Non-Hermitian Random Matrix Theory and Lattice QCD with Chemical Potential ◇

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In quantum chromodynamics (QCD) at nonzero chemical potential, the eigenvalues of the Dirac operator are scattered in the complex plane. Can the fluctuation properties of the Dirac spectrum be described by universal predictions of non-Hermitian random matrix theory? We introduce an unfolding procedure for complex eigenvalues and apply it to data from lattice QCD at finite chemical potential μ to construct the nearest-neighbor spacing distribution of adjacent eigenvalues in the complex plane. For intermediate values of μ, we find agreement with predictions of the Ginibre ensemble of random matrix theory, both in the confinement and in the deconfinement phase.

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NLO Corrections and Contribution of a Tensor Gluon Operator to the Process $\gamma^*\gamma \to \pi\pi$ ◇

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We have calculated the NLO corrections for the leading twist amplitude of the reaction $\gamma^*\gamma \to \pi\pi$ at large virtuality of the photon and at $W^2 << Q^2$. With a simple model for the two-pion quark and gluon distribution amplitudes we have estimated that the NLO effects may reduce the leading-order amplitude by as much as 30 %. We have found that besides the usual twist-2 quark and gluon operators the NLO amplitude receives contribution from a distribution associated with twist-2 tensor gluon operator. The new gluon distribution can be investigated by studying the azimuthal asymmetry of the cross section for $e + \gamma \to e' + \pi\pi$.

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Predictions of Chiral Random Matrix Theory and Lattice QCD Results ◇

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Chiral random matrix theory makes very detailed predictions for the spectral correlations of the QCD Dirac operator, both in the bulk of the spectrum and near zero virtuality. These predictions have been successfully tested in lattice QCD simulations by several groups. Moreover, the domain of validity of random matrix theory has been predicted theoretically and identified in lattice data. In this talk, the current numerical evidence is reviewed.

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QCD Aspects of Hadron Physics ◇

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Several topics in hadron physics at different scales of resolution are discussed. First, deep-inelastic scattering from nucleons and nuclei is viewed in a light-cone coordinate space picture. Then the smooth transition from parton to hadron degrees of freedom is demonstrated by analysing generalized Q^2-dependent polarizabilities of the nucleon. Turning to low energy QCD we summarize recent developments related to the role of strange quarks in Chiral $SU(3)$ Dynamics, a non-perturbative coupled channel approach to hadronic processes. Finally we elaborate on a unification of QCD Sum Rules with aspects of spontaneous chiral symmetry breaking in the analysis of quark-antiquark excitations of the condensed QCD vacuum and in nuclear matter.

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