Supersymmetric Features of Hadron Spectroscopy from Light-Front Holography

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QCD and QED share the same Lagrangian; in fact, QCD reduces in the $N_C \to 0$ limit to Abelian theory. Tools of hadron physics such as *light-front Hamiltonian* methods can be used to describe atoms in the relativistic domain, independent of the observer's motion. Conversely, the renormalization scale setting procedure developed for QED can be generalized to non-Abelian theory; it leads to the scheme-independent *Principle of Maximal Conformality* procedure for setting renormalization scales for pQCD, greatly improving the precision of QCD predictions. The formation of relativistic atoms leads to a method to describe the conversion of quarks and gluons to hadrons at the amplitude level. QCD also leads to new concepts in nuclear physics, such as *color transparency*, *hidden color*, and *flavor-dependent antishadowing.*

Superconformal algebra predicts remarkable connections between the masses of mesons and baryons of the same parity – *supersymmetric relations* between the bosonic and fermionic bound states of QCD, where the mesons have internal angular momentum $L_M = L_B + 1$, one unit higher than its baryon superpartner. One also predicts the existence of *tetraquarks* which are degenerate in mass with baryons with the same angular momentum. More generally one can apply the color-confining potential sequentially to generate strongly bound tetraquarks, pentaquarks, and even octoquarks. In fact the strongly bound $B = 2$ strangeness state discovered by Toshimitsu Yamazaki and Yoshinori Akaishi in $pp \to X + K^+$ collisions can be a $|uuduuds\bar{u} >$ *octoquark* state, bound together by a sequence of $3_C \times 3_C \to \bar{3}_C$ color interactions,

An effective supersymmetric light-front Hamiltonian for hadrons composed of light quarks can be constructed by embedding *superconformal quantum mechanics* into AdS space. The breaking of conformal symmetry determines a unique quark-confining light-front harmonic oscillator potential for hadrons, including spin-spin interactions. The mass-squared of the light hadrons can be expressed as a frame-independent decomposition of contributions from the LF kinetic energy, the confinement potential, and spin-spin contributions. The mass of the pion eigenstate vanishes in the $m_q \to 0$ chiral limit. Only one mass parameter κ appears; it sets the confinement mass scale, a universal slope for all Regge trajectories, the nonzero mass of the proton and other hadrons, as well as the mass parameter Λ_s of a QCD running coupling defined at all momenta. The matching of the high and low momentum-transfer regimes determines a scale Q_0 which sets the interface between perturbative and nonperturbative hadron dynamics, as well as the factorization scale for structure functions and distribution amplitudes.

For details see: arXiv:1606.04638, arXiv:1605.02572,arXiv:1604.08082.