On the Scaling Law of Multiplicity Distributions at High Energies (*) (**).

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Summary. — A formula to derive the scaling law of the multiplicity distributions is proposed from an analogy with the thermodynamical system. We assume a system exposed to adiabatic influences with respect to a production process, in which chemical potential plays an essential role to show the available scaling behaviour. At especially high energies, a new scaling function is expected which differs slightly from the KNO scaling function.

1. Introduction.

Convenient many times various ideas (1) have been proposed for the charged-prong multiplicity distribution function. The experimental deviations from the Poisson distribution were discussed in them, those come from the analysis of the correlation coefficients. Some of them (1) succeeded in showing the behaviours of the strong correlation at high energies. However, it is quite difficult for the models to reveal the sign change of the coefficients $f_2$, $f_3$ and $f_4$ around the incident momentum $P_L \sim 50$ GeV/c (2).

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Recently we presented a successful formula (3) (*). The point aimed in our formula is to investigate the structure of $f_\beta$ in the full available-energy region. The formula shows its characteristic aspect in the feature of the dispersion

$$D_\beta^2 = \langle n_+^2 \rangle - \langle n_- \rangle^2 \approx (C_0 + 1) \langle n_- \rangle + \left\{ \beta (\beta + 1) - 1 \right\} \langle n_- \rangle^2,$$

where $C_0$ is a constant and $\beta$ and $\gamma$ are the constants of the hypergeometric function.

In relation (1.1) the first term $(C_0 + 1) \langle n_- \rangle$ (**) $(\langle n_- \rangle$ is the average number of secondary negative charged particles) leads to the weak negative correlation at low energy. For increasing energy, the second term becomes dominant, i.e. $D_\beta$ behaves according to the Polya distribution (9). It should be noticed that our formula involves these two components.

Indeed our distribution function asymptotically becomes to satisfy the KNO scaling (5) like the others, but the reason seems to be obscure. The purpose of this paper is to propose the way to derive the scaling law of the multiplicity distributions (the KNO is an example of them) by using the thermodynamical method.

In the course of calculations, the chemical potential plays an essential role and is closely related to the structure of $D$.

In sect. 2 we shall show the formulæ to derive the KNO scaling as a symple case, assuming that the influence on the system considered is adiabatic. It is argued that the dependence of the two-body correlations on the scaling functions comes out clear if we take an especial scaling variable in sect. 3. The last section is devoted to trying to prospect the new scaling function at the quite very high energy.

2. – Statistic thermodynamical method for the KNO scaling.

Some years ago, KNO (KOBÃ, NIELSEN and OLESEN) expected the following scaling rule (4) with the help of the Feynman scaling in considering asymptotic energies:

$$\sigma_n^2 = P_n - \frac{1}{\langle n \rangle} \psi\left(\frac{n}{\langle n \rangle}\right),$$

(2.1)

(9) For the derivation, we used a grand partition function, in analogy with statistical thermodynamics, which is convenient to evaluate the correlation parameters.
(10) The experimental data suggest $C_0 \approx 1$. If $C_0 = 0$, this term is the same given by the Poisson distribution.