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An Agenda for Correlations*

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ABSTRACT

A brief discursive summary of the structure of events; some unanswered questions.

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To the familiar list of qualitative properties of collisions at high energy:

(a) Limited transverse momentum of secondaries;

(b) Leading particle effect (small inelasticity);

(c) Slowly increasing multiplicity of secondaries (mostly pions); experiments at the new accelerators have added several additional elements which appear to be equally fundamental:

(d) Scaling of inclusive cross sections;

(e) Independence of the incident particles ("factorization");

(f) Short-range order or clustering;

(g) A stable structure of events for primary energies from 100 to 2000 GeV/c.

In broad terms, the study of correlations (I should now prefer to use the term "structure of events") aims to probe the origin of these inclusive generalizations.

Through the study of the structure of events, we now know that short-range order is the dominant feature of particle production in the 100–2000 GeV/c regime. The strength of the short-range attraction between $\pi^+\pi^-$ greatly exceeds that between $\pi^+\pi^+$ or $\pi^-\pi^-$, as is to be expected from inclusive or exclusive duality considerations. All of the characteristics of the structure of nondiffractive events* can be reproduced by a simple independent cluster emission model in which the clusters carry less than two units of

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*I adopt the two-component picture as a useful artifice here.

charge and decay isotropically into about two charged particles on the average. A similar claim could already be made two years ago (chiefly inspired by the behavior of the two-particle correlation function, which returned these models to prominence), but today we may base it upon a much more diverse range of experimental distributions in collisions of different beams and targets. Included among the body of evidence is the fact that experiments are consistent with -- but do not imply -- local compensation of charge (and perhaps other quantum numbers), a property I would find difficult to understand outside the framework of an exchange picture, given the other facts in our possession. Testing the conjecture that an exchange picture lies behind the successes of the cluster model should be prominent among our future goals.

The cluster model appears over-simplified (can there really be no dynamical long-range correlations?) and is obviously nonunique, but has no failures for ordinary events. How do we face this situation? I propose an analogy with the parton model which seems to put in perspective many opinions expressed about the cluster model. To make my point, I juxtapose statements often heard about the two schemes:*

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*In the interest of diplomacy and fair play, I neglect to identify any of the speakers.

PARTON MODEL

Anything the parton model explains can be explained in other ways.

Why don't we see partons?

Partons are quarks.

The parton model is just a mechanistic representation for the basic underlying truth, which is the light-cone algebra.

Can partons really act as if they are free? The parton model is but an approximation valid in a large but finite (Q^2,ν) range. According to asymptotically-free field theories, Bjorken scaling will break down.

CLUSTER MODEL

Anything the cluster model explains can be explained in other ways.

Why don't we see clusters?

Clusters are resonances.

The cluster model is just a mechanistic representation for the basic underlying truth, which is short-range order.

Can clusters really act independent, while σ_t is increasing? The cluster model is but an approximation, valid in a large but finite energy range. According to Reggeon field theory, the structure of events will be completely different at infinite energy.

Having thus disposed of the issues of philosphy and prejudice which might have occupied our attention, I turn now to this season's shopping list. Many of the entries are old but, like a demanding child, I am going to keep asking for them until someone gives them to me. For these purposes it is convenient to distinguish five classes of events.

(1). Ordinary events ("soft collisions"). We still have no information on the range of correlations among $B\bar{B}$, $K\bar{K}$, πK, πB, etc., i.e., on the mobility of internal quantum numbers other than charge. To come closer to understanding how Nature conserves energy and momentum, we need to know the spectrum of leading particles for fixed topologies. How independent are the spectra of the two leading particles? Are there intrinsic long-range correlations? Do azimuthal correlations contain information of a fundamental nature, or are they merely sensitive to detailed properties of clusters?

(2). Diffractive events. The study of Pomeron-hadron scattering[1] in the same detail as we now study hadron-hadron scattering is of great interest. The study of correlations among particles in the missing mass (i.e., the structure of events in Pomeron-initiated events) has been particularly neglected.

(3). Large-$p_\perp$ Events ("hard scattering"). Correlations among the debris, already studied at the ISR, can be studied in the same detail wished for in (1).

(4). Double-Pomeron Exchange. In these events, the issue is the existence and nature[1] of Pomeron-Pomeron collisions.

(5). Events with no leading particles (two slow protons). Do they exist? Certainly the mundane mechanism (see Fig. 1) of baryon exchange, in analogy to the presumed mechanism for $\bar{p}p$ annihilation, will give rise to a cross section of order 1 mb. at Fermilab-ISR energies. But might there be a fundamentally different process? Usual events, in which most particles are produced by the interaction rather than by the throughgoing particles, may be imagined[2] to proceed by the steps shown in Figs. 2(a) and 2(b). The final step in which hadrons materialize has not been sketched. It is conceivable that two slow proton events could proceed instead by steps 2(a) and 2(c). Such events presumably would satisfy the hydrodynamical model hypothesis that the matter contained in the colliding hadrons stops in the first stage of particle production. Are events without leading particles spherically symmetric? Are they the true hydrodynamical events?[3] How does the multiplicity of secondaries differ from that in run-of-the mill events?

ACKNOWLEDGEMENTS

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REFERENCES

[1] C. Quigg, in Particles and Fields - 1973, edited by H. H. Bingham, M. Davier, and G. Lynch (AIP, New York), p. 520.

[2] L. Van Hove and S. Pokorski, Nucl. Phys. B86, 243 (1975) have championed this pictorial representation which is in fact more specific than we require in the present discussion.

[3] See, for example, E.L. Feinberg, Usp. Fiz. Nauk 104, 539 (1971) [English trans. Sov. Phys. - Uspekhi 14, 455 (1972)].

CAPTIONS

Fig. 1 Estimate of the cross section for two slow proton events by ordinary baryon exchange.

Fig. 2a Fliegende Pfannkuchen representation for two hadrons (containing quarks and glue) about to collide at high energy.

Fig. 2b The evolution of a normal collision, with through-going hadrons and particles produced by the interaction (in the gluepot).

Fig. 2c Evolution of the conjectured class of two slow proton events: The entire collection of hadronic stuff behaves statistically.

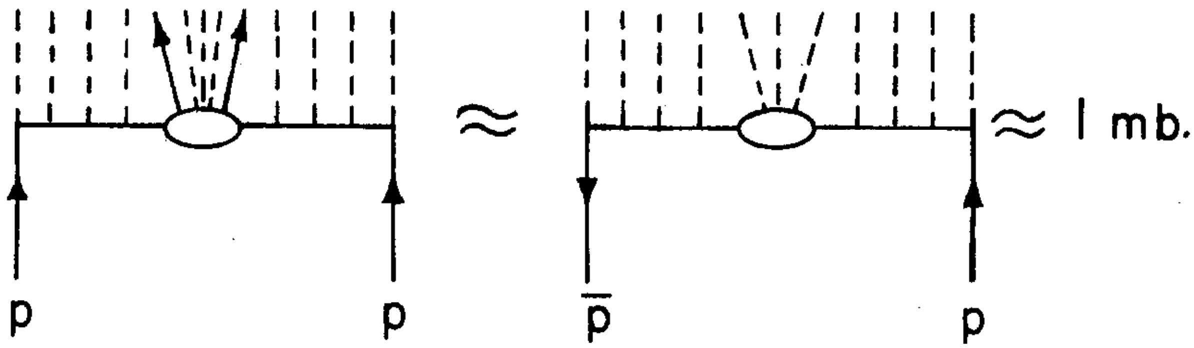

FIG. 1

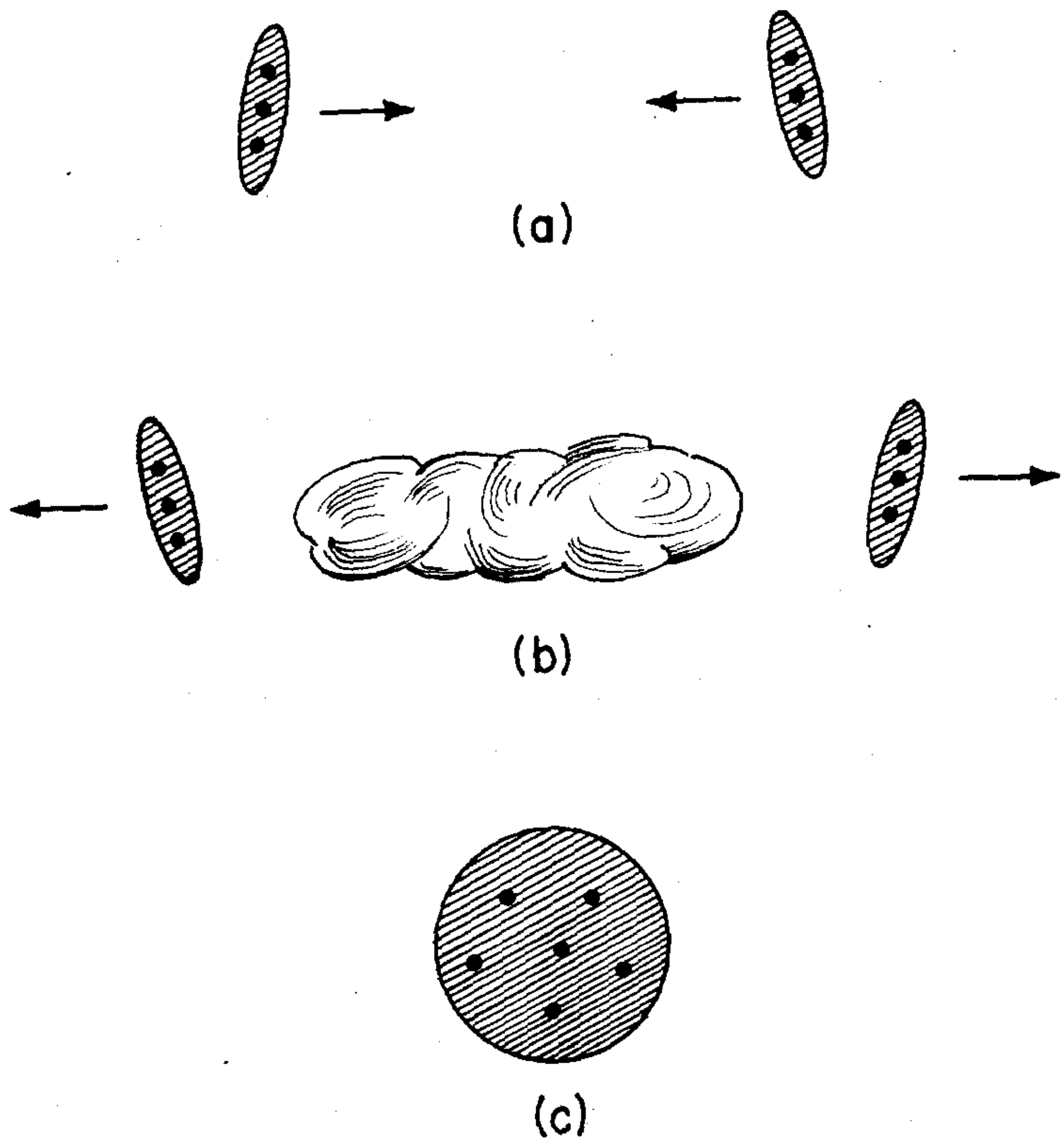

FIG. 2