Title:
Physical and nonphysical modes in the light front formulation for LC gauge and Lorentz gauge conditions.

Abstract:
We quantize the vector gauge fields in two different gauge fixing condition. The LC gauge is implemented explicitly by putting $A^+ = 0$ in all expressions, while the Lorentz gauge $\partial^\mu A_\mu = \partial_+ A_- + \partial_- A_+ - \partial_i A_i = 0$ is implemented by the Lagrange multiplier field Λ. In order to avoid the infra-red singularities the mass term is additionally added.

The procedure of light front quantization is novel, with the substantial role of Wightman functions. Then the structure of modes is analyzed in the momentum representation, where no inconsistence arise.

For non-vanishing mass term, we find a fundamental difference between the LC and Lorentz gauges. In the LC gauge we find three covariant modes, where only two of them are independent and two noncovariant mode. All these modes survive the massless limit leading to two covariant massless modes and two noncovariant modes. In the Lorentz gauge, for non-vanishing mass term, all four modes are covariant, as expected, but three of them are massive and one is massless. In the massless limit two covariant modes survive, but one massive mode and the massless mode mix together to form a mode which generates zero-norm states.

We conclude that in the true gauge field theory, without a mass term, in both gauges there are the same two covariant massless modes, but also they contain different non-physical modes. In this respect our analysis stay in a conflict with the doubly-transverse gauge propagator, which was introduced by Srivastava and Brodsky, Phys. Rev. D 64 045006 (2001). We argue that they have omitted the nonphysical mode contributions.