

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
$\tau_{1-}^{\#2\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha_\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta}$	3
$\tau_{1-}^{\#1\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha_\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\beta\alpha}$	3
$\sigma_{1-}^{\#2\alpha} == 0$	$\partial_\chi \partial_\beta \sigma^{\alpha\beta\chi}_\alpha == 0$	3
$\tau_{1+}^{\#1\alpha\beta} + i k \sigma_{1+}^{\#1\alpha\beta} == 0$	$\partial_\chi \partial^\alpha \tau^{\beta\chi}_\alpha + \partial_\chi \partial^\beta \tau^{\chi\alpha}_\alpha + \partial_\chi \partial^\chi \tau^{\alpha\beta}_\alpha ==$ $\partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}_\alpha + \partial_\delta \partial^\delta \partial_\chi \sigma^{\beta\chi\alpha}_\alpha ==$ $\partial_\chi \partial^\alpha \tau^{\chi\beta}_\alpha + \partial_\chi \partial^\beta \tau^{\alpha\chi}_\alpha + \partial_\chi \partial^\chi \tau^{\beta\alpha}_\alpha +$ $\partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta}_\alpha + \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\chi\beta}_\alpha$	3
$\sigma_{1+}^{\#1\alpha\beta} == \sigma_{1+}^{\#2\alpha\beta}$	$3 \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta}_\alpha +$ $2 \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi}_\alpha + \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\chi\beta}_\alpha ==$ $3 \partial_\delta \partial_\chi \partial^\delta \sigma^{\alpha\chi\delta}_\alpha + \partial_\delta \partial^\delta \partial_\chi \sigma^{\beta\chi\alpha}_\alpha$	3
$\sigma_{2-}^{\#1\alpha\beta\chi} == 0$	$3 \partial_\epsilon \partial_\delta \partial^\chi \partial^\alpha \sigma^{\beta\delta\epsilon}_\alpha + 3 \partial_\epsilon \partial^\epsilon \partial^\chi \partial^\alpha \sigma^{\beta\delta}_\delta +$ $2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\beta \sigma^{\alpha\chi\delta}_\delta + 4 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\beta \sigma^{\alpha\delta\chi}_\alpha +$ $2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\beta \sigma^{\chi\delta\alpha}_\alpha + 4 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\beta \sigma^{\alpha\beta\delta}_\delta +$ $2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\alpha\chi\delta}_\alpha + 2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \sigma^{\beta\chi\alpha}_\alpha +$ $3 \eta^{\beta\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\delta\epsilon}_\delta +$ $3 \eta^{\alpha\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\beta\delta\epsilon}_\epsilon +$ $3 \eta^{\beta\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\alpha\delta}_\delta ==$ $3 \partial_\epsilon \partial_\delta \partial^\chi \partial^\beta \sigma^{\alpha\delta\epsilon}_\epsilon + 3 \partial_\epsilon \partial^\epsilon \partial^\chi \partial^\beta \sigma^{\alpha\delta}_\delta +$ $2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\beta\chi\delta}_\delta + 4 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\beta\delta\chi}_\alpha +$ $2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\chi\delta\beta}_\beta + 2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\beta\delta\alpha}_\alpha +$ $4 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \sigma^{\alpha\beta\chi}_\alpha + 2 \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \sigma^{\alpha\chi\beta}_\beta +$ $3 \eta^{\alpha\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\delta\epsilon}_\delta +$ $3 \eta^{\beta\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\alpha\delta\epsilon}_\epsilon +$ $3 \eta^{\alpha\chi} \partial_\mu \partial^\mu \partial_\epsilon \partial^\epsilon \sigma^{\beta\delta}_\delta$	5
$\tau_{2+}^{\#1\alpha\beta} == 0$	$4 \partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta}_\delta + 2 \partial_\delta \partial^\delta \partial_\beta \partial^\alpha \tau^{\chi}_\chi +$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\alpha\beta}_\alpha + 3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\alpha}_\alpha +$ $2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \tau^{\chi\delta}_\delta ==$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi}_\alpha + 3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta}_\beta +$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi}_\alpha + 3 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha}_\alpha +$ $2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \tau^{\chi}_\chi$	5
Total constraints/gauge generators:		28

Quadratic (free) action	
S==	
$\iiint \iiint \Big(6 \, f^{\alpha\beta} \, \tau_{\alpha\beta} + 6 \, \omega^{\alpha\beta\chi} \, \sigma_{\alpha\beta\chi} - 15 \, r_3 \, \partial_\beta \omega_{\alpha\beta}^\theta \, \partial_\theta \omega^{\alpha\beta}_\alpha + 9 \, r_3 \, \partial_\mu \omega_{\beta\theta}^\theta \, \partial^\mu \omega^{\alpha\beta}_\alpha +$ $9 \, r_3 \, \partial_\alpha \omega^{\alpha\beta\gamma} \, \partial_\theta \omega_{\beta\gamma}^\theta - 18 \, r_3 \, \partial^\mu \omega_{\beta\gamma}^{\alpha\beta} \, \partial_\mu \omega_{\alpha\beta}^\theta +$ $15 \, r_3 \, \partial_\alpha \omega^{\alpha\beta\gamma} \, \partial_\theta \omega_{\beta\gamma}^\theta + 30 \, r_3 \, \partial^\mu \omega_{\alpha\beta}^{\alpha\beta} \, \partial_\mu \omega_{\beta\gamma}^\theta +$ $4 \, t_2 \, \omega_{\mu\theta\alpha} \, \partial^\theta f^{\alpha\mu} + 2 \, t_2 \, \partial_\mu f_{\mu\theta} \, \partial^\theta f^{\alpha\mu} - t_2 \, \partial_\mu f_{\theta\mu} \, \partial^\theta f^{\alpha\mu} -$ $t_2 \, \partial_\mu f_{\alpha\theta} \, \partial^\theta f^{\alpha\mu} + t_2 \, \partial_\theta f_{\alpha\mu} \, \partial^\mu f^{\alpha\mu} - t_2 \, \partial_\theta f_{\mu\alpha} \, \partial^\mu f^{\alpha\mu} -$ $4 \, t_2 \, \omega_{\alpha\theta\mu} \, (\omega^{\alpha\mu\theta} + \partial^\theta f^{\alpha\mu}) + 2 \, t_2 \, \omega_{\alpha\mu\theta} \, (\omega^{\alpha\mu\theta} + 2 \, \partial^\theta f^{\alpha\mu}) +$ $8 \, r_2 \, \partial_\beta \omega_{\alpha\mu\theta} \, \partial^\theta \omega^{\alpha\beta\mu}_\alpha - 4 \, r_2 \, \partial_\beta \omega_{\alpha\theta\mu} \, \partial^\theta \omega^{\alpha\beta\mu}_\mu +$ $4 \, r_2 \, \partial_\beta \omega_{\mu\theta\alpha} \, \partial^\theta \omega^{\alpha\beta\mu}_\alpha - 24 \, r_3 \, \partial_\beta \omega_{\mu\theta\alpha} \, \partial^\theta \omega^{\alpha\beta\mu}_\mu -$ $2 \, r_2 \, \partial_\mu \omega_{\alpha\beta\theta} \, \partial^\theta \omega^{\alpha\beta\mu}_\mu + 2 \, r_2 \, \partial_\theta \omega_{\alpha\beta\mu} \, \partial^\theta \omega^{\alpha\beta\mu}_\mu -$ $4 \, r_2 \, \partial_\theta \omega_{\alpha\mu\beta} \, \partial^\theta \omega^{\alpha\beta\mu}_\mu) [t, x, y, z] dz dy dx dt$	

$\omega_{1+}^{\#1} \dagger \alpha\beta$	$\omega_{1+}^{\#2} \dagger \alpha\beta$	$f_{1+}^{\#1} \dagger \alpha\beta$	$\omega_{1-}^{\#1} \dagger \alpha$	$\omega_{1-}^{\#2} \dagger \alpha$	$f_{1-}^{\#1} \dagger \alpha$	$f_{1-}^{\#2} \dagger \alpha$
$\omega_{1+}^{\#1} \dagger \alpha\beta$	$\frac{2t_2}{3}$	$\frac{\sqrt{2}t_2}{3}$	$\frac{1}{3}i\sqrt{2}kt_2$	0	0	0
$\omega_{1+}^{\#2} \dagger \alpha\beta$	$\frac{\sqrt{2}t_2}{3}$	$\frac{t_2}{3}$	$\frac{ikt_2}{3}$	0	0	0
$f_{1+}^{\#1} \dagger \alpha\beta$	$-\frac{1}{3}i\sqrt{2}kt_2$	$-\frac{1}{3}i\sqrt{2}kt_2$	$\frac{k^2t_2}{3}$	0	0	0
$\omega_{1-}^{\#1} \dagger \alpha$	0	0	0	$-\frac{3k^2r_3}{2}$	0	0
$\omega_{1-}^{\#2} \dagger \alpha$	0	0	0	0	0	0
$f_{1-}^{\#1} \dagger \alpha$	0	0	0	0	0	0
$f_{1-}^{\#2} \dagger \alpha$	0	0	0	0	0	0

$\sigma_{1+}^{\#1} \dagger \alpha\beta$	$\sigma_{1+}^{\#2} \dagger \alpha\beta$	$\tau_{1+}^{\#1} \dagger \alpha\beta$	$\sigma_{1-}^{\#1} \dagger \alpha$	$\sigma_{1-}^{\#2} \dagger \alpha$	$\tau_{1-}^{\#1} \dagger \alpha$	$\tau_{1-}^{\#2} \dagger \alpha$
$\sigma_{1+}^{\#1} \dagger \alpha\beta$	$\frac{6}{(3+k^2)^2t_2}$	$\frac{3\sqrt{2}}{(3+k^2)^2t_2}$	$\frac{3i\sqrt{2}k}{(3+k^2)^2t_2}$	0	0	0
$\sigma_{1+}^{\#2} \dagger \alpha\beta$	$\frac{3\sqrt{2}}{(3+k^2)^2t_2}$	$\frac{3}{(3+k^2)^2t_2}$	$\frac{3ik}{(3+k^2)^2t_2}$	0	0	0
$\tau_{1+}^{\#1} \dagger \alpha\beta$	$-\frac{3i\sqrt{2}k}{(3+k^2)^2t_2}$	$-\frac{3ik}{(3+k^2)^2t_2}$	$\frac{3k^2}{(3+k^2)^2t_2}$	0	0	0
$\sigma_{1-}^{\#1} \dagger \alpha$	0	0	0	$-\frac{2}{3k^2r_3}$	0	0
$\sigma_{1-}^{\#2} \dagger \alpha$	0	0	0	0	0	0
$\tau_{1-}^{\#1} \dagger \alpha$	0	0	0	0	0	0
$\tau_{1-}^{\#2} \dagger \alpha$	0	0	0	0	0	0

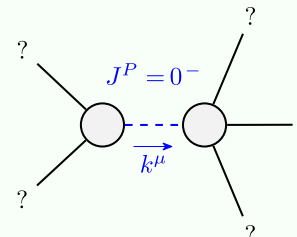
$\sigma_{0+}^{\#1} \dagger$	$\tau_{0+}^{\#1} \dagger$	$\tau_{0+}^{\#2} \dagger$	$\sigma_{0-}^{\#1} \dagger$
0	0	0	0
$\tau_{0+}^{\#1} \dagger$	0	0	0
$\tau_{0+}^{\#2} \dagger$	0	0	0
$\sigma_{0-}^{\#1} \dagger$	0	0	$\frac{1}{k^2r_2+t_2}$

$\omega_{0+}^{\#1} \dagger$	$f_{0+}^{\#1} \dagger$	$f_{0+}^{\#2} \dagger$	$\omega_{0-}^{\#1} \dagger$
0	0	0	0
$f_{0+}^{\#1} \dagger$	0	0	0
$f_{0+}^{\#2} \dagger$	0	0	0
$\omega_{0-}^{\#1} \dagger$	0	0	$k^2r_2+t_2$

$\sigma_{2+}^{\#1} \dagger \alpha\beta$	$f_{2+}^{\#1} \dagger \alpha\beta$	$\omega_{2-}^{\#1} \dagger \alpha\beta\chi$
$\omega_{2+}^{\#1} \dagger \alpha\beta$	$-\frac{3k^2r_3}{2}$	0
$f_{2+}^{\#1} \dagger \alpha\beta$	0	0
$\omega_{2-}^{\#1} \dagger \alpha\beta\chi$	0	0

$\sigma_{2+}^{\#1} \dagger \alpha\beta$	$\tau_{2+}^{\#1} \dagger \alpha\beta$	$\sigma_{2-}^{\#1} \dagger \alpha\beta\chi$
$\sigma_{2+}^{\#1} \dagger \alpha\beta$	$-\frac{2}{3k^2r_3}$	0
$\tau_{2+}^{\#1} \dagger \alpha\beta$	0	0
$\sigma_{2-}^{\#1} \dagger \alpha\beta\chi$	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

No massless particles

Unitarity conditions

$r_2 < 0 \ \&\& \ t_2 > 0$