

Particle spectrograph

Wave operator and propagator

Source constraints		Fundamental fields	Multiplicities
SO(3) irreps			
$\tau^{#2}_{0+} == 0$		$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$	1
$\tau^{#1}_{0+} - 2 \, i \, k \, \sigma^{#1}_{0+} == 0$		$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau^\alpha_\alpha + 2 \, \partial_\chi \partial^\chi \partial_\beta \sigma^{\alpha\beta}_\alpha$	1
$\tau^{#2\alpha}_{1-} + 2 \, i \, k \, \sigma^{#2\alpha}_{1-} == 0$		$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta} + 2 \, \partial_\delta \partial^\delta \partial_\chi \partial_\beta \sigma^{\alpha\beta\chi}$	3
$\tau^{#1\alpha}_{1-} == 0$		$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\beta\alpha}$	3
$\tau^{#1\alpha\beta}_{1+} + i \, k \, \sigma^{#2\alpha\beta}_{1+} == 0$		$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\beta \tau^{\chi\alpha} + \partial_\chi \partial^\chi \tau^{\alpha\beta} +$ $2 \, \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2 \, \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi} ==$ $\partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha\chi} +$ $\partial_\chi \partial^\chi \tau^{\beta\alpha} + 2 \, \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}$	3
$\tau^{#1\alpha\beta}_{2+} - 2 \, i \, k \, \sigma^{#1\alpha\beta}_{2+} == 0$		$-i \, (4 \, \partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2 \, \partial_\delta \partial^\delta \partial^\beta \partial^\alpha \tau^{\chi\chi} -$ $3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi} - 3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} -$ $3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi} - 3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha} +$ $3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\beta\alpha} +$ $4 \, i \, k^\chi \, \partial_\epsilon \partial_\chi \partial^\beta \partial^\sigma \sigma^{\delta\epsilon}_\delta -$ $6 \, i \, k^\chi \, \partial_\epsilon \partial_\delta \partial_\chi \partial^\sigma \sigma^{\beta\delta\epsilon}_\epsilon -$ $6 \, i \, k^\chi \, \partial_\epsilon \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon}_\epsilon +$ $2 \, \eta^{\alpha\beta} \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} +$ $6 \, i \, k^\chi \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\alpha\delta\beta}_\beta +$ $6 \, i \, k^\chi \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\beta\delta\alpha}_\alpha -$ $2 \, \eta^{\alpha\beta} \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \tau^{\chi\chi}_\chi -$ $4 \, i \, \eta^{\alpha\beta} \, k^\chi \, \partial_\phi \partial^\phi \partial_\epsilon \partial_\chi \sigma^{\delta\epsilon}_\delta) == 0$	5
Total constraints/gauge generators:			16

Quadratic (free) action

$$S = \int \int \int \int (\frac{1}{6} (2 \, \omega^{\alpha i}_\alpha (t_1 \, \omega^{\theta}_{\prime \, \theta} - 2 \, t_3 \, \omega^{\kappa}_{\prime \, \kappa}) + 6 \, f^{\alpha\beta} \, \tau_{\alpha\beta} + 6 \, \omega^{\alpha\beta\chi} \, \sigma_{\alpha\beta\chi} -$$
  
$$4 \, t_1 \, \omega^{\theta}_{\theta} \, \partial_{\prime} f^{\alpha i} + 8 \, t_3 \, \omega^{\kappa}_{\kappa} \, \partial_{\prime} f^{\alpha i} + 4 \, t_1 \, \omega^{\theta}_{\theta} \, \partial_{\prime} f^{\alpha}_{\alpha} -$$
  
$$8 \, t_3 \, \omega^{\kappa}_{\prime \, \kappa} \, \partial_{\prime} f^{\alpha}_{\alpha} - 2 \, t_1 \, \partial_{\prime} f^{\theta}_{\theta} \, \partial_{\prime} f^{\alpha}_{\alpha} + 4 \, t_3 \, \partial_{\prime} f^{\kappa}_{\kappa} \, \partial_{\prime} f^{\alpha}_{\alpha} -$$
  
$$2 \, t_1 \, \partial_{\prime} f^{\alpha i} \, \partial_{\theta} f^{\theta}_{\alpha} + 4 \, t_1 \, \partial_{\prime} f^{\alpha}_{\alpha} \, \partial_{\theta} f^{\theta}_{\prime} - 6 \, t_1 \, \partial_{\omega} f_{\prime\theta} \, \partial^{\theta} f^{\alpha i} -$$
  
$$3 \, t_1 \, \partial_{\omega} f_{\theta\prime} \, \partial^{\theta} f^{\alpha i} + 3 \, t_1 \, \partial_{\prime} f_{\alpha\theta} \, \partial^{\theta} f^{\alpha i} + 3 \, t_1 \, \partial_{\theta} f_{\alpha\prime} \, \partial^{\theta} f^{\alpha i} +$$
  
$$3 \, t_1 \, \partial_{\theta} f_{\prime\alpha} \, \partial^{\theta} f^{\alpha i} + 6 \, t_1 \, \omega_{\alpha\theta\prime} ( \omega^{\alpha i\theta} + 2 \, \partial^{\theta} f^{\alpha i}) +$$
  
$$8 \, r_2 \, \partial_\beta \omega_{\alpha\theta} \, \partial^\theta \omega^{\alpha\beta\prime} - 4 \, r_2 \, \partial_\beta \omega_{\alpha\theta\prime} \, \partial^\theta \omega^{\alpha\beta\prime} +$$
  
$$4 \, r_2 \, \partial_\beta \omega_{\prime\theta\alpha} \, \partial^\theta \omega^{\alpha\beta\prime} - 2 \, r_2 \, \partial_{\prime} \omega_{\alpha\beta\theta} \, \partial^\theta \omega^{\alpha\beta\prime} +$$
  
$$2 \, r_2 \, \partial_\theta \omega_{\alpha\beta\prime} \, \partial^\theta \omega^{\alpha\beta\prime} - 4 \, r_2 \, \partial_\theta \omega_{\alpha\prime\beta} \, \partial^\theta \omega^{\alpha\beta\prime} +$$
  
$$4 \, t_3 \, \partial_{\prime} f^{\alpha i} \, \partial_{\kappa} f^{\kappa}_{\alpha} - 8 \, t_3 \, \partial_{\prime} f^{\alpha}_{\alpha} \, \partial_{\kappa} f^{\kappa\prime}) [t, x, y, z] dz dy dx dt$$

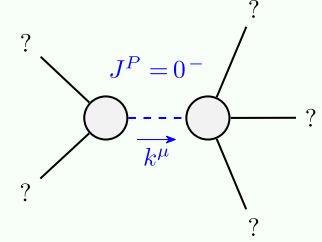
$\sigma^{#1}_{1+} + \alpha\beta$	$\sigma^{#2}_{1+} + \alpha\beta$	$\tau^{#1}_{1+} + \alpha\beta$	$\sigma^{#1}_{1-} \alpha$	$\sigma^{#2}_{1-} \alpha$	$\tau^{#1}_{1-} \alpha$	$\tau^{#2}_{1-} \alpha$
$\sigma^{#1}_{1+} + \alpha\beta$	$0$	$-\frac{\sqrt{2}}{t_1+k^2t_1}$	$0$	$0$	$0$	$0$
$\sigma^{#2}_{1+} + \alpha\beta$	$-\frac{\sqrt{2}}{t_1+k^2t_1}$	$\frac{1}{(1+k^2)^2t_1}$	$0$	$0$	$0$	$0$
$\tau^{#1}_{1+} + \alpha\beta$	$-\frac{i\sqrt{2}k}{t_1+k^2t_1}$	$-\frac{k^2}{(1+k^2)^2t_1}$	$0$	$0$	$0$	$0$
$\sigma^{#1}_{1-} + \alpha$	$0$	$0$	$\frac{2(t_1+t_3)}{3t_1t_3}$	$-\frac{\sqrt{2}(t_1-2t_3)}{3(1+2k^2)t_1t_3}$	$0$	$-\frac{2ik t_1-4ikt_3}{3t_1t_3+6k^2t_1t_3}$
$\sigma^{#2}_{1-} + \alpha$	$0$	$0$	$0$	$\frac{t_1+4t_3}{3(1+2k^2)^2t_1t_3}$	$0$	$\frac{i\sqrt{2}k(t_1+4t_3)}{3(1+2k^2)^2t_1t_3}$
$\tau^{#1}_{1-} + \alpha$	$0$	$0$	$0$	$0$	$0$	$0$
$\tau^{#2}_{1-} + \alpha$	$0$	$0$	$0$	$-\frac{2ikt_1-4ikt_3}{3t_1t_3+6k^2t_1t_3}$	$-\frac{i\sqrt{2}k(t_1+4t_3)}{3(1+2k^2)^2t_1t_3}$	$\frac{2k^2(t_1+4t_3)}{3(1+2k^2)^2t_1t_3}$

$\omega^{#1}_{1+} + \alpha\beta$	$\omega^{#2}_{1+} + \alpha\beta$	$f^{#1}_{1+} + \alpha\beta$	$\omega^{#1}_{1-} \alpha$	$\omega^{#2}_{1-} \alpha$	$f^{#1}_{1-} \alpha$	$f^{#2}_{1-} \alpha$
$\omega^{#1}_{1+} + \alpha\beta$	$-\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	$0$	$0$	$0$	$0$
$\omega^{#2}_{1+} + \alpha\beta$	$-\frac{t_1}{\sqrt{2}}$	$0$	$0$	$0$	$0$	$0$
$f^{#1}_{1+} + \alpha\beta$	$\frac{ikt_1}{\sqrt{2}}$	$0$	$0$	$0$	$0$	$0$
$\omega^{#1}_{1-} + \alpha$	$0$	$0$	$\frac{1}{6}(t_1+4t_3)$	$\frac{t_1-2t_3}{3\sqrt{2}}$	$0$	$\frac{1}{3}i k(t_1-2t_3)$
$\omega^{#2}_{1-} + \alpha$	$0$	$0$	$\frac{t_1-2t_3}{3\sqrt{2}}$	$\frac{t_1+t_3}{3}$	$0$	$\frac{1}{3}i\sqrt{2}k(t_1+t_3)$
$f^{#1}_{1-} + \alpha$	$0$	$0$	$0$	$0$	$0$	$0$
$f^{#2}_{1-} + \alpha$	$0$	$0$	$-\frac{1}{3}i k(t_1-2t_3)$	$-\frac{1}{3}i\sqrt{2}k(t_1+t_3)$	$0$	$\frac{2}{3}k^2(t_1+t_3)$

$\sigma^{#1}_{0+} + \alpha\beta$	$\sigma^{#2}_{0+} + \alpha\beta$	$\tau^{#1}_{0+} + \alpha\beta$	$\sigma^{#1}_{0-} + \alpha$	$\sigma^{#2}_{0-} + \alpha$	$\tau^{#1}_{0-} + \alpha$	$\tau^{#2}_{0-} + \alpha$
$\sigma^{#1}_{0+} + \alpha\beta$	$\frac{1}{(1+2k^2)^2t_3}$	$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_3}$	$0$	$0$	$0$	$0$
$\sigma^{#2}_{0+} + \alpha\beta$	$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_3}$	$\frac{2k^2}{(1+2k^2)^2t_3}$	$0$	$0$	$0$	$0$
$\tau^{#1}_{0+} + \alpha\beta$	$0$	$0$	$0$	$0$	$0$	$0$
$\tau^{#2}_{0+} + \alpha\beta$	$0$	$0$	$0$	$0$	$0$	$0$
$\sigma^{#1}_{0-} + \alpha$	$0$	$0$	$k^2r_2-t_1$	$0$	$0$	$0$
$\sigma^{#2}_{0-} + \alpha$	$0$	$0$	$0$	$0$	$0$	$0$
$\tau^{#1}_{0-} + \alpha$	$0$	$0$	$0$	$0$	$0$	$0$
$\tau^{#2}_{0-} + \alpha$	$0$	$0$	$0$	$0$	$0$	$0$

$\sigma^{#1}_{2+} + \alpha\beta$	$\sigma^{#2}_{2+} + \alpha\beta$	$\tau^{#1}_{2+} + \alpha\beta$	$\sigma^{#1}_{2-} + \alpha\beta\chi$	$\sigma^{#2}_{2-} + \alpha\beta\chi$	$\tau^{#1}_{2-} + \alpha\beta\chi$	$\tau^{#2}_{2-} + \alpha\beta\chi$
$\sigma^{#1}_{2+} + \alpha\beta$	$\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	$0$	$0$	$0$	$0$
$\sigma^{#2}_{2+} + \alpha\beta$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	$\frac{4k^2}{(1+2k^2)^2t_1}$	$0$	$0$	$0$	$0$
$\tau^{#1}_{2+} + \alpha\beta$	$0$	$0$	$0$	$0$	$0$	$0$
$\tau^{#2}_{2+} + \alpha\beta$	$0$	$0$	$0$	$0$	$0$	$0$
$\sigma^{#1}_{2-} + \alpha\beta\chi$	$0$	$0$	$0$	$0$	$0$	$0$
$\sigma^{#2}_{2-} + \alpha\beta\chi$	$0$	$0$	$0$	$0$	$0$	$0$
$\tau^{#1}_{2-} + \alpha\beta\chi$	$0$	$0$	$0$	$0$	$0$	$0$
$\tau^{#2}_{2-} + \alpha\beta\chi$	$0$	$0$	$0$	$0$	$0$	$0$

Massive and massless spectra



Massive particle	
Pole residue:	$-\frac{1}{r_2} > 0$
Polarisations:	1
Square mass:	$\frac{t_1}{r_2} > 0$
Spin:	0
Parity:	Odd

(No massless particles)

Unitarity conditions

$r_2 < 0 \&\& t_1 < 0$