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

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

Quadratic (free) action

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

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

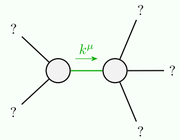
	$\omega_{2^+}^{\#1\,\alpha\beta}$	$f_{2^+}^{\#1\,\alpha\beta}$	$\omega_{2^-}^{\#1}{}_{\alpha\beta\chi}$
$\omega_{2^+}^{\#1}\dagger^{\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{i\,k\,t_1}{\sqrt{2}}$	0
$f_{2^+}^{\#1}\dagger^{\alpha\beta}$	$\frac{i\,k\,t_1}{\sqrt{2}}$	$k^2\,t_1$	0
$\omega_{2^-}^{\#1}\dagger^{\alpha\beta\chi}$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

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

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

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

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