

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

$\sigma_{1+}^{\#1} + \alpha\beta$	$\sigma_{1+}^{\#2} + \alpha\beta$	$\tau_{1+}^{\#1} + \alpha\beta$	$\sigma_{1-}^{\#1} - \alpha$	$\tau_{1-}^{\#1} - \alpha$	$\tau_{1-}^{\#2} - \alpha$
0	$-\frac{\sqrt{2}}{t_1+k^2t_1}$	$-\frac{i\sqrt{2}k}{t_1+k^2t_1}$	0	0	0
$-\frac{\sqrt{2}}{t_1+k^2t_1}$	$\frac{-2k^2(2r_3+r_5)+t_1}{(1+k^2)^2t_1^2}$	$\frac{-2ik^3(2r_3+r_5)+ikt_1}{(1+k^2)^2t_1^2}$	0	0	0
$\frac{i\sqrt{2}k}{t_1+k^2t_1}$	$\frac{i(2k^3(2r_3+r_5)+kt_1)}{(1+k^2)^2t_1^2}$	$\frac{-2k^4(2r_3+r_5)+k^2t_1}{(1+k^2)^2t_1^2}$	0	0	0
0	0	0	$\frac{1}{k^2(2r_3+r_5)}$	0	$-\frac{i}{k(1+2k^2)(2r_3+r_5)}$
0	0	0	0	0	$\frac{6k^2(2r_3+r_5)+t_1}{\sqrt{2}k(1+2k^2)^2(2r_3+r_5)t_1}$
0	0	0	0	0	0
0	0	0	$\frac{i}{k(1+2k^2)(2r_3+r_5)}$	0	$\frac{6k^2(2r_3+r_5)+t_1}{(1+2k^2)^2(2r_3+r_5)t_1}$

Quadratic (free) action

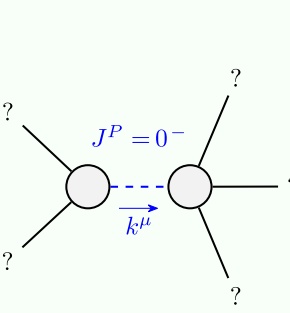
$$S = \iiint \left( f^{\alpha\beta} \tau_{\alpha\beta} + \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} + \right. \\ \frac{1}{6} t_1 (2 \omega^{\alpha\chi} \omega_{\alpha\beta} \omega_{\theta}^{\beta} - 4 \omega_{\alpha}^{\theta} \omega_{\theta}^{\beta} \partial_{\chi} f^{\alpha\chi} + 4 \omega_{\beta}^{\theta} \omega_{\theta}^{\beta} \partial_{\chi} f^{\alpha} - 2 \partial_{\chi} f^{\theta} \omega_{\theta}^{\beta} \\ \partial^{\chi} f^{\alpha} - 2 \partial_{\chi} f^{\alpha\chi} \partial_{\theta} f_{\alpha}^{\theta} + 4 \partial^{\chi} f^{\alpha} \partial_{\theta} f_{\alpha}^{\theta} - 6 \partial_{\alpha} f_{\beta}^{\theta} \partial^{\theta} f^{\alpha\chi} - \\ 3 \partial_{\alpha} f_{\theta\chi} \partial^{\theta} f^{\alpha\chi} + 3 \partial_{\chi} f_{\alpha\theta} \partial^{\theta} f^{\alpha\chi} + 3 \partial_{\theta} f_{\alpha\chi} \partial^{\theta} f^{\alpha\chi} + \\ 3 \partial_{\theta} f_{\alpha\beta\chi} \partial^{\theta} f^{\alpha\chi} + 6 \omega_{\alpha\theta\chi} (\omega^{\alpha\chi\theta} + 2 \partial^{\theta} f^{\alpha\chi})) + \\ \frac{1}{3} r_2 (4 \partial_{\beta} \omega_{\alpha\theta} \partial^{\theta} \omega^{\alpha\beta} - 2 \partial_{\beta} \omega_{\alpha\theta\chi} \partial^{\theta} \omega^{\alpha\chi} - \partial_{\chi} \omega_{\alpha\beta\theta} \partial^{\theta} \omega^{\alpha\beta} - \\ 2 \partial_{\theta} \omega_{\alpha\beta\chi} \partial^{\theta} \omega^{\alpha\beta\chi} - 2 \partial_{\theta} \omega_{\alpha\beta\chi} \partial^{\theta} \omega^{\alpha\beta\chi} - \\ 2 r_3 (\partial_{\beta} \omega_{\alpha\theta} \partial^{\theta} \omega^{\alpha\beta} + \partial_{\chi} \omega_{\beta\theta} \partial^{\theta} \omega^{\alpha\beta} + \partial_{\alpha} \omega^{\alpha\beta\chi} \partial_{\theta} \omega_{\chi}^{\beta} - \\ 2 \partial^{\chi} \omega^{\alpha\beta} \partial_{\alpha} \partial_{\theta} \omega_{\beta}^{\theta} + \partial_{\alpha} \omega^{\alpha\beta\chi} \partial_{\theta} \omega_{\chi}^{\beta} - \\ 2 \partial^{\chi} \omega^{\alpha\beta} \partial_{\alpha} \partial_{\theta} \omega_{\chi}^{\beta} + 2 \partial_{\beta} \omega_{\alpha\theta} \partial^{\theta} \omega^{\alpha\beta\chi}) + \\ r_5 (\partial_{\chi} \omega_{\theta}^{\kappa} \partial^{\theta} \omega_{\kappa}^{\alpha\chi} \partial_{\alpha} \omega_{\theta}^{\beta} - \partial_{\theta} \omega_{\alpha\chi}^{\kappa} \partial^{\theta} \omega_{\kappa}^{\alpha\chi} - (\partial_{\alpha} \omega^{\alpha\chi\theta} - 2 \partial^{\theta} \omega^{\alpha\chi}) \\ (\partial_{\kappa} \omega_{\theta}^{\kappa} - \partial_{\chi} \omega_{\theta}^{\chi})) [t, x, y, z] dz dy dx dt$$

$\omega_{1+}^{\#1} + \alpha\beta$	$\omega_{1+}^{\#2} + \alpha\beta$	$f_{1+}^{\#1} + \alpha\beta$	$\omega_{1-}^{\#1} - \alpha$	$\omega_{1-}^{\#2} - \alpha$	$f_{1-}^{\#2} - \alpha$
$k^2(2r_3+r_5) - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{ikt_1}{\sqrt{2}}$	0	0	0
$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0
$\frac{ikt_1}{\sqrt{2}}$	0	0	0	0	0
0	0	0	$k^2(2r_3+r_5) + \frac{t_1}{6}$	$\frac{t_1}{3\sqrt{2}}$	0
0	0	0	$\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	$\frac{1}{3}i\sqrt{2}kt_1$
0	0	0	0	0	0
0	0	0	$-\frac{1}{3}ikt_1$	$-\frac{1}{3}i\sqrt{2}kt_1$	$\frac{2k^2t_1}{3}$

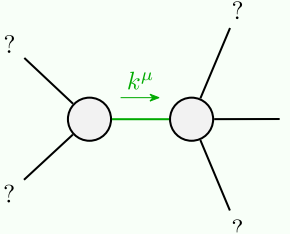
$\omega_{2+}^{\#1} + \alpha\beta$	$f_{2+}^{\#1} + \alpha\beta$	$\omega_{2-}^{\#1} - \alpha\beta\chi$
$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	0
$\frac{ikt_1}{\sqrt{2}}$	$k^2t_1$	0
0	0	$\frac{t_1}{2}$

$\omega_{0+}^{\#1} +$	$f_{0+}^{\#1} +$	$\omega_{0+}^{\#2} +$
$6k^2r_3$	0	0
0	0	0
0	0	0
0	0	$k^2r_2 - t_1$

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



Quadratic pole	
Pole residue:	$-\frac{1}{(2r_3+r_5)t_1^2} > 0$
Polarisations:	2

Unitarity conditions

$r_2 < 0 \ \&\& \ r_5 < -2\,r_3 \ \&\& \ t_1 < 0$