily identified experimentally since in this case a hyperon and K-meson are emitted at the angle of $\sim 180^{0}$ with a quite definite energy ($E_{K} \sim 0.7$ BeV, $E_{\Lambda} \sim 0.5$ BeV, $E_{\Sigma} \sim 0.44$ BeV).

In similar processes the production of a cascade hyperon is also possible

$$\tilde{p} + d \rightarrow \Xi^{-} + K^{+} + K^{0}$$

as well as

$$\tilde{p} + d \rightarrow \Xi^{0} + K^{0} + K^{0}$$

if a neutral cascade hyperon really exists.

The author would like to express his gratitude to L.I. Lapidus, B.M. Pontecorvo and R.M. Ryndin for discussion and critical remarks. He is also grateful to D. Miller who kindly gave the experimental data before their publication.

References

1. B.M. Pontecorvo JETP, 30, 947 (1956).
2. R. Durbin, H. Loar, I. Steinberger Phys.Rev. 84, 581 (1951).
3. E. Segre Antinucleons UCRL-8260 (1958).
4. D. Miller (private communication, July 1958).
5. E.O. Okonov "On a Possible Existence of a Neutral Meson with a Isotopic Spin O". Report. Laboratory of High Energies (1958).
6. M. Gell-Mann Phys. Rev. 106 1297 (1957).
7. A. Pais Phys. Rev. 110, 574 (1958).

The Russian variant of this paper was received by Publishing Department on February 3, 1959.