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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part III

III-7-10. Interpretation of the Two-Centre Model within the Hydrodynamical Theory*

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1. In the work[1] it was shown that in certain cases kinematics of the so-called "two maxima showers"[2),3)] can be considered from the standpoint of the hydrodynamical theory[4]. In that note the authors used the model of an ideal meson liquid for description of emission of the excited system and a study is carried out on the influence of viscosity on the angular and energy distribution of particles produced near the front of a scattered bunch.

When the coefficient of viscosity

$$\zeta = \frac{\mu}{\sigma_\pi} \ll 1$$

(μ—mass of π-meson, σ_π—interaction cross section), one can show[5] that the effect of viscosity in the region of a general solution is not great and it diminishes with the increase of the primary energy E_0 if ζ=const. At the same time, near the front, where $\partial u_i/\partial x^i > 1$ (u^i—4-velocity, $x_i = x, y, z, t$; i= 1, 2, 3, 4), even an account of the small viscosity can essentially change the character of angular and energy distributions of secondary particles[6]. Dissipation of energy of a simple wave[6] leads to production of an additional number of particles and increase of inelasticity of the elementary act. Since the particles produced during the scattering are the fastest (in the c.m. system), it will be displayed as the production of "two maxima" in the angular distribution of all shower particles.

2. Estimates show that, in the case ζ= const., the additional number of particles (produced during the scattering in the region of a simple wave)

$$\Delta N = 0.4 \ln \frac{E_0}{\mu}$$

($M=c=1$, M—mass of a nucleon). For $E_0 = 10^{13}$ eV, $N=3.5$, thus all together about 7 particles are produced due to dissipation, while at the first moment after collision there were 12 particles.

Considering the value $D = \frac{N_e - N_i}{n_s}$ as a criterion for a two-maximum character of the angular distribution[3], (n_s—total multiplicity of the process, N_i—the number of particles within the interval $x = \pm 0.6 \pm \sigma$ $x = \log \operatorname{tg} \theta_L$, θ_L—emergence angle of the particles in laboratory system, σ—dispersion of angular distribution, N_e—the number of particles outside that interval) we obtain $D=0.37$. According to the reference[3] it means an evident two-maximum character of the angular distribution. With increase of E_0 the D-value will slowly decrease.

3. If one assumes another temperature dependence for the viscosity, for example $\zeta \sim T^3$ (*i.e.* the viscosity[7] of a "gas" of quantum statistical fluctuations with the correlation length $1/T$), then for ΔN we shall have

$$\Delta N = \kappa E_0^{1/2}$$

where the coefficient κ is of the order of 1 and must be determined from the experiment.

In this case the D-value increases with the energy and the total multiplicity of the process will be intermediate between the function $E_0^{1/4}$ and $E_0^{1/2}$.

Obviously, the interpretation put forward for the cases of two-maximum showers is completely applicable for the cases of both nucleon-nucleus and nucleon-nucleon collisions. However, for the latter one can use an additional assumption about an incomplete transfer of nucleon energy to the excited system.

* This paper was read by G. B. Zhdanov.

References

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Discussion

Zatsepin, G. T.: The idea of Emelyanov and Rosental is very nice, but the basic idea of Landau's hydrodynamical theory ($p/\varepsilon=1/3$) has no experimental foundation. Experiments show that $p/\varepsilon<1/3$.

Zhdanov, G. B.: Yes, I agree with you, but the main point of the authors was to show that there is no direct contradiction between the predictions of the Landau theory and the experimentally observed distributions.

Namiki, M.: I wonder that the constancy of ζ was assumed overall processes from very high temperature to very low temperature. Can we consider the results to have only a qualitative meaning?

Zhdanov: I suppose your point of view to be correct. The authors get only qualitative conclusions.

Yamaguchi, Y.: Are there any difference between π-N and N-N interactions in this theory? For example, do two fire-balls occur also in π-N collisions with fair probability?

Zhdanov: I suppose that there must be no significant difference between π-N and N-N interactions in this respect.

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III-7-11. Many-Body Theoretical Approach to the Fire-Ball Model in Multiple Production of Particles

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The "fire ball" observed in multiple production of particles is interpreted and analysed as a correlated assembly of produced particles like superfluid. It is shown that the momentum spectrum of produced mesons has a form dk/k^2 assuming $\lambda\phi^4$ for the final meson-meson interaction Hamiltonian. A possibility of the many fire-ball model is briefly discussed. Before discussing these problems a possible reduction of the S-matrix element or the cross section of the overall process is presented, in which its final interaction part may be separated from the part of high energy interaction in short collision time.

§1. Introduction

About twenty years ago Heisenberg[1)] and others expected that the multiple production of particles in super-high energy phenomena would inform us about the interaction mechanism at a short distance among elementary particles or the fundamental principle as symbolized by the "universal length". Ne-