

# The Lorentz generators of the Gauge nonfixing strings

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# Algebra

- Conventional string (OCQ)

$$[X^i(\sigma), \Pi^j(\sigma')] = -i\hbar\delta^{ij}\delta(\sigma' - \sigma)$$

$$L_m|*\rangle = 0 \quad (m > 0)$$

and

$$[X^S(\sigma), \Pi^S(\sigma')] = +i\hbar\delta(\sigma' - \sigma)$$

- Our method

$$[X^i(\sigma), \Pi^j(\sigma')] = -i\hbar\delta^{ij}\delta(\sigma' - \sigma)$$

$$L_m|*\rangle = 0 \quad (\forall m)$$

and

$$[X^S(\sigma), \Pi^S(\sigma')] = F(L'_m)$$

# Naming of the Freedoms

$X^+, X^-$  : transverse

$X^S$  :  $p^\mu$  proportional

$X^L$  : orthogonal to  $X^+, X^-, X^S$

- By Lorentz transformation,  $X^S$  acts as a Lorentz scalar, and  $X^+, X^-$ , and  $X^L$  linearly mix as a three vector.

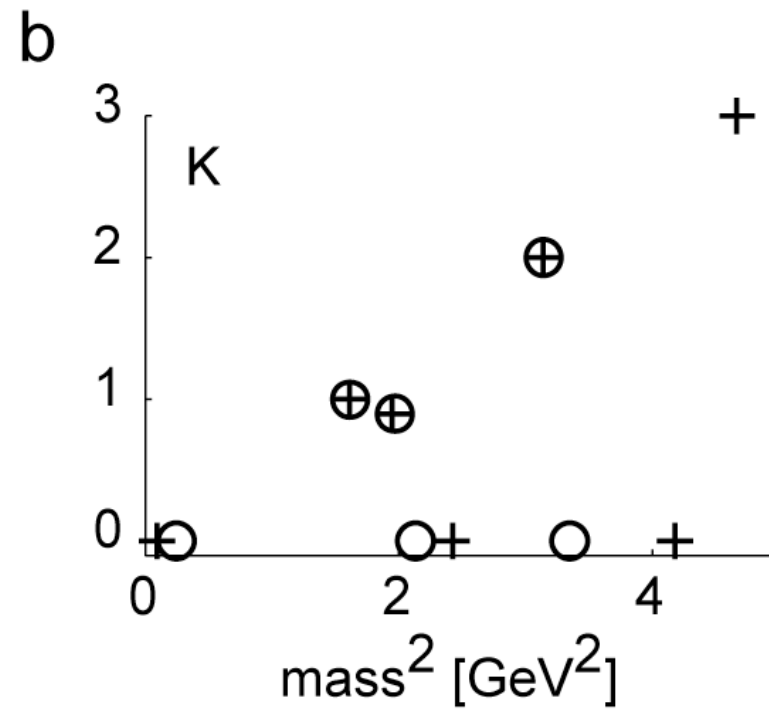
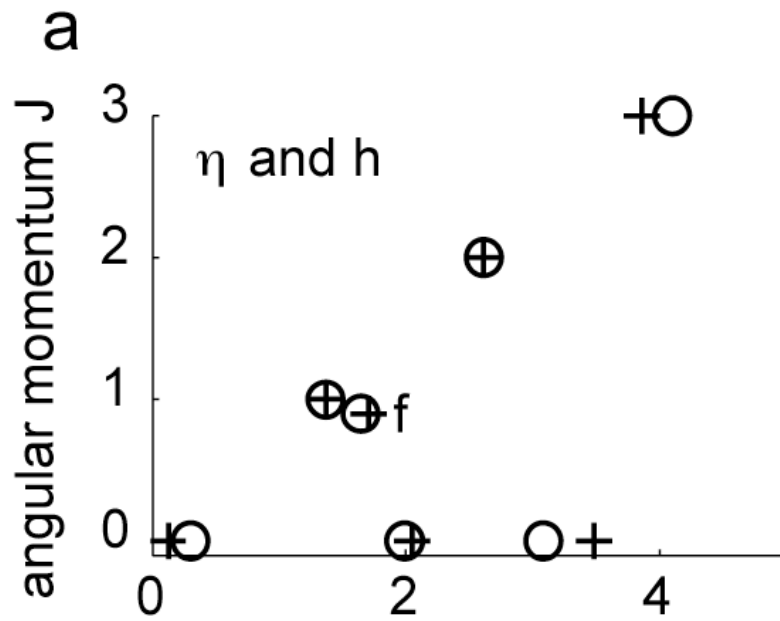
# Consequence of our algebra:

The possible states:

State	spin	$(L_0 - a) = 0$
$ 0\rangle$	0	$p^2 = -2a$
$\alpha_{-1}^i  0\rangle$	1	$p^2 = 2 - 2a$
$\sum_i \alpha_{-1}^i \alpha_{-1}^i  0\rangle$	0	$p^2 = 4 - 2a - (D - 1)/p^2$
$\alpha_{-2}^i  0\rangle$	1	$p^2 = 2 - 2a - 4/p^2$
$\alpha_{-1}^i \alpha_{-1}^j  0\rangle$	2	$p^2 = 4 - 2a$
$\alpha_{-3}^i  0\rangle$	1	
$\sum_i \alpha_{-2}^i \alpha_{-1}^i  0\rangle$	0	$p^2 = 4 - 2a - (D - 1)/p^2$
$\epsilon_{kij} \alpha_{-2}^i \alpha_{-1}^j  0\rangle$	1	$p^2 = 4 - 2a - (D - 1)/p^2$
$\alpha_{-2}^i \alpha_{-1}^j  0\rangle$	2	
$\alpha_{-1}^i (\alpha_{-1}^j \alpha_{-1}^j)  0\rangle$	1	
$\zeta_{ijk} \alpha_{-1}^i \alpha_{-1}^j \alpha_{-1}^k  0\rangle$	3	
...		

No negative norm states!

# Real Meson Spectrum



# Criticism:

In the light-cone gauge,  
 $D = 26$  was required to restore Lorentz invariance.  
Your theory should be the Same.

Of course, NOT.

I will show explicit Lorentz algebra.

# Result: These forms proper Lorentz algebra

$$\begin{aligned} M_{i0} &= (x_i p_0 - x_0 p_i) \\ &\quad -i \sum_n \left\{ \frac{p}{|\mathbf{p}|} e_i^l (\alpha_n^{l\dagger} \alpha_n^L - \alpha_n^{L\dagger} \alpha_n^l) + \mathbf{e}^m \cdot \frac{\partial \mathbf{e}^l}{\partial p_i} p_0 \alpha_n^{l\dagger} \alpha_n^m \right\}, \\ M_{ij} &= (x_i p_j - x_j p_i) \\ &\quad -i \left( e_i^l e_j^m + \mathbf{e}^m \cdot \frac{\partial \mathbf{e}^l}{\partial p_i} p_j - (i \leftrightarrow j) \right) \alpha^{l\dagger} \alpha^m, \end{aligned}$$



# Derivation:

- L polarization boosts into L and transverse

$$\frac{1}{p}(|\mathbf{p}|, p^0 \mathbf{e}^p) \rightarrow \frac{1}{p}(|\mathbf{p}| + \boldsymbol{\beta} \cdot \mathbf{e}^p p^0, p^0 \mathbf{e}^p + \boldsymbol{\beta} |\mathbf{p}|) \equiv \varepsilon^{L'}$$

$$\varepsilon^{L'} = \varepsilon^L(p') - \frac{p}{|\mathbf{p}|} \sum_l (\boldsymbol{\beta} \cdot \mathbf{e}^l) \varepsilon^l(p').$$

- Transverse boosts into:

$$\varepsilon^{l'} = \varepsilon^l(p') + (\boldsymbol{\beta} \cdot \mathbf{e}^l) \frac{p}{|\mathbf{p}|} \varepsilon^L(p') + \sum_m \mathbf{e}^l \cdot \frac{\partial \mathbf{e}^m}{\partial p_j} \beta_j p_0 \varepsilon^m(p')$$

Then Generators are:

$$M_{i0} = (x_i p_0 - x_0 p_i) - i \sum_n \left\{ \frac{p}{|\mathbf{p}|} e_i^l (\alpha_n^{l\dagger} \alpha_n^L - \alpha_n^{L\dagger} \alpha_n^l) + \mathbf{e}^m \cdot \frac{\partial \mathbf{e}^l}{\partial p_i} p_0 \alpha_n^{l\dagger} \alpha_n^m \right\}$$

$$M_{ij} = (x_i p_j - x_j p_i) - i \sum_n \left( e_i^l e_j^m + \mathbf{e}^m \cdot \frac{\partial \mathbf{e}^l}{\partial p_i} p_j - (i \leftrightarrow j) \right) \alpha_n^{l\dagger} \alpha_n^m$$

Then it's easy to confirm:

$$[M_{i0}, M_{j0}] = -iM_{ij}$$

$$[M_{ij}, M_{k0}] = i\delta_{ik}M_{j0} - i\delta_{jk}M_{i0},$$

$$[M_{ij}, M_{kh}] = i\delta_{ik}M_{jh} - i\delta_{ih}M_{jk} - i\delta_{jk}M_{ih} + i\delta_{jh}M_{ik}$$

OK!

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