Correlation among charged secondary particles in interactions of antinucleons with tantalum nuclei at a momentum of 6.1 GeV/c

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Experimental results on the multiplicity of charged secondary particles and their correlations in $\overline{N}$ Ta interactions are reported. The correlation dependence appears to indicate a qualitative distinction between the annihilation process in a nucleus and nucleon-nucleus interactions.

The effects of primary interest in research on the interaction of antinucleons with nuclei are those which distinguish this process from both elementary $\overline{N}N$ annihilation and nucleon-nucleus interactions. It has been pointed out[1] that the annihilation of an $\overline{N}$ inside a heavy nucleus might lead to the production of a blob of hot matter in the nucleus. An antinucleon energy ~ 6 GeV would be the optimum for this process, since the relative weight of the annihilation at this energy would be $\sim 40\%$, and the mean free path of antinucleons in the nuclear matter would be ~ 3 fm. For a tantalum nucleus with a radius ~ 7 fm. most of the antinucleons would annihilate inside the nucleus. The blob of nuclear matter formed in the process, with an initial energy density $\epsilon \simeq 3.3$ GeV/fm^3, would propagate through the nucleus at a velocity ~ 0.86 c, expanding and capturing the nearest nucleons of the nucleus. A droplet of hot matter inside a nucleus might have a longer lifetime than in annihilation with a free nucleon, because other nucleons of the nucleus are close to the annihilation region. It might thus be possible to produce the conditions required for the production of an equilibrium quark-gluon plasma, whose decay would be accompanied by corresponding signals.[2,3]

TABLE I. n_{ch}—Multiplicity of charged secondary particles: n_-—multiplicity of negative charge particles: n_g—multiplicity of "gray" particles, primarily protons, with momenta from 0.3 to 1 GeV/c (the lower boundary on the detection of protons is set by the thickness of the tantalum plate); $n_s = n_{ch} - n_g$—multiplicity of "fast" particles, primarily π mesons.

	$\langle n_{ch} \rangle$	$\langle n_- \rangle$	$\langle n_g \rangle$	$\langle n_s \rangle$
$\overline{n}$Ta	9.10 ± 0.22	2.01 ± 0.08	5.06 ± 0.23	4.04 ± 0.13
$\overline{p}$Ta	8.54 ± 0.30	1.97 ± 0.10	4.75 ± 0.29	3.79 ± 0.17
$\overline{d}$Ta $\rightarrow \overline{p}_s + X$	6.27 ± 0.26	1.70 ± 0.07	2.54 ± 0.22	3.73 ± 0.14
pTa	7.19 ± 0.19	1.09 ± 0.05	4.12 ± 0.12	3.04 ± 0.05

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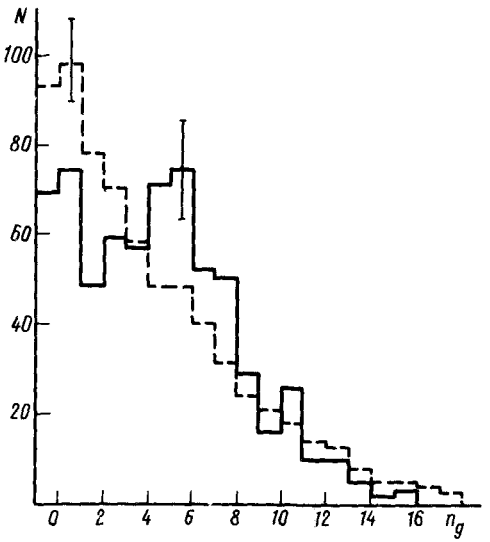

FIG. 1. Distribution of events in the multiplicity n_g (gray particles) for $\bar{n}$ Ta (solid line) and $\bar{p}$Ta (dashed line) interactions.

In the present letter we report the experimental results of an inspection of ~70 000 stereo photographs taken at the Lyudmila two-meter liquid-hydrogen bubble chamber. A tantalum plate with a thickness of 3 mm was placed in the working volume of the chamber. The chamber was then exposed to a beam of antideuterons with a momentum of[4] 12.2 GeV/c at the accelerator of the Institute of High-Energy Physics. Antineutrons and antiprotons were produced in the stripping of antideuterons at hydrogen in the chamber. In addition to the $\bar{n}$ Ta and $\bar{p}$ Ta interactions, which are dominated by intranucleus annihilation, we identified the reaction $\bar{d}$ Ta$\rightarrow\bar{p}_s + X$ with a spectator antiproton among the secondary particles. In this reaction the annihi-

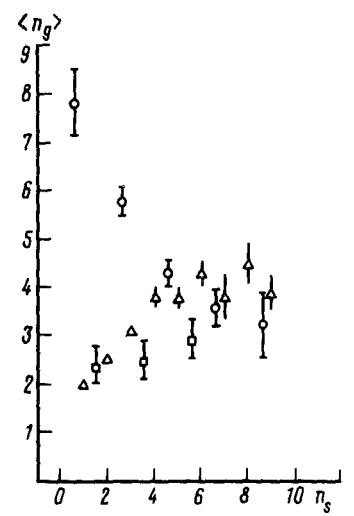

FIG. 2. Correlation dependence of $\langle n_g \rangle$ on n_s for the following interactions: ○—$\bar{n}$ Ta at 6.1 GeV/c; △—$\bar{p}$Em at 6.2 GeV/c; peripheral $\bar{n}$ Ta at 6.1 GeV/c.

lations occur for the most part at the periphery of the nucleus.

Table I lists the experimental results on the multiplicity of charged secondary particles. Shown for comparison there are the results of Ref. 5 for pTa interactions at a proton momentum of 8 GeV/c.

Figure 1 shows distributions in the multiplicity n_g (gray particles) for the $\bar{n}$ Ta and pTa interactions. The maximum in the distribution for $\bar{n}$ Ta is evidence of a significant component from annihilation of antineutrons in the tantalum nucleus.

Figure 2 shows the correlation dependence of the average multiplicity n_g on n_s, for three types of reactions: $\bar{n}$ Ta, $\bar{n}$ Ta (peripheral), and pEm (Ref. 6). It can be seen from this figure that the dependence of $\langle n_g \rangle$ on n_s in the interactions of antineutrons at the surface of the nucleus is qualitatively the same as in the pEm data. On the other hand, the behavior of $\langle n_g \rangle$ at small values of n_s for $\bar{n}$ Ta interactions is greatly different. This difference is evidence that the annihilation of antinucleons inside a nucleus is accompanied by the production of a large number of secondary nucleons, with a nearly total suppression of π-meson production. These events might be caused, in particular, by the involvement of a large number of nucleons of the nucleus in the annihilation process and by the production of a blob of matter with a high baryon density, in which the production of π mesons would be suppressed.

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