

Particle spectrograph

Wave operator and propagator

Source constraints		
SO(3) irreps	Fundamental fields	Multiplicities
$\sigma_0^{\#1} == 0$	$\epsilon \eta_{\alpha\beta\chi\delta} \partial^\delta \sigma^{\alpha\beta\chi} == 0$	1
$\tau_{0+}^{\#2} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$	1
$\tau_{0+}^{\#1} - 2 \, i \, k \, \sigma_{0+}^{\#1} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau^\alpha_\alpha$	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
$\tau_{1-}^{\#1\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\beta\alpha}$	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
$\tau_{2+}^{\#1\alpha\beta} - 2 \, i \, k \, \sigma_{2+}^{\#1\alpha\beta} == 0$	$-i \, (4 \, \partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2 \, \partial_\delta \partial^\delta \partial^\beta \partial^\alpha \tau^\chi_\chi -$ $3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi} - 3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} -$ $3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi} - 3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha} +$ $3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\beta\alpha} +$ $4 \, i \, k^\chi \, \partial_\epsilon \partial_\chi \partial^\beta \partial^\alpha \sigma^\delta_\epsilon -$ $6 \, i \, k^\chi \, \partial_\epsilon \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon} -$ $6 \, i \, k^\chi \, \partial_\epsilon \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon} +$ $2 \, \eta^{\alpha\beta} \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} +$ $6 \, i \, k^\chi \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\alpha\delta\beta} +$ $6 \, i \, k^\chi \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\beta\delta\alpha} -$ $2 \, \eta^{\alpha\beta} \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \tau^\chi_\chi -$ $4 \, i \, \eta^{\alpha\beta} \, k^\chi \, \partial_\phi \partial^\phi \partial_\epsilon \partial_\chi \sigma^\delta_\epsilon)$	5
Total constraints/gauge generators:		17

$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1-}^{\#1} \dagger^{\alpha}$	$\sigma_{1-}^{\#2} \dagger^{\alpha}$	$\tau_{1-}^{\#1} \dagger^{\alpha}$	$\tau_{1-}^{\#2} \dagger^{\alpha}$
$\frac{1}{k^2 (2 \, r_1 + r_5)}$	$\frac{1}{\sqrt{2} \, (k^2 + k^4) (2 \, r_1 + r_5)}$	$\frac{i}{\sqrt{2} \, (k + k^3) (2 \, r_1 + r_5)}$	0	0	0	0
$\frac{1}{\sqrt{2} \, (k^2 + k^4) (2 \, r_1 + r_5)}$	$\frac{6 \, k^2 (2 \, r_1 + r_5) + t_1}{2 \, (k + k^3)^2 (2 \, r_1 + r_5) t_1}$	$\frac{i \, (6 \, k^2 (2 \, r_1 + r_5) + t_1)}{2 \, k (1 + k^2)^2 (2 \, r_1 + r_5) t_1}$	0	0	0	0
$-\frac{i}{\sqrt{2} \, (k + k^3) (2 \, r_1 + r_5)}$	$-\frac{i \, (6 \, k^2 (2 \, r_1 + r_5) + t_1)}{2 \, k (1 + k^2)^2 (2 \, r_1 + r_5) t_1}$	$\frac{6 \, k^2 (2 \, r_1 + r_5) + t_1}{2 \, (1 + k^2)^2 (2 \, r_1 + r_5) t_1}$	0	$\frac{\sqrt{2}}{t_1 + 2 \, k^2 t_1}$	$\frac{\sqrt{2}}{t_1 + 2 \, k^2 t_1}$	$\frac{2 \, i \, k}{t_1 + 2 \, k^2 t_1}$
0	0	0	0	0	0	0
0	0	0	$\frac{\sqrt{2}}{t_1 + 2 \, k^2 t_1}$	0	0	$-\frac{i \, \sqrt{2} \, k (2 \, k^2 (r_1 + r_5) + t_1)}{(t_1 + 2 \, k^2 t_1)^2}$
0	0	0	0	0	0	0
0	0	0	$-\frac{2 \, i \, k}{t_1 + 2 \, k^2 t_1}$	$\frac{i \, \sqrt{2} \, k (2 \, k^2 (r_1 + r_5) + t_1)}{(t_1 + 2 \, k^2 t_1)^2}$	0	$\frac{-4 \, k^4 (r_1 + r_5) + 2 \, k^2 t_1}{(t_1 + 2 \, k^2 t_1)^2}$

Quadratic (free) action

$$S == \iiint (\frac{1}{3} \tau_{\alpha\beta} \omega^\theta_{,\theta} + 3 f^{\alpha\beta} \tau_{\alpha\beta} + 3 \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - 6 t_1 \omega^\theta_{,\alpha} \partial_\theta f^{\alpha\iota} + 6 t_1 \omega^\theta_{,\iota} \partial_\theta f^\alpha_{,\alpha} - 3 t_1 \partial_\iota f^\theta_{,\theta} \partial^\iota f^\alpha_{,\alpha} - 3 t_1 \partial_\iota f^{\alpha\iota} \partial_\theta f^\theta_{,\alpha} + 6 t_1 \partial^\iota f^\alpha_{,\alpha} \partial_\theta f^\theta_{,\iota} + 2 t_1 \omega_{\theta\alpha} \partial^\theta f^{\alpha\iota} - 2 t_1 \partial_\alpha f_{,\theta} \partial^\theta f^{\alpha\iota} - 2 t_1 \partial_\alpha f_{,\theta\iota} \partial^\theta f^{\alpha\iota} + t_1 \partial_\iota f_{,\alpha} \partial^\theta f^{\alpha\iota} + 2 t_1 \partial_\iota f_{,\alpha\theta} \partial^\theta f^{\alpha\iota} + t_1 \partial_\iota f_{,\alpha\theta} \partial^\theta f^{\alpha\iota} + 2 t_1 \partial_\theta f_{,\alpha\iota} \partial^\theta f^{\alpha\iota} + t_1 \partial_\theta f_{,\iota\alpha} \partial^\theta f^{\alpha\iota} + t_1 \omega_{\alpha\iota\theta} (\omega^{\alpha\iota\theta} + 2 \partial^\theta f^{\alpha\iota}) + t_1 \omega_{\alpha\theta\iota} (\omega^{\alpha\iota\theta} + 4 \partial^\theta f^{\alpha\iota}) - 4 r_1 \partial_\beta \omega_{\alpha\iota\theta} \partial^\theta \omega^{\alpha\beta\iota} + 2 r_1 \partial_\beta \omega_{\alpha\theta\iota} \partial^\theta \omega^{\alpha\beta\iota} - 8 r_1 \partial_\beta \omega_{,\iota\theta\alpha} \partial^\theta \omega^{\alpha\beta\iota} - 2 r_1 \partial_\iota \omega_{\alpha\beta\theta} \partial^\theta \omega^{\alpha\beta\iota} + 2 r_1 \partial_\theta \omega_{\alpha\beta\theta} \partial^\theta \omega^{\alpha\beta\iota} + 2 r_1 \partial_\theta \omega_{\alpha\iota\beta} \partial^\theta \omega^{\alpha\beta\iota} + 3 r_5 \partial_\theta \omega^\kappa_{,\kappa} \partial^\theta \omega^\alpha_{,\alpha} - 3 r_5 \partial_\alpha \omega^{\alpha\iota\theta} \partial_\kappa \omega^\kappa_{,\theta} + 6 r_5 \partial^\theta \omega^\alpha_{,\alpha} \partial_\kappa \omega^\kappa_{,\iota} + 3 r_5 \partial_\alpha \omega^{\alpha\iota\theta} \partial_\kappa \omega^\kappa_{,\iota} - 6 r_5 \partial^\theta \omega^\alpha_{,\alpha} \partial_\kappa \omega^\kappa_{,\theta})) [t, x, y, z] dz dy dx dt$$

$\sigma_{0+}^{\#1} \dagger$	$\tau_{0+}^{\#1} \dagger$	$\tau_{0+}^{\#2} \dagger$	$\sigma_{0-}^{\#1} \dagger$
$-\frac{1}{(1+2 \, k^2)^2 t_1}$	$\frac{i \, \sqrt{2} \, k}{(1+2 \, k^2)^2 t_1}$	0	0
$-\frac{i \, \sqrt{2} \, k}{(1+2 \, k^2)^2 t_1}$	$-\frac{2 \, k^2}{(1+2 \, k^2)^2 t_1}$	0	0
0	0	0	0
0	0	0	0

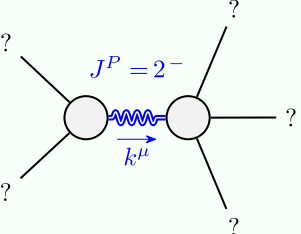
$\sigma_{2+}^{\#1} \dagger^{\alpha\beta}$	$\tau_{2+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{2-}^{\#1} \dagger^{\alpha\beta\chi}$
$\frac{2}{(1+2 \, k^2)^2 t_1}$	$-\frac{2 \, i \, \sqrt{2} \, k}{(1+2 \, k^2)^2 t_1}$	0
$\frac{2 \, i \, \sqrt{2} \, k}{(1+2 \, k^2)^2 t_1}$	$\frac{4 \, k^2}{(1+2 \, k^2)^2 t_1}$	0
$\sigma_{2-}^{\#1} \dagger^{\alpha\beta\chi}$	0	$\frac{2}{2 \, k^2 r_1 + t_1}$

$\omega_{2+}^{\#1} \dagger^{\alpha\beta}$	$f_{2+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2-}^{\#1} \dagger^{\alpha\beta\chi}$
$\frac{t_1}{2}$	$-\frac{i \, k t_1}{\sqrt{2}}$	0
$f_{2+}^{\#1} \dagger^{\alpha\beta}$	$\frac{i \, k t_1}{\sqrt{2}}$	0
$\omega_{2-}^{\#1} \dagger^{\alpha\beta\chi}$	0	$k^2 r_1 + \frac{t_1}{2}$

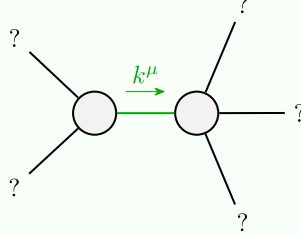
$\omega_{0+}^{\#1} \dagger$	$f_{0+}^{\#1} \dagger$	$f_{0+}^{\#2} \dagger$	$\omega_{0-}^{\#1} \dagger$
$-t_1$	$i \, \sqrt{2} \, k t_1$	0	0
$-i \, \sqrt{2} \, k t_1$	$-2 \, k^2 t_1$	0	0
0	0	0	0
0	0	0	0

$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1-}^{\#1} \dagger^{\alpha}$	$\omega_{1-}^{\#2} \dagger^{\alpha}$	$f_{1-}^{\#1} \dagger^{\alpha}$	$f_{1-}^{\#2} \dagger^{\alpha}$
$k^2 (2 \, r_1 + r_5) + \frac{t_1}{6}$	$-\frac{t_1}{3 \, \sqrt{2}}$	$-\frac{i \, k t_1}{3 \, \sqrt{2}}$	0	0	0	0
$-\frac{t_1}{3 \, \sqrt{2}}$	$\frac{t_1}{3}$	$\frac{i \, k t_1}{3}$	0	0	0	0
$\frac{i \, k t_1}{3 \, \sqrt{2}}$	$-\frac{1}{3} \frac{i \, k t_1}{k}$	$\frac{k^2 t_1}{3}$	0	0	0	0
0	0	0	$k^2 (r_1 + r_5) - \frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	$i \, k t_1$	0
0	0	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
0	0	0	0	0	0	0
0	0	0	$-i \, k t_1$	0	0	0

Massive and massless spectra



Massive particle	
Pole residue:	$-\frac{1}{r_1} > 0$
Polarisations:	5
Square mass:	$-\frac{t_1}{2 r_1} > 0$
Spin:	2
Parity:	Odd



Quadratic pole	
Pole residue:	$\frac{1}{(2 r_1 + r_5) t_1^2 p^2} > 0$
Polarisations:	2

Unitarity conditions

$r_1 < 0 \ \&\& \ r_5 > -2 \, r_1 \ \&\& \ t_1 > 0$