laboratory staff for emulsion scanning and measurements.

[1] Alma-Ata - Cracow - Dubna - Leningrad - Moscow - Tashkent - Ulan-Bator Collaboration, Phys. Lett. 39B, 282 (1972). JINR Report RI-6504, Dubna, 1972.
[2] Alma-Ata - Leningrad - Moscow - Tashkent Collaboration, FIAN Preprint No. 67, 1973; ZhETF Pis. Red. 18, No. 1 (in press).

AZIMUTHAL CORRECTIONS FOR pp COLLISIONS AT 20 - 70 GeV AND THE MULTIPERIPHERAL MODEL

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The distributions of the angles between the transverse momenta of secondary particles from pp collisions were investigated as functions of p_0 (21, 50 and 67 GeV/c), the multiplicity, and the difference of the longitudinal momenta. The data contradict qualitatively the multiperipheral model.

Since the single-particle distributions are not critical enough to choose between the different models of multiple generation, great interest attaches to the study of the multiparticle distributions and correlations. One of the simplest types of two-particle correlations is the distribution with respect to the angle between the transverse momenta of the secondary particles

$$\phi = \arccos\left(p_{\perp i}\, p_{\perp j} / |\, p_{\perp i}\, |\, |p_{\perp j}\, |\right), \qquad 0 \leqslant \phi \leqslant \pi .$$

If the particles are emitted independently, the ϕ-distribution is uniform in the interval $[0,\pi]$. The transverse-momentum conservation law leads to an excess of angles ϕ that are close to π, and makes the distribution asymmetrical with an asymmetry angle $\alpha = (n_2 - n_1)/n > 0$ ($n_{1,2}$ are the number of particle pairs with $\phi = 0 - \pi/2$ and $\pi/2 - \pi$, respectively, $n = n_1 + n_2$).

Highly characteristic dynamic correlations with respect to ϕ are observed in the multiperipheral model (MPM) at small numbers (1 - 2) of particles in the node of the multiperipheral chain (diagram of the "comb" type). Owing to the local conservation of the transverse momentum in the nodes of the diagram, strong correlations arise in the MPM (a tendency towards $\phi \sim \pi$) for particles from one or neighboring nodes (i.e., particle with close longitudinal momenta); these correlations weaken rapidly when the number of intermediate nodes between the chosen pair of particles or the difference between their longitudinal momenta increases [1 - 3]. This behavior should be observed for all p_0 and n_{ch} (multiplicity), since the distributions with respect to the subenergies s_i and the 4-momentum transfers t_i are fixed along the chain.

Other multiple-generation models do not give such definite predictions with respect to the ϕ-distribution. However, if the particle production comes from one or several "massive" centers (the pionization, fireball, or diffraction models), one should expect a weak dependence of the ϕ-distribution on the difference of the longitudinal momenta, i.e., the presence of the so-called long-range correlations even at large (but finite) p_0 and n_{ch}.

We have investigated the ϕ-distributions in pp collisions at $p_0 = 21$, 50, and 67 GeV/c as functions of p_0, n_{ch}, $\Delta\lambda \equiv \Delta \log \tan\theta \simeq 2.3\, \Delta y$ (θ is the lateral angle and y is the speed in the l.s.) and of the difference between the serial numbers of the particles when they are arranged in order of $\lambda \sim y$. The experimental material consisted respectively of 455, 537, and 645 events with $n_{ch} \geq 2$ at the indicated p_0. The selection criteria and several general characteristics of the events were described in [5 - 7].

Figure 1 shows by way of example[1)] the summary ϕ-distributions for $n_{ch} = 4$ and the curves calculated by the Monte Carlo method using a simplified phase-space model with allowance for the conservation of the transverse momentum. It was assumed in the calculations that the probability of appearance of unobservable (neutral) particles is 1/3. It turned out that the summary

[1)] Since the number of considered histograms reached 1000, Figs. 1 - 3 show only a small fraction of the data, pertaining to the most "representative" n_{ch} ($n_{ch} = 4$ and 6).

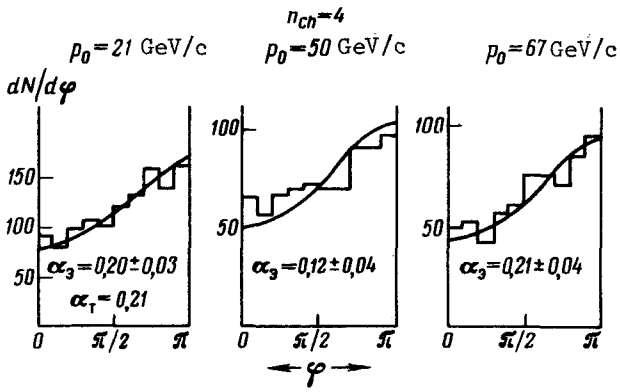

Fig. 1

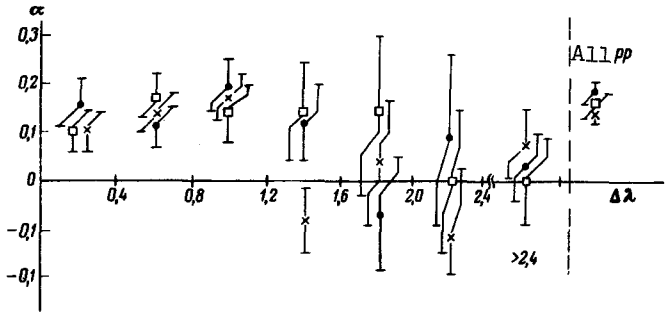

Fig. 2

Fig. 1. Summary ϕ-distributions for $n_{ch} = 4$. The experimental (α_e) and calculated (α_T) asymmetry coefficients are shown.

Fig. 2. Dependence of α on $\Delta\lambda$ for $n_{ch} = 6$. The squares, circles, and crosses show the data for $p_0 = 21$, 50, and 67 GeV/c, respectively.

correlations agree quantitatively with those governed by purely kinematic factors, and the asymmetry of the distribution, becoming weaker with increasing n_{ch}, does not depend on p_0 at fixed values of n_{ch}. As expected, the asymmetry of the ϕ-distribution decreases with increasing p_0 for the entire ensemble of the pp collisions, starting with a trivial increase of the average multiplicity.

Figure 2 shows (again by way of example) the dependence of α on $\Delta\lambda$ for $n_{ch} = 6$. We see that within the limits of errors α can be regarded as independent[2] of $\Delta\lambda$. The asymmetry of the ϕ-distribution at all fixed $\Delta\lambda$ decreases with increasing n_{ch} (and with increasing p_0 for the entire ensemble of the pp collision) to the same degree as for the summary distribution. These features contradict the MPM qualitatively.

Figure 3, finally, shows the ϕ-distributions for different combinations of pairs of serial numbers of the particles - neighboring, every other, every two, etc., for $n_{ch} = 4$ at $p_0 = 67$ GeV/c. An analysis performed for all n_{ch} has shown that, in contradiction to the MPM predictions, there is no weakening of the correlations with increasing distance between particles along the chain. As before, a "kinematic" weakening of the asymmetry of the distributions with

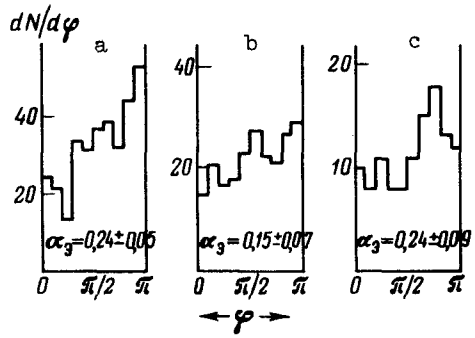

Fig. 3. ϕ-Distributions for the particle-number combinations 12 + 23 + 34 (a), 13 + 24 (b), and 14 (c) for $n_{ch} = 4$ at $p_0 = 67$ GeV/c

[2] A certain decrease of α at $\Delta\lambda \gtrsim 1,2$ can be seen in Fig. 2. Analysis has shown that the difference in α for the subgroups with $\Delta\lambda < 1.2$ and $\Delta\lambda > 1.2$ is statistically ensured only for $n_{ch} = 6$ and all pp collisions at $p_0 = 67$ GeV/c. In the interval $\Delta\lambda < 1.2$ there are contained in this case approximately half the secondary particles. If confirmed, this effect would denote a tendency to particle clustering, but the inadequacy of the statistics makes it premature, in our opinion, to discuss this possibility further (see also the discussion of the data of Fig. 3).

increasing n_{ch} is observed for any pair combination.

Thus, the experimental data on the ϕ-distributions contradicts qualitatively the most widely used MPM variant. We note that for the reaction $pp \to pp2\pi^+2\pi^-$ at $p_0 = 23$ GeV/c such a contradiction was noted earlier in [1], but in [3] the same data were reconciled with the MPM by taking resonance production into account[3]. The present results cannot be noticeably altered by taking into account the experimentally observed resonance-production frequency. It is not excluded, of course, that the obtained data can be explained within the framework of the MPM for example at the expense of making the nodes much "heavier" (clustering).

A more detailed analysis of the two-particle correlations in pN collisions at accelerator energy will be the subject of a subsequent paper.

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[1] J. H. Friedman, C. Risk, and D. B. Smith, Phys. Rev. Lett. 28, 191 (1972).
[2] F. Duimio and G. Marchesini, Nucl. Phys. B48, 318 (1972).
[3] L. E. Gendenshtein, ZhETF Pis. Red. 17, 37 (1973) [JETP Lett. 17, 26 (1973)].
[4] El. L. Berger, M. Jacob, and R. Slansky, Phys. Rev. 6, 2580 (1972).
[5] S. A. Azimov et al., Izv. AN SSSR ser. fiz. 34, 1912 (1970).
[6] S. A. Azimov et al., Izv. AN UsSSR, ser. fiz-mat. No. 4 (1973).
[7] ACDLMTU Collaboration, Phys. Lett. 39B, 282 (1972).

INHOMOGENEOUS BROADENING OF EPR SPECTRA UNDER CONDITIONS OF RAPID ROTATIONAL DIFFUSION

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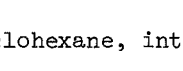
It was observed in [1, 2] that inhomogeneously broadened EPR lines are saturated by a monochromatic microwave pulse, several dips appear on the line contours. The widths of the dips are much smaller than the width of the envelope. This phenomenon, called discrete saturation, was attributed in [2, 3] to the presence of forbidden transitions produced as a result of hyperfine dipole interaction of the electron spin of the paramagnetic center with the nuclear spins of the solid matrix. In these experiments, however, the width of the envelope was as a rule larger than the nuclear zeeman frequency, $\Delta H > \gamma_n H_0$, so that the forbidden transitions corresponding to simultaneous flipping of the electron and nuclear spins, could not be separated, since they were within the limits of the EPR line envelope. In addition, the propagation of the saturation within the inhomogeneously broadened EPR line (its homogenization) was not investigated. In the present paper we show, with the EPR spectrum of a stable iminoxyl radical in a plastic crystal, that discrete saturation is indeed connected with forbidden transitions and is accompanied in this case by fast homogenization. The choice of a plastic crystal to serve as a matrix was dictated by the possibility of separating the allowed and forbidden transitions in the EPR spectrum [4], owing to the line narrowing under conditions of rapid rotational diffusion, which characteristic of plastic crystals, which have as a rule globular molecules and highly symmetrical cubic lattices [5]. The investigations were performed in cyclohexane and camphor crystals in the plastic region. The results turned out to be qualitatively the same, and we present below data for cyclohexane, into which the radical  , previously used to investigate rotational diffusion in viscous and polymer media [6, 7] was introduced at a concentration $\sim 10^{18}$ cm^{-3}. The measurements were performed by the electron-electron double-resonance method (EDR) developed in [8]. The EDR method consists of a stationary saturation of one of the lines of the multicomponent EPR spectrum with a strong microwave pump field, followed by observation of the influence of this saturation on the intensity of other spectral lines with the aid of a weak microwave field of another frequency. An EDR spectrometer with $\nu_0 \sim 9300$ MHz is described in [9]. The EDR signal is separated by modulating the pump at the same frequency, 330 Hz, at which the observation is carried out. Forbidden transition

[3] We note that to obtain agreement with the MPM the author of [3] had to assume an anomalously large heavy-isobar production cross section.