

Analytic Structure of the Landau Gauge Gluon and Ghost Propagators

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Outline

- Motivation
- DSEs of Landau gauge Yang-Mills
- Vertex Ansatz and Euclidean results
- Complex Results
- Perspectives

Motivation

Fundamental questions:

- Gluon screening – Color confinement
- BRST breaking

Practical questions:

- Glueball spectroscopy

Motivation

- Lattice Glueball computations

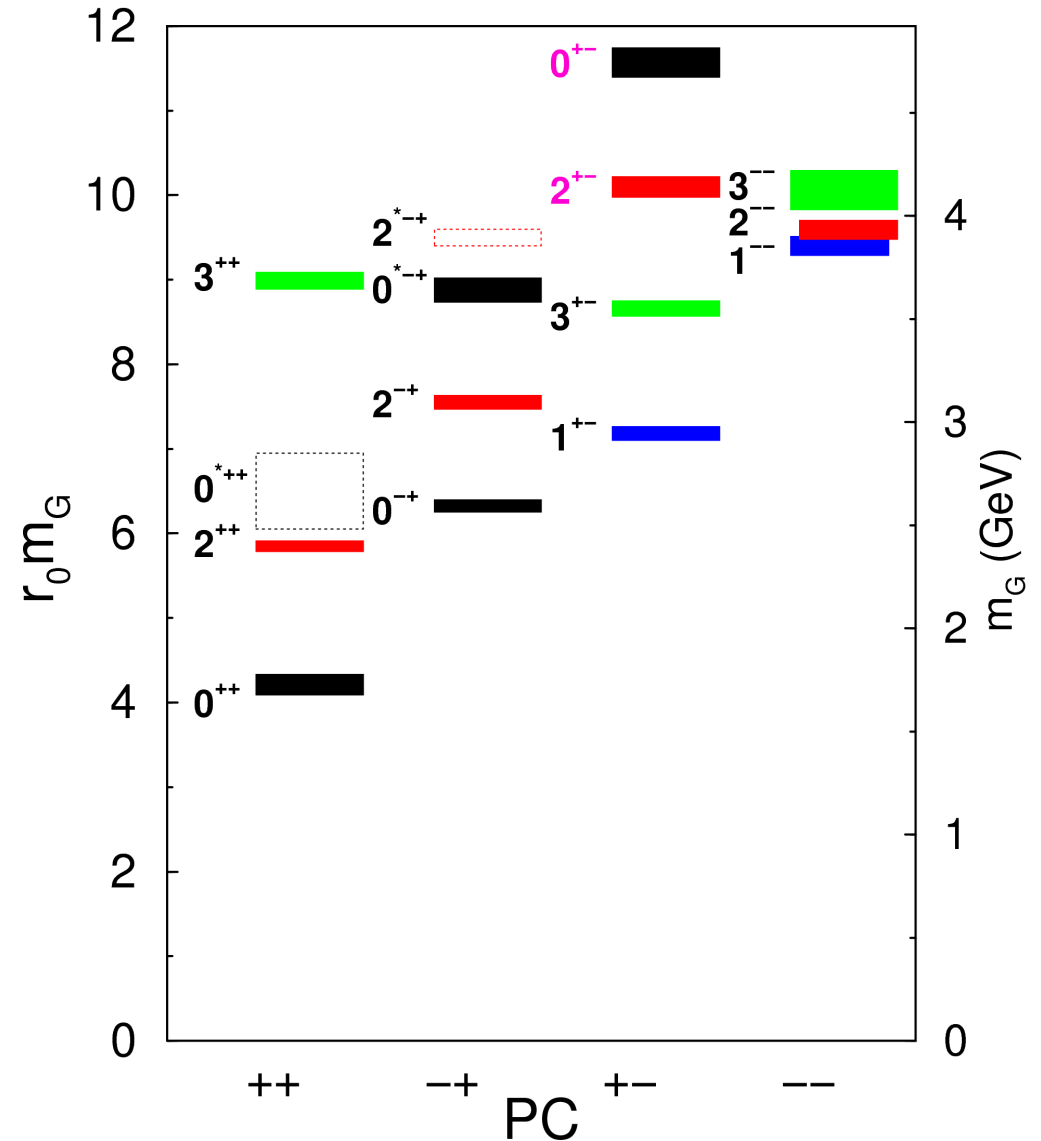
quenched QCD:

[Bali, 1993],

[Morningstar, Peardon, 1999]

unquenched:

[Richards et al., 2010]

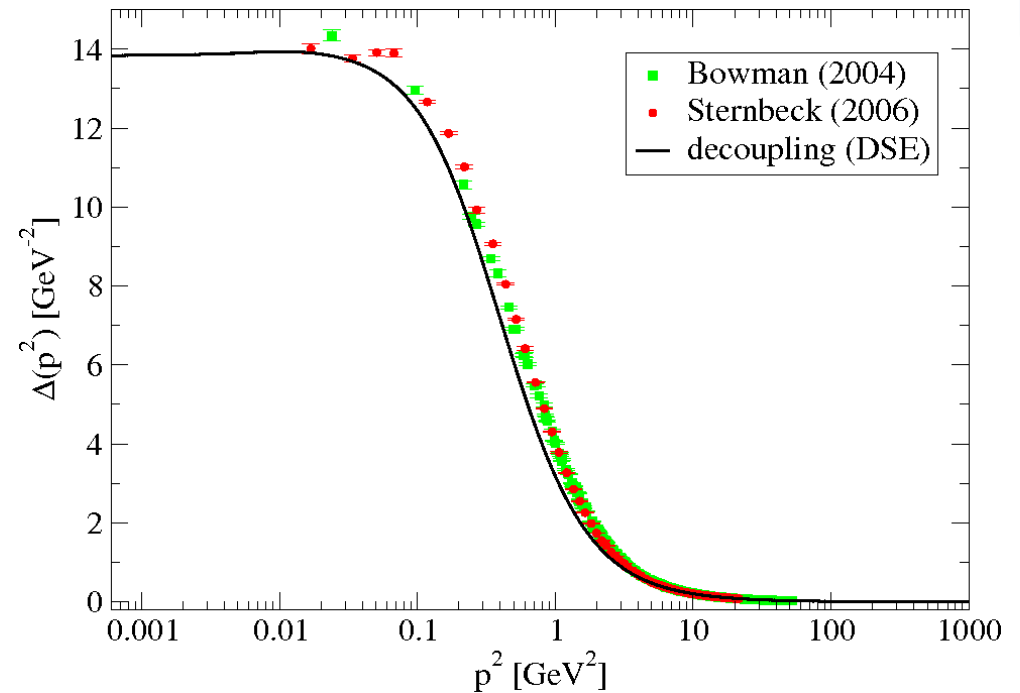


Motivation

- Landau Gauge Gluon propagator - Lattice

- Lattice data -> massive Gluon Propagator

[Cucchieri & Mendez, 2007]



[Fischer, Pawłowski, 2008]

- DSE results

[Aguilar, Binosi, Papavassiliou, 2008]

Motivation

IR Gluon

- Gribov-type propagators

$$D(p^2) = C \frac{p^2}{p^4 + b^2} \quad \rightarrow \text{purely imaginary poles}$$

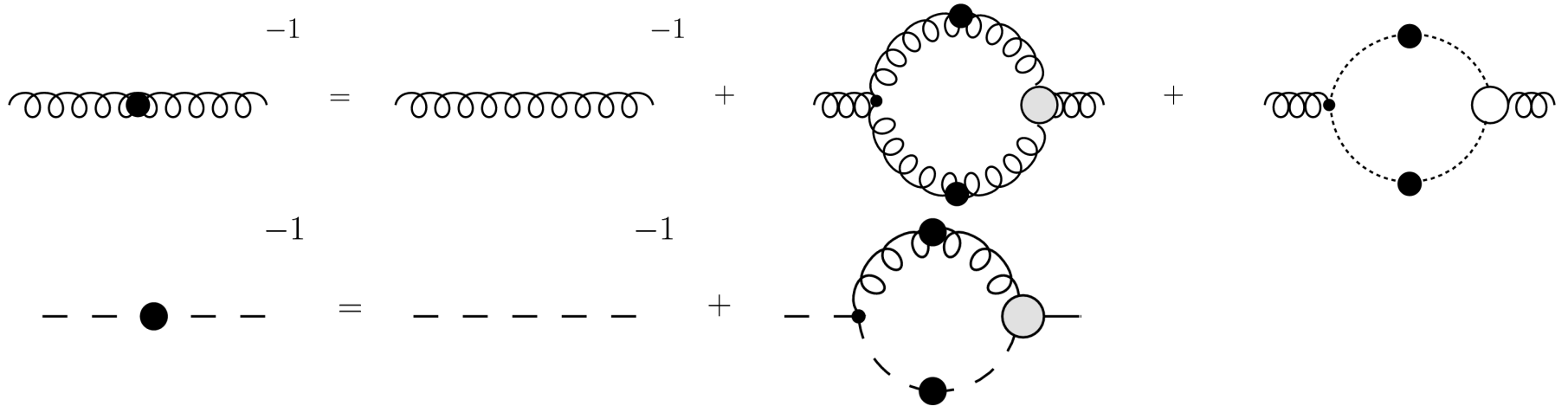
- Gribov-Stingl

$$D(p^2) = C \frac{p^2 + d}{(p^2 + a)^2 + b^2} \quad \rightarrow \text{complex conjugated poles}$$

- Refined Gribov-Zwanziger [Dudal et al., 2008]

$$D(p^2) = C \frac{(p^2 + d)(p^2 + l)}{(p^4 + u^2 p^2 + t^2)(p^2 + v)} \quad \rightarrow \text{pairs of c.c. poles and real ones}$$

Ghost Gluon System



- Gluon

$$D_{\mu\nu}^{ab}(p^2) = \delta^{ab} \left(g_{\mu\nu} - \frac{p_\mu p_\nu}{p^2} \right) \frac{Z(p^2)}{p^2}$$

- Ghost

$$D^{ab}(p^2) = -\delta^{ab} \frac{G(p^2)}{p^2}$$

- Ghost Gluon Vertex

$$\Gamma_\mu^{abc}(p, q, k) = i f^{abc} q_\mu$$

- 3 Gluon Vertex

$$\Gamma_{\mu\nu\rho}^{abc}(p, q, k) = f^{abc} \tilde{\Gamma}_{\mu\nu\rho}(p, q, k)$$

Vertex Ansatz

- 3-Gluon Ansatz

$$\tilde{\Gamma}_{\mu\nu\rho}(p, q) = \frac{1}{Z_1} \frac{G^{-2-6\delta}(p^2)}{Z^{1+3\delta}(q^2)} \frac{G^{-2-6\delta}((p-q)^2)}{Z^{1+3\delta}((p-q)^2)} \Gamma_{\mu\nu\rho}^0(p, q)$$

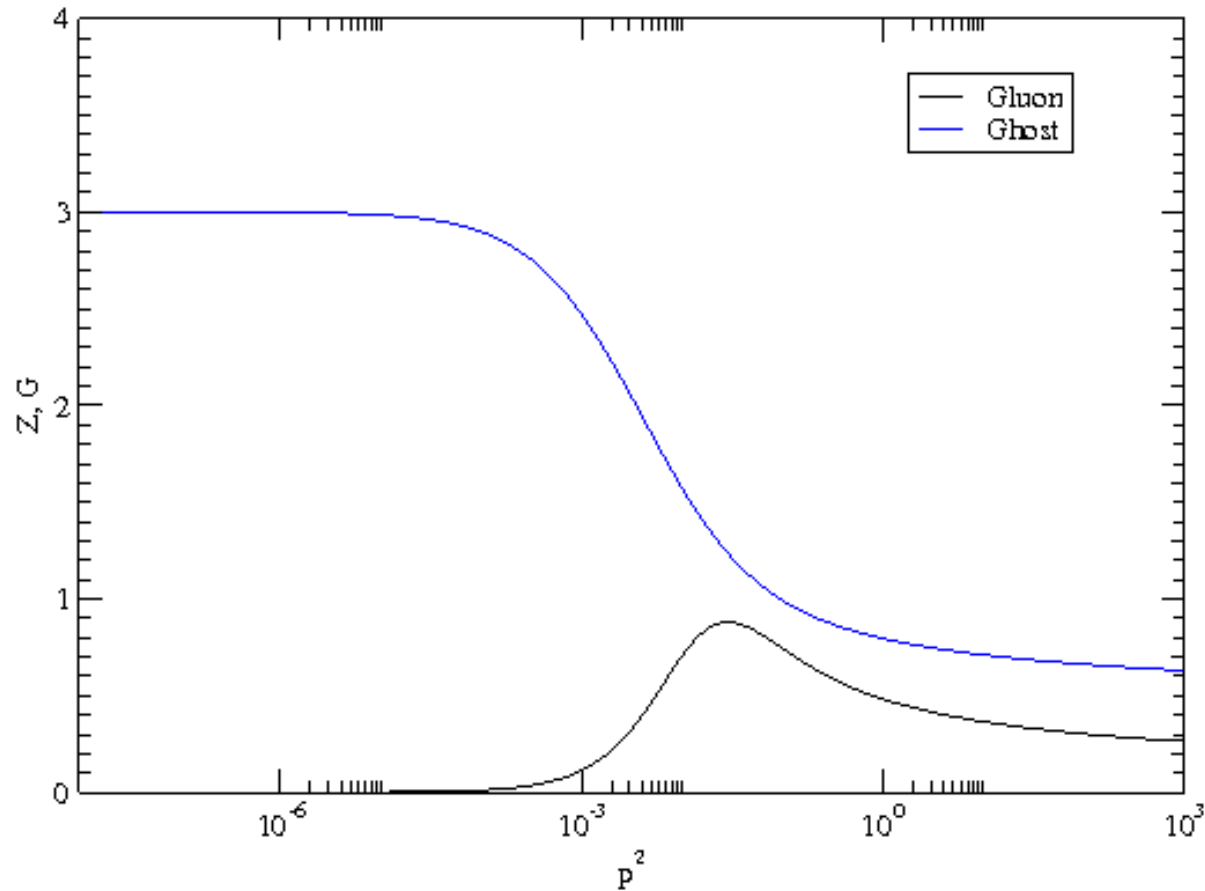
- resummed perturbation theory in UV

$$G(x) = G(s) \left[\omega \log \left(\frac{x}{s} \right) + 1 \right]^\delta$$

$$Z(x) = Z(s) \left[\omega \log \left(\frac{x}{s} \right) + 1 \right]^\gamma$$

- Here: decoupling solution – IR finite Gluon propagator + finite $G(0)$ [Fischer, Pawłowski, 2008]

Euclidean Results

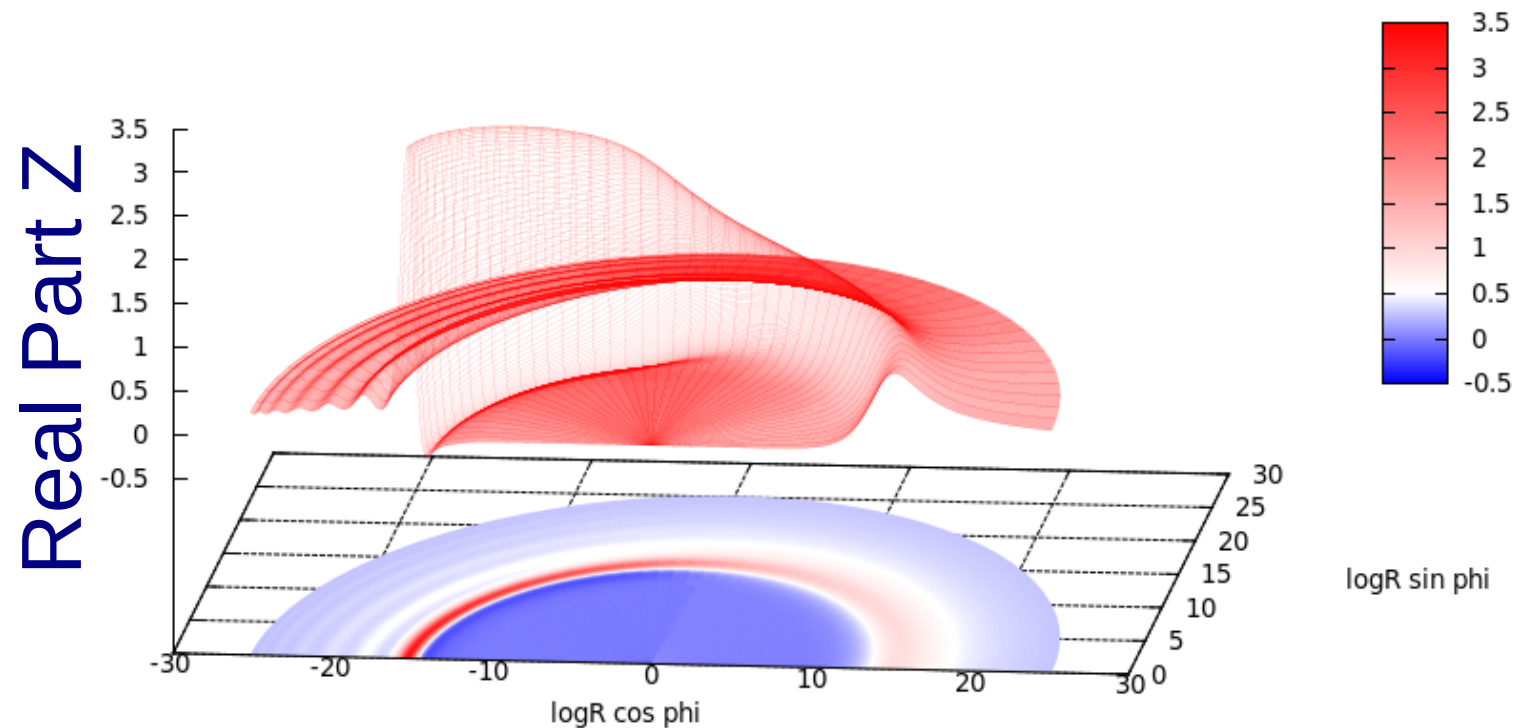


- Complex solution via Contour method
[Maris, 1993]

Complex Structure Gluon (Preliminary)

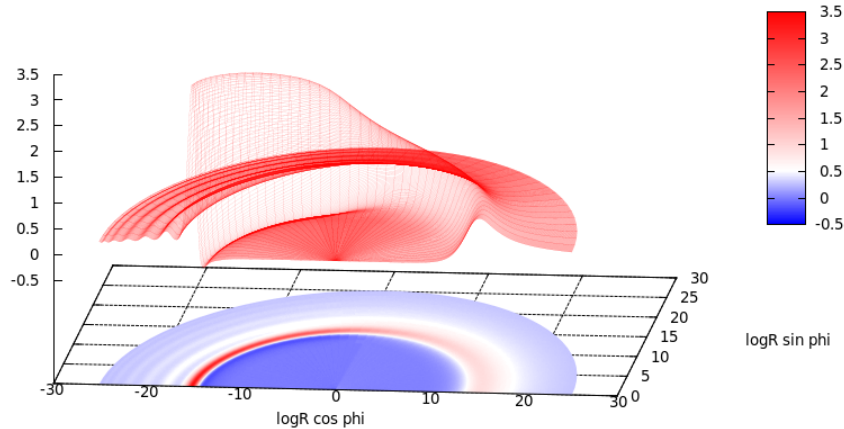
- Log Transformation

$$z = x + iy \rightarrow (\log \varrho + a) \cos \phi + i (\log \varrho + a) \sin \phi$$



Complex Structure Gluon (Preliminary)

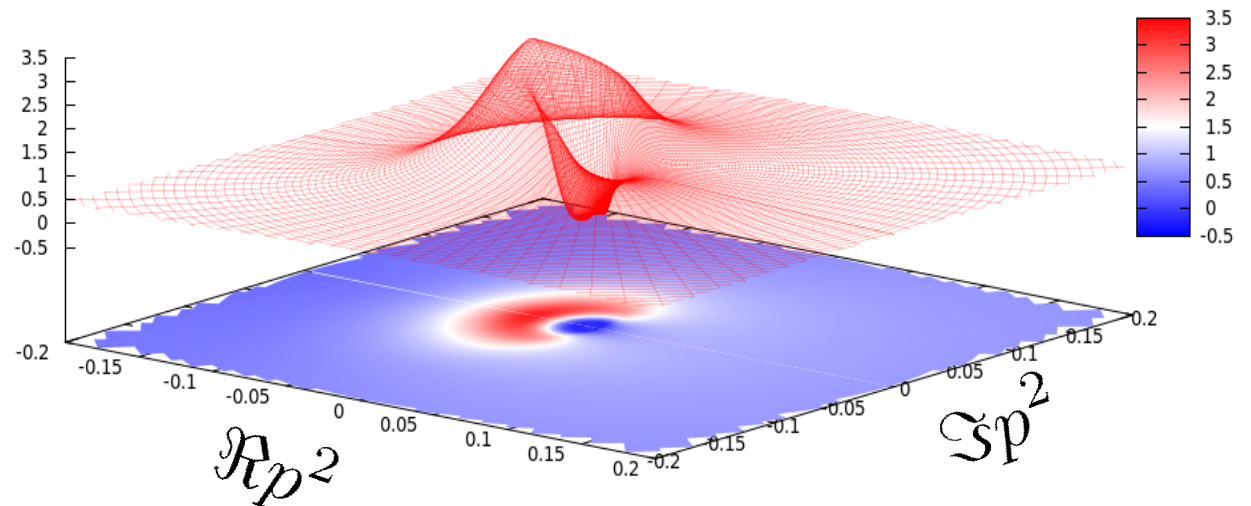
Real Part Gluon



Log scale

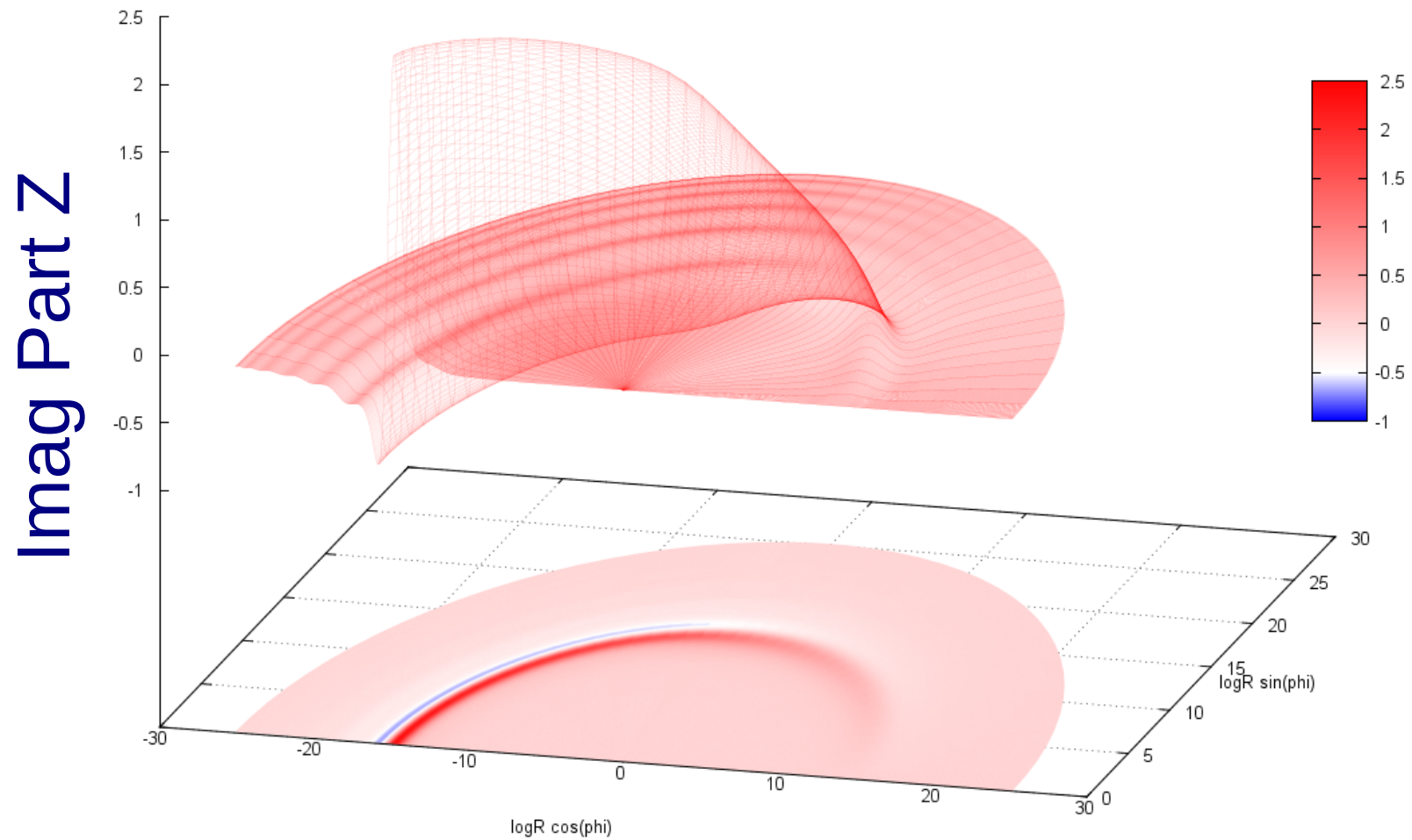
Real Part Gluon

Linear scale



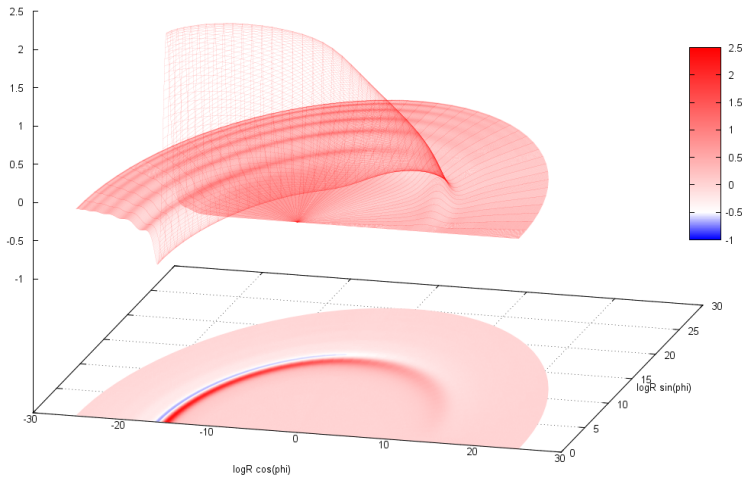
Complex Structure Gluon (Preliminary)

Imaginary part Gluon



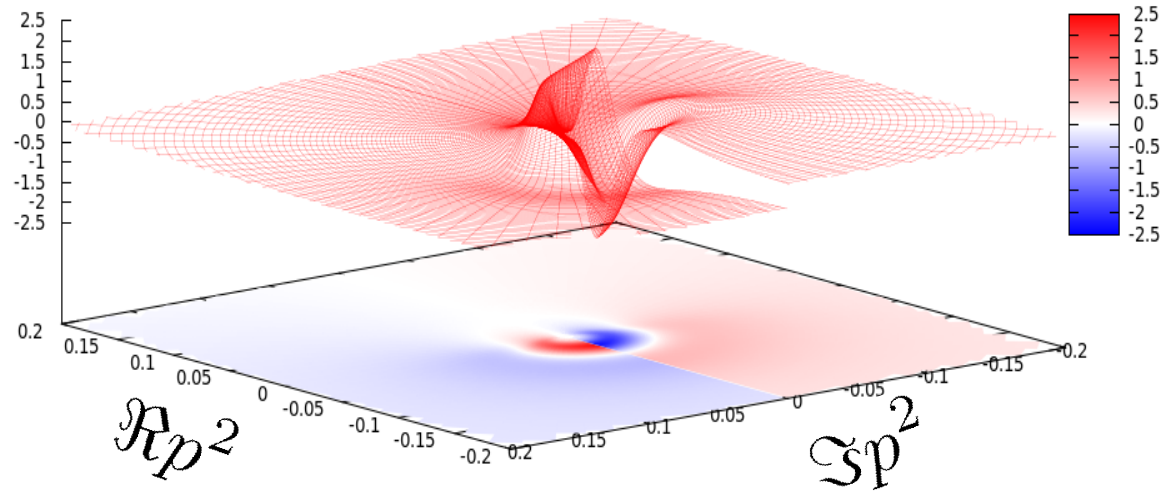
Complex Structure Gluon (Preliminary)

Imaginary part Gluon



Log scale

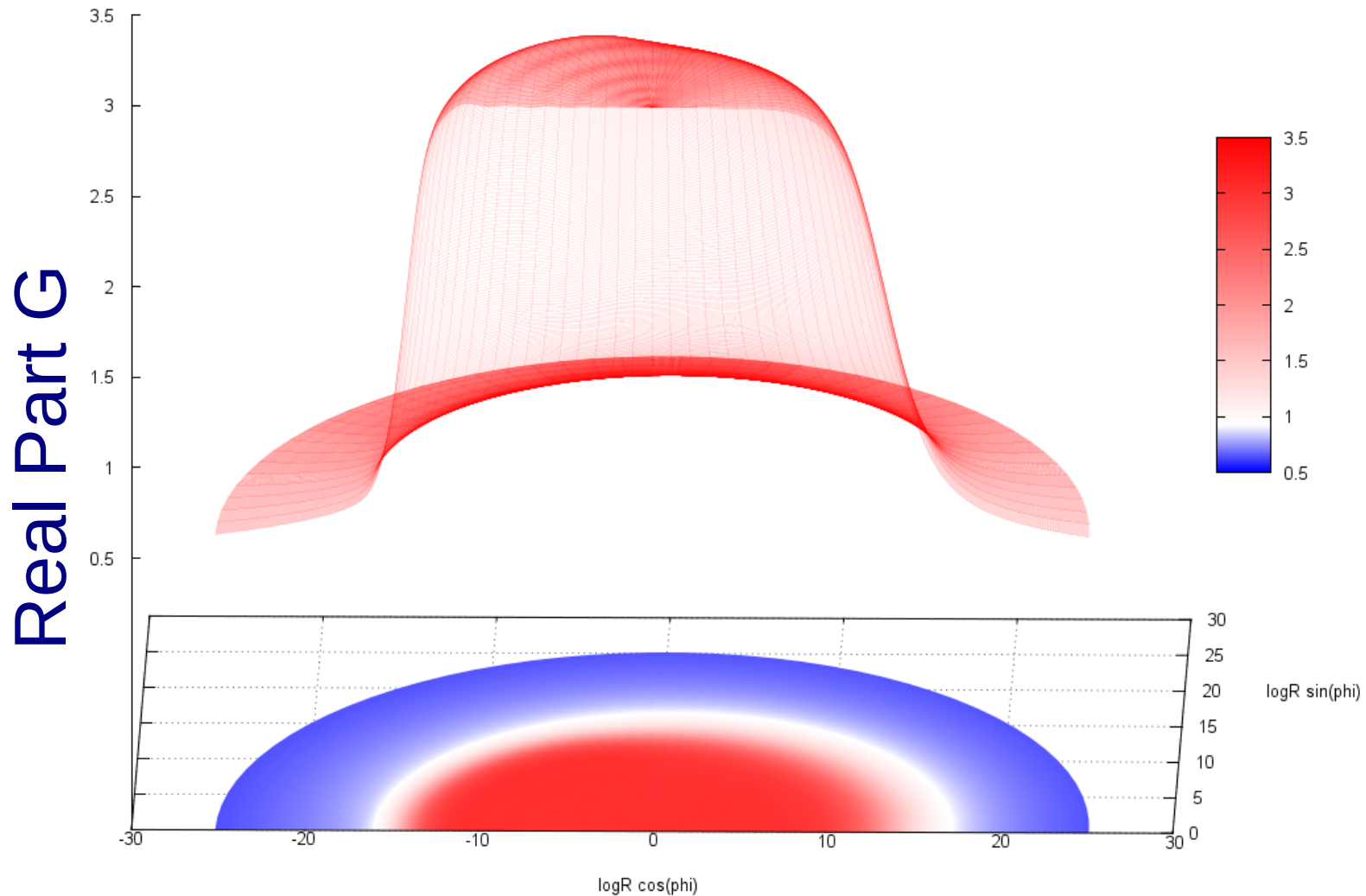
Imag Part Gluon



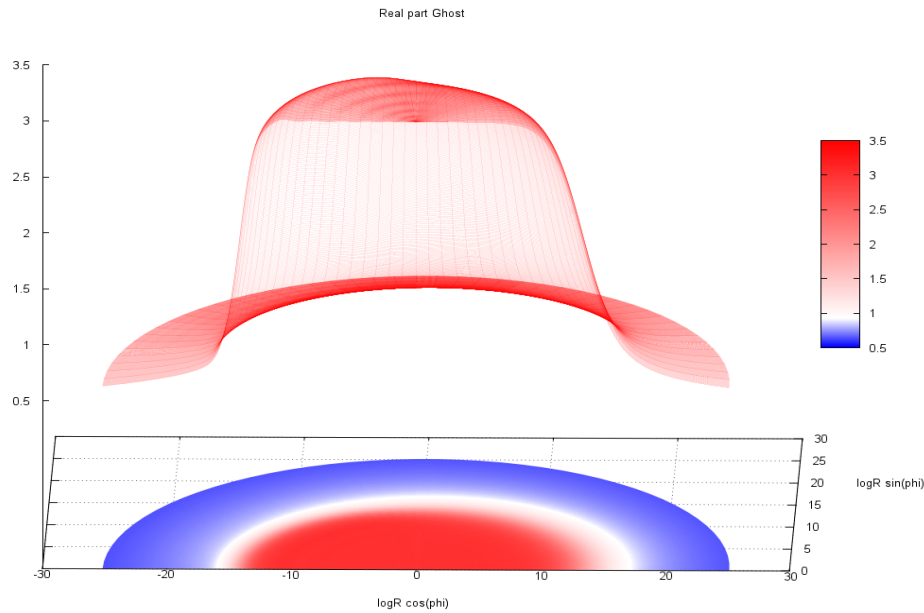
Linear scale

Complex Structure Ghost (Preliminary)

Real part Ghost

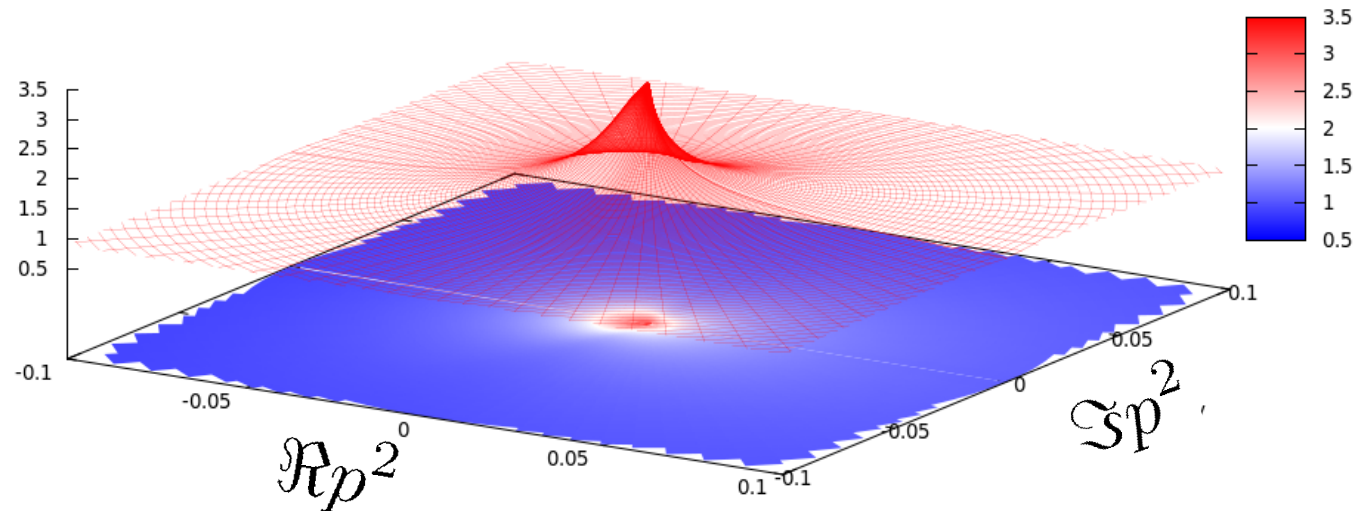


Complex Structure Ghost (Preliminary)



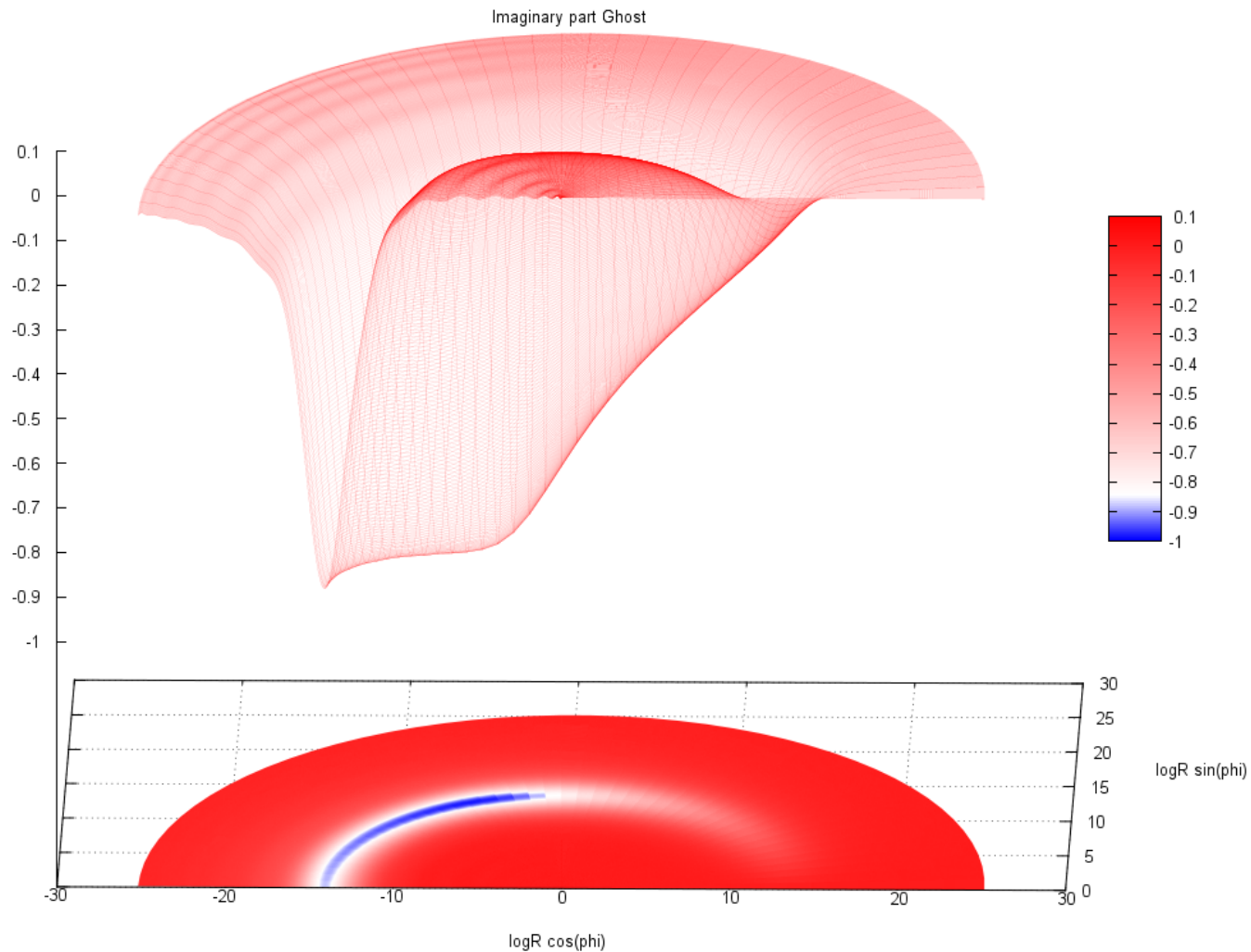
Log scale

Linear scale

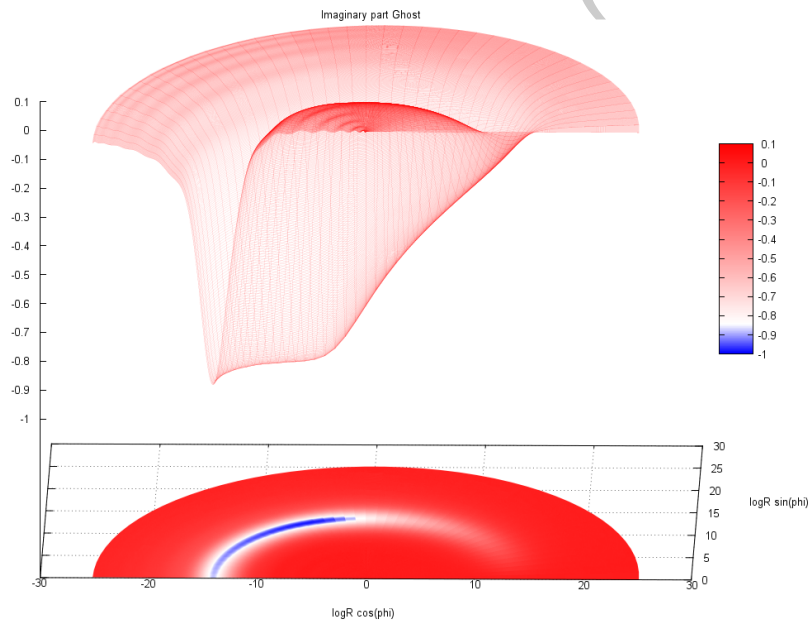


Complex Structure Ghost (Preliminary)

Imag Part G



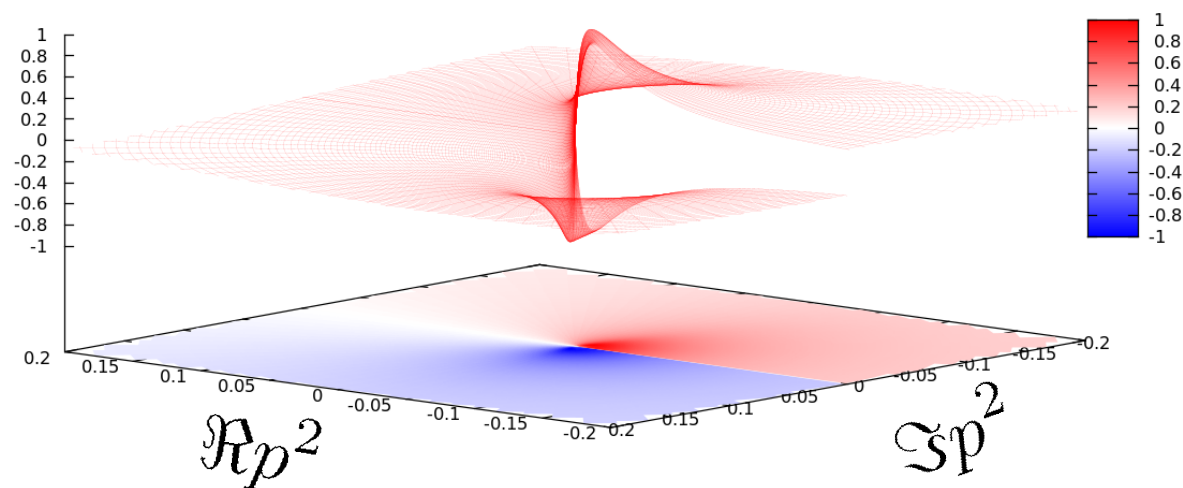
Complex Structure Ghost (Preliminary)



Log scale

Imaginary part Ghost

Linear scale



Conclusions

- Complex decoupling solution of YM DSEs
- No complex poles
- Branch cuts

Perspectives

- Spectral density – Positivity violations
- Inclusion of 2-loop diagrams
- Glueball spectra and properties via BSE