How solid is the theory of saturation?

- What is the theory of saturation?
  - Balitsky-Kovchegov equation
  - Balitsky hierarchy
  - Color Glass Condensate
  - Bartels unitarity program – QCD reggeon field theory
- All approaches are based on QCD.

BK equation

- Equation for dipole scattering amplitude:
  $N(Y, r, b), \quad r = u - v, \quad b = (u + v)/2$

$$\frac{\partial N_{uv}}{\partial Y} = \frac{\overline{\alpha}_s}{2\pi} \int d^2w \frac{(u-v)^2}{(u-w)^2(w-v)^2} \{N_{uw} + N_{wv} - N_{uv} - N_{uw}N_{wv}\}$$

- Derived in mean field approximation: $\langle N_{uw}N_{wv}\rangle = \langle N_{uw}\rangle \langle N_{wv}\rangle$.
- Saturation scale and geometric scaling found from traveling wave approach.
- Local unitarity: $N(b) < 1$. No Froissart-like bound because of perturbative gluons.
- Next-to-leading order form known, although a small discrepancy with the NLL BFKL kernel still not resolved.

Balitsky hierarchy

- In Balitsky hierarchy: $\langle N_{uw} N_{wv} \rangle \neq \langle N_{uw} \rangle \langle N_{wv} \rangle$
- Infinite system of equations for correlators of Wilson lines

$$U(u) = P \exp\left\{ ig \int dx^- A^+(x^-, u) \right\}, \qquad N_{uv} = 1 - \frac{1}{N_c} \mathrm{Tr} \left\langle U^\dagger(u) U(v) \right\rangle_Y$$

- Numerical effect in comparison to BK equation is small for N_{uv}.
- No pomeron loops: $m \to n$ transitions for $m > n$.
- Conjecture on the pomeron loop implementation from the analogy to birth-death processes. Diffusive scaling.

Color Glass Condensate

- Soft gluons radiated by valence quarks form strong color fields, $A^a \sim 1/g_s$, in the saturated state.
- Weight $W_Y(\rho^a)$ for stochastic quarks sources. JIMWLK equation for W_Y.
- Any correlators of soft color fields involves integration over color charges with the weight W_Y.
- Pomeron loops formulated as duality transformation for the JIMWLK Hamiltonian.
- Factorization theorems for one and two gluon production in scattering of two color glass fields formulated.

QCD Reggeon field theory

- Reggeized gluons and interaction kernels as basic objects.
- Systematical studies of $n \to m$ gluon transition in the leading $\ln(1/x)$ approximation.
- Derivation of multi-pomeron (and odderon) vertices.
- Relations to dipole picture:
  - triple-pomeron vertex (agrees)
  - forward jet production with triple pomeron vertex (disagrees?)

Questions

- Saturation and dipole model beyond leading $ln(1/x)$.
- NLL BK equation phenomenology.
- Pomeron loops (diffusive scaling) in data.
- Is dipole model applicable to full final state computation?
- Effects beyond large N_c approximation – color reconnection.
- LHC physics with saturation.