

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

$\sigma_{1+}^{#1} + \alpha\beta$	$\sigma_{1+}^{#2} + \alpha\beta$	$\tau_{1+}^{#1} + \alpha\beta$	$\sigma_{1-}^{#1} - \alpha$	$\sigma_{1-}^{#2} - \alpha$	$\tau_{1-}^{#1} - \alpha$	$\tau_{1-}^{#2} - \alpha$
$\frac{1}{k^2 r_5}$	$\frac{1}{\sqrt{2} (k^2 r_5 + k^4 r_5)}$	$\frac{i}{\sqrt{2} (k r_5 + k^3 r_5)}$	0	0	0	0
$\frac{1}{\sqrt{2} (k^2 r_5 + k^4 r_5)}$	$\frac{6 k^2 r_5 + t_1}{2 (k + k^3)^2 r_5 t_1}$	$\frac{i (6 k^2 r_5 + t_1)}{2 k (1 + k^2)^2 r_5 t_1}$	0	0	0	0
$-\frac{i}{\sqrt{2} (k r_5 + k^3 r_5)}$	$-\frac{i (6 k^2 r_5 + t_1)}{2 k (1 + k^2)^2 r_5 t_1}$	$\frac{6 k^2 r_5 + t_1}{2 (1 + k^2)^2 r_5 t_1}$	0	0	0	0
0	0	0	0	$\frac{\sqrt{2}}{t_1 + 2 k^2 t_1}$	0	$\frac{2 i k}{t_1 + 2 k^2 t_1}$
0	0	0	$\frac{\sqrt{2}}{t_1 + 2 k^2 t_1}$	$\frac{-2 k^2 r_5 + t_1}{(t_1 + 2 k^2 t_1)^2}$	0	$-\frac{i \sqrt{2} k (2 k^2 r_5 t_1)}{(t_1 + 2 k^2 t_1)^2}$
0	0	0	0	0	0	0
0	0	0	$-\frac{2 i k}{t_1 + 2 k^2 t_1}$	$\frac{i \sqrt{2} k (2 k^2 r_5 t_1)}{(t_1 + 2 k^2 t_1)^2}$	0	$\frac{-4 k^4 r_5 + 2 k^2 t_1}{(t_1 + 2 k^2 t_1)^2}$

Quadratic (free) action

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

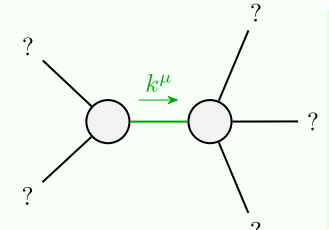
$\frac{t_1}{2}$	$-\frac{i k t_1}{\sqrt{2}}$	0
$\frac{i k t_1}{\sqrt{2}}$	$k^2 t_1$	0
0	0	$\frac{t_1}{2}$

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

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

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

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

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