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Nearly perturbative QCD coupling with lattice-motivated zero IR limit

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The product of the gluon dressing function and the square of the ghost dressing function in the Landau gauge can be regarded to represent, apart from the inverse power corrections $1/Q^{2n}$, a nonperturbative generalization $A(Q^2)$ of the perturbative QCD running coupling $a(Q^2)$ ($\equiv \alpha_s(Q^2)/\pi$). Recent large volume lattice calculations for these dressing functions strongly indicate that such a generalized coupling goes to zero as $A(Q^2) \sim Q^2$ when the squared momenta Q^2 go to zero ($Q^2 \ll 1\ \mathrm{GeV}^2$). We construct such a QCD coupling $A(Q^2)$ which fulfills also various other physically motivated conditions. At high momenta it becomes the underlying perturbative coupling $a(Q^2)$ to a very high precision. And at intermediately low momenta $Q^2 \sim 1\ \mathrm{GeV}^2$ it gives results consistent with the data of the semihadronic τ lepton decays as measured by OPAL and ALEPH. The coupling is constructed in a dispersive way, ensuring as a byproduct the holomorphic behavior of $A(Q^2)$ in the complex Q^2-plane which reflects the holomorphic behavior of the spacelike QCD observables. Application of the Borel sum rules to τ-decay $V + A$ spectral functions allows us to obtain values for the gluon (dimension-4) condensate and the dimension-6 condensate, which reproduce the measured OPAL and ALEPH data to a significantly better precision than the perturbative $\overline{\mathrm{MS}}$ coupling (+OPE) approach. The comparison with the experimental V-channel Adler function, related with the $e^+e^- \to$ hadrons ratio, at low $Q^2 \sim 1\ \mathrm{GeV}^2$, also gives results considerably better than with the usual $\overline{\mathrm{MS}}$ pQCD+OPE approach.

Experimental Collaboration

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