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The Dark Side of the Propagators: analytical approach to QCD in the infrared of Minkowski space.

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Since most of the non-perturbative approaches to QCD rely on numerical calculations in the *Euclidean* space, many important dynamical information cannot be easily extracted because of the ill-defined problem of analytic continuation for a limited set of data points.

On the other hand, by a shift of the expansion point, a perturbative approach has been developed[1,2] that has the nice feature of providing one-loop analytical functions for the propagators that are in perfect agreement with the data of lattice simulations in the Euclidean space. These functions are generally analytic and can be studied in Minkowski space, yielding a direct proof of positivity violation and confinement.

The expansion has been extended to full QCD [3], including a set of chiral quarks, in order to give a unified description of dynamical mass generation and chiral symmetry breaking, yielding new insights on the coupled quark, gluon and ghost propagators in the infrared of Minkowski space, that is still basically unexplored.

While dealing with the exact Lagrangian, the modified expansion is based on *massive* free-particle propagators, is safe in the infrared and is equivalent to the standard perturbation theory in the UV [2,3]. By dimensional regularization, all diverging mass terms cancel exactly without including spurious mass counterterms that would spoil the gauge and chiral symmetry of the Lagrangian. If optimized, the *massive* expansion provides a variational tool disguised to look like a perturbative method, without any phenomenological parameter, from first principles.

Among the main findings, universal scaling properties are predicted for the inverse dressing functions and shown to be satisfied by the lattice data. Complex conjugated poles are found for the gluon propagator, in agreement with the *i-particle* scenario. No complex poles are found for the quark propagators but the positivity constraints of the spectral functions are badly violated by the explicit presence of negative-norm multiparticle states below the two-particle threshold.

[1] F. Siringo, *Perturbative study of Yang-Mills theory in the infrared*, arXiv:1509.05891.

[2] F. Siringo, *Analytical study of Yang-Mills theory in the infrared from first principles*, Nucl.Phys.B907, 572 (2016); arXiv:1511.01015.

[3] F. Siringo, *Analytic structure of QCD propagators in Minkowski space*, arXiv:1605.07357

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