Particle spectrograph

Wave operator and propagator

Source constraints

SO(3) irreps	Fundamental fields	Multiplicities
$\tau^{\#2}_{0^+} == 0$	$\partial_\beta\partial_\alpha\tau^{\alpha\beta} == 0$	1
$\tau^{\#1}_{0^+} == 0$	$\partial_\beta\partial_\alpha\tau^{\alpha\beta} == \partial_\beta\partial^\beta\tau^\alpha{}_\alpha$	1
$\tau^{\#2\,\alpha}_{1^-} + 2\,i\,k\,\sigma^{\#1\,\alpha}_{1^-} == 0$	$\partial_\chi\partial_\beta\partial^\alpha\tau^{\beta\chi} + 2\,(\partial_\delta\partial^\delta\partial_\chi\partial^\alpha\sigma^{\beta\chi}{}_\beta - \partial_\delta\partial^\delta\partial_\chi\partial_\beta\sigma^{\alpha\beta\chi} + \partial_\delta\partial^\delta\partial_\chi\partial^\chi\sigma^{\alpha\beta}{}_\beta) == \partial_\chi\partial^\chi\partial_\beta\tau^{\alpha\beta}$	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
$\sigma^{\#1\,\alpha}_{1^-} == \sigma^{\#2\,\alpha}_{1^-}$	$\partial_\chi\partial^\alpha\sigma^{\beta\chi}{}_\beta + \partial_\chi\partial^\chi\sigma^{\alpha\beta}{}_\beta == 0$	3
$\tau^{\#1\,\alpha\beta}_{1^+} + i\,k\,\sigma^{\#2\,\alpha\beta}_{1^+} == 0$	$\partial_\chi\partial^\alpha\tau^{\beta\chi} + \partial_\chi\partial^\beta\tau^{\chi\alpha} + \partial_\chi\partial^\chi\tau^{\alpha\beta} + 2\,\partial_\delta\partial_\chi\partial^\alpha\sigma^{\beta\chi\delta} + 2\,\partial_\delta\partial^\delta\partial_\chi\sigma^{\alpha\beta\chi} == \partial_\chi\partial^\alpha\tau^{\chi\beta} + \partial_\chi\partial^\beta\tau^{\alpha\chi} + \partial_\chi\partial^\chi\tau^{\beta\alpha} + 2\,\partial_\delta\partial_\chi\partial^\beta\sigma^{\alpha\chi\delta}$	3
$\tau^{\#1\,\alpha\beta}_{2^+} - 2\,i\,k\,\sigma^{\#1\,\alpha\beta}_{2^+} == 0$	$-i\,(4\,\partial_\delta\partial_\chi\partial^\beta\partial^\alpha\tau^{\chi\delta} + 2\,\partial_\delta\partial^\delta\partial^\beta\partial^\alpha\tau^\chi{}_\chi - 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\alpha\tau^{\beta\chi} - 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\beta\tau^{\alpha\chi} - 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\chi\tau^{\alpha\beta} + 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\chi\tau^{\beta\alpha} + 4\,i\,k^\chi\,\partial_\epsilon\partial_\chi\partial^\beta\partial^\alpha\sigma^{\delta\epsilon}{}_\delta - 6\,i\,k^\chi\,\partial_\epsilon\partial_\delta\partial_\chi\partial^\alpha\sigma^{\beta\delta\epsilon} - 6\,i\,k^\chi\,\partial_\epsilon\partial_\delta\partial_\chi\partial^\beta\sigma^{\alpha\delta\epsilon} + 2\,\eta^{\alpha\beta}\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi\tau^{\chi\delta} + 6\,i\,k^\chi\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi\sigma^{\alpha\delta\beta} + 6\,i\,k^\chi\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi\sigma^{\beta\delta\alpha} - 2\,\eta^{\alpha\beta}\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\delta\tau^\chi{}_\chi - 4\,i\,\eta^{\alpha\beta}\,k^\chi\,\partial_\phi\partial^\phi\partial_\epsilon\partial_\chi\sigma^{\delta\epsilon}{}_\delta) == 0$	5
Total constraints/gauge generators:		19

Quadratic (free) action

$$\mathcal{S} == \iiiint (f^{\alpha\beta}\,\tau_{\alpha\beta} + \omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} + \frac{1}{6}\,t_1\,(2\,\omega^{\alpha\prime}{}_\alpha\,\omega_\prime{}^\theta{}_\theta - 4\,\omega_\alpha{}^\theta{}_\theta\,\partial_\prime f^{\alpha\prime} + 4\,\omega_\prime{}^\theta{}_\theta\,\partial^\prime f^\alpha{}_\alpha - 2\,\partial_\prime f^\theta{}_\theta - \partial^\prime f^\alpha{}_\alpha - 2\,\partial_\prime f^{\alpha\prime}\,\partial_\theta f_\alpha{}^\theta + 4\,\partial^\prime f^\alpha{}_\alpha\,\partial_\theta f_\prime{}^\theta - 6\,\partial_\alpha f_{\prime\theta}\,\partial^\theta f^{\alpha\prime} - 3\,\partial_\alpha f_{\theta\prime}\,\partial^\theta f^{\alpha\prime} + 3\,\partial_\prime f_{\alpha\theta}\,\partial^\theta f^{\alpha\prime} + 3\,\partial_\theta f_{\alpha\prime}\,\partial^\theta f^{\alpha\prime} + 3\,\partial_\theta f_{\prime\alpha}\,\partial^\theta f^{\alpha\prime} + 6\,\omega_{\alpha\theta\prime}\,(\omega^{\alpha\prime\theta} + 2\,\partial^\theta f^{\alpha\prime})) - 4\,r_3\,(\partial_\beta\omega_\prime{}^\theta{}_\theta\,\partial^\prime\omega^{\alpha\beta}{}_\alpha + \partial_\alpha\omega^{\alpha\beta\prime}\,\partial_\theta\omega_\prime{}^\theta{}_\beta - 2\,\partial^\prime\omega^{\alpha\beta}{}_\alpha\,\partial_\theta\omega_\prime{}^\theta{}_\beta + \partial_\beta\omega_{\prime\theta\alpha}\,\partial^\theta\omega^{\alpha\beta\prime}) + \frac{1}{3}\,r_1\,(9\,\partial_\beta\omega_\prime{}^\theta{}_\theta\,\partial^\prime\omega^{\alpha\beta}{}_\alpha + 3\,\partial_\prime\omega_\beta{}^\theta{}_\theta\,\partial^\prime\omega^{\alpha\beta}{}_\alpha + 3\,\partial_\alpha\omega^{\alpha\beta\prime}\,\partial_\theta\omega_\beta{}^\theta{}_\prime - 6\,\partial^\prime\omega^{\alpha\beta}{}_\alpha\,\partial_\theta\omega_\beta{}^\theta{}_\prime + 9\,\partial_\alpha\omega^{\alpha\beta\prime}\,\partial_\theta\omega_\prime{}^\theta{}_\beta - 18\,\partial^\prime\omega^{\alpha\beta}{}_\alpha\,\partial_\theta\omega_\prime{}^\theta{}_\beta - 4\,\partial_\beta\omega_{\alpha\prime\theta}\,\partial^\theta\omega^{\alpha\beta\prime} + 2\,\partial_\beta\omega_{\alpha\theta\prime}\,\partial^\theta\omega^{\alpha\beta\prime} + 4\,\partial_\beta\omega_{\prime\theta\alpha}\,\partial^\theta\omega^{\alpha\beta\prime} - 2\,\partial_\prime\omega_{\alpha\beta\theta}\,\partial^\theta\omega^{\alpha\beta\prime} + 2\,\partial_\theta\omega_{\alpha\beta\prime}\,\partial^\theta\omega^{\alpha\beta\prime} + 2\,\partial_\theta\omega_{\alpha\prime\beta}\,\partial^\theta\omega^{\alpha\beta\prime}))[t,\,x,\,y,\,z]\,dt\,dz\,dy\,dx\,dt$$

	$\sigma^{\#1}_{1^+\,\alpha\beta}$	$\sigma^{\#2}_{1^+\,\alpha\beta}$	$\tau^{\#1}_{1^+\,\alpha\beta}$	$\sigma^{\#1}_{1^-\,\alpha}$	$\sigma^{\#2}_{1^-\,\alpha}$	$\tau^{\#1}_{1^-\,\alpha}$	$\tau^{\#2}_{1^-\,\alpha}$
$\sigma^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	0	$-\frac{\sqrt{2}}{t_1+k^2\,t_1}$	$-\frac{i\,\sqrt{2}\,k}{t_1+k^2\,t_1}$	0	0	0	0
$\sigma^{\#2}_{1^+}{}^\dagger{}^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2\,t_1}$	$\frac{-2\,k^2\,r_1+t_1}{(1+k^2)^2\,t_1{}^2}$	$-\frac{i\,(2\,k^3\,r_1-k\,t_1)}{(1+k^2)^2\,t_1{}^2}$	0	0	0	0
$\tau^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	$\frac{i\,\sqrt{2}\,k}{t_1+k^2\,t_1}$	$\frac{i\,(2\,k^3\,r_1-k\,t_1)}{(1+k^2)^2\,t_1{}^2}$	$\frac{-2\,k^4\,r_1+k^2\,t_1}{(1+k^2)^2\,t_1{}^2}$	0	0	0	0
$\sigma^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$\frac{6}{(3+4\,k^2)^2\,t_1}$	$\frac{6\,\sqrt{2}}{(3+4\,k^2)^2\,t_1}$	0	$\frac{12\,i\,k}{(3+4\,k^2)^2\,t_1}$
$\sigma^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$\frac{6\,\sqrt{2}}{(3+4\,k^2)^2\,t_1}$	$\frac{12}{(3+4\,k^2)^2\,t_1}$	0	$\frac{12\,i\,\sqrt{2}\,k}{(3+4\,k^2)^2\,t_1}$
$\tau^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	0	0	0	0
$\tau^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$-\frac{12\,i\,k}{(3+4\,k^2)^2\,t_1}$	$-\frac{12\,i\,\sqrt{2}\,k}{(3+4\,k^2)^2\,t_1}$	0	$\frac{24\,k^2}{(3+4\,k^2)^2\,t_1}$

	$\omega^{\#1}_{1^+\,\alpha\beta}$	$\omega^{\#2}_{1^+\,\alpha\beta}$	$f^{\#1}_{1^+\,\alpha\beta}$	$\omega^{\#1}_{1^-\,\alpha}$	$\omega^{\#2}_{1^-\,\alpha}$	$f^{\#1}_{1^-\,\alpha}$	$f^{\#2}_{1^-\,\alpha}$
$\omega^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	$k^2\,r_1 - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{i\,k\,t_1}{\sqrt{2}}$	0	0	0	0
$\omega^{\#2}_{1^+}{}^\dagger{}^{\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$f^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	$\frac{i\,k\,t_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$\frac{t_1}{6}$	$\frac{t_1}{3\,\sqrt{2}}$	0	$\frac{i\,k\,t_1}{3}$
$\omega^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$\frac{t_1}{3\,\sqrt{2}}$	$\frac{t_1}{3}$	0	$\frac{1}{3}\,i\,\sqrt{2}\,k\,t_1$
$f^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	0	0	0	0
$f^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$-\frac{1}{3}\,i\,k\,t_1$	$-\frac{1}{3}\,i\,\sqrt{2}\,k\,t_1$	0	$\frac{2\,k^2\,t_1}{3}$

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

	$\omega^{\#1}_{0^+\,}$	$f^{\#2}_{0^+\,}$	$f^{\#1}_{0^+\,}$	$\omega^{\#1}_{0^+\,}$
$\omega^{\#1}_{0^+}{}^\dagger$	0	0	0	$6\,k^2\,(-r_1+r_3)$
$f^{\#1}_{0^+}{}^\dagger$	0	0	0	0
$f^{\#2}_{0^+}{}^\dagger$	0	0	0	0
$\omega^{\#1}_{0^+}{}^\dagger$	0	0	0	0

	$\sigma^{\#1}_{0^+\,}$	$\tau^{\#1}_{0^+\,}$	$\tau^{\#2}_{0^+\,}$	$\sigma^{\#1}_{0^-\,}$
$\sigma^{\#1}_{0^+}{}^\dagger$	$\frac{1}{6\,k^2\,(-r_1+r_3)}$	0	0	0
$\tau^{\#1}_{0^+}{}^\dagger$	0	0	0	0
$\tau^{\#2}_{0^+}{}^\dagger$	0	0	0	0
$\sigma^{\#1}_{0^-}{}^\dagger$	0	0	0	$-\frac{1}{t_1}$

$\frac{t_1}{2}$	$-\frac{i\,k\,t_1}{\sqrt{2}}$	0
$\frac{i\,k\,t_1}{\sqrt{2}}$	$k^2\,t_1$	0
0	0	$k^2\,r_1 + \frac{t_1}{2}$

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

(No massless particles)

Unitarity conditions

$r_1 < 0 \;\&\&\; t_1 > 0$