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
$\sigma_{0^+}^{\#1} == 0$	$\partial_\beta \sigma^{\alpha\beta}{}_\alpha == 0$	1
$\tau_{1^-}^{\#2\,\alpha} + 2\,i\,k\,\sigma_{1^-}^{\#2\,\alpha} == 0$	$\partial_\chi \partial_\theta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta} + 2\,\partial_\delta \partial^\delta \partial_\chi \partial_\beta \sigma^{\alpha\beta\chi}$	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
$\tau_{1^+}^{\#1\,\alpha\beta} + i\,k\,\sigma_{1^+}^{\#2\,\alpha\beta} == 0$	$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\chi \tau^{\alpha\beta} + 2\,\partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2\,\partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi} == \partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha\chi} + 2\,\partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi}$	3
$\tau_{2^+}^{\#1\,\alpha\beta} - 2\,i\,k\,\sigma_{2^+}^{\#1\,\alpha\beta} == 0$	$-i\,(4\,\partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2\,\partial_\delta \partial^\delta \partial^\beta \partial^\alpha \tau^\chi{}_\chi - 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} - 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi} - 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\beta\alpha} + 4\,i\,k^\chi\,\partial_\epsilon \partial_\chi \partial^\beta \partial^\alpha \sigma^{\delta\epsilon}{}_\delta - 6\,i\,k^\chi\,\partial_\epsilon \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon} - 6\,i\,k^\chi\,\partial_\epsilon \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon} + 2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} + 6\,i\,k^\chi\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\alpha\delta\beta} + 6\,i\,k^\chi\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\beta\delta\alpha} - 2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \tau^\chi{}_\chi - 4\,i\,\eta^{\alpha\beta}\,k^\chi\,\partial_\phi \partial^\phi \partial_\epsilon \partial_\chi \sigma^{\delta\epsilon}{}_\delta) == 0$	5
Total constraints/gauge generators:		17

Quadratic (free) action

$$\mathcal{S} == \iiiint \tfrac{1}{6} (2\,t_1\,\omega^{\alpha\iota}{}_\alpha\,\omega_\iota{}^\theta{}_\theta + 6\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} - 4\,t_1\,\omega^\theta{}_\alpha{}^\iota\,\partial_\iota f^{\alpha\iota}{}_\theta + 4\,t_1\,\omega_\iota{}^\theta{}_\theta\,\partial^\iota f^\alpha{}_\alpha - 2\,t_1\,\partial_\iota f^{\alpha\iota}{}_\theta\,\partial^\theta f^\alpha{}_\alpha - 2\,t_1\,\partial_\iota f^{\alpha\iota}{}_\theta\,\partial^\theta f^\alpha{}_\alpha + 4\,t_1\,\partial^\iota f^\alpha{}_\alpha\,\partial_\theta f_\iota{}^\theta - 6\,t_1\,\partial_\alpha f_{\iota\theta}\,\partial^\theta f^{\alpha\iota} - 3\,t_1\,\partial_\alpha f_{\theta\iota}\,\partial^\theta f^{\alpha\iota} + 3\,t_1\,\partial_\iota f_{\alpha\theta}\,\partial^\theta f^{\alpha\iota} + 3\,t_1\,\partial_\theta f_{\alpha\iota}\,\partial^\theta f^{\alpha\iota} + 6\,t_1\,\omega_{\alpha\theta\iota}\,(\omega^{\alpha\iota\theta} + 2\,\partial^\theta f^{\alpha\iota}) + 8\,r_2\,\partial_\beta \omega_{\alpha\iota\theta}\,\partial^\theta \omega^{\alpha\beta\iota} - 4\,r_2\,\partial_\beta \omega_{\alpha\theta\iota}\,\partial^\theta \omega^{\alpha\beta\iota} + 4\,r_2\,\partial_\beta \omega_{\iota\theta\alpha}\,\partial^\theta \omega^{\alpha\beta\iota} - 2\,r_2\,\partial_\iota \omega_{\alpha\beta\theta}\,\partial^\theta \omega^{\alpha\beta\iota} + 2\,r_2\,\partial_\theta \omega_{\alpha\beta\iota}\,\partial^\theta \omega^{\alpha\beta\iota} - 4\,r_2\,\partial_\theta \omega_{\alpha\iota\beta}\,\partial^\theta \omega^{\alpha\beta\iota} + 6\,r_5\,\partial_\theta \omega^{\alpha\beta\iota}{}_\kappa\,\partial^\theta \omega^{\alpha\iota}{}_\alpha - 6\,r_5\,\partial_\theta \omega_\iota{}^\kappa{}_\theta\,\partial^\theta \omega^{\alpha\iota}{}_\alpha + 6\,r_5\,\partial_\alpha \omega^{\alpha\iota\theta}\,\partial_\kappa \omega_\iota{}^\kappa{}_\theta + 12\,r_5\,\partial^\theta \omega^{\alpha\iota}{}_\alpha\,\partial_\kappa \omega_\iota{}^\kappa{}_\theta + 6\,r_5\,\partial_\alpha \omega^{\alpha\iota\theta}\,\partial_\kappa \omega_\theta{}^\kappa{}_\iota - 12\,r_5\,\partial^\theta \omega^{\alpha\iota}{}_\alpha\,\partial_\kappa \omega_\theta{}^\kappa{}_\iota)\,[t, x, y, z]\,dz\,dy\,dx\,dt$$

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

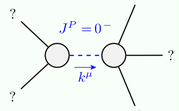
	$\sigma_{2^+}^{\#1\,\alpha\beta\chi}$	$\tau_{2^+}^{\#1\,\alpha\beta}$	$\sigma_{2^-}^{\#1\,\alpha\beta\chi}$
$\sigma_{2^+}^{\#1\,\alpha\beta}\,\dagger^{\alpha\beta}$	$\frac{2}{(1 + 2\,k^2)^2\,t_1}$	$-\frac{2\,i\,\sqrt{2}\,k}{(1 + 2\,k^2)^2\,t_1}$	0
$\tau_{2^+}^{\#1\,\alpha\beta}\,\dagger^{\alpha\beta}$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

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}\,\dagger$	0	0	0	$k^2\,r_2 - t_1$
$f_{0^+}^{\#1}\,\dagger$	0	0	0	0
$f_{0^+}^{\#2}\,\dagger$	0	0	0	0
$\omega_{0^-}^{\#1}\,\dagger$	$k^2\,r_2 - t_1$	0	0	$\frac{1}{k^2\,r_2 - t_1}$

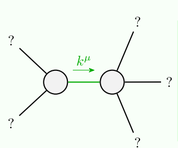
	$\omega_{2^+}^{\#1\,\alpha\beta}$	$f_{2^+}^{\#1\,\alpha\beta}$	$\omega_{2^-}^{\#1\,\alpha\beta\chi}$
$\omega_{2^+}^{\#1}\,\dagger^{\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{i\,k\,t_1}{\sqrt{2}}$	0
$f_{2^+}^{\#1}\,\dagger^{\alpha\beta}$	$\frac{i\,k\,t_1}{\sqrt{2}}$	$k^2\,t_1$	0
$\omega_{2^-}^{\#1}\,\dagger^{\alpha\beta\chi}$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

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

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:	$-\frac{1}{r_5\,{t_1}^2} > 0$
Polarisations:	2

Unitarity conditions

$r_2 < 0$ && $r_5 < 0$ && $t_1 < 0$