Particle spectrograph

Wave operator and propagator

Source constraints

SO(3) irreps	Fundamental fields	Multiplicities
$\sigma^{\#1}_{0^-} == 0$	$\epsilon\, \eta_{\alpha\beta\chi\delta}\, \partial^\delta \sigma^{\alpha\beta\chi} == 0$	1
$\tau^{\#2}_{0^+} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$	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
$\tau^{\#1\,\alpha\beta}_{1^+} == 0$	$\partial_\chi\partial^\alpha \tau^{\beta\chi} + \partial_\chi\partial^\beta \tau^{\chi\alpha} + \partial_\chi\partial^\chi \tau^{\alpha\beta} ==$ $\partial_\chi\partial^\alpha \tau^{\chi\beta} + \partial_\chi\partial^\beta \tau^{\alpha\chi} + \partial_\chi\partial^\chi \tau^{\beta\alpha}$	3
$\sigma^{\#2\,\alpha\beta}_{1^+} == 0$	$\partial_\delta\partial_\chi\partial^\alpha \sigma^{\beta\chi\delta} + \partial_\delta\partial^\delta\partial_\chi \sigma^{\alpha\beta\chi} == \partial_\delta\partial_\chi\partial^\beta \sigma^{\alpha\chi\delta}$	3
$\tau^{\#1\,\alpha\beta}_{2^+} == 0$	$4\, \partial_\delta\partial_\chi\partial^\beta\partial^\alpha \tau^{\chi\delta} + 2\, \partial_\delta\partial^\delta\partial^\beta\partial^\alpha \tau^\chi{}_\chi +$ $3\, \partial_\delta\partial^\delta\partial_\chi\partial^\chi \tau^{\alpha\beta} + 3\, \partial_\delta\partial^\delta\partial_\chi\partial^\chi \tau^{\beta\alpha} +$ $2\, \eta^{\alpha\beta}\, \partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi \tau^{\chi\delta} == 3\, \partial_\delta\partial^\delta\partial_\chi\partial^\alpha \tau^{\beta\chi} +$ $3\, \partial_\delta\partial^\delta\partial_\chi\partial^\alpha \tau^{\chi\beta} + 3\, \partial_\delta\partial^\delta\partial_\chi\partial^\beta \tau^{\alpha\chi} +$ $3\, \partial_\delta\partial^\delta\partial_\chi\partial^\beta \tau^{\chi\alpha} + 2\, \eta^{\alpha\beta}\, \partial_\epsilon\partial^\epsilon\partial_\delta\partial^\delta \tau^\chi{}_\chi$	5
$\sigma^{\#1\,\alpha\beta}_{2^+} == 0$	$3\, \partial_\delta\partial_\chi\partial^\alpha \sigma^{\beta\chi\delta} + 3\, \partial_\delta\partial_\chi\partial^\beta \sigma^{\alpha\chi\delta} +$ $2\, \eta^{\alpha\beta}\, \partial_\epsilon\partial^\epsilon\partial_\delta \sigma^{\chi\delta}{}_\chi == 2\, \partial_\delta\partial^\beta\partial^\alpha \sigma^{\chi\delta}{}_\chi +$ $3\, (\partial_\delta\partial^\delta\partial_\chi \sigma^{\alpha\chi\beta} + \partial_\delta\partial^\delta\partial_\chi \sigma^{\beta\chi\alpha})$	5
Total constraints/gauge generators:		25

	$\sigma^{\#1}_{1^+\,\alpha\beta}$	$\sigma^{\#2}_{1^+\,\alpha\beta}$	$\tau^{\#1}_{1^+\,\alpha\beta}$	$\sigma^{\#1}_{1^-\,\alpha}$	$\sigma^{\#2}_{1^-\,\alpha}$	$\tau^{\#1}_{1^-\,\alpha}$	$\tau^{\#2}_{1^-\,\alpha}$
$\sigma^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	$\frac{1}{k^2\,(2 r_1+r_5)}$	0	0	0	0	0	0
$\sigma^{\#2}_{1^+}{}^\dagger{}^{\alpha\beta}$	0	0	0	0	0	0	0
$\tau^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	0	0	0	0	0	0	0
$\sigma^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$\frac{1}{k^2\,(r_1+r_5)}$	$\frac{\sqrt{2}}{k^2\,(1+2k^2)\,(r_1+r_5)}$	0	$\frac{2 i}{k\,(1+2k^2)\,(r_1+r_5)}$
$\sigma^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$\frac{\sqrt{2}}{k^2\,(1+2k^2)\,(r_1+r_5)}$	$\frac{3k^2\,(r_1+r_5)+2t_3}{(k+2k^3)^2\,(r_1+r_5)\,t_3}$	0	$\frac{i\sqrt{2}\,(3k^2\,(r_1+r_5)+2t_3)}{k\,(1+2k^2)^2\,(r_1+r_5)\,t_3}$
$\tau^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	0	0	0	0
$\tau^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$-\frac{2 i}{k\,(1+2k^2)\,(r_1+r_5)}$	$-\frac{i\sqrt{2}\,(3k^2\,(r_1+r_5)+2t_3)}{k\,(1+2k^2)^2\,(r_1+r_5)\,t_3}$	0	$\frac{6k^2\,(r_1+r_5)+4t_3}{(1+2k^2)^2\,(r_1+r_5)\,t_3}$

Quadratic (free) action

$$S == \iiiint \Big(\tfrac{1}{3}\,(-2 t_3\, \omega^{\alpha\iota}{}_\alpha\, \omega_\iota{}^\kappa{}_\kappa + 3\, f^{\alpha\beta}\, \tau_{\alpha\beta} + 3\, \omega^{\alpha\beta\chi}\, \sigma_{\alpha\beta\chi} + 4 t_3\, \omega_\alpha{}^\kappa{}_\kappa\, \partial_\iota f^{\alpha\iota} - 4 t_3\, \omega_\iota{}^\kappa{}_\kappa\, \partial^\iota f^\alpha{}_\alpha + 2 t_3\, \partial_\iota f^\kappa{}_\kappa\, \partial^\iota f^\alpha{}_\alpha - 4 r_1\, \partial_\beta\omega_{\alpha\iota\theta}\, \partial^\theta\omega^{\alpha\beta\iota} + 2 r_1\, \partial_\beta\omega_{\alpha\theta\iota}\, \partial^\theta\omega^{\alpha\beta\iota} - 8 r_1\, \partial_\beta\omega_{\iota\theta\alpha}\, \partial^\theta\omega^{\alpha\beta\iota} - 2 r_1\, \partial_\iota\omega_{\alpha\beta\theta}\, \partial^\theta\omega^{\alpha\beta\iota} + 2 r_1\, \partial_\theta\omega_{\alpha\beta\iota}\, \partial^\theta\omega^{\alpha\beta\iota} + 2 r_1\, \partial_\theta\omega_{\alpha\iota\beta}\, \partial^\theta\omega^{\alpha\beta\iota} + 3 r_5\, \partial_\iota\omega_\theta{}^\kappa{}_\kappa\, \partial^\theta\omega^{\alpha\iota}{}_\alpha - 3 r_5\, \partial_\theta\omega_\iota{}^\kappa{}_\kappa\, \partial^\theta\omega^{\alpha\iota}{}_\alpha + 2 t_3\, \partial_\iota f^{\alpha\iota}\, \partial_\kappa f_\alpha{}^\kappa - 4 t_3\, \partial^\iota f^\alpha{}_\alpha\, \partial_\kappa f_\iota{}^\kappa - 3 r_5\, \partial_\alpha\omega^{\alpha\iota\theta}\, \partial_\kappa\omega_\iota{}^\kappa{}_\theta + 6 r_5\, \partial^\theta\omega^{\alpha\iota}{}_\alpha\, \partial_\kappa\omega_\iota{}^\kappa{}_\theta + 3 r_5\, \partial_\alpha\omega^{\alpha\iota\theta}\, \partial_\kappa\omega_\theta{}^\kappa{}_\iota - 6 r_5\, \partial^\theta\omega^{\alpha\iota}{}_\alpha\, \partial_\kappa\omega_\theta{}^\kappa{}_\iota)\Big)[t, x, y, z]\, dz\, dy\, dx\, dt$$

	$\omega^{\#1}_{1^+\,\alpha\beta}$	$\omega^{\#2}_{1^+\,\alpha\beta}$	$f^{\#1}_{1^+\,\alpha\beta}$	$\omega^{\#1}_{1^-\,\alpha}$	$\omega^{\#2}_{1^-\,\alpha}$	$f^{\#1}_{1^-\,\alpha}$	$f^{\#2}_{1^-\,\alpha}$
$\omega^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	$k^2\,(2 r_1+r_5)$	0	0	0	0	0	0
$\omega^{\#2}_{1^+}{}^\dagger{}^{\alpha\beta}$	0	0	0	0	0	0	0
$f^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	0	0	0	0	0	0	0
$\omega^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$k^2\,(r_1+r_5)+\frac{2 t_3}{3}$	$-\frac{\sqrt{2}\, t_3}{3}$	0	$-\frac{2}{3}\, i\, k\, t_3$
$\omega^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$-\frac{\sqrt{2}\, t_3}{3}$	$\frac{t_3}{3}$	0	$\frac{1}{3}\, i\, \sqrt{2}\, k\, t_3$
$f^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	0	0	0	0
$f^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$\frac{2\, i\, k\, t_3}{3}$	$-\frac{1}{3}\, i\, \sqrt{2}\, k\, t_3$	0	$\frac{2 k^2\, t_3}{3}$

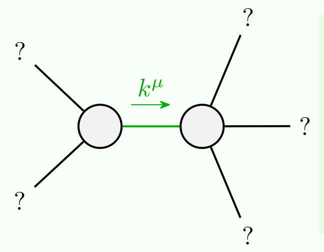
	$\sigma^{\#1}_{2^+\,\alpha\beta}$	$\tau^{\#1}_{2^+\,\alpha\beta}$	$\sigma^{\#1}_{2^-\,\alpha\beta\chi}$
$\sigma^{\#1}_{2^+}{}^\dagger{}^{\alpha\beta}$	0	0	0
$\tau^{\#1}_{2^+}{}^\dagger{}^{\alpha\beta}$	0	0	0
$\sigma^{\#1}_{2^-}{}^\dagger{}^{\alpha\beta\chi}$	0	0	$\frac{1}{k^2\, r_1}$

	$\omega^{\#1}_{2^+\,\alpha\beta}$	$f^{\#1}_{2^+\,\alpha\beta}$	$\omega^{\#1}_{2^-\,\alpha\beta\chi}$
$\omega^{\#1}_{2^+}{}^\dagger{}^{\alpha\beta}$	0	0	0
$f^{\#1}_{2^+}{}^\dagger{}^{\alpha\beta}$	0	0	0
$\omega^{\#1}_{2^-}{}^\dagger{}^{\alpha\beta\chi}$	0	0	$k^2\, r_1$

	$\omega^{\#1}_{0^+}$	$f^{\#1}_{0^+}$	$f^{\#2}_{0^+}$	$\omega^{\#1}_{0^-}$
$\omega^{\#1}_{0^+}{}^\dagger$	t_3	$-i\,\sqrt{2}\, k\, t_3$	0	0
$f^{\#1}_{0^+}{}^\dagger$	$i\,\sqrt{2}\, k\, t_3$	$2 k^2\, t_3$	0	0
$f^{\#2}_{0^+}{}^\dagger$	0	0	0	0
$\omega^{\#1}_{0^-}{}^\dagger$	0	0	0	0

	$\sigma^{\#1}_{0^+}$	$\tau^{\#1}_{0^+}$	$\tau^{\#2}_{0^+}$	$\sigma^{\#1}_{0^-}$
$\sigma^{\#1}_{0^+}{}^\dagger$	$\frac{1}{(1+2k^2)^2\, t_3}$	$-\frac{i\,\sqrt{2}\, k}{(1+2k^2)^2\, t_3}$	0	0
$\tau^{\#1}_{0^+}{}^\dagger$	$\frac{i\,\sqrt{2}\, k}{(1+2k^2)^2\, t_3}$	$\frac{2k^2}{(1+2k^2)^2\, t_3}$	0	0
$\tau^{\#2}_{0^+}{}^\dagger$	0	0	0	0
$\sigma^{\#1}_{0^-}{}^\dagger$	0	0	0	0

Massive and massless spectra



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

(No massive particles)

Unitarity conditions

$r_1 < 0\ \&\&\ (r_5 < -r_1\ \|\ r_5 > -2 r_1)\ \|\ r_1 > 0\ \&\&\ -2 r_1 < r_5 < -r_1$