

Towards the hadronic QCD spectrum from perturbative scattering amplitudes

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[InspireHep](#)

[[PB 2605.05349](#)]

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all-IPNP meeting

The University of Edinburgh



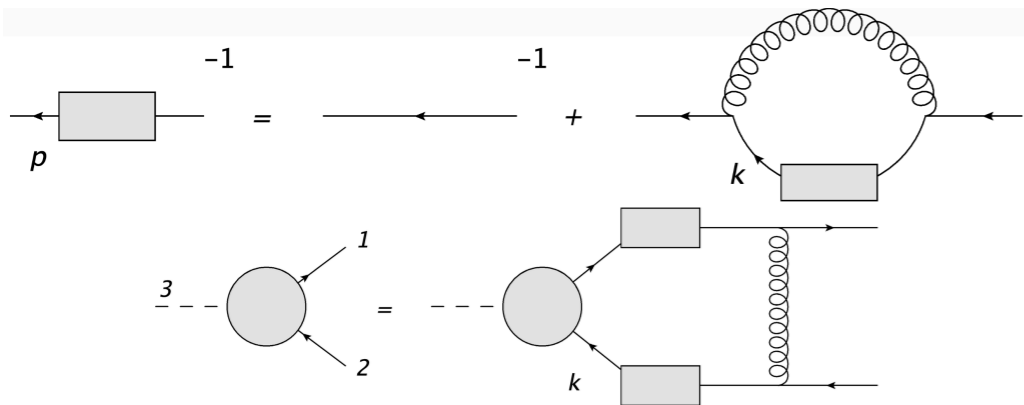
European Research Council

Established by the European Commission

Motivation : analytic QCD spectrum

analytic

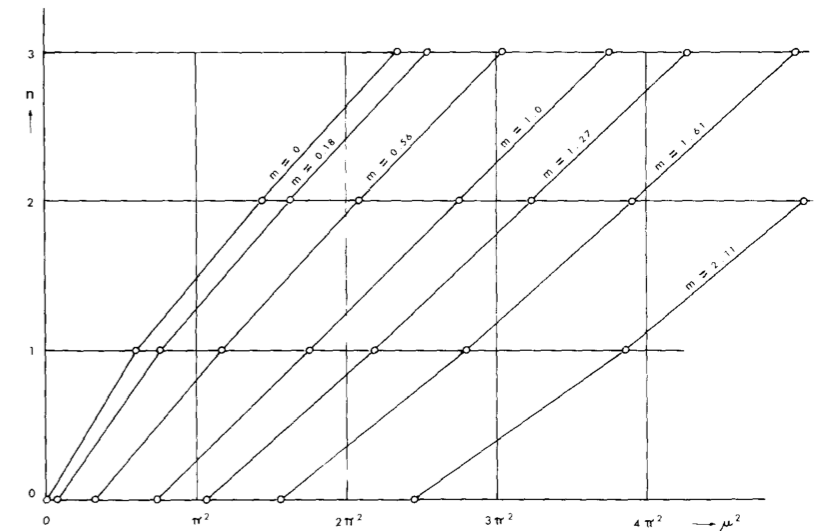
[t Hooft 1974 "2D model of mesons"]



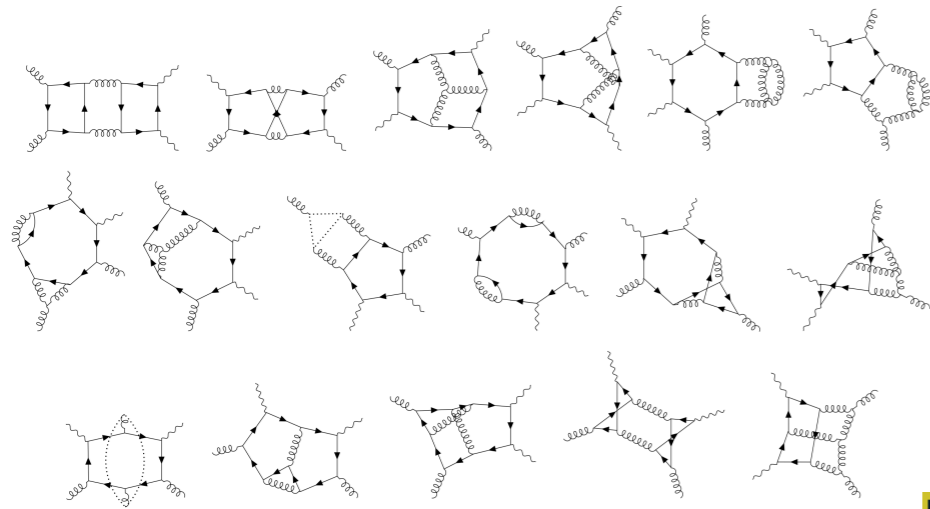
$$\mu^2(k) \simeq \pi^2 k$$

analytic
mass gap

numerical

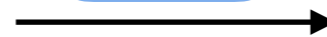


decades of progress later



perturbative scattering amplitudes

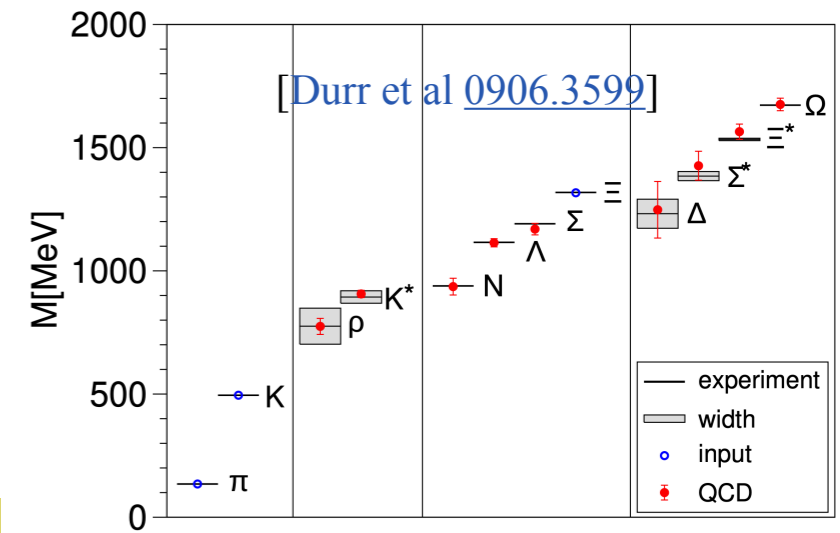
goal



Home — Millennium Problems — Yang-Mills & the Mass Gap

Yang-Mills Existence and Mass Gap. Prove that for any compact simple gauge group G , a non-trivial quantum Yang-Mills theory exists on \mathbb{R}^4 and has a mass gap $\Delta > 0$. Existence includes establishing axiomatic properties at least as strong as those cited in [45, 35].

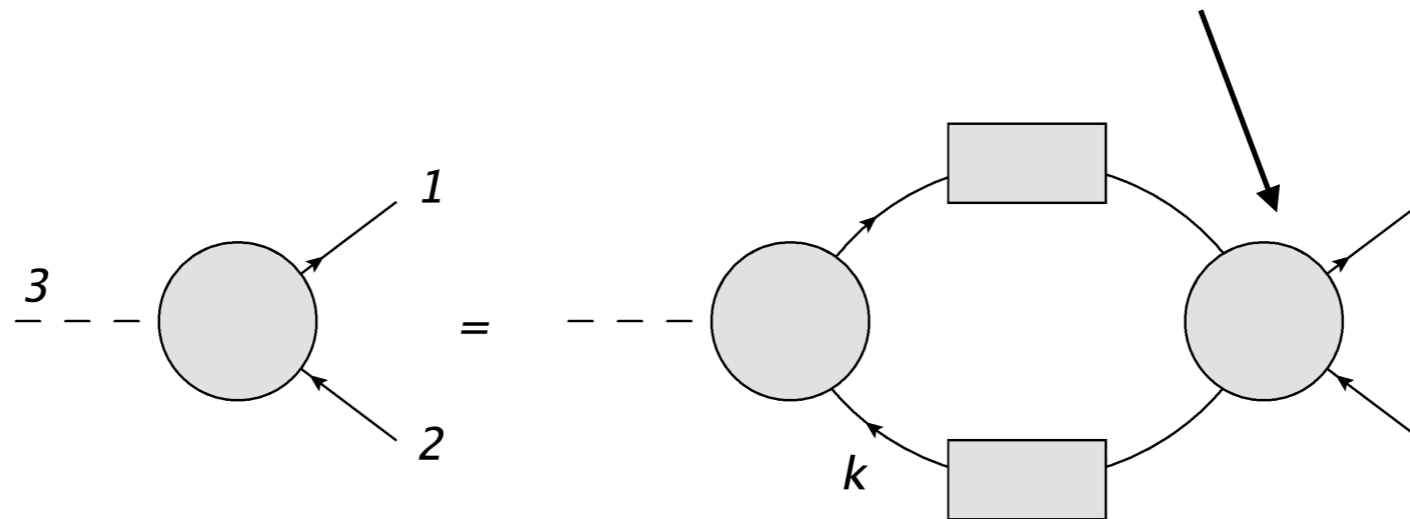
Unsolved



nonperturbative lattice QCD

Proposed methodology

mesonic Bethe-Salpeter equation requires 4-quark kernel



alternative to an infinite tower of coupled Dyson-Schwinger integral equations

no truncation
ambiguity

$$K = K_{\text{pert}} + K_{\text{nonpert}} = \sum_{n \geq 0} c_n^{(0)} g^n + \sum_i e^{-\frac{s_i}{g}} \sum_{n \geq 0} c_n^{(i)} g^n$$

from all-loop calculation

from transseries resurgence

done here

Subleading large N_f approximation

full theory : QCD in $d = 4$ with $N_c = 3$ colors and $N_f = 5$ light quarks

approximation

't Hooft : QCD in $d = 2$
at leading order in
 $N_c \rightarrow \infty$ while $g^2 N_c = \text{fixed}$

here

QCD in $d = 4 - 2\epsilon$
at subleading order in
with $N_f \rightarrow \infty$ while $g^2 N_f = \text{fixed}$

requirements :



1. make an all-loop calculation feasible;
2. be systematically improvable;
3. and preserve asymptotic freedom.



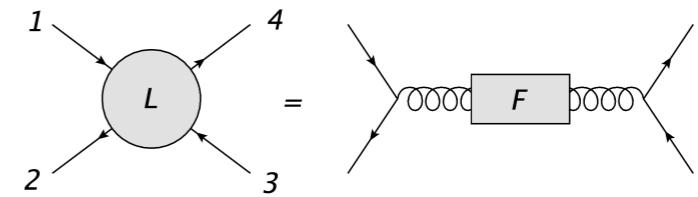
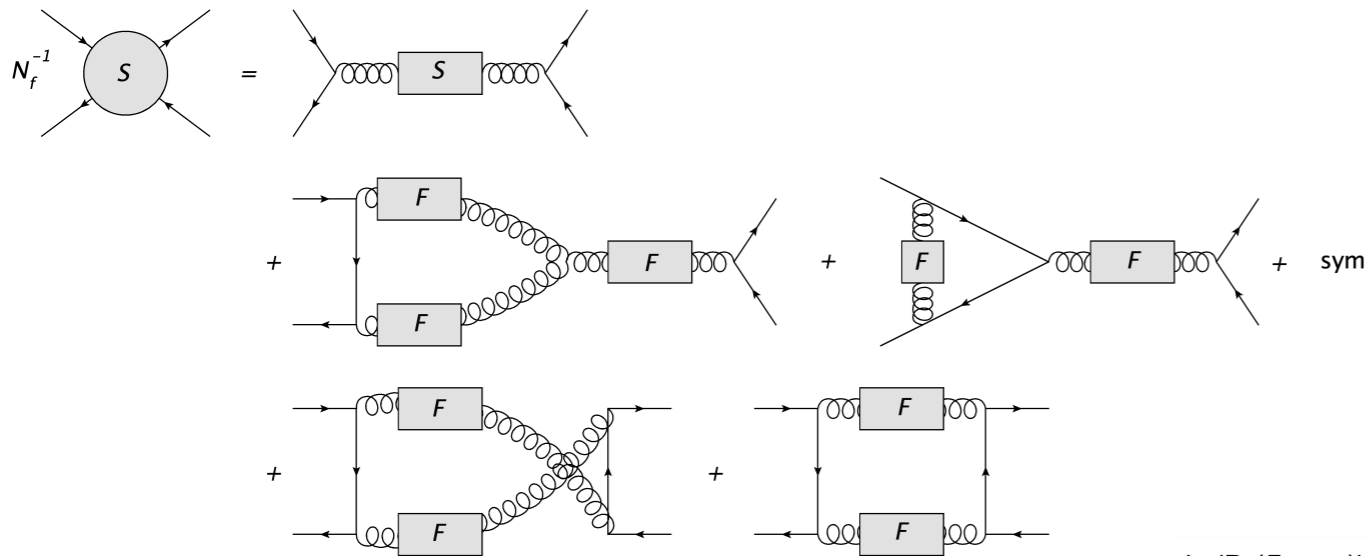
$$\beta_0 = - \left(\frac{11}{3} N_c - \frac{2}{3} N_f \right) < 0$$

$$3 = N_c < N_f < 5.5 N_c = 16.5$$

weaker nonperturbative effects

better convergence

Analytic bare all-loop results

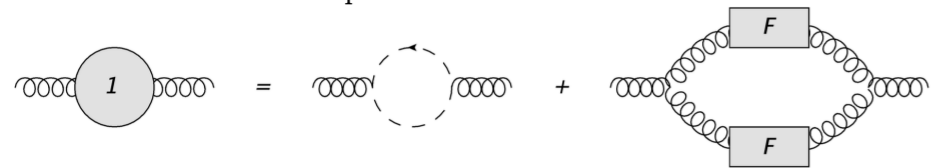


~10 MB of PolyLogs

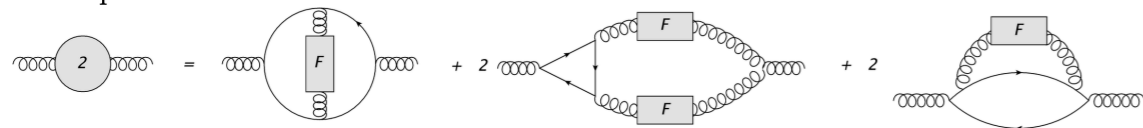
At subleading order in large N_f , the all-loop 1PI gluon propagator

$$N_f^{-1} \text{gluon } S = \text{gluon } 1 + \text{gluon } 2 + \text{gluon } 3$$

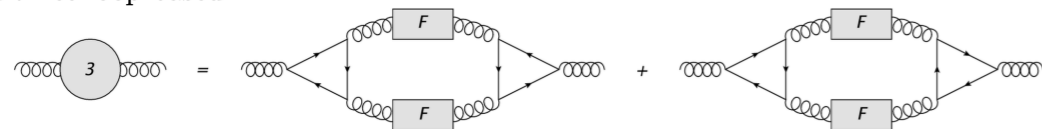
receives contributions from one-loop-based



two-loop-based

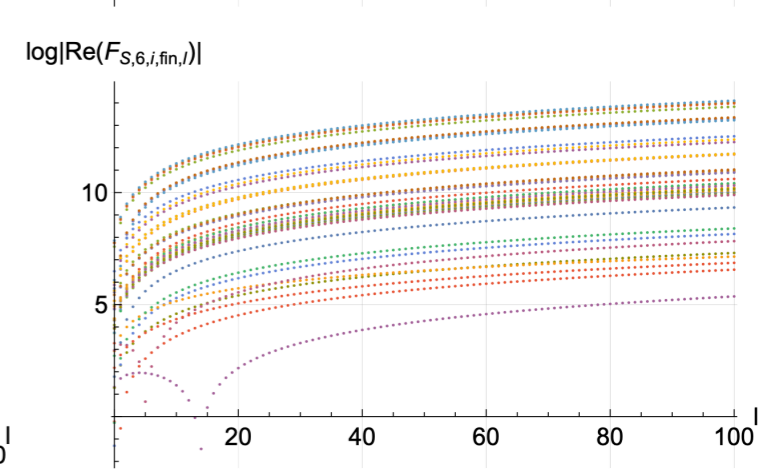
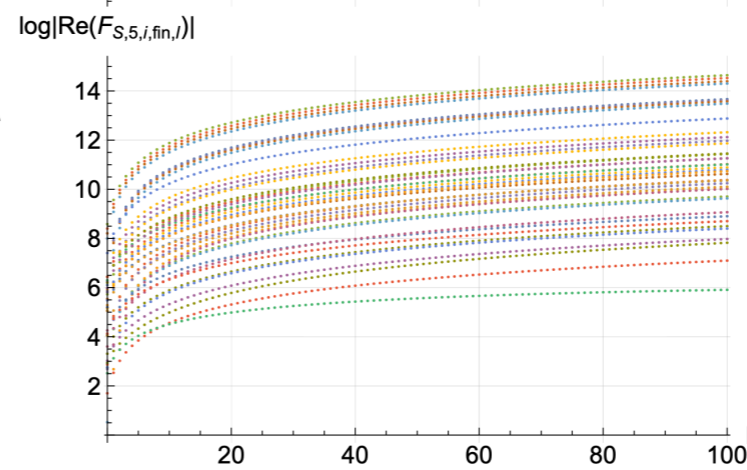
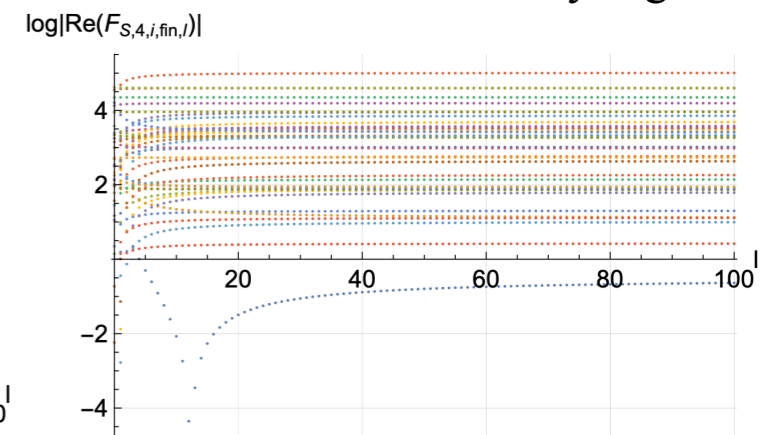
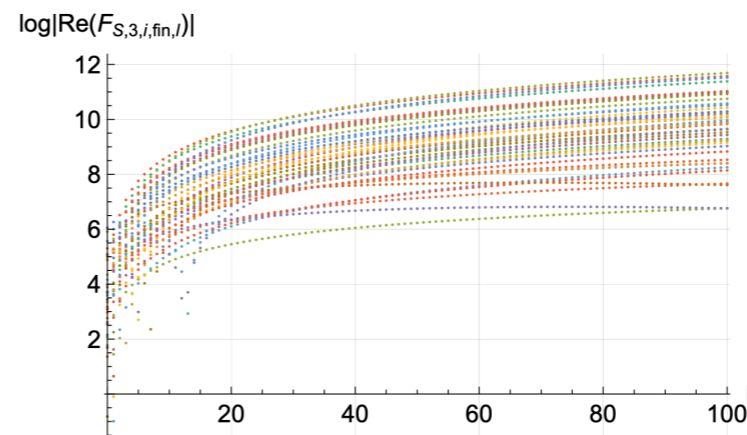


and three-loop-based



Feynman diagrams that involve up to infinite quark loop chains

$$\text{gluon } F = \sum_{n=0}^{\infty} \text{gluon } \text{quark loop } 1 \dots \text{quark loop } n$$



more on Amplitudes Meeting
Tue 02.06.2026 2pm

THANK YOU