

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
$\tau_{0+}^{\#1} - 2 \, i \, k \, \sigma_{0+}^{\#1} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau^\alpha_\alpha + 2 \, \partial_\chi \partial^\chi \partial_\beta \sigma^{\alpha\beta}_\alpha$	1
$\tau_{1+}^{\#2\alpha} + 2 \, i \, k \, \sigma_{1+}^{\#2\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta X} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta} + 2 \, \partial_\delta \partial^\delta \partial_\chi \partial_\beta \sigma^{\alpha\beta X}$	3
$\tau_{1-}^{\#1\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta X} == \partial_\chi \partial^\chi \partial_\beta \tau^{\beta\alpha}$	3
$\tau_{1+}^{\#1\alpha\beta} + i \, k \, \sigma_{1+}^{\#2\alpha\beta} == 0$	$\partial_\chi \partial^\alpha \tau^{\beta X} + \partial_\chi \partial^\beta \tau^{\chi\alpha} + \partial_\chi \partial^\chi \tau^{\alpha\beta} +$ $2 \, \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2 \, \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta X} ==$ $\partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha X} +$ $\partial_\chi \partial^\chi \tau^{\beta\alpha} + 2 \, \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}$	3
$\tau_{2+}^{\#1\alpha\beta} - 2 \, i \, k \, \sigma_{2+}^{\#1\alpha\beta} == 0$	$-i \, (4 \, \partial_\delta \partial_\chi \partial_\beta \partial^\alpha \tau^{\chi\delta} + 2 \, \partial_\delta \partial^\delta \partial_\beta \partial^\alpha \tau^{\chi\chi} -$ $3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta X} - 3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} -$ $3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha X} - 3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha} +$ $3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3 \, \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\beta\alpha} +$ $4 \, i \, k^\chi \, \partial_\epsilon \partial_\chi \partial_\beta \partial^\alpha \sigma^{\delta\epsilon}_\delta -$ $6 \, i \, k^\chi \, \partial_\epsilon \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon}_- -$ $6 \, i \, k^\chi \, \partial_\epsilon \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon}_+ +$ $2 \, \eta^{\alpha\beta} \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} +$ $6 \, i \, k^\chi \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\alpha\delta\beta}_+ +$ $6 \, i \, k^\chi \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\beta\delta\alpha}_- -$ $2 \, \eta^{\alpha\beta} \, \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \tau^{\chi\chi}_- -$ $4 \, i \, \eta^{\alpha\beta} \, k^\chi \, \partial_\phi \partial_\epsilon \partial_\chi \sigma^{\delta\epsilon}_\delta) == 0$	5
Total constraints/gauge generators:		16

Quadratic (free) action

$$S = \iiint \! \! \! \int (f^{\alpha\beta} \, \tau_{\alpha\beta} + \omega^{\alpha\beta\chi} \, \sigma_{\alpha\beta\chi} +$$
$$\frac{1}{2} t_1 (2 \, \omega^{\alpha\iota}_\alpha \, \omega^{\theta}_\iota{}_\theta - 4 \, \omega^{\theta}_\alpha \, \partial_\iota f^{\alpha\iota} + 4 \, \omega^{\theta}_\iota{}_\theta \, \partial^\iota f^\alpha_\alpha -$$
$$2 \, \partial_\iota f^\theta_\theta \, \partial^\iota f^\alpha_\alpha - 2 \, \partial_\iota f^{\alpha\iota} \, \partial_\theta f^\theta_\alpha + 4 \, \partial^\iota f^\alpha_\alpha \, \partial_\theta f^\theta_\iota - 2 \, \partial_\omega f^\theta_\iota \partial^\theta f^{\alpha\iota} - \partial_\alpha f_{\theta\iota} \partial^\theta f^{\alpha\iota} + \partial_\iota f_{\alpha\theta} \partial^\theta f^{\alpha\iota} + \partial_\theta f_{\alpha\iota} \partial^\theta f^{\alpha\iota} +$$
$$\partial_\theta f_{\iota\alpha} \partial^\theta f^{\alpha\iota} + 2 \, \omega_{\alpha\theta\iota} (\omega^{\alpha\iota\theta} + 2 \, \partial^\theta f^{\alpha\iota})) -$$
$$\frac{1}{3} r_1 (3 \, \partial_\beta \omega^{\theta}_\iota \partial^\iota \omega^{\alpha\beta}_\alpha - 3 \, \partial_\iota \omega^{\theta}_\beta \partial^\iota \omega^{\alpha\beta}_\theta - 3 \, \partial_\alpha \omega^{\alpha\beta\iota}_\alpha \partial_\theta \omega^{\theta}_\iota +$$
$$6 \, \partial^\iota \omega^{\alpha\beta}_\alpha \partial_\theta \omega^{\theta}_\iota + 3 \, \partial_\alpha \omega^{\alpha\beta\iota}_\alpha \partial_\theta \omega^{\theta}_\iota{}_\beta - 6 \, \partial^\iota \omega^{\alpha\beta}_\alpha \partial_\theta \omega^{\theta}_\iota{}_\beta + 4 \, \partial_\beta \omega_{\alpha\iota\theta} \partial^\theta \omega^{\alpha\beta\iota}_- - 2 \, \partial_\beta \omega_{\alpha\theta\iota} \partial^\theta \omega^{\alpha\beta\iota}_- -$$
$$8 \, \partial_\beta \omega_{\iota\theta\alpha} \partial^\theta \omega^{\alpha\beta\iota}_+ + 2 \, \partial_\iota \omega_{\alpha\beta\theta} \partial^\theta \omega^{\alpha\beta\iota}_- - 2 \, \partial_\theta \omega_{\alpha\beta\iota} \partial^\theta \omega^{\alpha\beta\iota}_- -$$
$$2 \, \partial_\theta \omega_{\alpha\iota\beta} \partial^\theta \omega^{\alpha\beta\iota}_+) [t, x, y, z] d z d y d x d t$$

$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1+}^{\#2}$	$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1-}^{\#1} \alpha$	$\sigma_{1-}^{\#2}$	$\tau_{1-}^{\#1} \alpha$	$\tau_{1-}^{\#2}$	$\tau_{1-}^{\#1} \alpha$
$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2}t_1$	$-\frac{i\sqrt{2}k}{t_1+k^2}t_1$	0	0	0	0	0
$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2}t_1 + \frac{t_1}{(1+k^2)^2t_1^2}$	$-\frac{i(2k^3r_1-kt_1)}{(1+k^2)^2t_1^2}$	0	0	0	0	0
$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{i\sqrt{2}k}{t_1+k^2}t_1$	$\frac{-2k^4r_1+k^2t_1}{(1+k^2)^2t_1^2}$	0	0	0	0	0
$\sigma_{1-}^{\#1} \dagger^\alpha$	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2}t_1$	0	$\frac{2ik}{t_1+2k^2}t_1$	0
$\sigma_{1-}^{\#2} \dagger^\alpha$	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2}t_1$	0	$\frac{i\sqrt{2}k}{(1+2k^2)^2}t_1$	0
$\tau_{1-}^{\#1} \dagger^\alpha$	0	0	0	0	0	0	0
$\tau_{1-}^{\#2} \dagger^\alpha$	0	0	0	$-\frac{2ik}{t_1+2k^2}t_1$	$-\frac{i\sqrt{2}k}{(1+2k^2)^2}t_1$	$\frac{2k^2}{(1+2k^2)^2}t_1$	0

$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1+}^{\#2}$	$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1-}^{\#1} \alpha$	$\omega_{1-}^{\#2}$	$f_{1-}^{\#1} \alpha$	$f_{1-}^{\#2}$	$f_{1-}^{\#1} \alpha$
$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$k^2r_1 - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{ikt_1}{\sqrt{2}}$	0	0	0	0
$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega_{1-}^{\#1} \dagger^\alpha$	0	0	0	$-\frac{t_1}{2}$	0	$\frac{t_1}{\sqrt{2}}$	$i k t_1$
$\omega_{1-}^{\#2} \dagger^\alpha$	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

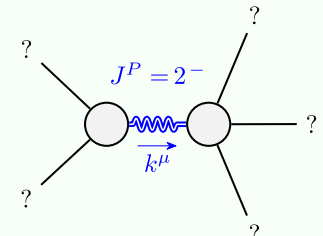
$\omega_{0+}^{\#1} \dagger$	$\omega_{0+}^{\#2}$	$f_{0+}^{\#1}$	$\omega_0^{\#1}$
$\omega_{0+}^{\#1} \dagger$	$-t_1$	$i\sqrt{2}kt_1$	0
$f_{0+}^{\#1} \dagger$	$-i\sqrt{2}kt_1$	$-2k^2t_1$	0
$f_{0+}^{\#2} \dagger$	0	0	0
$\omega_0^{\#1} \dagger$	0	0	$-t_1$

$\sigma_{2+}^{\#1} \dagger^{\alpha\beta}$	$\tau_{2+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{2-}^{\#1} \alpha\beta\chi$
$\sigma_{2+}^{\#1} \dagger^{\alpha\beta}$	$\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$
$\tau_{2+}^{\#1} \dagger^{\alpha\beta}$	$\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	$\frac{4k^2}{(1+2k^2)^2t_1}$
$\sigma_{2-}^{\#1} \dagger^{\alpha\beta\chi}$	0	$\frac{2}{2k^2r_1+t_1}$

$\omega_{0+}^{\#1} \dagger$	$f_{0+}^{\#1}$	$f_{0+}^{\#2}$	$\omega_0^{\#1}$
$\omega_{0+}^{\#1} \dagger$	$i\sqrt{2}kt_1$	0	0
$f_{0+}^{\#1} \dagger$	$-2k^2t_1$	0	0
$f_{0+}^{\#2} \dagger$	0	0	0
$\omega_0^{\#1} \dagger$	0	0	$-t_1$

$\omega_{2+}^{\#1} \dagger^{\alpha\beta}$	$f_{2+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2-}^{\#1} \alpha\beta\chi$
$\omega_{2+}^{\#1} \dagger^{\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$
$f_{2+}^{\#1} \dagger^{\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	k^2t_1
$\omega_{2-}^{\#1} \dagger^{\alpha\beta\chi}$	0	$k^2r_1 + \frac{t_1}{2}$

Massive and massless spectra



Massive particle

Pole residue:	$-\frac{1}{r_1} > 0$
Polarisations:	5
Square mass:	$-\frac{t_1}{2r_1} > 0$
Spin:	2
Parity:	Odd

(no massless particles)

Unitarity conditions

$r_1 < 0 \ \&\& \ t_1 > 0$