PROCEEDINGS OF SCIENCE

Color Confinement, Hadron Dynamics, and Hadron Spectroscopy from Light-Front Holography and Superconformal Algebra

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QCD is not supersymmetrical in the traditional sense – the QCD Lagrangian is based on quark and gluonic fields, not squarks nor gluinos. However, its hadronic eigensolutions conform to a representation of superconformal algebra, reflecting the underlying conformal symmetry of chiral QCD and its Pauli matrix representation.Ê Ê TheÊ eigensolutionsÊ of superconformal algebra provide a unified Regge spectroscopy of meson, baryon, and tetraquarks of the same parity and twistÊ as equal-mass members of the same 4-plet representation with a universal Regge slope.Ê The pion $q\bar{q}$ eigenstate has zero mass for $m_q = 0$.Ê The superconformal relations also can be extended toÊ heavy-light quark mesons and baryons.Ê The combined approach of light-front holography and superconformal algebra also provides insight into the origin of the QCD mass scale and color confinement.Ê A key observation is the remarkable dAFF principle which shows how a mass scale can appear in the Hamiltonian and the equations of motion while retaining the conformal symmetry of the action.Ê When one applies the dAFF procedure to chiral QCD, a mass scale κ appears which determines universal Regge slopes, hadron masses in the absence of the Higgs coupling, and the mass parameter underlying the Gaussian functional form of the nonperturbative QCD running coupling:Ê $\alpha_s(Q^2) \propto \exp -Q^2/4\kappa^2$,Ê in agreement with the effective chargeÊ determined from measurements of the Bjorken sum rule. The mass scale κ underlying hadron massesÊ can be connected to the parameterÊ Ê$\Lambda_{\overline{MS}}$ in the QCD running coupling by matching its predicted nonperturbative form to the perturbative QCD regime. The result is an effective coupling $\alpha_s(Q^2)$Ê defined at all momenta.Ê ÊOne also obtains empirically viable predictions for spacelike and timelike hadronic form factors, structure functions, distribution amplitudes, and transverse momentum distributions.Ê

XIII Quark Confinement and the Hadron Spectrum - Confinement2018
31 July - 6 August 2018
Maynooth University, Ireland

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[†]A footnote may follow.

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References

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