

Particle spectrograph

Wave operator and propagator

Source constraints			
SO(3) irreps	Fundamental fields		Multiplicities
$\sigma_0^{\#1} == 0$	$\partial_\beta \sigma^{\alpha\beta}_\alpha == 0$		1
$\tau_0^{\#1} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau^\alpha_\alpha$		1
$\tau_0^{\#2} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$		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
$\tau_2^{\#1\alpha\beta} - 2\,i\,k\,\sigma_2^{\#1\alpha\beta} == 0$	$-i\,(4\,\partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2\,\partial_\delta \partial^\delta \partial^\beta \partial^\alpha \tau^\chi_\chi -$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi} - 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} -$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi} - 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha} +$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\beta\alpha} +$ $4\,i\,k^\chi\,\partial_\epsilon \partial_\chi \partial^\beta \partial^\alpha \sigma^{\delta\epsilon}_\delta -$ $6\,i\,k^\chi\,\partial_\epsilon \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon}_\epsilon -$ $6\,i\,k^\chi\,\partial_\epsilon \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon}_\epsilon +$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} +$ $6\,i\,k^\chi\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\alpha\delta\beta} +$ $6\,i\,k^\chi\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\beta\delta\alpha}_\alpha -$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \tau^\chi_\chi -$ $4\,i\,\eta^{\alpha\beta}\,k^\chi\,\partial_\phi \partial^\phi \partial_\epsilon \partial_\chi \sigma^{\delta\epsilon}_\delta) == 0$	5	
Total constraints/gauge generators:			17

$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1-}^{\#1} \dagger^{\alpha}$	$\sigma_{1-}^{\#2} \dagger^{\alpha}$	$\tau_{1-}^{\#1} \dagger^{\alpha}$	$\tau_{1-}^{\#2} \dagger^{\alpha}$
$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2t_1}$	$-\frac{i\sqrt{2}k}{t_1+k^2t_1}$	0	0	0	0
$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2t_1}$	$-\frac{i(2k^3r_5+t_1)}{(1+k^2)^2t_1^2}$	0	0	0	0
$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{i\sqrt{2}k}{t_1+k^2t_1}$	$\frac{-2k^4r_5+k^2t_1}{(1+k^2)^2t_1^2}$	0	0	0	0
$\sigma_{1-}^{\#1} \dagger^{\alpha}$	0	0	$\frac{1}{k^2r_5}$	$-\frac{1}{\sqrt{2}(k^2r_5+2k^4r_5)}$	0	$-\frac{i}{kr_5+2k^3r_5}$
$\sigma_{1-}^{\#2} \dagger^{\alpha}$	0	0	$-\frac{1}{\sqrt{2}(k^2r_5+2k^4r_5)}$	$\frac{6k^2r_5+t_1}{2(k+2k^2)^2r_5t_1}$	0	$\frac{i(6k^2r_5+t_1)}{\sqrt{2}k(1+2k^2)^2r_5t_1}$
$\tau_{1-}^{\#1} \dagger^{\alpha}$	0	0	0	0	0	0
$\tau_{1-}^{\#2} \dagger^{\alpha}$	0	0	$\frac{i}{kr_5+2k^3r_5}$	$-\frac{i(6k^2r_5+t_1)}{\sqrt{2}k(1+2k^2)^2r_5t_1}$	0	$\frac{6k^2r_5+t_1}{(1+2k^2)^2r_5t_1}$

Quadratic (free) action

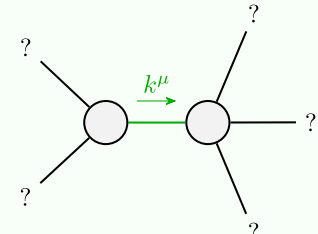
$$S = \iiint \! \! \! \int (\! f^{\alpha\beta} \tau_{\alpha\beta} + \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} +$$
$$\frac{1}{6} t_1 (2 \omega^{\alpha\iota}_\alpha \omega^{\theta}_\iota \omega^{\theta}_\theta - 4 \omega^{\theta}_\alpha \omega^{\alpha\iota}_\theta \partial_\iota f^{\alpha\iota}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

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

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

$\sigma_{0+}^{\#1} \dagger^{\alpha\beta}$	$\tau_{0+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{0-}^{\#1} \dagger^{\alpha\beta}$
$\sigma_{0+}^{\#1} \dagger^{\alpha\beta}$	0	0
$\tau_{0+}^{\#1} \dagger^{\alpha\beta}$	0	0
$\tau_{0+}^{\#2} \dagger^{\alpha\beta}$	0	0
$\sigma_{0-}^{\#1} \dagger^{\alpha\beta}$	0	$-\frac{1}{t_1}$

Massive and massless spectra



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

(No massive particles)

Unitarity conditions

$$r_5 < 0 \ \&\& \ t_1 < 0 \ || \ t_1 > 0$$