Particle spectrograph

Wave operator and propagator

Source constraints

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

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

Quadratic (free) action

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

	$\mathcal{A}_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\mathcal{A}_{0^+}^{\#2}$
$\mathcal{A}_{0^+}^{\#1}\dagger$	$-t_1$	$i\sqrt{2}\,k\,t_1$	0	0
$f_{0^+}^{\#1}\dagger$	$-i\sqrt{2}\,k\,t_1$	$-2 k^2 t_1$	0	0
$f_{0^+}^{\#2}\dagger$	0	0	0	0
$\mathcal{A}_{0^-}^{\#1}\dagger$	0	0	0	0

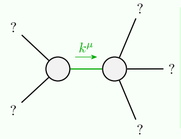
	$\mathcal{A}_{2^+}^{\#1\,\alpha\beta}$	$f_{2^+}^{\#1\,\alpha\beta}$	$\mathcal{A}_{2^-}^{\#1}{}_{\alpha\beta\chi}$
$\mathcal{A}_{2^+}^{\#1\,\alpha\beta}\dagger$	$\frac{t_1}{2}$	$-\frac{i k t_1}{\sqrt{2}}$	0
$f_{2^+}^{\#1\,\alpha\beta}\dagger$	$\frac{i k t_1}{\sqrt{2}}$	$k^2 t_1$	0
$\mathcal{A}_{2^-}^{\#1}\dagger^{\alpha\beta\chi}$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

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

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

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

Massive and massless spectra



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

(No massive particles)

Unitarity conditions

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