Characteristics of nucleons in central collisions of relativistic nuclei of the iron group with Ag and Br nuclei and the nuclear pionization effect

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The experimental characteristics of protons and α particles—total disintegration products of the interacting nuclei in the collisions with a small impact parameter are obtained. The experimental data are compared with the calculations based on the model of the collective interaction mechanism—nuclear pionization.

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The collisions of nuclei with the maximum number of interacting nucleons are of great interest in the study of the dynamics of strong interactions and new collective effects. an important requirement in this case is the collection of comprehensive ex-

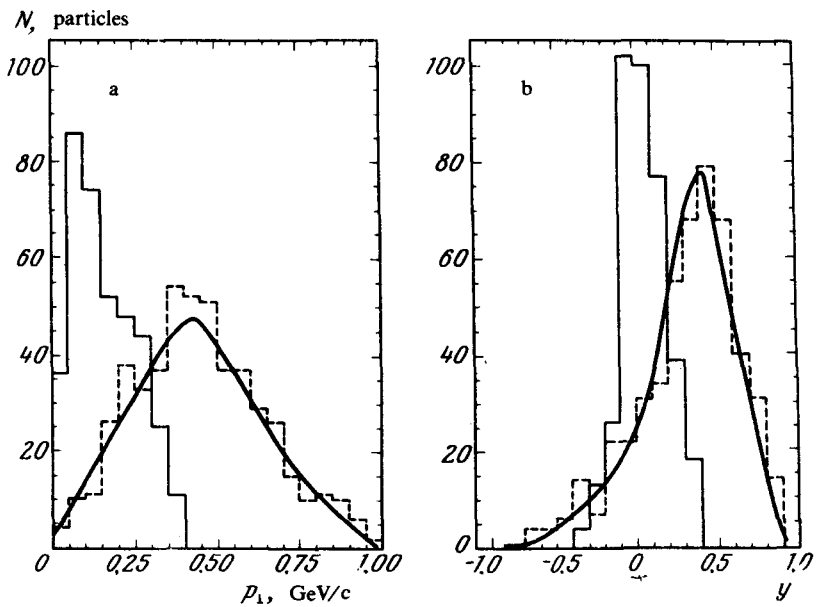

FIG. 1. The distributions of particles-disintegration products of the target-nucleus according to the transverse momentum (a) and according to the velocity (b). The solid histogram represents particles with energy 0–75 MeV and the dashed histogram denotes particles with energy 75–450 MeV. The curves represent the calculation for the overlapped part of the target-nucleus. In the distributions the particles with $Z \geqslant 2$ are replaced by the appropriate number of protons.

perimental data on all the disintegration products of the colliding nuclei. Such information is practically not available for the interaction of nuclei with an energy $E_{kin} > 2$–3 GeV/nucleon.

In this paper we examine the interactions of cosmic-ray nuclei of the iron group with a charge $Z = 20$–26 and $E_{kin} = 2$–15 Gev/nucleon with the Ag, Br nuclei in a relativistic nuclear photographic emulsion in the case of almost complete overlap of their geometric cross sections. We selected 20 events with the number of interacting nucleons of the incident nucleus $n_{in} \geqslant 40$ on the basis of the condition: $N_b + N_g = N_h \geqslant 30$ and $N_b \leqslant 10$ (Ref. 1) (N_b and N_g are the number of strongly ionizing charged particles with an energy $E_{kin} \leqslant 31$ MeV/nucleon and $31 < E_{kin} \leqslant 450$ Mev/nucleon, respectively) and 12 events with $n_{int} \sim 25$ on the basis of the condition: $N_h \geqslant 30$ and $N_b > 10$. We analyzed the energy distributions, the transverse momentum distributions

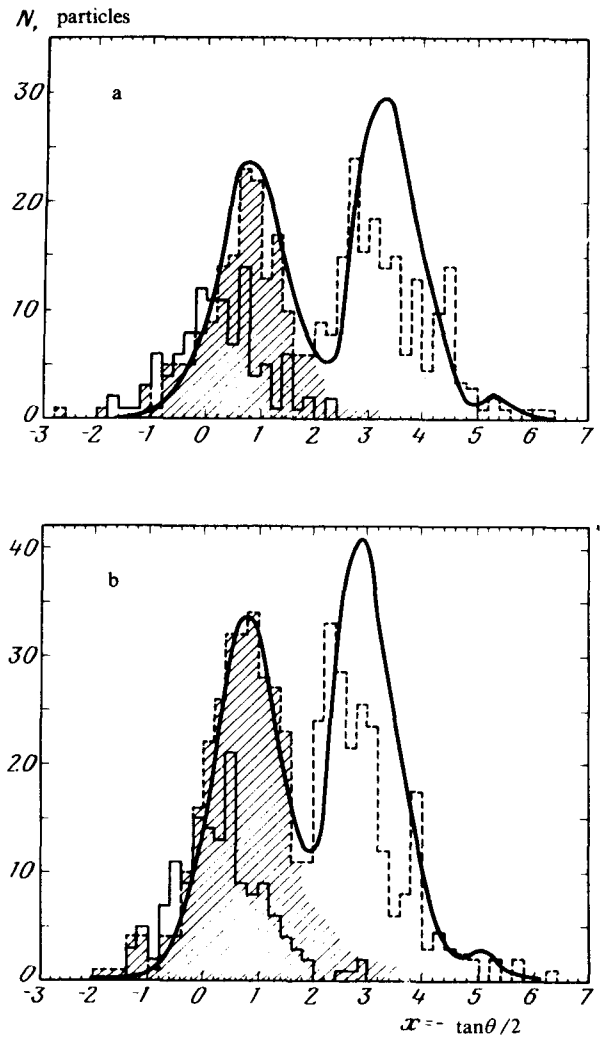

FIG. 2. The pseudovelocity distributions of protons and α particles-total disintegration products of the colliding nuclei in the events with $n_{int} \geqslant 40$: a, Energy of the incident nucleus $E_{kin} = 7$–15 GeV/nucleon, 8 events; b, $E_{kin} = 2$–7 GeV/nucleon, 11 events. The histogram represents experimental data: the solid histogram represents particles with $E_{kin} \leqslant 75$ MeV, the dashed histogram denotes particles with $E_{kin} > 75$ MeV, and the crosshatched histogram represents particles with $E_{kin} = 75$–450 MeV. The curves represent the calculation for the baryon clusters produced by the overlapped parts of the Ag and Br target-nucleus and the incident Fe nucleus with $E_{kin} = 8$ GeV/nucleon (a) and $E_{kin} = 5$ GeV/nucleon (b).

$p_\perp$, and the velocity distributions $y = 1/2\,[\ln(E+p_\parallel)/(E-p_\parallel)]$ (E is the total energy and $p_\parallel$ is the longitudinal momentum) of the particles with an energy $E_{\text{kin}} < 450$ MeV/nucleon and pseudovelocity distributions $x = -\ln\tan(\theta/2)$ of all the protons and α particles-the total disintegration products of the colliding nuclei.

The goal of our work is to identify in the experimental distributions the regions produced by the decay of different parts of the interacting nuclei and to compare the experimental data with the calculation based on the model of the collective interaction mechanism.[2]

The energy of the particles is a convenient characteristic, which makes it possible to identify the regions in which the disintegration products of the overlapped or nonoverlapped parts of the nuclei during the interaction are dominant. A comparison of the energy spectra obtained by us earlier[1] in the events with different degree of overlap of the nuclei, $n_{\text{int}} \geqslant 40$ and $n_{\text{int}} \sim 25$, showed that the energy interval 0–75 MeV/nucleon corresponds primarily to the particles from the nonoverlapped part; the particles with energy $E_{\text{kin}} > 75$ MeV are emitted mainly in the decay of the overlapped part of the target-nucleus. This conclusion also follows from a comparison of the $p_\parallel$ and y distributions, which differ greatly for the particles with the energy 0–75 MeV/nucleon and 75–450 MeV/nucleon (Figs. 1a and 1b). The pseudovelocity distribution (Fig. 2) has a

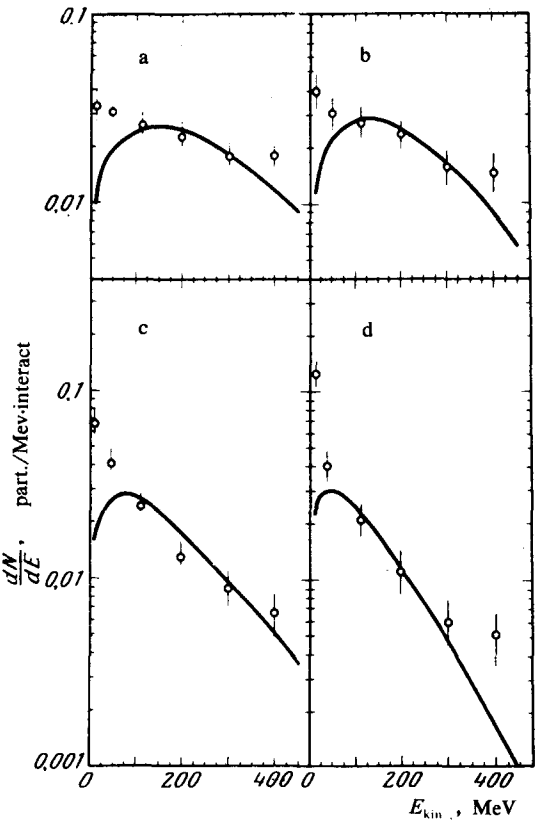

FIG. 3. The energy spectrum of particles with energy $E_{\text{kin}} < 450$ MeV in different intervals of $\cos\theta$: 1.0–0.8 (a), 0.8–0.5 (b), 0.5–0 (c), represent the calculation for the overlapped part of the target-nucleus.

spatial and energy separation of the protons from the overlapped parts of the target-nucleus (the crosshatched histogram) and from the incident nucleus at the energy $E_{kin} \sim 450$ MeV.[3] The energy spectra of particles from the target-nucleus ($E_{kin} < 450$ MeV) in different angle intervals are shown in Fig. 3.[4]

The experimental characteristics are compared with the calculation according to the model of nuclear pionization.[2] The mechanism of nuclear pionization assume that the gluon fields of nucleons from the overlapped parts of the colliding nuclei are stripped collectively and that these fields combine into a single pionization cluster. The quark component of the nucleons is comprised of two excited baryon clusters that emit mainly nucleons. It is assumed that the momentum of the δP gluon field of the hadrons is converted to excitation of the pionized cluster and that the momentum of the quark component $(1-\delta)P$ is conserved, where $\delta \approx 0.25$ is that part of the momentum of the hadron which belongs to its gluon field. The velocities and masses of the pionization and baryon clusters are determined by the parameter δ and by the degree of excitation of the nuclear material, which occurs as a result of nuclear pionization. The disintegration temperature of the pionization cluster is equal to $T = \mu = 0.14$ GeV.

The results of the calculation for protons-disintegration products of the baryon clusters produced by the overlapped parts of the nuclei in the interactions of Fe + Ag and Br with the impact parameter $B \leqslant 2$ *F*, are shown in Figs. 1–3. The calculated data are in good agreement with the experimental characteristics of the particles with an energy < 75 MeV at the disintegration temperature of the baryon clusters $T_N \approx 0.10$ GeV.

By comparing the data we were able to confirm the mechanism of nuclear pionization, the basis of the model,[2] which predicts the formation of two baryon clusters from the overlapped parts of the incident nucleus and the target-nucleus. This clearly contradicts the idea of a single composite system—a nuclear fireball—which is the nucleon and meson source and which includes the overlapped parts of the colliding nuclei.

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[3] The protons-disintegration products of the incident nucleus were separated from the angular distribution of all the shower particles by using the method described in Refs. 3–5.
[4] The characteristics of the particles from the target-nucleus, which depend weakly on the energy of the incident nucleus, are shown in Figs. 1 and 3 in the interval 2–15 GeV/nucleon.

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