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New Perspectives for QCD

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AdS/QCD, together with "Light-Front Holography," provides an analytic, frame-independent color-confining first approximation to QCD which is remarkably successful in accounting for light-quark meson and baryon spectroscopy, hadronic form factors, and other hadronic observables. A remarkable holographic feature of hadron dynamics in AdS space in five dimensions is that it is dual to Hamiltonian theory in physical space-time, quantized at fixed light-front time. This light-front holographic principle provides a precise relation between the bound-state amplitudes in AdS space and the boost-invariant light-front wavefunctions describing the internal structure of hadrons in physical space-time. The hadronic eigensolutions of the light-front QCD Hamiltonian satisfy a single-variable relativistic equation of motion, analogous to the nonrelativistic radial Schrödinger equation. The color-confining potential is determined uniquely using a method based on conformally invariant quantum mechanics. The resulting potential is color-confining and reproduces the observed linear Regge behavior of the light-quark hadron spectrum in both orbital angular momentum and the radial node number. The pion mass vanishes in the chiral limit, and other features of chiral symmetry are satisfied. The elastic and transition form factors of the pion and the nucleons are also found to be well described in this framework. A number of novel phenomenological consequences will be discussed, including hadronization at the amplitude level. I will also discuss how the renormalization scale of the QCD coupling can be determined by using the "Principle of Maximum Conformality," providing scheme-independent predictions and eliminating an unnecessary source of systematic error in pQCD predictions.