Light-front quantization

From the White Paper by the Board of Directors of ILCAC, Inc.

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Light-front Quantization

- ILCAC, Inc. URL: http://www.ilcacin.org/
- framework for analysis of hadrons in QCD:
  \[ x^+ = t + z, \quad x^- = t - z, \quad p^- = E - p_z, \quad p^+ = E + p_z \]
- nonperturbative Hamiltonian eigenvalue problem:
  \[ \mathcal{P}^- |P^+, \vec{P}_\perp\rangle = \frac{M^2 + P^2_\perp}{P_+} |P^+, \vec{P}_\perp\rangle \]
- well-defined Fock-state expansion:
  \[ |\text{proton}\rangle = \psi_{uud}|uud\rangle + \psi_{uudg}|uudg\rangle + \psi_{uudq\bar{q}}|uudq\bar{q}\rangle + \cdots \]
- boost-invariant & process-independent wave functions
  - free of vacuum contributions
- Minkowski space: time-like and space-like processes
- no fermion doubling
- no formulation-specific light-quark problem
Progress & Successes

- direct evidence for a Maldacena duality conjecture
  – SDLCQ Collaboration (Pinsky, jrh, et al.)
- massively parallel Lanczos code
  – Vary et al.
- nonperturbative QED in an arbitrary covariant gauge
  – Chabysheva and jrh
- relativistic quark models based on light-front holography
  – Brodsky and De Téramond
- effective-particle representation via renormalization gp
  – Wilson and Głazek
- methods for finite-temperature calculations
  – SDLCQ Collaboration, Beyer and Strauss
Goals & Challenges

- calculation of hadron masses, wave functions, form factors, GPDs, ...
  - light-front coupled-cluster method
- analysis of hadronic and nuclear phenomenology
  - at zero and finite temperature
- understanding of vacuum structure
  - zero modes, effective interactions
- construction of nonperturbative regularization
  - St Petersburg group (Paston et al.)
- classification of total angular momentum eigenstates
  - rotations about $x$ and $y$ are dynamical
- physics of intense laser fields
  - nonperturbative strong-field QED