where $\Delta\nu'_{cat}$ and $\Delta\nu''_{cat}$ are the deviations of the first and second waves, respectively, from the center of the amplification line, $\Delta\nu_p$ is the width of the resonator bandwidth, and $\Delta\nu_D$ is the Doppler width.

This frequency shift does not exceed several hundred kHz and cannot be resolved by the scanning interferometer (its resolution is of the order of 50 MHz).

When the excitation conditions are changed in one of the gaps (by decreasing the cadmium vapor pressure), generation of oscillations with a shift C/L (200 MHz) is observed (Fig. 3). When the cadmium vapor pressure is decreased in one of the arms, a transition is observed towards generation of oscillations with a shift 2C/L (400 MHz).

Thus, under the indicated experimental conditions the mean ion velocity, determined by the cataphoresis, lies in the range 110 - 150 m/sec, and the cadmium ion concentration, determined from the average ion velocity and from the cadmium consumption, is 4×10^{12} cm^{-3}.

[1] M. Druyvestein, Physics 2, 255 (1935).
[2] J.P. Goldsborough, J. Quantum Electr. QE-5, No. 6 (1969).

CORRELATION BETWEEN THE TRANSVERSE AND LONGITUDINAL MOMENTA IN MULTIPLE GENERATION

N.N. Roinishvili and E.N. Sherrer
Physics Institute, Georgian Academy of Sciences
Submitted 29 January 1971
ZhETF Pis. Red. 13, No. 5, 243 - 246 (5 March 1971)

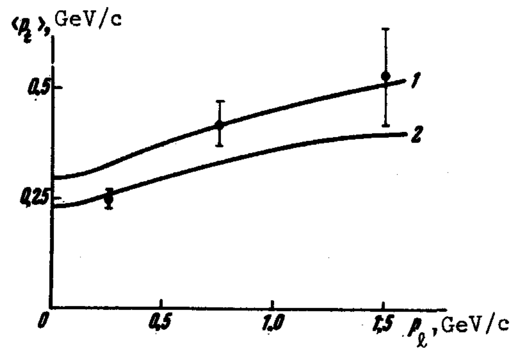
In recent investigations of inelastic interactions of hadrons, either with accelerators or at cosmic energies, particular attention has been paid to the correlation between the transverse and longitudinal momenta of the secondary particles. This problem is of interest because it is assumed in most theoretical researches that these two variables are either entirely independent of each other or only very weakly connected. On the other hand, experiments have shown that the differential cross section of the interaction cannot be factorized in terms of p_t and p_ℓ [1]:

$$\frac{d^2\sigma}{dp_t\,dp_\ell} \neq f(p_t)\phi(p_\ell) .$$

The latter becomes manifest in two facts. The mean value $\langle p_t \rangle$ turns out to be a function of p_ℓ [2 - 5]. In addition, the slope of the p_ℓ spectrum in a semilog scale turns out to be a decreasing function

$$\ln\frac{d\sigma}{d|p_\ell|} = -b(p_t)|p_\ell| . \qquad (1)$$

We obtained the corresponding relations at $\sim 5 \times 10^{11}$ eV using apparatus consisting of a cloud chamber in a magnetic field and an ionization calorimeter [6]. Figure 1 shows the correlations between $\langle p_t \rangle$ and p_ℓ, and Fig. 2 shows the dependence of the p_ℓ spectra on p_t. These data agree with the results observed at accelerator energies not only qualitatively but also quantitatively.



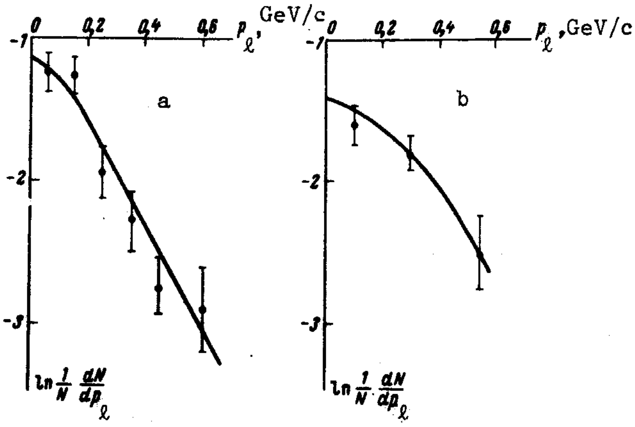


Fig. 1. $\langle p_t \rangle$ vs p_ℓ in the c.m.s. of the charged secondary particles. The experimental points were obtained at $E_0 \sim 5 \times 10^{11}$ eV. The curves correspond to different T_t at T_ℓ = 0.25 GeV/c: 1 - T_t = 0.16 (GeV/c)$^{-1}$, b_{calc} = 3.4, b_{exp} = 3.5 ± 0.1: 2 - T_t = 0.12 (GeV/c)$^{-1}$, b_{calc} = 2.4, b_{exp} = 2.2 ± 0.1

Fig. 2. a) Spectrum of p_ℓ at $0 \leq p_t \leq 0.2$ GeV/c. Calculated curve - the same for T_t = 0.16 GeV/c and T_ℓ = 0.25 GeV/c. b) The same at $0.2 \leq p_t \leq 0.4$ GeV/c, b is the exponent in the spectrum $(dN/dp_\ell) = \exp[-b|p_\ell|]$.

The purpose of the present paper is to prove that the responsibility for the $p_t - p_\ell$ correlation lies not in the matrix element of the interaction but in its phase volume.

Before we compare the newly observed data on the inelastic process with the theoretical models, we must, in our opinion, verify each time the extent to which these data lie outside the framework of the obvious requirements imposed on multiple particle generation. The obvious requirements are the laws governing the phase volume of the process in question and the complicated nucleon structure. Unfortunately, this is a rather complicated problem. An attempt to solve it consistently at accelerator energies was made in [7], and it cannot be solved as yet at cosmic energies without making some approximations.

These approximations reduce to a thermodynamic description of the collision process.

It is shown in [8] that by regarding the hadron as a system with an infinite number of degress of freedom it is possible to describe satisfactorily the regularities of the secondary-particle wave volume with the aid of a Planck distribution. On the other hand, it is known that the fact that the strongly-interacting particles are not pointlike distorts the phase volume in the transverse direction, but hardly changes it in the longitudinal direction. The hadron matter after the collision must therefore be described with two temperatures, one longitudinal (T_ℓ), which carries information concerning the kinematic relations of the phase volume, and the other transverse (T_t), and responsible for the transverse-momentum cutoff due to the hadron structure. T_ℓ is determined from the average energy per particle in the interaction

$$\epsilon = \frac{\langle k \rangle E_0^c}{\langle n \rangle},$$

where <k> is the average inelasticity coefficient, E_0^c is the energy of the incoming particles in the c.m.s., <n> is the average multiplicity, and T_t is estimated, as usual, from the transverse momentum.

For our experiment, T_ℓ = 0.25 GeV and T_t = 0.14 GeV.

Unlike in [9], where information on the $p_t - p_\ell$ correlation was lost because $d^2\sigma/dp_t dp_\ell$ was assumed in a factorized form, we represent the two-temperature distribution in the form

$$\frac{d^2\sigma}{dp_t\, dp_\ell} = \frac{p_t}{\exp\left\{\left[\left(\frac{p_\ell}{T_\ell}\right)^2 + \left(\frac{p_t}{T_t}\right)^2 + \frac{m^2}{T_\ell T_t}\right]^{1/2}\right\} - 1}.$$

The consequence of this distribution is shown by the solid curves of Figs. 1 and 2.

We see that they are in very good agreement with the experimental data. We note that the analysis of the distribution shown by us indicates that only the absolute values of $\langle p_t \rangle$ and $b(p_t)$ depend on the temperature, whereas the correlation between p_t and p_ℓ is incorporated in the very form of the distribution. In other words, the correlation is due to the phase volume, whereas the concrete values of $\langle p_t \rangle$ are connected with the hadron structure.

The foregoing suggests the conclusion that at the present-day accuracy of the experiments on the correlations between p_t and p_ℓ it can be asserted that the interaction matrix element produces practically no connection between these two parameters.

In conclusion we emphasize once more that we have used a two-temperature distribution not from model considerations, but as a good approximation of the laws of the phase volume of a spatially extended system of particles with an infinite number of degrees of freedom.

The authors take pleasure in thanking Professor E.L. Andronikashvili, their colleagues, and the computer staff of the Physics Institute of the Georgian Academy of Sciences for support, discussions, and help.

[1] R.R. Kinsey, T.W. Morris, and R.S. Panvini, 15th Internat. Conf. on Elementary Particles, Kiev, 1970.
[2] M. Bardadin et al., Proc. 1963 Siena Conference.
[3] Chan Hong-Mo, Loskiewiez, and Allison, Nuovo Cim. 57A, 93 (1968).
[4] O.L. Berdzenishvili, L.L. Gabuniya, D.I. Garibashvili, et al., Izv. AN SSSR ser. fiz. 34, 1907 (1970).
[5] V.V. Guseva, N.G. Zenevinskaya, K.A. Kotel'nikov, et al. ibid. 34, No. 9 (1970).
[6] E.L. Andronikashvili, D.I. Garibashvili, and D.B. Kakauridze, in: Yadernye vzaimodeistviya pri vysokikh energiyakh (Nuclear Interactions at High Energies), Metzniereba Press, p. 88, 1969.
[7] R. Sosnowski and W. Wojcik, Colloquium on Multiple Generation, Paris, 1970.

[8] I. Hagedorn, ibid.

SUPERCONDUCTIVITY OF BERYLLIUM FILMS EVAPORATED JOINTLY WITH ZINC ETIOPORPHYRIN

N.E. Alekseevskii, V.I. Tsebro, and E.I. Filippovich
Institute of Physics Problems, USSR Academy of Sciences
Submitted 2 February 1971
ZhETF Pis. Red. 13, No. 5, 247 - 250 (5 March 1971)

As is well known [1, 2], a beryllium film condensed on a cold substrate becomes superconducting in the temperature region from 5.4 to 8.6°K. The critical temperature is a function of the film thickness [2]. We have investigated the critical temperature of beryllium films evaporated jointly with zinc etioporphyrin (Zn-ep) on a substrate having the temperature of liquid helium. The possibility of increasing the transition temperature by simultaneously evaporating a metallic and nonmetallic component has already been discussed in the literature [3]. The use of Zn-ep as the nonmetallic component is of additional interest because Zn-ep is one of the possible objects in which the electron-electron superconductivity mechanism may be observed [4].

The preparation of the films and the measurement of their critical temperature were carried out with the apparatus described in [2]. The Be and the Zn-ep were evaporated simultaneously from two tungsten evaporators. Figure 1 shows the superconducting-transition curve of one of the beryllium films evaporated jointly with Zn-ep. The thickness of such a film, estimated from the change in the frequency of a quartz thickness gauge, was ≳500 Å, i.e., it was considerably larger than the critical thickness (d_{crit} ∿ 200 Å) of beryllium films, cf., [2][1]. As seen from the curve, T_c of such a film equals 10.2°K.[2] After heating to room temperature, no superconductivity was observed down to 1.5°K. The room-temperature resistance of the film was ∿500 ohm.

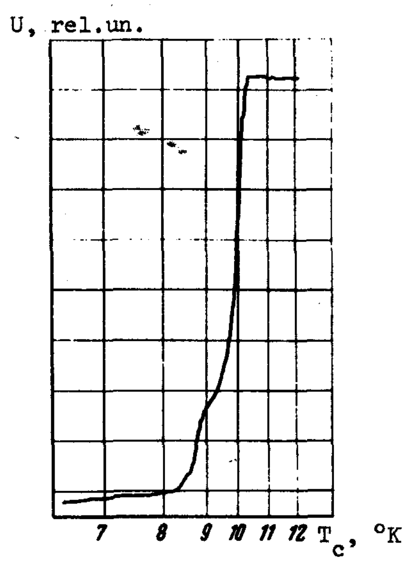


Fig. 1. Superconducting transition curve of a Be film evaporated together with zinc etioporphyrin.

Besides the films obtained by simultaneous evaporation of Be and Zn-ep, we prepared also films by alternately evaporating Be and Zn-ep layers. The results of one such experiment are given in Table 1, where Δf is the change of the frequency of the quartz thickness gauge, in Hz.

Table 1

	Be	Zn – ep	Be	Zn – ep	Be
Δf, Hz,	100	260	75	470	70
T_c, °K	7,7	7.7	7.7	7,7	7,7

[1]) According to our estimates, the Be to Zn-ep ratio in such a film was 3:1.

[2]) T_c corresponds to the start of the transition throughout. The inflection on the transition curve may be connected with the inhomogeneity of the layer.