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The Quark Model via an hbar expansion of QCD

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I discuss the possibility that the quark model emerges as the lowest order of an hbar expansion of QCD bound states. Bound state calculations are generally complicated by backward (in time) motion of their relativistic constituents (Z-graphs, corresponding to pair production in a time-ordered formulation). I show that in the absence of loops (i.e., at lowest order in hbar) bound state dynamics may equivalently be formulated using a vacuum where all antifermion states are filled (d^\dag|0> = 0) and fermions only propagate forward in time. The derivation of the Dirac equation in an external potential then becomes straightforward. Fermion-antifermion states are bound by the instantaneous Coulomb (A^0) potential which is determined by the equation of motion (EOM) for each Fock state amplitude. The EOM has a homogeneous solution which gives a linear potential when the direction of the instantaneous field is along the pair separation, as required for minimal action. The solutions are expected to be exact at lowest order in hbar, as evidenced by the fact that the the bound states (evaluated at equal time in all frames) have Lorentz covariant energies, while their relativistic wave functions transform in a novel way.

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