SEARCH FOR ANGULAR CORRELATIONS IN STARS WITH FRAGMENTS PRODUCED BY 9-GeV PROTONS

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About 7000 angles between the tracks of fragments and "black" tracks in disintegrations produced in interactions between 9-GeV protons and heavy nuclei in emulsion were measured. The angular distribution of the black tracks relative to the fragment tracks was found to be isotropic. The distribution of black tracks in stars with fragments and in ordinary stars was the same.

In discussions of the mechanism of the interaction of fast particles with nuclei, the fragmentation process was considered to be connected with the transfer of a large energy to the nucleus as a result of the production and absorption of mesons in the nucleus.[1] In the part of the nucleus in which the pion is absorbed, the nucleon-nucleon bonds are disturbed and the surface tension and Coulomb repulsion forces lead to the emission of individual nucleons and multiply charged particles (called fragments) from a local region of the nucleus.

If the fragments and the nucleons emitted at the same time are produced in such a process, whose characteristics are determined by the energy and momentum conservation laws for a given local volume of the nucleus, then angular correlations should occur between different particles taking part in the process, as a consequence of the conservation laws.

It is of interest to consider whether or not fragments of charge $Z = 4-7$ observed in emulsion[2] exposed to high-energy particles are the result of such a process. In this case a spatial correlation will occur between the multiply charged particles and the remaining particles in the disintegrations. Moreover, the angular distribution of the fragments and the accompanying particles will differ from the angular distribution of "black" and "gray" tracks in ordinary disintegrations of emulsion nuclei without fragments.

To investigate these angular distributions we used the nuclear emulsion technique. Stacks of PR and NIKFI-R emulsions 200 and 400 μ thick were exposed to 9-GeV protons at the proton synchrotron of the Joint Institute of Nuclear Research. In scanning the emulsion, we selected disintegrations of heavy nuclei containing one track made by a particle of charge $Z = 4-7$ and energy greater than 1–2 MeV per nucleon.

In these disintegrations we measured all angles between the black tracks ($E_p < 30$ MeV) and the fragments, and all angles between black tracks and the incident beam protons. The measurements were made on a special MIGÉ-1 microscope which recorded the coordinates of the individual points of the tracks on a magnetic tape. The space angles and direction cosines were calculated from these data with a VUM-1 electronic computer specially adapted for this purpose. The average accuracy of the space-angle determinations was 1°. The use of this arrangement made it possible to reduce the time required for the measurements and data reduction by a factor of 10.

About 7000 space angles were measured. The mean number of prongs per star (excluding the fragment) was 12.5, which, when compared with the data of Perfilov et al.,[2] indicates that some gray tracks (500 MeV $> E_p \geq 30$ MeV) were included. The fragment angular distribution relative to the beam protons is similar to that given in [2].

The angular distribution of the black prongs relative to the fragments is shown in Fig. 1. As is seen from the figure, the distribution is close to isotropic, i.e., for the given statistics, no correlation between the emission of a fragment and the emission of other particles is observed.

Figure 2 shows the angular distribution of black tracks relative to the beam protons in disintegrations with fragments; also shown is the angular distribution of black tracks relative to the beam in ordinary disintegrations (without fragments) of heavy nuclei.[3] Comparison of these distributions by means of the χ^2 test showed that they can be regarded as compatible. If it is recalled that

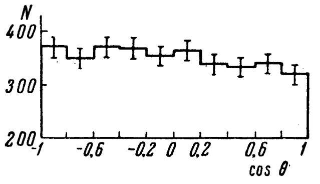

FIG. 1. Angular distribution of black prongs relative to fragments.

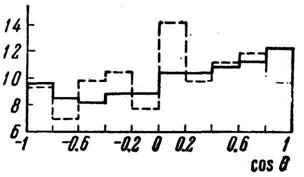

FIG. 2. Angular distribution (in percent) of black prongs relative to the proton beam in stars with fragments (solid line) and in stars without fragments (dashed line).

ordinary disintegrations of heavy nuclei induced by high-energy protons are well described by the cascade-evaporation model,[4] there is no reason to resort to a new model to explain the occurrence of multiply charged particles and the disintegrations in which they appear. It is, of course, possible that not only nucleons, but also larger clusters of nucleons (fragments) take part in the cascade and in the evaporation.

Finally, we note that the ratio of the number of tracks in the forward and backward directions relative to the proton beam is 1.26 ± 0.06 for black prongs and 2.1 ± 0.4 for fragments. Hence the fragments are emitted considerably more anisotropically than the nucleons and α particles. This comparison does not contradict an earlier hypothesis[5] that the multiply charged particles are produced mainly in the quasi-elastic scattering of secondary particles on the instantaneous substructures of the nucleus, i.e., in the cascade process, which also explains their relatively large anisotropy.

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