DIFFRACTIVE DISSOCIATION AND THE EARLY KNO SCALING

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The assumption of asymptotic validity of early KNO scaling combined with the existence of diffraction is shown to result in strong restrictions on the asymptotic multiplicity distributions.

In this note we discuss the conditions imposed on the diffractive dissociation by the phenomenon of early KNO scaling [1]. It was noted some time ago that the simple-minded two component picture, although describing correctly the same data, is asymptotically incompatible with the early KNO scaling [2]. In particular, the nonzero limits of low multiplicity cross-sections combined with constant total cross-section and growing average multiplicity lead inevitably to the divergence of the asymptotic scaling function

$$\psi(z) \equiv \lim_{\langle n\rangle\to\infty} \langle n\rangle\, \sigma_n/\sigma_t \tag{1}$$

at $z = n/\bar{n}$ tending to zero. No indication for such singularity is seen in present data. Thus in the simplest two-component picture the early scaling (at least for small z) is expected to be only an intermediate energy effect and the true asymptotic limit is very different.

We would like to discuss here the opposite point of view: assuming that the early scaling will survive asymptotically, we look for the necessary modifications and restrictions imposed on the multiplicity distribution.

Our results may be formulated in a simple theorem:

Assumptions:

1) Let the scaling function $\psi(z)$ be non-singular for all z

$$\lim_{\langle n\rangle\to\infty} \langle n\rangle\, \sigma_n/\sigma < \infty \tag{2}$$

2) Let the topological cross-section σ_n tend asymptotically to the finite non-zero limits at least for some n

$$\lim_{\langle n\rangle\to\infty} \sigma_n = c_n \neq 0 \tag{3}$$

Then:

1) The total cross-section has to grow asymptotically at least as fast as the average multiplicity

$$\lim_{\langle n\rangle\to\infty} \langle n\rangle/\sigma_t = g < \infty \tag{4}$$

2a) For $g \neq 0$ all the topological cross-sections have the same asymptotic value

$$c_n = c \equiv \frac{1}{g}\psi(0) \tag{5}$$

b) For $g = 0$ the asymptotic cross-sections grow indefinitely with multiplicity

$$\lim_{n\to\infty} c_n = \infty \tag{6}$$

The proof of the statements above is straightforward and follows immediately from the definition of the scaling function (1). The last statement is true if the total cross-section does not grow faster than its diffractive part (a sum of asymptotic limits).

Our first result shows the necessity of growing total cross-section unless the average multiplicity saturates at some finite value. Due to the Froissart bound our assumptions are shown to be in conflict with the power-like asymptotic increase of the average multiplicity suggested by some fits.

Secondly, if the asymptotic behaviour of the total cross-section is the same as that of the average multiplicity, all the topological cross-sections are asymptotically equal. This result, surprisingly strong, holds e.g. for the case of logarithmic increase of diffractive cross-section (triple Pomeron contribution) and conventional average multiplicity.

Perhaps most surprising is the last result. It shows that an alternative to the asymptotically flat multiplicity distribution is given by the diffractive cross sections rising to infinity with multiplicity. Up to now, no model seems to predict such an effect.

Let us mention that the possible weak (logarithmic) decrease of the asymptotic topological cross-sections weakens our conclusions, but some of them remain unchanged. In particular, a power-like increase of the average multiplicity is still impossible and the non-vanishing value of scaling function at $z = 0$ results in the common value of the leading term for all the topological cross-sections

$$\lim_{\langle n \rangle \to \infty} \sigma_i/\sigma_k = 1 \tag{7}$$

To summarize, we have shown that the assumption of asymptotic validity of early KNO scaling combined with the existence of energy independent diffraction results in very strong restrictions on the asymptotic multiplicity distribution. A careful investigation of the future high energy data may show if these conditions are compatible with the observed trends and, consequently, if the KNO scaling with non-singular scaling curve may survive asymptotically.

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References

[1] Z. Koba, H.B. Nielsen, P. Olesen, Nuclear Phys., B40 (1972) 317;
P. Slattery, Phys. Rev. Letters 29 (1972) 1624, Phys. Rev. D7 (1973) 2073.

[2] K. Fialkowski, H.I. Miettinen, Phys. Letters 43B (1973) 493.