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New Results for Hadron Physics from Light-Front Holography and Superconformal Algebra

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Light-front holography provides a precise relation between the bound-state amplitudes in the fifth dimension of AdS space and the boost-invariant light-front wavefunctions describing the internal structure of hadrons in physical space-time. The resulting valence Fock-state wavefunctions of the light-front QCD Hamiltonian satisfy a relativistic equation of motion, analogous to the nonrelativistic radial Schrödinger equation, with an effective confining potential. If one requires that the effective action which underlies the QCD Lagrangian to remain conformally invariant and extends the formalism of de Alfaro, Fubini and Furlan to light front Hamiltonian theory, the potential has a unique form of a harmonic oscillator potential, and a mass gap arises. The result is a nonperturbative relativistic light-front wave equation which incorporates color confinement and other essential spectroscopic and dynamical features of hadron physics, including a massless pion for zero quark mass and linear Regge trajectories with the same slope in the radial quantum number n and orbital angular momentum L . One can also construct an effective QCD light-front Hamiltonian for both mesons and baryons based on superconformal algebra. The superconformal construction is shown to be equivalent to a semiclassical approximation to light-front QCD and its embedding in AdS space. The specific breaking of conformal invariance determines a unique effective confinement potential. The generalized supercharges connect the baryon and meson spectra to each other in a remarkable manner. We also show how the mass scale underlying confinement and hadron masses determines the scale controlling the evolution of the perturbative QCD coupling. The relation between scales is obtained by matching the nonperturbative dynamics, as described by an effective conformal theory mapped to the light-front and its embedding in AdS space, to the perturbative QCD regime. The result is an effective coupling defined at all momenta.

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