ONE- AND TWO-CENTER PROCESSES IN INELASTIC INTERACTIONS AT ENERGIES ABOVE 100 GeV

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A method of dividing high-energy interactions with multiple-particle generation into central and peripheral interactions has been proposed in [1]. This method is based on an analysis of the 4-momenta transferred between the particle groups in the interaction. In calculations of the 4-momenta Δ_i^2 transferred between particle groups, performed by this method in [2, 3], the secondary particles were arranged either in order of increasing angle or in order of decreasing momentum in the laboratory frame. We, in contrast, used the same method but with a new arrangement of the secondary particles, namely, we calculated the 4-momentum t_j^2 transferred from the primary particle to each particle in the shower,

$$t_j^2 = (P_0 - P_j)^2 , \qquad (1)$$

where P_0 and P_j are the 4-momenta of the primary and of the j-th particle. It is obvious that $t_{j\,min}$ should correspond to the 4-momentum transferred between the incident and scattered primary particles.

The particles were numbered in increasing order of t_j^2. Then, as usual, we calculated Δ_i^2 and separated the one-center and two-center events on the basis of the form of the dependence of Δ_i^2 on i.

We have processed in this manner the nuclear interactions between cosmic particles with average energy E_0 = 400 GeV and a polyethylene target, as registered in the Tskhra-Tskaro installation [4].

The showers classified as one-center and two-center events were 9 and 15 in number, respectively. We shall show below that the distinguishing features of one- and two-center events are well described by the fireball model, and we shall henceforth refer to them as one- and two-fireball events. The table lists their characteristics.

	N	$\bar{E}_0$	$\bar{n}_s$	$\bar{\varepsilon}_{si}$	$\bar{\gamma}$	$\bar{\sigma}$	$\bar{p}_\perp$	$\bar{K}$	$\bar{\varepsilon}_i^*$	M_f
One-fireball	9	288	8.30	0.52	1.00	0.34	0.37	0.35	0.52	6.50
Two-fireball	15	453	15.50	0.60	1.12	0.47	0.37	0.33	0.53	6.30

N is the number of showers in the given group, E_0 the interaction energy, n_s the charged-particle multiplicity, $\bar{\varepsilon}_{si}$ the average particle energy in the rest system of the charged secondary particles (S-system), $\bar{\gamma}$ the average Lorentz factor of each of the two fireballs relative to the S-system, σ the variance in the distribution of the quantity log tan θ_i, $p_\perp$ the transverse momentum, K

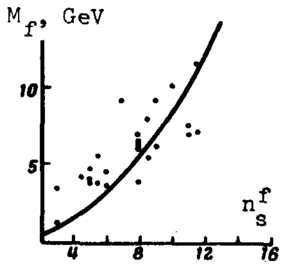

Fig.1

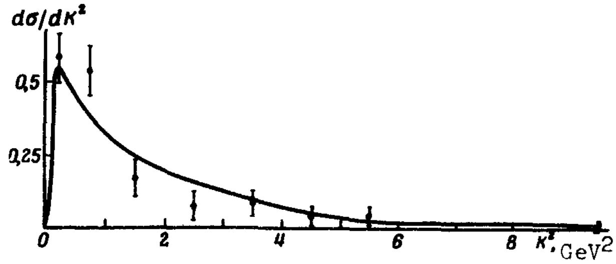

Fig.2

Fig. 1. Fireball mass vs. multiplicity of charged secondary particles.

Fig. 2. Distribution with respect to K^2. Solid curve - prediction of fireball theory.

the transfer coefficient, $\bar{\varepsilon}^*_{is}$ the average particle energy in the fireball rest system, and M_f the fireball mass with the neutral particles taken into account.

The following features of the table are of interest:

1. The average multiplicity of two-fireball events is approximately double that of one-fireball events, $\bar{n}_s^{(1)} = (1/2)\bar{n}_s^{(2)}$. This ratio of the average multiplicities for one-fireball and two-fireball cases, registered in the same installation, was obtained by us for the first time. An average multiplicity $n_s = 8 \pm 0.5$ is given in [5] for production of one fireball, and it follows from [6, 7] that for two-fireball events the average multiplicity per fireball is approximately 5 - 10 particles.

2. The average particle energies in the fireball rest system, $\bar{\varepsilon}_{si}$ for one-center events and $\bar{\varepsilon}^*_i$ for two-center ones, are approximately equal, $\bar{\varepsilon}_{si}$ = 0.52 ± 0.08 GeV and ε^*_i = 0.53 ± 0.40 GeV. A similar value was obtained for $\bar{\varepsilon}_{is}$ in [3, 5].

3. The fireball masses in both groups are also practically equal

$$M_f^{(1)} = 6.5 \pm 1\ \mathrm{GeV}/c^2, \quad M_f^{(2)} = 6.3 \pm 0.7\ \mathrm{GeV}/c^2$$

which, incidentally, is a consequence of Items 1 and 2.

4. Of great importance is the observed fact that showers with larger multiplicity have larger anisotropy.

5. Figure 1 shows a plot of the fireball mass M_f against the number $n_s^{\pm}$ of charged particles in one fireball.

Figure 1 does not contradict the notion that the fireball decay has a statistical nature, whereby the average number of secondary particles is proportional to the square root of the fireball mass. The curve in the figure is calculated from the empirical formula

$$n_s^{\pm} = 3{,}44\,(M_f - 0{,}2)^{1/2},$$

which agrees well enough with the experimental points.

All these features fit well in the framework of the fireball model, and are difficult to explain from any other point of view.

A peripheral theory of fireballs has by now been developed [8], and a comparison of the experimental results with its predictions is of particular interest.

1) A preliminary statistical reduction of our material has shown that the number of events in which one fireball is produced is equal to the number of two-fireball events, with 10% accuracy. This estimate of the probability of generation of different numbers of fireballs at 400 GeV is in good agreement with the prediction of fireball theory.

2) a. The theoretically-predicted distribution with respect to the squares of the 4-momenta transferred between the nucleons and the fireballs, for one-fireball cases, and between the nucleons and fireballs as well as between two fireballs for two-fireball cases, $\Delta_{i\ min} = K^2$, is in good agreement with our experimental distribution (Fig. 2).

b. The theoretical calculations indicate that K^2 is practically independent of the total energy and its distribution has a maximum at $K^2 = 0.5$ GeV^2. Its mean value, however, is somewhat larger and amounts to 1 - 2 GeV^2. Our data give a most probable value $K^2 = 0.5$ GeV^2 and a mean value $\bar{K}^2 = 1.7$ GeV^2.

3) The value obtained by us for the fireball mass is in good agreement with the data of the Tien-Shan and the Polish groups [3, 6, 7], and does not disagree in principle with the theoretical value, which has so far been determined only for asymptotically high energies.

As seen from the foregoing, our experimental data are in good agreement both with the predictions of the fireball model based on kinematic singularities, and with the predictions of the fireball theory.

However, only appropriate theoretical calculations, or else simulation of the events by the Monte Carlo method, can resolve the question of the existence of fireballs.

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OBSERVATION OF FAST ELECTRONS PRODUCED BY INJECTION OF A PLASMOID INTO A TRANSVERSE MAGNETIC FIELD

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When a plasma current enters a transverse magnetic field, the energy should become redistributed among the ionic and electronic components. This redistribution was considered theoretically by many workers [1 - 5], using as