THE SUPER-CRITICAL POMERON IN QCD

- " THE SINGLE GLUON POMERON "

High-energy total cross-sections, inclusive cross-sections, and all diffractive cross-sections, are described by the exchange of the pomeron ($\mathbb{P}$). *There are two, apparently very different, fundamental experimental properties of the* $\mathbb{P}$ -

A) 35 years of experiment/phenomenology/theory =>

$\mathbb{P}$ $\approx$ **A REGGE POLE.**

B) DIS diffractive scaling violations at HERA =>

$\mathbb{P}$ $\approx$ **A SINGLE GLUON.**

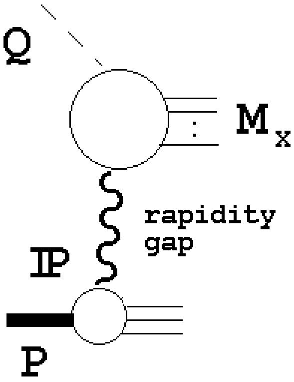
Both properties are very difficult to reconcile with perturbative QCD and, in particular, the 2 gluon BFKL $\mathbb{P}$*. I will argue that A) and B) are closely related* **- BOTH depend crucially on "non-perturbative" properties of hadrons.**

I will show that A) and B) are satisfied because the $\mathbb{P}$ *carries color-charge parity* $C_c = -1$ *and,* **at short distances, is in a** *Super-Critical phase of Reggeon Field Theory.*

The main purpose of this talk is to relate QCD to Reggeon Field Theory via the Super-Critical $\mathbb{P}$**.** *It is necessary to exploit the full power of* **"Multi-Regge theory".**

DIS DIFFRACTIVE SCALING VIOLATIONS

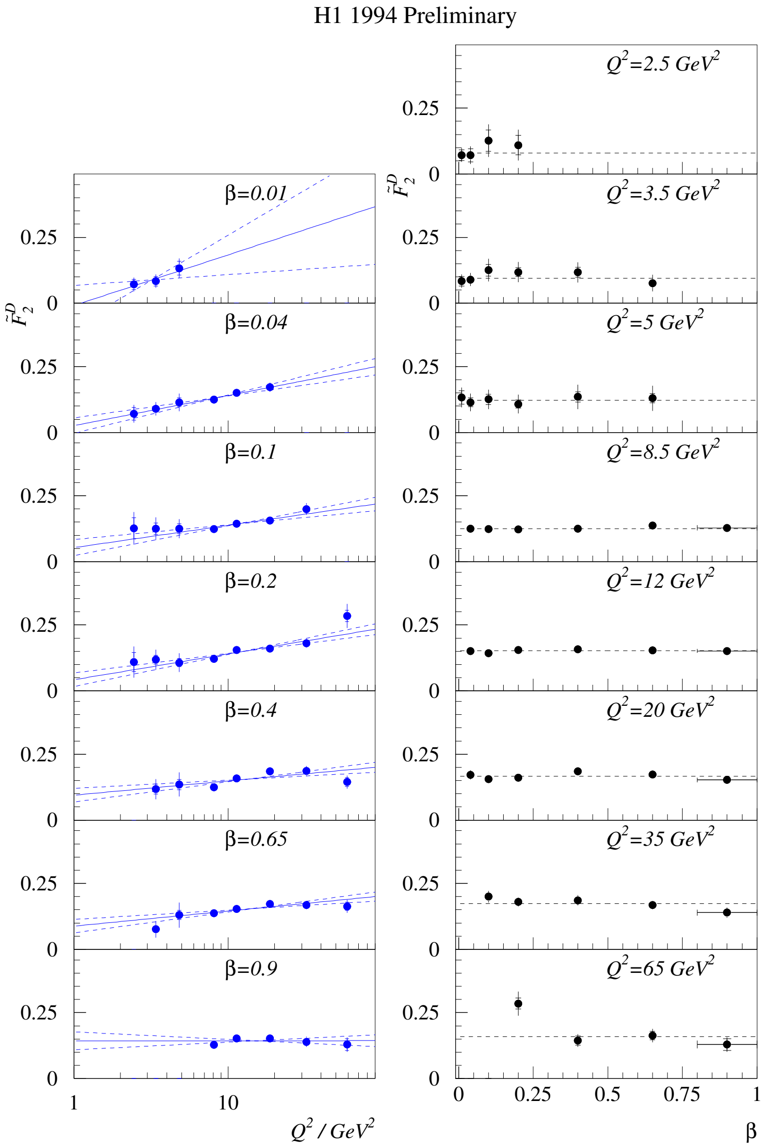
$$F_2^D(x_{\mathbb{P}}, \beta, Q^2) \equiv$$



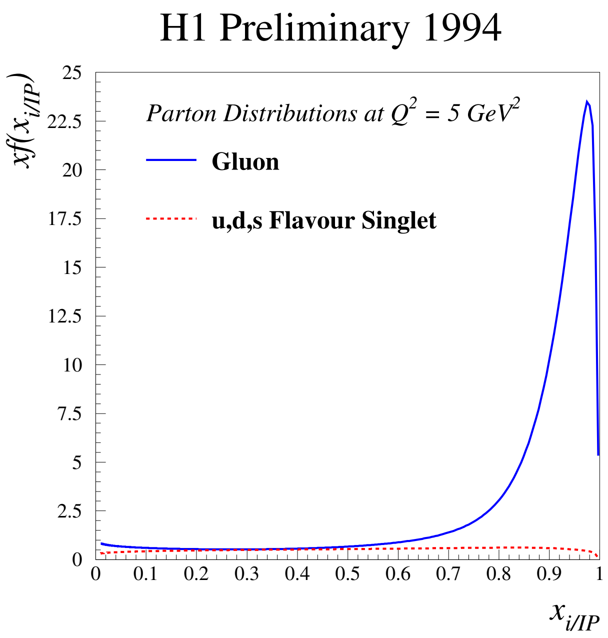
$$W^2 = (P+Q)^2$$
$$\beta = \frac{Q^2}{Q^2 + M_X^2}$$

$x_{\mathbb{P}} \sim 0 \quad \downarrow$

$$x_{\mathbb{P}} = \frac{Q^2 + M_X^2}{Q^2 + W^2}$$



$\longleftrightarrow$ **positive $\ln Q^2$ scaling violations in $F_2^D(x_{\mathbb{P}}, \beta, Q^2)$.** *Fitting to DGLAP evolution, H1 extract a $\mathbb{P}$ structure function which, at $Q^2 = 5\ GeV^2$, has a* **SINGLE GLUON** *carrying nearly all the $\mathbb{P}$ momentum.*



In perturbative QCD (BFKL Pomeron) scale-invariance =>

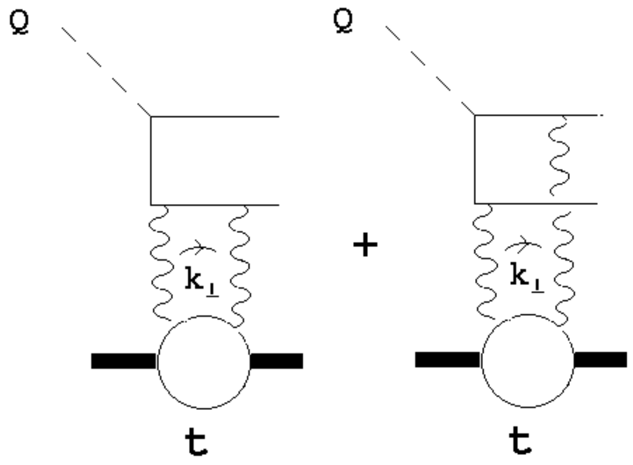
NO diffractive scaling violations ! (Also fixed J- plane singularity)

In lowest order there are TWO diagrams.
For $k_\perp^2 \sim Q^2 >> t$

$$\int \frac{d^2k_\perp}{k_\perp^4} \sim \frac{1}{Q^2}$$

$$\rightarrow \; F_2^D \sim 1/Q^4 \quad =>$$

leading-twist $\leftrightarrow k_\perp << Q^2$**.**



Can impose $k_\perp^2 > \Lambda_{IR}$ *, but* **scale-invariance** *($\leftrightarrow$ IR finiteness $\leftrightarrow$ gauge invariance) => the* Λ_{IR} **dependence cancels** *between the two diagrams*

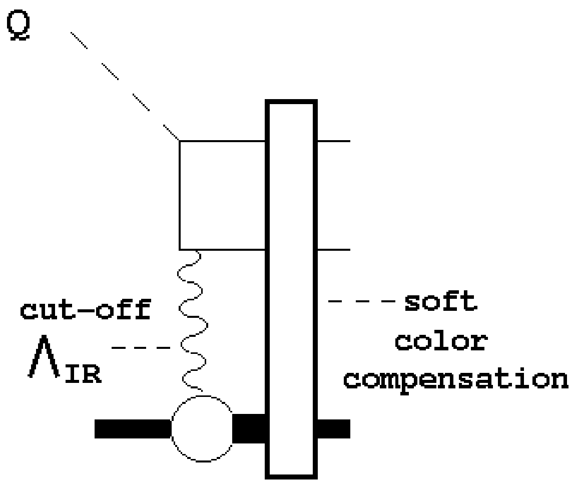
$$=> \quad \textbf{no} \quad \ln\,[\Lambda_{IR}] \quad => \quad \textbf{no} \quad \ln\,[Q^2]$$

The same cancellation occurs for any "soft Pomeron model" defined via two "non-perturbative" gluon propagators.

NO cancellation (of $\ln[Q^2]$**)**
requires one hard gluon
- with cut-off Λ_{IR} **-**
plus a color compensating
interaction with $\langle k_\perp \rangle << \Lambda_{IR}$**.**
$\leftrightarrow$ *gauge invariance is violated unless the soft interaction*

$$\not\equiv \quad \textit{single gluon} \quad =>$$

a distinguishing quantum number ?



The Regge pole property of the $\mathbb{P}$ led *(≈ 30 years ago)* **to the development of the "Reggeon Calculus"** (Gribov) **- which subsequently became the Reggeon Field Theory (RFT).**

The Critical $\mathbb{P}$ description of rising total cross-sections was discovered ≈ 7 years later. Migdal, Polyakov, Ter-Martirosyan; Abarbanel, Bronzan

I will formulate RFT for the $\mathbb{P}$ by using the same abstract multi-regge theory that I subsequently apply to QCD. *I will describe both the Critical and Super-Critical $\mathbb{P}$ solutions.*

I will then outline the application of multi-regge theory to massless quark QCD. *Existing Regge limit QCD calculations, plus new calculations of further multi-Regge limits, allow very complicated scattering processes to be described by gluon reggeon diagrams.*

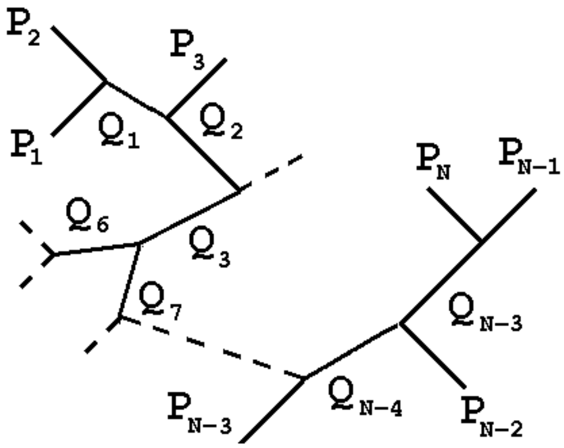
The infra-red triangle anomaly produces reggeon interactions that play a crucial dynamical role. *With the SU(3) gauge symmetry broken to SU(2), these interactions produce infra-red divergences which isolate physical hadrons scattering via $\mathbb{P}$ exchange*. **(The $\mathbb{P}$ and hadrons emerge together.)**

The $\mathbb{P}$ is a Regge pole - *essentially a reggeized gluon* **- in the Super-Critical Phase of RFT. The Critical $\mathbb{P}$ is associated with the restoration of SU(3) gauge symmetry.**

I begin by, very briefly, listing the **basic elements of multi-Regge theory.**

MULTI-REGGE THEORY - the key ingredients are

i) *Angular Variables*



$$M_N(P_1, \ldots, P_N)$$
$$\equiv M_N\left(t_1, \ldots, t_{N-3}, g_1, \ldots, g_{N-3}\right)$$

$g_j \in$ **SO(3) - little group of** Q_j

$$\begin{array}{llll} \rightarrow \quad (N-3) & t_i & (\equiv Q_i^2) & \\ (N-3) & z_j & (\equiv \cos\theta_j) & \leftrightarrow J_j \\ (N-4) & u_k & (\equiv e^{i\omega_k}) & \leftrightarrow n_k \end{array}$$

ii) *Multi-Regge Limits* $z_1, \ldots, z_{N-3} \longrightarrow \infty$ *and*
Helicity-Pole Limits $\leftrightarrow$ **some** z_i **, some** $u_{jk} \longrightarrow \infty$

iii) *Partial-wave Expansions*

$$f(g) = \sum_{J=0}^{\infty} \sum_{|n|,|n'|<J} D^J_{nn'}(g) a_{Jnn'}$$

$$\rightarrow \quad M_N(\underset{\sim}{t}, \underset{\sim}{g}) = \sum_{\underset{\sim}{J},\underset{\sim}{n},\underset{\sim}{n}'} \prod_i D^{J_i}_{n_i n_i'}(g_i) \; a_{\underset{\sim}{J},\underset{\sim}{n},\underset{\sim}{n}'}(\underset{\sim}{t})$$

iv) *Asymptotic Dispersion Relations (disperse in* $z_1, \ldots, z_{N-3}$*)*

$$M_N(p_1, \ldots p_N) = \sum_C M_N^C(p_1, \ldots, p_N) + M^0$$

$$M_N^C(p_1, \ldots, p_N) = \frac{1}{(2\pi i)^{N-3}} \int \frac{ds_1' \ldots ds_{N-3}' \Delta^C(\underset{\sim}{t}, \underset{\sim}{w}, s_1', s_2', \ldots, s_{n-3}')}{(s_1' - s_1)(s_2' - s_2) \ldots (s_{N-3}' - s_{N-3})}$$

Σ_C **is over all sets of (N-3) Regge limit asymptotic cuts.** *The resulting "hexagraph" spectral component separation* (Stapp,ARW) *is crucial for the development of multiparticle complex angular theory.*

v) *Froissart-Gribov (F-G) Continuation of Hexagraph P-W Amplitudes and Sommerfeld-Watson (S-W) Representations* **e.g.**

$$M_6^H(z_1, z_2, z_3, u_1, u_2, t_1, t_2, t_3)$$
$$= \frac{1}{8} \int_{C_{n_2}} \frac{dn_2\, {u_2^{n_2}}}{\sin \pi n_2} \int_{C_{n_1}} \frac{dn_1\, u_1^{n_1}}{\sin \pi(n_1 - n_2)} \int_{C_{J_1}} \frac{dJ_1\ d^{J_1}_{0,n_1}(z_1)}{\sin \pi(J_1 - n_1)}$$
$$\times \sum_{\substack{J_2 - n_1 = N_1 = 0 \\ J_3 - n_2 = N_2 = 0}}^{\infty} d^{J_2}_{n_1,n_2}(z_2) d^{J_3}_{n_2,0}(z_3) a^H_{N_2 N_3}(J_1, n_1, n_2, \underset{\sim}{t})$$

$\longrightarrow$ **asymptotic behaviour in multi-Regge and helicity-pole limits.**

vi) *Multiparticle t-channel Unitarity in the J-plane*

Multiparticle phase-space $\leftrightarrow$ $i \int d\rho(t, t_1, \ldots) \int dg_L \prod_j dg_j$

Unitarity $\rightarrow$

$$M^+(g) - M^-(g) = i \int d\rho \int dg_L \prod_j dg_j\, M^+(g_L, g_1..) M^-(g_L^{-1} g, g_1..)$$

Partial-wave projection $\rightarrow$ $a^+_J - a^-_J = i \int d\rho\ \Sigma_{\underset{\sim}{N},\underset{\sim}{n}}\ a^+_{J\underset{\sim}{N}\underset{\sim}{n}} a^-_{J\underset{\sim}{N}\underset{\sim}{n}}$

Continuation to complex J *(for spectral components)* $\rightarrow$

$$a^+_J - a^-_J = i \int d\rho \int \frac{dn_1 dn_2}{sin\pi(J - n_1 - n_2)} \int \frac{dn_3 dn_4}{sin\pi(n_1 - n_3 - n_4)} \cdots$$
$$\sum_{\underset{\sim}{N}} a^+_{J\underset{\sim}{N}\underset{\sim}{n}} a^-_{J\underset{\sim}{N}\underset{\sim}{n}}$$

"Nonsense poles" at $J = n_1 + n_2 - 1,\ n_1 = n_3 + n_4 - 1, \ldots$ *combined with Regge poles and* $\int d\rho$ $\longrightarrow$ **Regge Cuts** ,

e.g. at $J = \alpha_M(t) = M\alpha(t/M^2) - M + 1$ *for* M *identical reggeons.*

vii) *Reggeon Unitarity*

In ANY multiparticle F-G amplitude, *the J-plane regge cut discontinuity due to M Regge poles $\underset{\sim}{\alpha} = (\alpha_1, \alpha_2, \cdots \alpha_M)$ is given by*

$$\underset{J\,=\,\alpha_M(t)}{\text{DISC}} \left[a_{\underset{\sim}{N}\underset{\sim}{n}}(J)\right] \;=\; \xi_M \int d\hat{\rho}\; \frac{a_{\underset{\sim}{\alpha}}(J^+)a_{\underset{\sim}{\alpha}}(J^-)\delta\left(J-1-\Sigma_{k=1}^{M}(\alpha_k-1)\right)}{\sin\frac{\pi}{2}(\alpha_1-\tau_1')\ldots\sin\frac{\pi}{2}(\alpha_M-\tau_M')}$$

(Gribov, Pomeranchuk, Ter-Martirosyan; ARW)

Writing $t_i = k_i^2$ (with $\int dt_1 dt_2 \lambda^{-1/2}(t,t_1,t_2) = 2\int d^2k_1 d^2k_2 \delta^2(k-k_1-k_2)$)
$\int d\rho$ **can be** *written in terms of two dimensional " $k_\perp$ " integrations* $\rightarrow$ **correspondence with high-energy (s-channel) calculations.**

POMERON RFT

If the $\mathbb{P}$ *is a Regge pole,* **all multi- $\mathbb{P}$ exchanges and interactions must satisfy the reggeon unitarity equations.**

We can write an effective lagrangian in terms of fields $\bar{\psi}(\underset{\sim}{x}, y)$ and $\psi(\underset{\sim}{x}, y)$ that, respectively, create and destroy pomerons *($\underset{\sim}{x}$ = impact parameter, y = rapidity)*

$$\mathcal{L}(\bar{\psi},\psi) = \frac{1}{2}i\bar{\psi}\overleftrightarrow{\frac{\partial}{\partial y}}\psi - \Delta_0\bar{\psi}\psi - \alpha_0'\nabla\bar{\psi}\cdot\nabla\psi + \alpha_0''\nabla^2\bar{\psi}\cdot\nabla^2\psi$$

$$\cdots + \frac{-i}{2}\left[r_0\bar{\psi}^2\psi + r_0\bar{\psi}\psi^2 + r_{01}\bar{\psi}\psi\nabla^2\psi + \cdots\right] + \frac{1}{6}\left[\lambda_0\bar{\psi}^3\psi + \lambda_0\bar{\psi}\psi^3 + \cdots\right] + \cdots.$$

The free part of the lagrangian corresponds to the Regge pole propagator $[J-1+\Delta_0+\alpha' k_\perp^2 + \alpha'' k_\perp^4]^{-1}$. *The "momemtum space" Feynman diagrams, with a complete set of interactions (the higher-order interactions require a $k_\perp$ cut-off), provide*

A GENERAL SOLUTION OF REGGEON UNITARITY.

By expanding in powers of $\epsilon = 4 - D$ *(D is the number of transverse dimensions)* **a renormalization group fixed-point solution is found giving asymptotically rising total cross-sections**

$$\sigma_T \underset{s \to \infty}{\sim} \ln s^{\eta} \ , \qquad \qquad \eta = \frac{\epsilon}{12} + O(\epsilon^2)$$

The resulting " Critical $\mathbb{P}$ " description of amplitudes and cross-sections satisfies all known unitarity constraints in both the t-channel and the s-channel.

What is the new phase appearing at the critical point?

THE SUPER-CRITICAL POMERON

Close to the critical point we can use the triple $\mathbb{P}$ theory with lagrangian

$$\mathcal{L}_R = \frac{1}{2}\bar{\psi}\frac{\overleftrightarrow{\partial}}{\partial y}\psi - \alpha_0' \nabla\bar{\psi}\nabla\psi + \Delta_0\bar{\psi}\psi - \frac{1}{2}ir_0\left[\bar{\psi}\psi^2 + \bar{\psi}^2\psi\right]$$

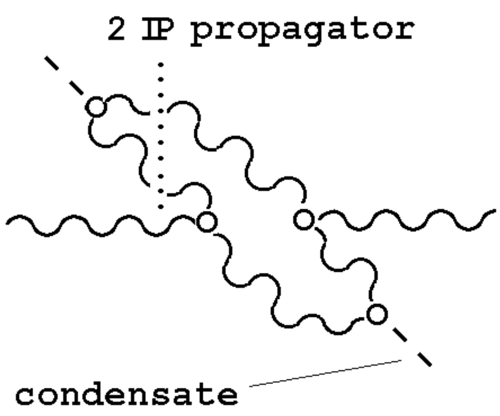
To define a theory with $\Delta_0 < 0$ ($\alpha_{\mathbb{P}}^0 > 1$) we look for a classical field configuration minimizing the "potential"

$$V(\bar{\psi}, \psi) = \Delta_0\bar{\psi}\psi + \frac{ir_0}{2}(\bar{\psi}^2\psi + \bar{\psi}\psi^2)$$

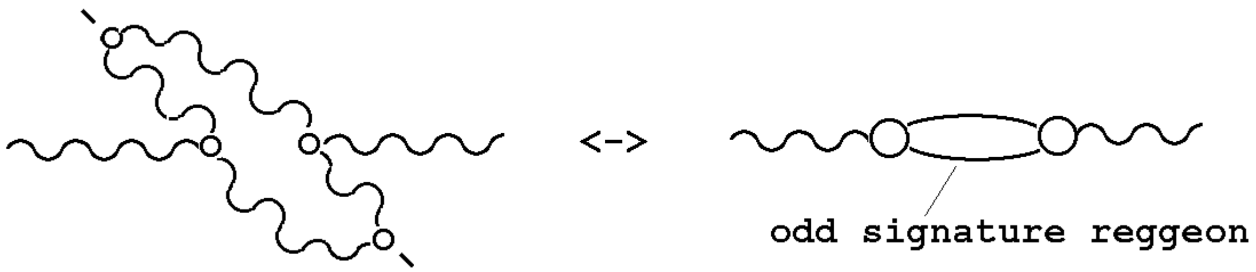
We can define a "Super-Critical" solution by using the stationary point $\psi = \bar{\psi} = \frac{2i\Delta_0}{3r_0}$ to introduce a " $\mathbb{P}$ condensate".

The condensate generates new classes of RFT diagrams whose physical interpretation is apriori not apparent.

e.g. diagrams such as



The $k_\perp$ poles produced by the zero energy 2 $\mathbb{P}$ propagators can be interpreted as particle poles. In this case the diagram describes a $\mathbb{P}$ transition to 2 odd-signature reggeons with trajectory degenerate with that of the $\mathbb{P}$, i.e.



In general, divergences in rapidity produced by $\Delta_0 < 0$ are converted to vector particle divergences in $k_\perp$,

=> the Super-Critical phase is characterized by the "deconfinement of a vector particle" on the $\mathbb{P}$ trajectory !!

Is this phase realized in QCD? *The appearance of a "reggeized gluon" (i.e. a reggeized vector particle) strongly suggests the spontaneous breaking of a gauge symmetry.*

REGGEON DIAGRAMS IN QCD

It is well-known that leading-log Regge limit calculations in perturbative QCD lead to *"reggeization of the gluon"* **and, in non-leading logs, to** *"reggeon diagrams"* **in which the** *"reggeons" are reggeized gluons.*

Note that **because the gluon is a Regge pole** *in the J-plane,* **reggeon unitarity requires that reggeon diagrams appear** *in higher-orders.*

Gluon reggeon diagrams involve $k_\perp$ integrals, just like the $\mathbb{P}$ RFT diagrams, but **gluon particle poles ($1/k_i^2$) are present in addition to reggeon propagators, e.g.**

$$\textbf{two-reggeon state} \quad \leftrightarrow \quad \int \frac{d^2k_1}{k_1^2}\frac{d^2k_2}{k_2^2} \;\; \frac{\delta^2(k_1'+k_2'-k_1-k_2)}{J-1+\Delta(k_1^2)+\Delta(k_2^2)}$$

Effectively, *to find the $\mathbb{P}$ in QCD,* **we must see the odd-signature gluon particle poles disappear,** *leaving only an even signature $\mathbb{P}$.*

In part, we need to find the reverse of the RFT phase-transition to the Super-Critical $\mathbb{P}$.

It is essential to study hadrons (as reggeons) and the $\mathbb{P}$ simultaneously => **need to construct reggeon diagrams for multi-regge and helicity-pole limits of multi-quark** *(and multi-gluon)* **amplitudes.**

Reggeon unitarity is an essential tool.

REGGEON DIAGRAMS FOR HELICITY-POLE LIMITS

S-W representations show "helicity-pole" limits involve a single (analytically-continued) partial-wave amplitude.

Reggeon unitarity then implies that *such limits can be described by reggeon diagrams involving* **two-dimensional "transverse momenta".** (Since the large momenta involved can not be confined to a single plane, the "$k_\perp$-planes" involved contain lightlike momenta.)

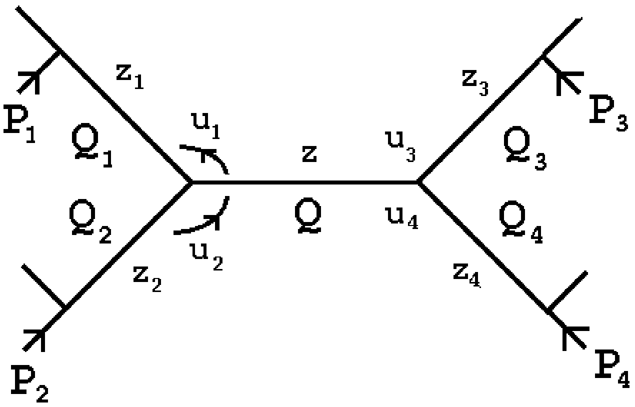
e.g. for an eight-particle amplitude, consider a "helicity-pole limit" in which

$z, u_1, u_2, u_3, u_4 \ \to \infty$ **, i.e.**
in terms of invariants -

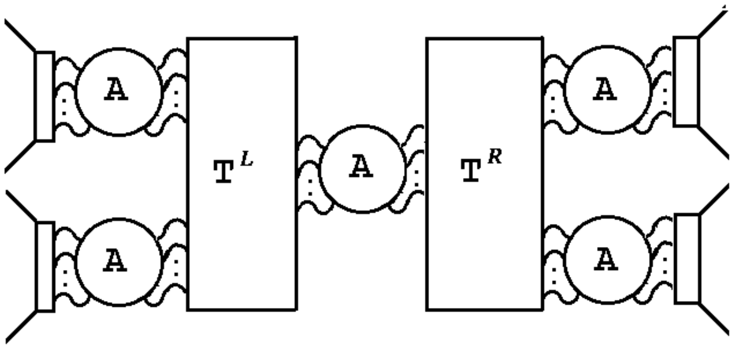
$P_1.P_2 \sim u_1 u_2, \quad P_1.P_3 \sim u_1 z u_3, \ ...$

$P_1.Q_3 \sim u_1 z, \quad Q_1.Q_3 \sim z \ ...$

and $P_1.Q, \ P_2.Q, \ ...$ *finite*



Reggeon unitarity → a set of diagrams of the form



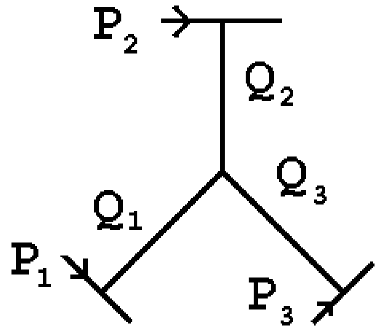
where 

contains all elastic scattering reggeon diagrams. T^L, T^R **contain connected and disconnected interactions that involve both elastic scattering reggeon vertices** *("helicity non-flip")* **and also new**

"reggeon helicity-flip" vertices.

"Helicity-flip vertices" play a crucial dynamical role in my analysis. They do not appear in the reggeon diagrams describing elastic scattering and multi-Regge production processes.

Such vertices are most simply isolated by considering a "non-planar" triple-regge limit involving three light-cone momenta

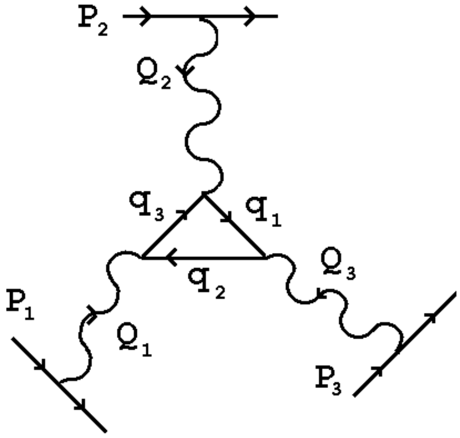


$P_1 \to (p_1, p_1, 0, 0) \quad p_1 \to \infty \quad Q_1 \to (0, 0, q_2, -q_3)$

$P_2 \to (p_2, 0, p_2, 0) \quad p_2 \to \infty \quad Q_2 \to (0, -q_1, 0, q_3)$

$P_3 \to (p_3, 0, 0, p_3) \quad p_3 \to \infty \quad Q_3 \to (0, q_1, -q_2, 0)$

In particular, consider three quarks scattering via gluon exchange with a quark loop triple-gluon coupling



$$\to \qquad g^6 \; \frac{p_1 p_2 p_3}{t_1 t_2 t_3} \;\; \Gamma_{1^+2^+3^+}(q_1, q_2, q_3)$$

where $t_i = Q_i^2$, $\gamma_{i^+} = \gamma_0 + \gamma_i$, *and* $\Gamma_{\mu_1\mu_2\mu_3}$ *is the* **quark triangle diagram**

$$\Gamma_{\mu_1\mu_2\mu_3} = i \int \frac{d^4k \;\; Tr\{\gamma_{\mu_1}(\not{q}_3 + \not{k} + m)\gamma_{\mu_2}(\not{q}_1 + \not{k} + m)\gamma_{\mu_3}(\not{q}_2 + \not{k} + m)\}}{[(q_1 + k)^2 - m^2][(q_2 + k)^2 - m^2][(q_3 + k)^2 - m^2]}$$

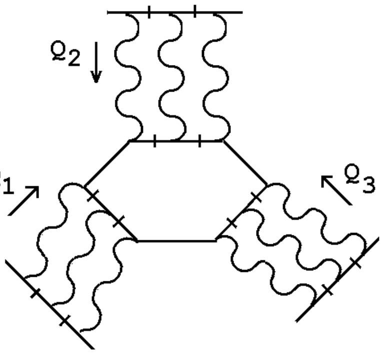
For the " $O(m^2)$ **" part of** $\Gamma_{1^+2^+3^+}$ *the limits* $q_1, q_2, q_3 \sim Q \to 0$, *and* $m \to 0$ **do not commute. (This is an "infra-red anomaly" due to the triangle Landau singularity).**

$$\Gamma_{1^+2^+3^+, m^2} \underset{Q \sim 0}{\sim} Q \; i \; m^2 \int \frac{d^4k}{[k^2 - m^2]^3} \underset{m \to 0}{\longrightarrow} R \, Q \;\; \neq \;\; 0$$

Including color factors and summing diagrams **-** $\Gamma_{1^+2^+3^+,m^2}$ *appears only in helicity-flip triple-regge vertices coupling reggeon states which each have* **"anomalous color parity"** ($C_c = -\tau$)

($\tau =$ signature and color parity is defined via $A^i_{ab} \to -A^i_{ba}$ for gluon color matrices.)

e.g.



Each 3-reggeon state has odd signature but *even color parity,* **e.g.** $f_{ijk}d_{jrs}A^kA^rA^s$ **(c.f. the winding-number current** $K^i_\mu = \epsilon_{\mu\nu\gamma\delta}f_{ijk}d_{jrs}A^k_\nu A^r_\gamma A^s_\delta$ **).** *Here the survival of $O(m^2)$ processes as $m \to 0$ reproduces the chirality violation of instanton interactions.*

Note that $\Gamma_{1^+2^+3^+,m^2}$ **has** $[k_\perp]$**-dimension 1 !!**

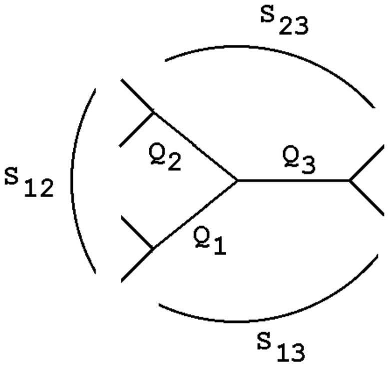
Normal reggeon interactions have $[k_\perp]$**-dimension 2 .**

When combined with transverse momentum conservation i.e. $\delta^2(k_\perp)$, the normal interactions produce a scale-invariant (and even conformal invariant) massless theory.

Because of it's anomalous dimension, $\Gamma_{1^+2^+3^+,m^2}$ **can only appear in special multi-Regge limits where the large invariants contribute an extra momentum factor.**

The non-planar triple-regge limit discussed above is an example. In this case

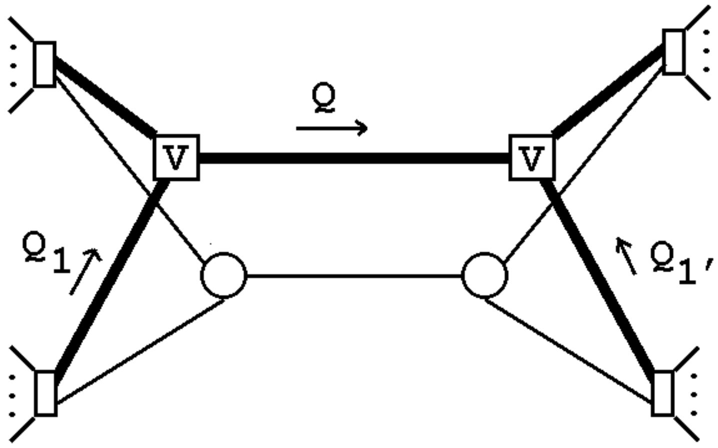
$$p_1p_2p_3Q_i \;\leftrightarrow\; (p_1p_3)^{1/2}(p_2p_3)^{1/2}(p_1p_2)^{1/2}Q_i$$
$$\equiv\; (s_{31})^{1/2}(s_{23})^{1/2}(s_{12})^{1/2}\; Q_i$$



The anomalous dimension also implies a "violation" of conventional reggeon Ward identities, i.e. when $m \to 0$, the vertex does not vanish sufficiently fast in the limit that $\forall\ Q_i \to 0$.

As a consequence, an infra-red divergence appears as $m \to 0$ in a large class of non-planar multi-regge diagrams where $Q_1 \sim Q_2 \sim Q_3 \sim 0$ is part of the integration region.

A candidate diagram is



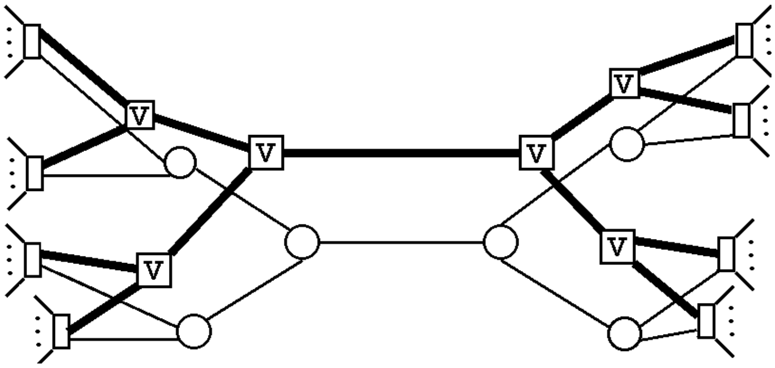
Both ▬ *and* — *are reggeon states. The divergence occurs for $Q, Q_1, Q_{1'} \sim 0$ as $m \to 0$ if the vertex V contains $\Gamma_{1^+2^+3^+,m^2}$. This requires that* ▬ *be an anomalous color parity reggeon state.*

To discuss whether the divergence is cancelled by other diagrams requires a systematic analysis which begins with the SU(3) gauge symmetry initially broken to SU(2) *(c.f. an instanton is associated with an SU(2) subgroup.)* **"Complimentarity" implies that the symmetry can be smoothly restored.**

With the symmetry broken, the divergence occurs when

- — **is an SU(2) singlet state containing one or more massive reggeized gluons (or quarks)**
- ▬ **is an SU(2) singlet combination of massless gluons with $C_c = -\tau = +1 \equiv$ ("anomalous odderon")**

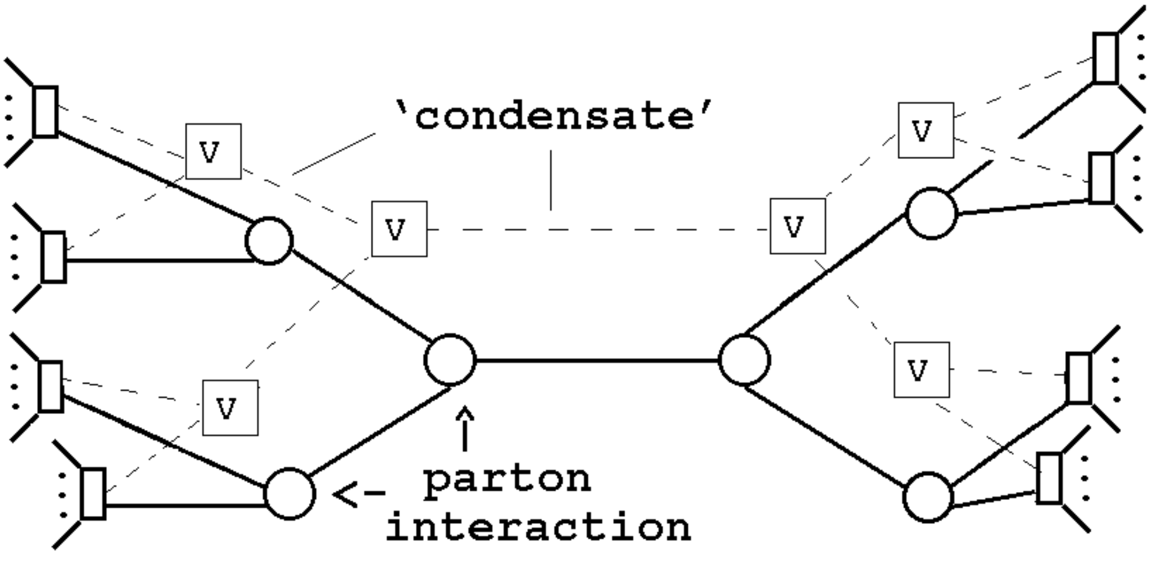
Higher-order diagrams containing a divergence include those of the form



There is an overall logarithmic divergence (when the quark mass $m \to 0$) from that part of the integration region where all Q_i entering each V vertex vanish.

"Physical amplitudes" are given by the coefficient of the divergence => **all anomalous odderon reggeon states carry zero** $k_\perp$ $\leftrightarrow$ *an anomalous odderon "reggeon condensate".*

There is always a "parton process" which carries the kinematic properties of the dynamical interaction.



In effect, the parton interaction takes place in a "condensate" background which results from **the infra-red quark triangle anomaly** *(≡ to the chirality violation produced by instanton interactions).*

The $\mathbb{P}$ can be described as an SU(2) singlet reggeized gluon with $C_c = \tau = -1$, in the $C_c = -\tau = +1$ condensate
$\longrightarrow$ *a Regge pole with* $\tau = -C_c = +1$ **.**

"Hadrons" are similarly (constituent) quark reggeon states in the condensate background.

(I believe that "stability" within the condensate requires chiral symmetry breaking, and that this is necessary for the color charge parity of the $\mathbb{P}$ to be consistent with it's appearance in total cross-sections and elastic scattering. I will not discuss these issues here.)

All features of Super-Critical $\mathbb{P}$ RFT are present. *Again I will not discuss the details.*

Because of complimentarity, restoration of SU(3) gauge symmetry *(which effectively involves decoupling a Higgs scalar field)* **is straightforward with a cut-off $|k_\perp| < \Lambda_\perp$.**

Therefore, the QCD "soft $\mathbb{P}$" is described by RFT and carries a crucial remnant of the construction i.e. *odd SU(3) color charge parity => the two-gluon BFKL Pomeron does not contribute!*

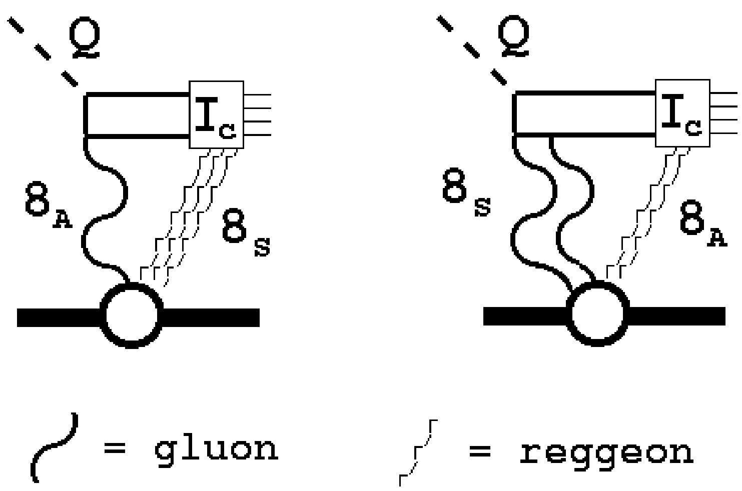
To remove $\Lambda_\perp$ the $\mathbb{P}$ should be Critical - *this is related to the quark content of the theory and I will not discuss it here.*
A-priori, *for a particular value of* $\Lambda_\perp$, **the theory may be above, or below, the critical point.**

DEEP-INELASTIC SCATTERING *(SU(3) gauge symmetry)*

DIS diffractive scattering exposes the simplest perturbative contribution to the $\mathbb{P}$*.* $C_c = -1$ => **4 gluon exchange.**
An anomalous *("non-perturbative")* **coupling I_c to chirality-violating processes must be involved.**

There are two distinct 4 gluon contributions, i.e. *either 2 or 3 (reggeized) gluons form an anomalous color parity state with an* I_c *coupling.*

In the Regge limit *(finite Q^2)* **the** 8_s **two gluon state gives an even signature reggeon with a "pointlike" coupling to the quark loop.**



In higher-orders, the 8_A *single gluon and the* 8_s *two gluon configurations reggeize with identical trajectories.* **Hence regge-limit infrared divergences** *(due to the anomalous reggeon states)* **from the two contributions can directly cancel.**

At large Q^2 the single hard gluon dominates => the $\mathbb{P}$ is "in the Super-Critical phase" at the deep-inelastic scale
($\leftrightarrow$ *chirality-violation scale* $\ll$ *perturbative scale* $\sim Q^2$ **).**

$\longrightarrow$ the hard gluon $\mathbb{P}$ seen at HERA !!