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
$\tau_{1^-}^{\#2\,\alpha} == 0$	$\partial_\chi \partial_\beta \sigma^{\alpha\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta}$	3
$\tau_{1^-}^{\#1\,\alpha} == 0$	$\partial_\chi \partial_\beta \sigma^{\alpha\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\beta\alpha}$	3
$\sigma_1^{\#2\,\alpha} == 0$	$\partial_\chi \partial_\beta \sigma^{\alpha\beta\chi} == 0$	3
$\tau_{1^+}^{\#1\,\alpha\beta} + i\,k\,\sigma_{1^+}^{\#2\,\alpha\beta} == 0$	$\partial_\chi \sigma^{\alpha\chi} \tau^{\beta\chi} + \partial_\chi \sigma^{\beta\chi} \tau^{\alpha\beta} + \partial_\chi \partial^\chi \tau^{\alpha\beta} ==$ $2\,\partial_\delta \partial_\chi \sigma^{\alpha\chi} \sigma^{\beta\chi\delta} + 2\,\partial_\delta \partial_\chi \sigma^{\beta\chi} \sigma^{\alpha\chi\delta} == \partial_\chi \sigma^{\alpha\chi} \tau^{\beta\delta} + \partial_\chi \sigma^{\beta\chi} \tau^{\alpha\delta} +$ $\partial_\chi \partial^\chi \tau^{\beta\alpha} + 2\,\partial_\delta \partial_\chi \sigma^{\beta\delta} \sigma^{\alpha\chi\delta}$	3
$\sigma_2^{\#1\,\alpha\beta\chi} == 0$	$3\,\partial_\epsilon \partial_\delta \partial_\chi \sigma^{\alpha\delta\epsilon} \sigma^{\beta\delta\epsilon} + 3\,\partial_\epsilon \partial^\epsilon \partial^\chi \sigma^{\alpha\delta} \sigma^{\beta\delta}{}_\delta +$ $2\,\partial_\epsilon \partial_\delta \partial^\alpha \sigma^{\chi\epsilon} \sigma^{\beta\chi\delta} + 4\,\partial_\epsilon \partial_\delta \partial^\chi \sigma^{\alpha\epsilon} \sigma^{\beta\chi\delta} +$ $2\,\partial_\epsilon \partial_\delta \partial^\chi \sigma^{\alpha\chi} \sigma^{\beta\epsilon\delta} + 4\,\partial_\epsilon \partial_\delta \partial^\chi \sigma^{\beta\chi} \sigma^{\alpha\epsilon\delta} +$ $2\,\partial_\epsilon \partial_\delta \partial^\chi \sigma^{\beta\chi} \sigma^{\alpha\delta\epsilon} + 2\,\partial_\epsilon \partial_\delta \partial^\chi \sigma^{\alpha\chi} \sigma^{\beta\delta\epsilon} +$ $3\,\eta^{\beta\chi}\,\partial_\epsilon \partial_\phi \partial^\alpha \partial_\delta \sigma^{\epsilon\phi}{}_\delta + 3\,\eta^{\alpha\chi}\,\partial_\epsilon \partial_\phi \partial^\beta \partial_\delta \sigma^{\epsilon\phi}{}_\delta +$ $3\,\eta^{\beta\chi}\,\partial_\phi \partial^\beta \partial_\epsilon \partial^\alpha \sigma^{\epsilon\phi}{}_\delta == 3\,\partial_\epsilon \partial^\epsilon \partial^\chi \partial^\beta \sigma^{\alpha\delta}{}_\delta +$ $2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\beta\chi\delta} + 4\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \sigma^{\beta\alpha\chi} +$ $2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \sigma^{\alpha\beta\chi} + 2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \sigma^{\alpha\chi\beta} +$ $4\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \sigma^{\alpha\beta\chi} + 2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \sigma^{\alpha\chi\beta} +$ $3\,\eta^{\alpha\chi}\,\partial_\phi \partial^\beta \partial_\epsilon \partial^\epsilon \sigma^{\phi\delta}{}_\delta + 3\,\eta^{\beta\chi}\,\partial_\phi \partial^\alpha \partial_\epsilon \partial^\epsilon \sigma^{\phi\delta}{}_\delta +$ $3\,\eta^{\alpha\chi}\,\partial_\phi \partial^\beta \partial_\epsilon \partial^\epsilon \sigma^{\phi\delta}{}_\delta$	5
$\tau_{2^+}^{\#1\,\alpha\beta} == 0$	$4\,\partial_\theta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2\,\partial_\theta \partial^\beta \partial^\alpha \partial^\chi \tau^\chi{}_\chi +$ $3\,\partial_\theta \partial^\chi \partial^\alpha \tau^{\chi\beta} + 3\,\partial_\theta \partial^\chi \partial^\beta \tau^{\chi\alpha} +$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \tau^{\chi\delta} ==$ $3\,\partial_\theta \partial^\chi \partial^\alpha \tau^{\beta\chi} + 3\,\partial_\theta \partial^\chi \partial^\beta \tau^{\alpha\chi} + 3\,\partial_\theta \partial^\chi \partial_\chi \partial^\beta \tau^{\alpha\chi} +$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \tau^\chi{}_\chi$	5
	Total constraints/gauge generators:	25

Quadratic (free) action

$$S == \int\int\int \frac{1}{6} \left(6\, f^{\alpha\beta}{}_{\tau_{\alpha\beta}} + 6\, \omega^{\alpha\beta\chi}{}_{\sigma_{\alpha\beta\chi}} - 3\, r_3\, \partial_\theta \omega_{\iota}{}^{\theta}{}_{\alpha}{}^{\theta}\, \partial^\iota \omega^{\alpha\beta}{}_{\beta}{}^{\theta} - 3\, r_3\, \partial_\iota \omega^{\alpha\beta}{}_{\alpha}{}^{\theta}\, \partial_\theta \omega_{\beta}{}^{\iota}{}_{\theta} - 6\, r_3\, \partial^\iota \omega^{\alpha\beta}{}_{\beta}{}^{\theta}\, \partial_\theta \omega_{\iota}{}^{\theta}{}_{\alpha} + 3\, r_3\, \partial_\alpha \omega^{\alpha\beta\iota}\, \partial_\theta \omega_{\iota}{}^{\theta}{}_{\beta} + 6\, r_3\, \partial^\iota \omega^{\alpha\beta}{}_{\alpha}\, \partial_\theta \omega_{\iota}{}^{\theta}{}_{\beta} + 4\, t_2\, \omega_{\iota\beta\alpha}\, \partial^\beta f^{\alpha\iota} + 2\, t_2\, \partial_\alpha f_{\iota\theta}\, \partial^\beta f^{\alpha\iota} - t_2\, \partial_\alpha f_{\theta\iota}\, \partial^\beta f^{\alpha\iota} - t_2\, \partial_\iota f_{\alpha\theta}\, \partial^\beta f^{\alpha\iota} + t_2\, \partial_\theta f_{\alpha\iota}\, \partial^\beta f^{\alpha\iota} - t_2\, \partial_\theta f_{\iota\alpha}\, \partial^\beta f^{\alpha\iota} - 4\, t_2\, \omega_{\alpha\theta\iota}\, (\omega^{\alpha\iota\theta} + \partial^\theta f^{\alpha\iota}) + 2\, t_2\, \omega_{\alpha\iota\theta}\, (\omega^{\alpha\iota\theta} + 2\, \partial^\theta f^{\alpha\iota}) + 8\, r_2\, \partial_\beta \omega_{\alpha\theta}\, \partial^\theta \omega^{\alpha\beta\iota} - 4\, r_2\, \partial_\beta \omega_{\iota\theta\alpha}\, \partial^\theta \omega^{\alpha\beta\iota} + 4\, r_2\, \partial_\beta \omega_{\iota\theta\alpha}\, \partial^\theta \omega^{\alpha\beta\iota} - 24\, r_3\, \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_\iota \omega_{\kappa}{}^{\theta}\, \partial^\kappa \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} + 12\, r_5\, \partial^\theta \omega^{\alpha\iota}{}_{\alpha}\, \partial_\kappa \omega_{\theta}{}^{\kappa}{}_{\iota} \right) [t,\, x,\, y,\, z]\, dz\, dy\, dx\, dt$$

$\sigma_{1^+}^{\#1\,\alpha\beta}\,\dagger^{\alpha\beta}$

$\frac{1}{k^2\,(2\,r_3+r_5)}$	$-\frac{\sqrt{2}}{k^2\,(1+k^2)\,(2\,r_3+r_5)}$	$-\frac{i\,\sqrt{2}}{k\,(1+k^2)\,(2\,r_3+r_5)}$	0	0	0	0	0	0	0
$-\frac{\sqrt{2}}{k^2\,(1+k^2)\,(2\,r_3+r_5)}$	$\frac{3\,k^2\,(2\,r_3+r_5)+2\,t_2}{(k+k^3)^2\,(2\,r_3+r_5)^2}$	$\frac{i\,(3\,k^2\,(2\,r_3+r_5)+2\,t_2)}{k\,(1+k^2)^2\,(2\,r_3+r_5)^2}$	0	0	0	0	0	0	0
$-\frac{i\,\sqrt{2}}{k\,(1+k^2)\,(2\,r_3+r_5)}$	$-\frac{i\,(3\,k^2\,(2\,r_3+r_5)+2\,t_2)}{k\,(1+k^2)^2\,(2\,r_3+r_5)^2}$	$\frac{3\,k^2\,(2\,r_3+r_5)+2\,t_2}{(1+k^2)^2\,(2\,r_3+r_5)^2}$	0	0	0	0	0	0	0
0	0	0	0	$-\frac{2}{k^2\,(r_3+2\,r_5)}$	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

$\omega_{1^+}^{\#1\,\alpha\beta}\,\dagger^{\alpha\beta}$

$k^2\,(2\,r_3+r_5)+\frac{2\,t_2}{3}$	$\frac{\sqrt{2}\,t_2}{3}$	$-\frac{1}{3}\,i\,\sqrt{2}\,k\,t_2$	0	0	0	0	0	0	0
$\frac{\sqrt{2}\,t_2}{3}$	$\frac{t_2}{3}$	$-\frac{i\,t_2}{3}$	0	0	0	0	0	0	0
$-\frac{1}{3}\,i\,\sqrt{2}\,k\,t_2$	$\frac{i\,t_2}{3}$	$\frac{k^2\,t_2}{3}$	0	0	0	0	0	0	0
0	0	0	$\frac{1}{2}\,k^2\,(r_3+2\,r_5)$	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

$\sigma_0^{\#1}\,\dagger$ | $\tau_{0^+}^{\#1}\,\dagger^{\alpha\beta}$ | $\tau_{0^+}^{\#2}\,\dagger^{\alpha\beta}$ | $\sigma_{0^-}^{\#1}$

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	$\frac{1}{k^2\,r_2+t_2}$

$\omega_{2^+}^{\#1}\,\dagger^{\alpha\beta}$ | $f_{2^+}^{\#1}\,\dagger^{\alpha\beta}$ | $f_{2^+}^{\#2}\,\dagger^{\alpha\beta}$ | $\omega_{2^-}^{\#1}\,\dagger^{\alpha\beta\chi}$

$-\frac{3\,k^2\,r_3}{2}$	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

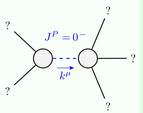
$\omega_{0^+}^{\#1}\,\dagger$ | $f_{0^+}^{\#1}\,\dagger$ | $f_{0^+}^{\#2}\,\dagger$ | $\omega_{0^-}^{\#1}\,\dagger$

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	$k^2\,r_2+t_2$

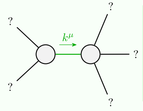
$\sigma_{2^+}^{\#1\,\alpha\beta}\,\dagger^{\alpha\beta\chi}$ | $\tau_{2^+}^{\#1\,\alpha\beta}\,\dagger^{\alpha\beta}$ | $\sigma_{2^-}^{\#1\,\alpha\beta}\,\dagger^{\alpha\beta\chi}$

$-\frac{2}{3\,k^2\,r_3}$	0	0
0	0	0
0	0	0

Massive and massless spectra



Massive particle	
Pole residue:	$-\frac{1}{r_2} > 0$
Polarisations:	1
Square mass:	$-\frac{t_2}{r_2} > 0$
Spin:	0
Parity:	Odd



Quadratic pole	
Pole residue:	$-\frac{1}{r_3\,(2\,r_3+r_5)\,(r_3+2\,r_5)\,p^2} > 0$
Polarisations:	2

Unitarity conditions

$$r_2 < 0 \,\&\&\, r_3 < 0 \,\&\&\, r_5 < -\frac{r_3}{2} \,\&\&\, t_2 > 0 \,\|\|\, r_2 < 0 \,\&\&\, r_3 < 0 \,\&\&\, r_5 > -2\,r_3 \,\&\&\, t_2 > 0 \,\|\|\, r_2 < 0 \,\&\&\, r_3 > 0 \,\&\&\, -2\,r_3 < r_5 < -\frac{r_3}{2} \,\&\&\, t_2 > 0$$