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# Supersymmetric Features of Hadron Physics and other Novel Properties of Quantum Chromodynamics from Light-Front holography and Superconformal Algebra

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A fundamental question in hadron and nuclear physics is how the mass scale for protons and other hadrons emerges from QCD, even in the limit of zero quark mass. I will discuss a new approach to the origin of the QCD mass scale and color confinement based on "lightfront holography", a formalism which relates the bound-state amplitudes in the fifth dimension of AdS space to the boost-invariant light-front wavefunctions describing the structure of hadrons in physical space-time. The result is a set of Poincarè-invariant bound-state wave equations which incorporate quark confinement and predict many observed spectroscopic and dynamical features of hadron physics, such as linear Regge trajectories with identical slope in both the radial quantum number and the internal orbital angular momentum.

Generalizing this procedure using superconformal algebra leads to a unified Regge spectroscopy of meson, baryon, and tetraquarks, including remarkable supersymmetric relations between the masses of mesons and baryons. The pion bound-state, although composite, is massless for zero quark mass.

One also can predict nonperturbative hadronic observables such as structure functions, transverse momentum distributions, and the distribution amplitudes defined from the hadronic light-front wavefunctions.

The analytic behavior of the QCD coupling controlling quark and gluon interactions at large and small distances is also determined. The result is an effective coupling defined at all momenta with a transition mass scale which sets the interface between perturbative and nonperturbative hadron dynamics. One also obtains a relation between the perturbative QCD mass scale and hadron masses. I will also briefly discuss how conformal constraints lead to the elimination of the renormalization scale ambiguity for perturbative QCD calculations.

## Summary

I will discuss a new approach to the origin of the QCD mass scale and color confinement based on "light-front holography", a formalism which relates the bound-state amplitudes in the fifth dimension of AdS space to the boost-invariant light-front wavefunctions describing the structure of hadrons in physical space-time. The result is a set of Poincarè-invariant bound-state wave equations which incorporate quark confinement and predict many observed spectroscopic and dynamical features of hadron physics.

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