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THE FRACTAL POMERON

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ABSTRACT

Intermittent patterns in multiparticle production processes suggest the existence of a fractal component of the Pomeron, due to cooperative phenomena in strongly interacting systems. Assuming factorization for this component we study its structure and its properties. The underlying multiparticle configurations in rapidity space correspond to a critical system which may be interpreted as the hadronic phase, near the critical temperature, in a quark-hadron phase transition process. The connection of this mechanism with existing theories for the Pomeron and its relevance to high-energy experiments, are discussed.

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The power-law behaviour of the factorial moments, observed recently in multiparticle production experiments at high energies [1], requires a systematic investigation in order to reveal the underlying dynamical mechanism. In fact, one may conjecture that a fractal structure of multihadron production suggested by these observations [2] may reflect in a simple and fundamental manner, at the level of the hadronic S -matrix, the complexity of the collective phenomena involved in the hadronization process, at the level of the quark-gluon $(q - g)$ dynamics at large distances. In this context, we consider the basic equations of intermittency suggested by Bialas and Peschanski [3].

$$F_p(\delta; \Delta) = \varphi_p(\Delta) \left(\frac{\delta}{\Delta} \right)^{-f_p}, \quad (\delta_0 \ll \delta \ll \Delta) \quad (1)$$

where

$$F_p(\delta; \Delta) \equiv \frac{(N(N-1) \dots (N-p+1))_\delta}{(N)_p^2}$$

In Eq. (1), Δ is the size of the hadronic system in rapidity and δ_0 is a minimal interval in rapidity space below which intermittency breaks down. The parameter δ_0 is connected with the maximal time scale (τ_h) in the hadronization process, $\delta_0 \sim \tau_h^{-1}$ [4]. In this work we study the implications of intermittency on the diffractive sector of the hadronic S -matrix. More specifically, we attempt to build up a self-consistent, factorizable Pomeron-like singularity by considering the contribution to s -channel unitarity of the multiparticle configurations in the rapidity space which satisfy the intermittency equations (1) with appropriate spectrum f_p . For this purpose and in order to specify the characteristics of the model, we consider a factorizable Mueller propagator $P_F(y_i - y_j; \delta_0)$ in the rapidity space which satisfies the following boundary condition:

$$\sigma_F = g_A g_B P_F(\Delta; \delta_0) \quad (2)$$

In Eq. (2), σ_F is the contribution of the intermittent multiparticle states to the total cross-section σ_{AB} of a hadronic collision $A + B$. The constants g_A , g_B are the couplings of P_F to the initial hadrons A and B respectively. On the other hand, the factorizable Mueller propagator $P_F(y_i - y_j; \delta_0)$ generates a specific class of inclusive processes which, as required by

self-consistency, must follow the same intermittent pattern with the states which build up the component σ_F of the total cross-section. The corresponding inclusive densities are given by the equations:

$$\begin{aligned} \langle \rho(y_1) \rho(y_2) \dots \rho(y_p) \rangle &= g^p \frac{P_F(y_1 + \frac{\Delta}{2}; \delta_0) P_F(\frac{\Delta}{2} - y_p; \delta_0)}{P_F(\Delta; \delta_0)} \prod_{i=2}^p P_F(y_i - y_{i-1}; \delta_0) \\ (p = 2, 3, \dots), \quad &(-\frac{\Delta}{2} < y_1 < y_2 < \dots < y_p < \frac{\Delta}{2}) \end{aligned} \quad (3)$$

where g is the internal coupling in the Mueller-Regge diagrams. In particular the pair correlation function for $|y_i| \ll \Delta$ ($i = 1, 2$) is written as follows:

$$\langle \rho(y_1) \rho(y_2) \rangle \approx g^2 P_F^{-1}(\Delta; \delta_0) \left[P_F(\frac{\Delta}{2}; \delta_0) \right]^2 P_F(y_2 - y_1; \delta_0) \quad (4)$$

Our basic assumption about the intermittent behaviour of the underlying multiparticle states leads to the conjecture that the production process has the structure of a random fractal in rapidity space and therefore the pair correlation function $\langle \rho(y_1) \rho(y_2) \rangle$ has, for $|y_1 - y_2| \gg \delta_0$, a power-law behaviour, characteristic of a fractal geometry in a one-dimensional space [5]. We have

$$\langle \rho(y_1) \rho(y_2) \rangle \sim |y_1 - y_2|^{d_F-1}, \quad (|y_1 - y_2| \gg \delta_0) \quad (5)$$

where d_F is the corresponding fractal dimension ($0 < d_F < 1$). From Eqs. (4) and (5) one obtains a similar behaviour for the propagator P_F .

$$P_F(y_1 - y_2; \delta_0, \eta) \sim |y_1 - y_2|^{-\eta}, \quad (|y_1 - y_2| \gg \delta_0) \quad (6)$$

where we have introduced the parameter $\eta = 1 - d_F$ ($0 < \eta < 1$). The power-law (6) corresponds to a branch-point singularity in the angular momentum plane, at the position $j = 1$, and the analytic structure of the Laplace transformed propagator $\tilde{P}_F(\xi; \delta_0, \eta)$, near this singularity, is

also characterized by a power-law behaviour ($\xi \equiv j - 1$):

$$\bar{P}_F(\xi; \delta_0, \eta) \sim \xi^{-1+\eta}, \quad (\xi \rightarrow 0) \quad (7)$$

We observe that the asymptotic region in rapidity distances, where the leading singularity at $\xi = 0$ dominates the propagator $P_F(y_1 - y_2; \delta_0, \eta)$, is specified by the minimal distance δ_0 occurring in the intermittent pattern [Eqs. (1) and (6)]. Therefore, the parameter δ_0 is a natural scale in the rapidity space and this remark suggests the following scaling property,

$$P_F(y; \delta_0, \eta) = \delta_0^{-1} h\left(\frac{y}{\delta_0}; \eta\right), \quad (0 \leq y \leq \Delta) \quad (8)$$

$$\bar{P}_F(\xi; \delta_0, \eta) = \bar{h}(\delta_0 \xi; \eta) \quad (9)$$

In the asymptotic region, $y \gg \delta_0$, we have

$$P_F(y; \delta_0, \eta) = \delta_0^{-1} \gamma(\eta) \left(\frac{y}{\delta_0}\right)^{-\eta}, \quad (\delta_0 \ll y \leq \Delta) \quad (10)$$

where the dependence on the fundamental parameters δ_0, η is explicitly shown. In this context, the fractal Pomeron is defined as a factorizable Mueller propagator $P_F(y_i - y_j; \delta_0, \eta)$ which satisfies the scaling condition (8) and the power-law (10) with $0 < \eta < 1$. Using now Eqs. (3) and (10) we find:

$$\langle \rho(y_1) \rho(y_2) \dots \rho(y_p) \rangle = [g\gamma(\eta)]^p \delta_0^{p(\eta-1)} \Delta^\eta (y_1 + \frac{\Delta}{2})^{-\eta} (\frac{\Delta}{2} - y_p)^{-\eta} \prod_{i=2}^p (y_i - y_{i-1})^{-\eta} \quad (11)$$

$$\langle \rho(y) \rangle = g\gamma(\eta) \delta_0^{\eta-1} \Delta^\eta (y + \frac{\Delta}{2})^{-\eta} (\frac{\Delta}{2} - y)^{-\eta} \quad (12)$$

with the following constraints:

$$|y_i \pm \frac{\Delta}{2}| \gg \delta_0, \quad |y_i - y_{i-1}| \gg \delta_0, \quad -\frac{\Delta}{2} < y_1 < y_2 < \dots < y_p < \frac{\Delta}{2} \quad (13)$$

Integrating the density $\langle \rho(y) \rangle$ in the region $|y| \leq \frac{\Delta}{2}$, we obtain a fractal growth for the average

multiplicity, valid for $\Delta \gg \delta_0$.

$$\langle N \rangle = g\gamma(\eta) \frac{[\Gamma(1-\eta)]^2}{\Gamma(2-2\eta)} \left(\frac{\Delta}{\delta_0}\right)^{1-\eta} \quad (14)$$

It has been shown recently [6] that the inclusive densities given by Eqs. (11) and (12) lead to a power-law behaviour of the factorial moments $F_p(\delta; \Delta)$ in the region $\delta_0 \ll \delta \ll \Delta$ and to a constant (Δ -independent) multiplicity moments $C_p = \frac{\langle N^p \rangle}{\langle N \rangle^p}$ in the limit $\delta = \Delta$, $\Delta \gg \delta_0$. We have [6]:

$$F_p(\delta; \Delta) = \frac{p! [\Gamma(1-\eta)]^{p-1}}{\Gamma[1+\eta+(1-\eta)p]} \left(\frac{\delta}{\Delta}\right)^{-\eta(p-1)}, \quad (\delta_0 \ll \delta \ll \Delta) \quad (15)$$

$$C_p = F_p(\delta = \Delta; \Delta) = \frac{p! [\Gamma(1-\eta)]^{1-p} [\Gamma(2-2\eta)]^p}{\Gamma[(p+1)(1-\eta)]}, \quad (\Delta \gg \delta_0) \quad (16)$$

This result shows that the fractal Pomeron generates, through the Mueller-Regge mechanism, inelastic processes which satisfy intermittency and asymptotic KNO scaling. Moreover, using Eq. (16), we write for the KNO scaling function $\psi(x)$ the following equations:

$$\int_0^\infty \psi(x) x^{p-1} dx = \frac{\Gamma(p) [\Gamma(1-\eta)]^{2-p} [\Gamma(2-2\eta)]^{p-1}}{\Gamma[p(1-\eta)]}, \quad (p = 3, 4, \dots) \quad (17)$$

$$\int_0^\infty \psi(x) dx = \int_0^\infty x \psi(x) dx = 1 \quad (18)$$

The asymptotic behaviour of C_p , given by the form

$$C_{p-1} \approx \Gamma(1-\eta) (1-\eta)^{-p(1-\eta)+1/2} \left[\frac{\Gamma(2-2\eta)}{\Gamma(1-\eta)} \right]^p e^{-\eta p} p^{\eta p}, \quad (p \gg 1) \quad (19)$$

guarantees [7] the uniqueness of the solution of the moment problem (17). Inverting Eqs. (17) and using the steepest descent method with the asymptotic form (19), we determine the scaling

function $\psi(x)$ in the limit $x \gg 1$. We have

$$\psi(x) = \frac{1}{2\pi i} \int_{c-i\infty}^{c+i\infty} \frac{\Gamma(p)\Gamma(1-\eta)^{2-p}\Gamma(2-2\eta)^{p-1}}{\Gamma[p(1-\eta)]} x^{-p} dp \quad (20)$$

$$\psi(x) \approx \frac{\Gamma(1-\eta)}{\sqrt{2\pi\eta}} \left[\frac{\Gamma(2-\eta)}{\Gamma(2-2\eta)} \right]^{\frac{1}{2\eta}} x^{\frac{1}{2\eta}} \exp(-\alpha x^{\frac{1}{\eta}}), \quad (x \gg 1) \quad (21)$$

where

$$\alpha \equiv \eta(1-\eta)^{\frac{1-\eta}{\eta}} \left[\frac{\Gamma(1-\eta)}{\Gamma(2-2\eta)} \right]^{\frac{1}{\eta}}.$$

From Eqs. (14) and (21) we obtain the N -hadron contribution, $P_F(N, \Delta; \delta_0, \eta)$, and its Laplace transformed, $\tilde{P}_F(N, \xi; \delta_0, \eta)$, to the fractal Pomeron, in the region $\Delta \gg \delta_0$, $\frac{N}{(N)} \gg 1$. We find

$$P_F(N, \Delta; \delta_0, \eta) \sim N^{\frac{1}{2\eta}} \Delta^{-\frac{1+\eta}{2\eta}} \exp(-f \Delta^{\frac{\eta-1}{\eta}} N^{\frac{1}{\eta}}) \quad (22)$$

$$\tilde{P}_F(N, \xi; \delta_0, \eta) \sim \exp(-N b \xi^{1-\eta}), \quad (N \gg 1) \quad (23)$$

where $f \equiv [g\gamma(\eta)\Gamma(1-\eta)]^{-\frac{1}{\eta}} \eta(1-\eta)^{\frac{1-\eta}{\eta}} \delta_0^{\frac{1-\eta}{\eta}}$, $b \equiv \delta_0^{1-\eta} [g\gamma(\eta)\Gamma(1-\eta)]^{-1}$.

On the other hand, due to factorization, the term $\tilde{P}_F(N, \xi; \delta_0, \eta)$ is expected to be generated by an exclusive propagator $\tilde{K}_F(\xi; \delta_0, \eta)$ as follows:

$$\tilde{P}_F(N, \xi; \delta_0, \eta) = [\tilde{K}_F(\xi; \delta_0, \eta)]^{N+1}, \quad (N = 0, 1, \dots) \quad (24)$$

Comparing Eqs. (23) and (24), we find

$$\tilde{K}_F(\xi; \delta_0, \eta) = \exp(-b \xi^{1-\eta}) \quad (25)$$

The propagator (25) corresponds to an effective two-body potential in rapidity space obtained by the steepest descent method [8]:

$$\mathcal{U}_{ef}(y_i - y_j) = \frac{1+\eta}{2\eta} \ln |y_i - y_j| + \frac{f}{|y_i - y_j|^{\frac{1-\eta}{\eta}}} \quad (26)$$

It is remarkable to notice that the propagator (25) which generates multihadron production processes associated with a fractal component of the Pomeron, leads also to a critical behaviour

of the corresponding Feynman-Wilson (FW) fluid, specified by the critical exponent η [6]. This observation implies that the fractal Pomeron is built up, through s -channel unitarity, by the rapidity configurations of a critical FW fluid with a factorizable effective interaction reflecting a higher order quark-hadron phase transition in the hadronization process. Using Eq. (25), we determine the structure of the fractal Pomeron in the ξ -plane, as follows:

$$\tilde{P}_F(\xi; \delta_0, \eta) = \sum_{N=0}^{\infty} \tilde{P}_F(N, \xi; \delta_0, \eta) \quad (27)$$

$$\tilde{P}_F(\xi; \delta_0, \eta) = [\exp(b \xi^{1-\eta}) - 1]^{-1} \quad (28)$$

The solution (28) satisfies the scaling requirements [Eqs. (8) and (9)] since $b \sim \delta_0^{1-\eta}$, and has the appropriate analytic structure near $\xi = 0$, leading to the power-law behaviour (6). Moreover, the intermittent pattern, generated by the form (28), has a minimal scale δ_m satisfying the equation $\mathcal{U}'_{eff}(\delta_m) = 0$ [6]. Self-consistency requires $\delta_m = \delta_0$ and also $g = 1$, if one compares Eqs. (10) and (28). These constraints specify completely the η -dependence of the component (28) giving

$$\gamma(\eta) = \frac{1-\eta}{\Gamma(1-\eta)} \left(\frac{2\eta}{1+\eta} \right)^{\eta}, \quad b = \delta_0^{1-\eta} \left(\frac{1+\eta}{2\eta} \right)^{\eta} \frac{1}{1-\eta} \quad (29)$$

Having discussed the physical origin and the self-consistency of the fractal Pomeron sector, we may now study the contribution of the component (28) to a hadronic process $A + B$ in an attempt to investigate the qualitative features of the fractal Pomeron phenomenology. For this purpose and using Eqs. (25) and (28) we write, in the ξ -plane, the contribution to the N -hadron production cross-section, $\tilde{\sigma}_F(N, \xi)$, and to the total cross-section, $\tilde{\sigma}_F(\xi)$, as follows:

$$\tilde{\sigma}_F(N, \xi) = g_A g_B \exp[-(N+1)b \xi^{1-\eta}], \quad (N = 0, 1, 2, \dots) \quad (30)$$

$$\tilde{\sigma}_F(\xi) = g_A g_B [\exp(b \xi^{1-\eta}) - 1]^{-1} \quad (31)$$

The inverse Laplace transform of Eq. (31) gives the contribution of the fractal Pomeron to the total cross-section for $\Delta \geq 0$ ($\Delta = \ln \frac{s}{s_0}$). The energy scale s_0 specifies the threshold of this

new mechanism and it is expected to be related with the critical energy density required for a confinement-deconfinement phase transition in this collision ($A+B$). In the asymptotic region, $\Delta \gg \delta_0$, one obtains the power-law behaviour

$$\sigma_F(s) = \frac{g_{AGB}}{\delta_0} \frac{1-\eta}{\Gamma(1-\eta)} \left(\frac{2\eta}{1+\eta} \right)^\eta (\delta_0^{-1} \ln \frac{s}{s_0})^{-\eta}, \quad (\ln \frac{s}{s_0} \gg \delta_0) \quad (32)$$

due to the leading singularity of $\bar{\sigma}_F(\xi)$ at $\xi = 0$. For lower values of Δ , close to the minimal scale δ_0 , the contribution σ_F to the total cross-section is obtained by the steepest descent method, applied to the inverse Laplace transform integrals of the terms $\bar{\sigma}_F(N, \xi)$. We find:

$$\sigma_F(s) = \frac{g_{AGB}(1+\eta)^{1/2}}{2\eta\delta_0\sqrt{\pi}} (\delta_0^{-1} \ln \frac{s}{s_0})^{-\frac{1+\eta}{2\eta}} \sum_{N=1}^{\infty} N^{\frac{1}{2\eta}} \exp \left[-\frac{1+\eta}{2(1-\eta)} N^{\frac{1}{2\eta}} (\delta_0^{-1} \ln \frac{s}{s_0})^{\frac{1+\eta}{2\eta}} \right] \quad (33)$$

$$(0 < \ln \frac{s}{s_0} \leq \Delta_0, \quad \Delta_0 \simeq 0(\delta_0))$$

The form (33) has a maximum, at the point $s_m \approx s_0 \exp \delta_0$, which is reached after a rapid increase of this new component of the total cross-section near its threshold at $\Delta = 0$ ($s = s_0$). In fact, in the region $0 < \Delta \leq \delta_0$, σ_F is dominated by the first term of the series (33) and therefore one obtains the following threshold behaviour:

$$\sigma_F(s) = \frac{g_{AGB}(1+\eta)^{1/2}}{2\eta\delta_0\sqrt{\pi}} (\delta_0^{-1} \ln \frac{s}{s_0})^{-\frac{1+\eta}{2\eta}} \exp \left[-\frac{1+\eta}{2(1-\eta)} (\delta_0^{-1} \ln \frac{s}{s_0})^{\frac{1+\eta}{2\eta}} \right] \quad (34)$$

$$(0 < \ln \frac{s}{s_0} \leq \delta_0)$$

Approximately, the maximum value of σ_F , obtained from Eq. (34), is given by the expression

$$\sigma_F^{(m)} \approx \frac{g_{AGB}(1+\eta)^{1/2}}{2\eta\delta_0\sqrt{\pi}} \exp \left[-\frac{1+\eta}{2(1-\eta)} \right] \quad (35)$$

Finally, in order to reveal the critical properties of the fractal Pomeron and especially the nature of the phase transition in the FW fluid, we introduce the generating function $Q(z, \Delta)$ which,

in the ξ -plane, is written as follows:

$$\tilde{Q}(z, \xi) = \sum_{N=0}^{\infty} z^N \tilde{P}_F(N, \xi; \delta_0, \eta) \quad (36)$$

$$\tilde{Q}(z, \xi) = [\exp(b\xi^{1-\eta}) - z]^{-1} \quad (37)$$

The generating function $Q(z, \Delta)$ plays the rôle of the grand-partition function of the FW fluid, at the critical temperature $T = T_c$, and z is the analogue fugacity of the system. In the thermodynamic limit ($\Delta \rightarrow \infty$) the partition function $Q(z, \Delta)$ is governed by the leading singularities of $\tilde{Q}(z, \xi)$ in the ξ -plane which, for $z > 1$, are located at the points

$$\xi_c(z) = (b^{-1} \ln z)^{\frac{1}{1-\eta}}, \quad \xi_0 = 0 \quad (38)$$

The dominant singularity at $\xi = \xi_c(z)$ is a moving pole, as a function of z , and the secondary singularity is a fixed branch point at $\xi = 0$. At the critical point, $z = 1$, the singularities (38) collide and for $0 < z < 1$ their rôle is interchanged. The branch point at $\xi = 0$ becomes dominant singularity and the moving pole disappears in the unphysical sheet. This mechanism in the ξ -plane represents, formally, a critical phenomenon in the FW fluid when $z \rightarrow 1$. Physically, the nature of the phase transition can be specified by studying the behaviour of the correlation function $C(y_1, y_2; z)$ near the critical point $z = 1$. Due to the factorization property, one is able to determine $C(y_1, y_2; z)$ for $z > 1$ and large rapidity distances in terms of the singularities (38) by employing again the Mueller-Regge approach for the study of the inclusive densities $\langle \rho(y; z) \rangle$ and $\langle \rho(y_1; z) \rho(y_2; z) \rangle$. We have,

$$C(y_1, y_2; z) = \langle \rho(y_1; z) \rho(y_2; z) \rangle - \langle \rho(y_1; z) \rangle \langle \rho(y_2; z) \rangle \quad (39)$$

$$\langle \rho(y; z) \rangle = \beta_0(z) \quad (40)$$

$$\langle \rho(y_1; z) \rho(y_2; z) \rangle = \beta_0^2(z) + g_0^2(z) \frac{\exp(-\xi_c |y_1 - y_2|)}{|y_1 - y_2|^{2-\eta}} \quad (41)$$

where $\beta_0(z)$ and $g_0(z)$ are appropriate internal couplings in the Mueller-Regge diagrams. Using Eqs. (39) to (41) for $z > 1$ and Eqs. (11) and (12) for the inclusive densities at the critical point

$z = 1$, where only the singularity at $\xi = 0$ survives, we finally obtain the following behaviour of the correlation function:

$$C(y_1, y_2; z) \sim \frac{\exp(-\xi_c |y_1 - y_2|)}{|y_1 - y_2|^{2-\eta}}, \quad z > 1, \quad |y_1 - y_2| \gg \delta_0 \quad (42)$$

$$C(y_1, y_2; z) \sim \frac{1}{|y_1 - y_2|^{2\eta}}, \quad z = 1, \quad |y_1 - y_2| \gg \delta_0 \quad (43)$$

We observe that for $z > 1$ the grand-partition function (37) generates a conventional hadronic system with short-range ordering in rapidity. The correlation length, $\delta_c = \xi_c^{-1}(z)$, is finite, the leading singularity is a simple pole with intercept $\alpha(0) = 1 + \xi_c(z)$ and the average multiplicity grows linearly with the size of the system, $\langle N \rangle \sim \Delta$ (bare Pomeron). At the critical point, $z = 1$, however, the system undergoes a higher order phase transition. The correlation length becomes infinitely large, $\delta_c \sim (z - 1)^{\frac{1}{1-\eta}}$, and a factorizable, branch-point singularity with intercept $\alpha_F(0) = 1$ dominates the system, leading to a fractal growth of the average multiplicity, $\langle N \rangle \sim \Delta^{1-\eta}$ (fractal Pomeron). In this sector, intermittent patterns are developed for small rapidity intervals δ , $\delta_0 \ll \delta \ll \Delta$, and KNO scaling is valid as a critical property, equivalent to Kadanoff scaling [6]. We conjecture that this critical behaviour of the FW fluid reflects the properties of the confinement-deconfinement phase transition at the critical temperature $T = T_c$. Therefore, we assume that the fractal Pomeron represents the contribution to hadronic cross-sections of newly hadronized states in a quark-hadron phase transition process, during the development of the collision. As a consequence, new and unexpected effects in diffractive scattering may be attributed to the underlying cooperative phenomena in the quark-gluon system which manifest themselves as a fractal Pomeron exchange mechanism. In particular, the component (34) of the total cross-section with its characteristic behaviour near the point $s = s_0$, has the qualitative features of a candidate for the new threshold mechanism advocated recently [9], as an alternative to the odderon hypothesis [10], in order to explain the unexpectedly large real part of the proton-antiproton scattering amplitude measured by the UA4 experiment [11] at the CERN collider. Quantitatively, there is enough freedom in the parameter space of our model to accommodate a large fraction of the real part of the forward elastic amplitude at collider energies, with the help of a dispersion relation [9]. However, a consistent phenomenology of the

fractal Pomeron would require a unified treatment of several new effects both in multiparticle production processes (intermittency) and in elastic or diffractive scattering (real to imaginary ratio, diffractive production of Centauro-type systems [12]). In connection with these new effects, one has to admit that further experimental studies are needed in order to clarify (a) whether the growth of factorial moments with decreasing rapidity intervals is a new, collective phenomenon beyond conventional hadronic physics, (b) whether high-energy measurements of the elastic amplitude require a non-standard picture for asymptotic behaviour and (c) whether quark matter can be diffractively produced in high-energy collisions in the form of Centauro-type systems [12].

Theoretically, it is not clear whether the fractal Pomeron belongs to a critical sector of the standard Reggeon field theory and therefore its connection with the critical Pomeron [13] is an open and interesting question. Although these two mechanisms have certain basic similarities like the underlying phase transition phenomenon and the validity of asymptotic KNO scaling, they lead to different contributions to the total cross-section. The fractal component decreases asymptotically like $\sigma_F \sim (\ln s)^{-\eta}$, $0 < \eta < 1$, whereas the critical Pomeron gives [14] $\sigma_c \sim (\ln s)^\nu$, $\nu > 0$. It seems that the intermittent configurations in the rapidity space, a basic ingredient for building up the fractal Pomeron, do not contribute significantly to the critical Pomeron mechanism.

In conclusion, we have investigated the properties of a self-consistent, factorizable component of the Pomeron which is the shadow of fractal structures in rapidity with a minimal scale δ_0 in the corresponding intermittent patterns. We have found a unique solution which satisfies these requirements, corresponding to a higher-order phase transition in the underlying FW fluid. This solution suggests that intermittency, quark-hadron phase transition and new threshold effects in elastic-diffractive scattering are dynamically interrelated phenomena.

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