

Particle spectrograph

Wave operator and propagator

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

Quadratic (free) action

$$S = \iiint \Big(\frac{1}{6} \, (2\,t_1\,\omega^\alpha_\alpha\,\omega^\theta_{\theta} + 6\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} - 4\,t_1\,\omega^\theta_\alpha\,\partial_\theta f^{\alpha\chi} +$$

$$4\,t_1\,\omega^\theta_{\theta}\,\partial_\theta f^\alpha_\alpha - 2\,t_1\,\partial_\theta f^\theta_\theta\,\partial_\theta f^\alpha_\alpha - 24\,r_3\,\partial_\beta \omega^\theta_{\theta}\,\partial_\theta \omega^{\alpha\beta}_\alpha -$$

$$2\,t_1\,\partial_\theta f^{\alpha\chi}\,\partial_\theta f^\theta_\alpha + 4\,t_1\,\partial_\theta f^\alpha_\alpha\,\partial_\theta f^\theta_\theta - 24\,r_3\,\partial_\alpha \omega^{\alpha\beta\theta}_{\theta}\,\partial_\theta \omega^\theta_{\theta} +$$

$$48\,r_3\,\partial_\theta \omega^{\alpha\beta}_\alpha\,\partial_\theta \omega^\theta_{\theta} - 6\,t_1\,\partial_\alpha \partial_\theta f^\theta_\theta\,\partial^\theta f^{\alpha\chi} - 3\,t_1\,\partial_\alpha \partial_\theta f^\theta_{\theta}\,\partial^\theta f^{\alpha\chi} +$$

$$3\,t_1\,\partial_\theta f^\alpha_{\alpha\theta}\,\partial^\theta f^{\alpha\chi} + 3\,t_1\,\partial_\theta f^\alpha_{\alpha\chi}\,\partial^\theta f^{\alpha\chi} + 3\,t_1\,\partial_\theta f^\alpha_{\alpha}\,\partial^\theta f^{\alpha\chi} +$$

$$6\,t_1\,\omega_{\alpha\theta\theta}\,(\omega^{\alpha\theta\theta} + 2\,\partial^\theta f^{\alpha\chi}) + 8\,r_2\,\partial_\beta \omega_{\alpha\theta\theta}\,\partial^\theta \omega^{\alpha\beta\chi}_\chi + 2\,r_2\,\partial_\theta \omega_{\alpha\beta\theta}\,\partial^\theta \omega^{\alpha\beta\chi}_\chi -$$

$$4\,r_2\,\partial_\beta \omega_{\alpha\theta\theta}\,\partial^\theta \omega^{\alpha\beta\chi}_\chi + 4\,r_2\,\partial_\beta \omega_{\theta\alpha\theta}\,\partial^\theta \omega^{\alpha\beta\chi}_\chi + 2\,r_2\,\partial_\theta \omega_{\alpha\beta\theta}\,\partial^\theta \omega^{\alpha\beta\chi}_\chi -$$

$$\partial^\theta \omega^{\alpha\beta\chi}_\chi - 2\,r_2\,\partial_\theta \omega_{\alpha\beta\theta}\,\partial^\theta \omega^{\alpha\beta\chi}_\chi) \Big) [t,\,x,\,y,\,z] \,dz\,dy\,dx\,dt$$

$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1-}^{\#1} \dagger^\alpha$	$\sigma_{1-}^{\#2} \dagger^\alpha$	$\tau_{1-}^{\#1} \dagger^\alpha$	$\tau_{1-}^{\#2} \dagger^\alpha$
$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1-}^{\#1} \dagger^\alpha$	$\sigma_{1-}^{\#2} \dagger^\alpha$	$\tau_{1-}^{\#1} \dagger^\alpha$	$\tau_{1-}^{\#2} \dagger^\alpha$
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
$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2}t_1$	$\frac{ik}{(1+k^2)^2}t_1$	0	0	0	0
$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{i\sqrt{2}k}{t_1+k^2}t_1$	$-\frac{k^2}{(1+k^2)^2}t_1$	0	0	0	0
$\sigma_{1-}^{\#1} \dagger^\alpha$	0	0	$\frac{6}{(3+4k^2)^2}t_1$	$\frac{6\sqrt{2}}{(3+4k^2)^2}t_1$	0	$\frac{12ik}{(3+4k^2)^2}t_1$
$\sigma_{1-}^{\#2} \dagger^\alpha$	0	0	$\frac{6\sqrt{2}}{(3+4k^2)^2}t_1$	$\frac{12}{(3+4k^2)^2}t_1$	0	$\frac{12i\sqrt{2}k}{(3+4k^2)^2}t_1$
$\tau_{1-}^{\#1} \dagger^\alpha$	0	0	0	0	0	0
$\tau_{1-}^{\#2} \dagger^\alpha$	0	0	$-\frac{12ik}{(3+4k^2)^2}t_1$	$-\frac{12i\sqrt{2}k}{(3+4k^2)^2}t_1$	0	$-\frac{24k^2}{(3+4k^2)^2}t_1$

$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1-}^{\#1} \dagger^\alpha$	$\omega_{1-}^{\#2} \dagger^\alpha$	$f_{1-}^{\#1} \dagger^\alpha$	$f_{1-}^{\#2} \dagger^\alpha$
$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1-}^{\#1} \dagger^\alpha$	$\omega_{1-}^{\#2} \dagger^\alpha$	$f_{1-}^{\#1} \dagger^\alpha$	$f_{1-}^{\#2} \dagger^\alpha$
$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{t_1}{2}$	$-\frac{ik t_1}{\sqrt{2}}$	0	0	0	0
$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0
$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{ik t_1}{\sqrt{2}}$	0	0	0	0	0
$\omega_{1-}^{\#1} \dagger^\alpha$	0	0	$\frac{t_1}{6}$	$\frac{t_1}{3\sqrt{2}}$	0	$\frac{ik t_1}{3}$
$\omega_{1-}^{\#2} \dagger^\alpha$	0	0	$\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	0	$\frac{1}{3}i\sqrt{2}kt_1$
$f_{1-}^{\#1} \dagger^\alpha$	0	0	0	0	0	0
$f_{1-}^{\#2} \dagger^\alpha$	0	0	$-\frac{1}{3}ik t_1$	$-\frac{1}{3}i\sqrt{2}kt_1$	0	$\frac{2k^2t_1}{3}$

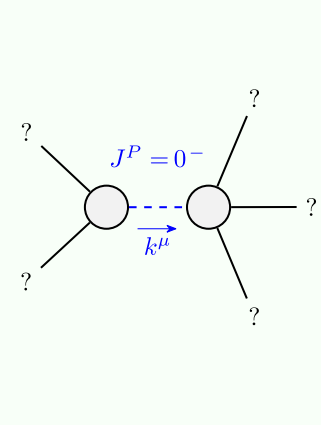
$\omega_{2+}^{\#1} \dagger^{\alpha\beta}$	$f_{2+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2-}^{\#1} \dagger^{\alpha\beta\chi}$
$\omega_{2+}^{\#1} \dagger^{\alpha\beta}$	$f_{2+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2-}^{\#1} \dagger^{\alpha\beta\chi}$
$\omega_{2+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{ik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

$\omega_{0+}^{\#1} \dagger^{\alpha\beta}$	$f_{0+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{0-}^{\#1} \dagger^{\alpha\beta\chi}$
$\omega_{0+}^{\#1} \dagger^{\alpha\beta}$	$f_{0+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{0-}^{\#1} \dagger^{\alpha\beta\chi}$
$\omega_{0+}^{\#1} \dagger^{\alpha\beta}$	0	0
$f_{0+}^{\#1} \dagger^{\alpha\beta}$	0	0
$f_{0+}^{\#2} \dagger^{\alpha\beta}$	0	0
$\omega_{0-}^{\#1} \dagger^{\alpha\beta\chi}$	0	$k^2 r_2 - t_1$

$\sigma_{0+}^{\#1} \dagger^{\alpha\beta}$	$\tau_{0+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{0+}^{\#2} \dagger^{\alpha\beta}$	$\sigma_{0-}^{\#1} \dagger^{\alpha\beta\chi}$
$\sigma_{0+}^{\#1} \dagger^{\alpha\beta}$	$\tau_{0+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{0+}^{\#2} \dagger^{\alpha\beta}$	$\sigma_{0-}^{\#1} \dagger^{\alpha\beta\chi}$
$\sigma_{0+}^{\#1} \dagger^{\alpha\beta}$	$\frac{1}{6k^2 r_3}$	0	0
$\tau_{0+}^{\#1} \dagger^{\alpha\beta}$	0	0	0
$\sigma_{0+}^{\#2} \dagger^{\alpha\beta}$	0	0	0
$\sigma_{0-}^{\#1} \dagger^{\alpha\beta\chi}$	0	0	$\frac{1}{k^2 r_2 - t_1}$

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

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

(no massless particles)

Unitarity conditions

$r_2 < 0 \ \&\& \ t_1 < 0$