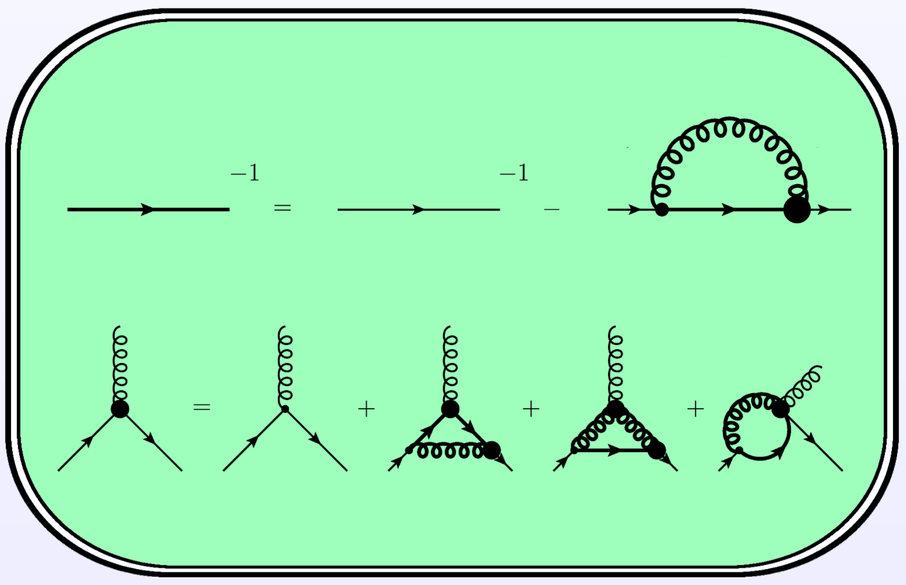
Karl-Franzens-Universität Graz
Institut für Physik, Fachbereich Theoretische Physik

FWF Der Wissenschaftsfonds.

The Quark-Gluon Vertex DSE: A Numerical Study using GPUs

Andreas Windisch, Markus Hopfer, Reinhard Alkofer

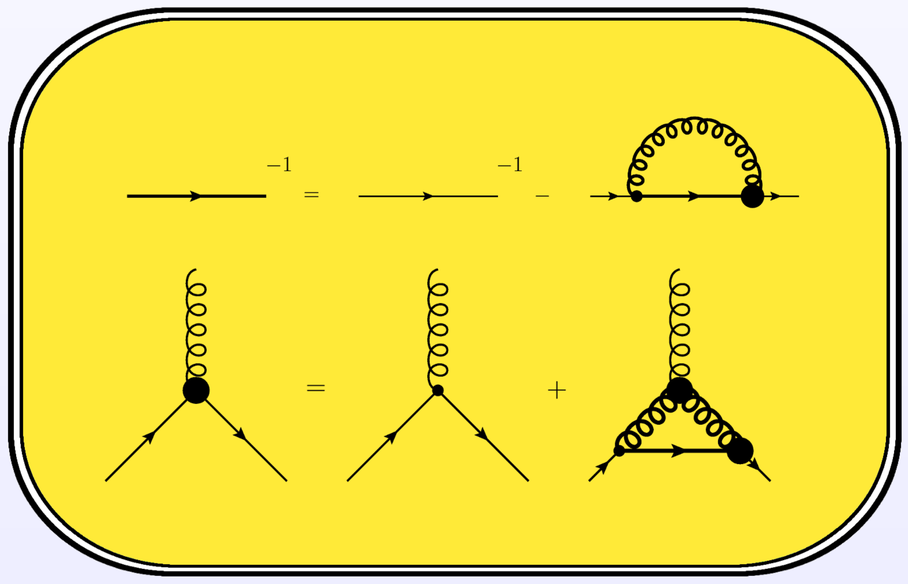
The Coupled System: Quark Propagator and Quark-Gluon Vertex



The coupled system has been studied thoroughly, [1]. Why revisiting it?

1. No *full* solution for the vertex DSE available so far
2. Use GPU power to solve the system – cf. poster by M. Hopfer
3. Provide a full solution as a basis for subsequent studies (finite T, μ)

Step 2: Non-Abelian Vertex Only



Take the non-Abelian vertex and neglect other terms

1. Abelian diagram suppressed by a factor of N_C^2 compared to non-Abelian, [1]
2. Solve this DSE with all vertex dressings (many, many terms)
3. Take gluon propagator from lattice fit, i.e. [5]

Starting Point: The Basis for the Vertex

Use the basis of Ball and Chiu for the vertex [2]:

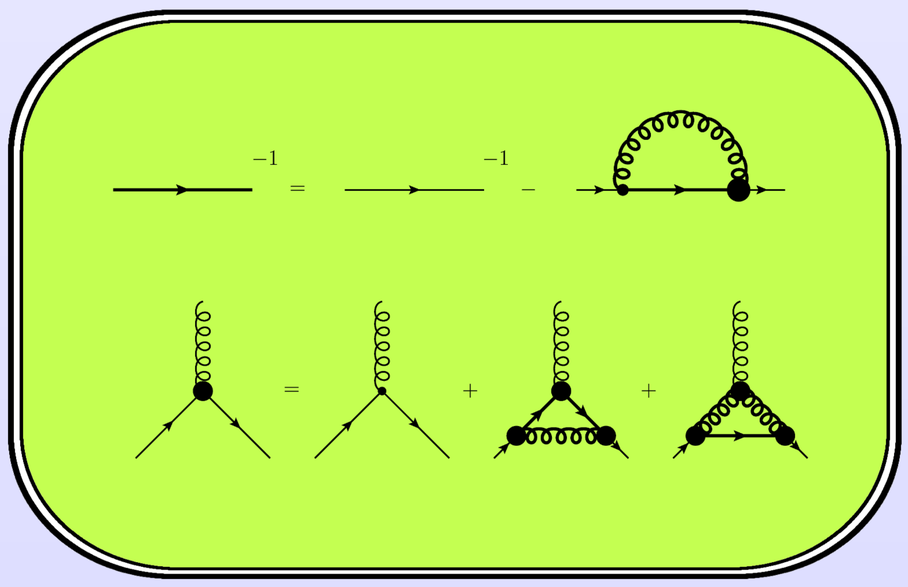
$$\Gamma^\mu = \sum_{i=1}^{4} \lambda_i L_i^\mu + \sum_{j=1}^{8} \tau_j T_j^\mu$$

$$L_1^\mu = \gamma^\mu$$
$$L_2^\mu = -(p\!\!\!/_1 + p\!\!\!/_2)(p_1 + p_2)^\mu$$
$$L_3^\mu = -i(p_1 + p_2)^\mu$$
$$L_4^\mu = -i\sigma^{\mu\nu}(p_1 + p_2)_\nu$$
$$T_1^\mu = i(p_1^\mu p_2 \cdot p_3 - p_2^\mu p_1 \cdot p_3)$$
$$T_2^\mu = (p_1^\mu p_2 \cdot p_3 - p_2^\mu p_1 \cdot p_3)(p\!\!\!/_1 + p\!\!\!/_2)$$
$$T_3^\mu = p\!\!\!/_3 p_3^\mu - p_3^2 \gamma^\mu$$
$$T_4^\mu = -i(p_3^2 \sigma^{\mu\nu}(p_1 + p_2)_\nu + 2p_3^\mu \sigma_{\lambda\nu} p_1^\lambda p_2 \nu)$$
$$T_5^\mu = i\sigma^{\mu\nu}(p_3)_\nu$$
$$T_6^\mu = (p_1^2 - p_2^2)\gamma^\mu + (p_1 + p_2)^\mu p\!\!\!/_3$$
$$T_7^\mu = \frac{i}{2}(p_1^2 - p_2^2)\xi^\mu - i(p_1 + p_2)^\mu \sigma_{\lambda\nu} p_2^\lambda p_1^\nu$$
$$T_8^\mu = -\gamma^\mu \sigma_{\lambda\nu} p_2^\lambda p_1^\nu - p\!\!\!/_2 p_1^\mu + p\!\!\!/_1 p_2^\mu$$

$$\xi^\mu = (p\!\!\!/_1 + p\!\!\!/_2)\gamma^\mu - (p_1 + p_2)^\mu; \qquad \sigma_{\mu\nu} = \frac{1}{2}(\gamma_\mu\gamma_\nu - \gamma_\nu\gamma_\mu)$$

Project onto the basis elements using `FORM`, [3].

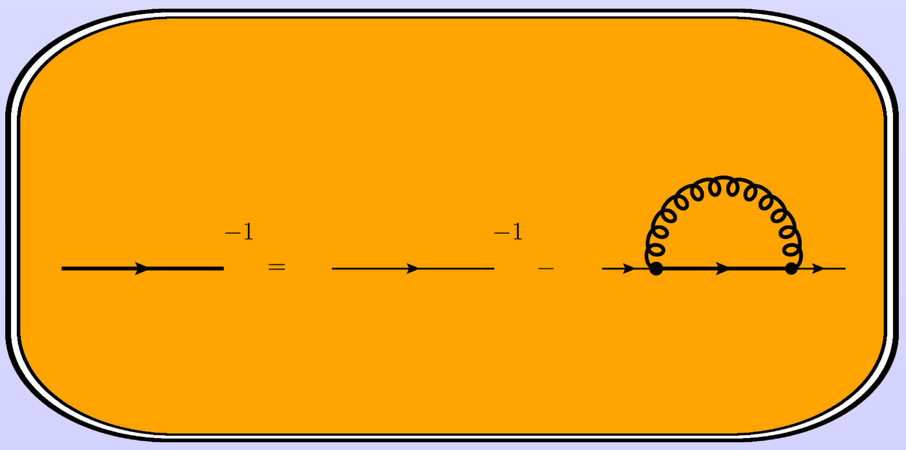
Step 3: The Real Thing



Solve the full vertex DSE

1. Vertex equation derived from 3PI effective action, [1]
2. Dressed gluon propagator again from lattice fit, [5]
3. Solve non-truncated vertex DSE (a HUGE number of terms)!
4. Compare to lattice results, [6]

Step 1: A (very) Preliminary Study on the GPU



Proof of concept: Take vertex bare on GPU, but allocate all 12 vertex dressings

1. Put only λ_1 to 1, $\lambda_i = 0,\ (i \neq 1), \tau_j = 0$
2. Solve propagator equation with all projections obtained earlier (many terms)
3. Reproduce results of [4]

Acknowledgments

This work is supported by the Austrian Science Fund, FWF, through the Doctoral Program on *Hadrons in Vacuum, Nuclei, and Stars* (FWF DK W1203-N16).

References

[1] R. Alkofer, C. S. Fischer, F. J. Llanes-Estrada and K. Schwenzer, Annals Phys. 324 (2009) 106 [arXiv:0804.3042 [hep-ph]].

[2] J. S. Ball and T. -W. Chiu, Phys. Rev. D 22 (1980) 2542.

[3] J. A. M. Vermaseren, math-ph/0010025.

[4] C. S. Fischer, hep-ph/0304233.

[5] C. S. Fischer, Phys. Rev. Lett. 103 (2009) 052003 [arXiv:0904.2700 [hep-ph]].

[6] J. I. Skullerud, P. O. Bowman, A. Kizilersu, D. B. Leinweber and A. G. Williams, JHEP 0304 (2003) 047 [hep-ph/0303176].