

Particle spectrograph

Wave operator and propagator

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

$\sigma_{1+}^{\#1} \dag^{\alpha\beta}$	$\sigma_{1+}^{\#2}$	$\tau_{1+}^{\#1} \dag^{\alpha\beta}$	$\sigma_{1-}^{\#1} \alpha$	$\sigma_{1-}^{\#2} \alpha$	$\tau_{1-}^{\#1} \alpha$	$\tau_{1-}^{\#2} \alpha$
0	$-\frac{\sqrt{2}}{t_1+k^2} \frac{k}{t_1}$	$-\frac{i \sqrt{2} k}{t_1+k^2} \frac{k}{t_1}$	0	0	0	0
$\sigma_{1+}^{\#2} \dag^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2} \frac{1}{t_1}$	$-\frac{i k}{(1+k^2)^2} t_1$	0	0	0	0
$\tau_{1+}^{\#1} \dag^{\alpha\beta}$	$-\frac{i \sqrt{2} k}{t_1+k^2} \frac{k}{t_1}$	$-\frac{k^2}{(1+k^2)^2} t_1$	0	0	0	0
$\sigma_{1-}^{\#1} \dag^\alpha$	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2} \frac{k}{t_1}$	0	$\frac{2ik}{t_1+2k^2} \frac{k}{t_1}$
$\sigma_{1-}^{\#2} \dag^\alpha$	0	0	$\frac{\sqrt{2}}{t_1+2k^2} \frac{k}{t_1}$	0	$\frac{i \sqrt{2} k}{(1+2k^2)^2} \frac{k}{t_1}$	0
$\tau_{1-}^{\#1} \dag^\alpha$	0	0	0	0	0	0
$\tau_{1-}^{\#2} \dag^\alpha$	0	0	$-\frac{2ik}{t_1+2k^2} \frac{k}{t_1}$	$-\frac{i \sqrt{2} k}{(1+2k^2)^2} \frac{k}{t_1}$	0	$\frac{2k^2}{(1+2k^2)^2} \frac{k}{t_1}$

Quadratic (free) action

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

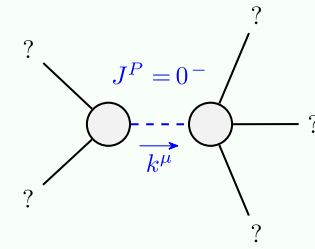
$\omega_{1+}^{\#1} \dag^{\alpha\beta}$	$\omega_{1+}^{\#2}$	$f_{1+}^{\#1} \dag^{\alpha\beta}$	$\omega_{1-}^{\#1} \alpha$	$\omega_{1-}^{\#2} \alpha$	$f_{1-}^{\#1} \alpha$	$f_{1-}^{\#2} \alpha$
$-\frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{i k t_1}{\sqrt{2}}$	0	0	0	0
$\omega_{1+}^{\#2} \dag^{\alpha\beta}$	0	0	0	0	0	0
$f_{1+}^{\#1} \dag^{\alpha\beta}$	0	0	0	0	0	0
$\omega_{1-}^{\#1} \dag^\alpha$	0	0	$-\frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0	$i k t_1$
$\omega_{1-}^{\#2} \dag^\alpha$	0	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
$f_{1-}^{\#1} \dag^\alpha$	0	0	0	0	0	0
$f_{1-}^{\#2} \dag^\alpha$	0	0	$-i k t_1$	0	0	0

$\omega_{0+}^{\#1} \dag$	$\omega_{0+}^{\#1}$	$f_{0+}^{\#1} \dag$	$\omega_{0-}^{\#1}$
-t ₁	i √2 k t ₁	0	0
$\omega_{0+}^{\#1} \dag$	-i √2 k t ₁	-2 k ² t ₁	0
$\omega_{0+}^{\#2} \dag$	0	0	0
$\omega_{0-}^{\#1} \dag$	0	0	k ² r ₂ - t ₁

$\omega_{2+}^{\#1} \dag^{\alpha\beta}$	$\omega_{2+}^{\#1}$	$f_{2+}^{\#1} \dag^{\alpha\beta}$	$\omega_{2-}^{\#1} \alpha\beta\chi$
$-\frac{i k t_1}{\sqrt{2}}$	$-\frac{i k t_1}{\sqrt{2}}$	$k^2 t_1$	0
$\omega_{2+}^{\#1} \dag^{\alpha\beta}$	0	0	0
$\omega_{2-}^{\#1} \dag^{\alpha\beta\chi}$	0	0	$\frac{t_1}{2}$

$\sigma_{2+}^{\#1} \dag^{\alpha\beta}$	$\tau_{2+}^{\#1} \dag^{\alpha\beta}$	$\sigma_{2-}^{\#1} \alpha\beta\chi$
$\frac{2}{(1+2k^2)^2} \frac{k}{t_1}$	$-\frac{2 i \sqrt{2} k}{(1+2k^2)^2} \frac{k}{t_1}$	0
$\tau_{2+}^{\#1} \dag^{\alpha\beta}$	$\frac{2 i \sqrt{2} k}{(1+2k^2)^2} \frac{k}{t_1}$	0
$\sigma_{2-}^{\#1} \dag^{\alpha\beta\chi}$	0	$\frac{2}{t_1}$

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 (see below)

Unitarity conditions

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