

Particle spectrograph

Wave operator and propagator

Source constraints			
SO(3) irreps	Fundamental fields		Multiplicities
$\sigma_0^{\#1} == 0$	$\partial_\beta \sigma^{\alpha\beta}_\alpha == 0$		1
$\tau_0^{\#1} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau^\alpha_\alpha$		1
$\tau_0^{\#2} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$		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
$\tau_1^{\#1\alpha\beta} + i\,k\,\sigma_1^{\#2\alpha\beta} == 0$	$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\beta \tau^{\chi\alpha} + \partial_\chi \partial^\chi \tau^{\alpha\beta} +$ $2\,\partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2\,\partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi} ==$ $\partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha\chi} +$ $\partial_\chi \partial^\chi \tau^{\beta\alpha} + 2\,\partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}$		3
$\tau_2^{\#1\alpha\beta} - 2\,i\,k\,\sigma_2^{\#1\alpha\beta} == 0$	$-i\,(4\,\partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2\,\partial_\delta \partial^\delta \partial_\beta \partial^\alpha \tau^\chi_\chi -$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi} - 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} -$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi} - 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha} +$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\beta\alpha} +$ $4\,i\,k^\chi\,\partial_\epsilon \partial_\chi \partial^\beta \partial^\alpha \sigma^{\delta\epsilon}_\delta -$ $6\,i\,k^\chi\,\partial_\epsilon \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon}_\epsilon -$ $6\,i\,k^\chi\,\partial_\epsilon \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon}_\epsilon +$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} +$ $6\,i\,k^\chi\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\alpha\delta\beta}_\beta +$ $6\,i\,k^\chi\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\beta\delta\alpha}_\alpha -$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \tau^\chi_\chi -$ $4\,i\,\eta^{\alpha\beta}\,k^\chi\,\partial_\phi \partial^\phi \partial_\epsilon \partial_\chi \sigma^{\delta\epsilon}_\delta) == 0$	5	
Total constraints/gauge generators:			17

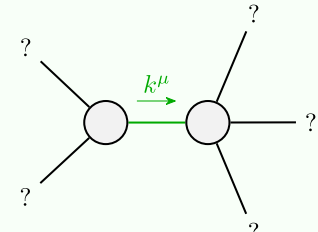
$\sigma_1^{#1} +^{\alpha\beta}$	$\sigma_1^{#2} +^{\alpha\beta}$	$\tau_1^{#1} +^{\alpha\beta}$	$\sigma_1^{#1} -^{\alpha}$	$\sigma_1^{#2} -^{\alpha}$	$\tau_1^{#1} -^{\alpha}$	$\tau_1^{#2} -^{\alpha}$
$\sigma_1^{#1} +^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2}t_1$	$-\frac{i\sqrt{2}k}{t_1+k^2}t_1$	0	0	0	0
$\sigma_1^{#2} +^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2}t_1$	$-\frac{i(2k^3r_5+t_1)}{(1+k^2)^2}t_1^2$	0	0	0	0
$\tau_1^{#1} +^{\alpha\beta}$	$\frac{i\sqrt{2}k}{t_1+k^2}t_1$	$\frac{-2k^4r_5+k^2t_1}{(1+k^2)^2}t_1^2$	0	0	0	0
$\sigma_1^{#1} -^{\alpha}$	0	0	$\frac{1}{k^2r_5}$	$-\frac{1}{\sqrt{2}(k^2r_5+2k^4r_5)}$	0	$-\frac{i}{kr_5+2k^3r_5}$
$\sigma_1^{#2} -^{\alpha}$	0	0	$-\frac{1}{\sqrt{2}(k^2r_5+2k^4r_5)}$	$\frac{6k^2r_5+t_1}{2(k+2k^2)^2r_5t_1}$	0	$\frac{i(6k^2r_5+t_1)}{\sqrt{2}k(1+2k^2)^2r_5t_1}$
$\tau_1^{#1} -^{\alpha}$	0	0	0	0	0	0
$\tau_1^{#2} -^{\alpha}$	0	0	$\frac{i}{kr_5+2k^3r_5}$	$-\frac{i(6k^2r_5+t_1)}{\sqrt{2}k(1+2k^2)^2r_5t_1}$	0	$\frac{6k^2r_5+t_1}{(1+2k^2)^2r_5t_1}$

Quadratic (free) action

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

$\mathcal{A}^{#1}_1 +^{\alpha\beta}$	$\mathcal{A}^{#2}_1 +^{\alpha\beta}$	$f^{#1}_1 +^{\alpha\beta}$	$\mathcal{A}^{#1}_1 -^{\alpha}$	$\mathcal{A}^{#2}_1 -^{\alpha}$	$f^{#1}_1 -^{\alpha}$	$f^{#2}_1 -^{\alpha}$
$\mathcal{A}^{#1}_1 +^{\alpha\beta}$	$k^2r_5 - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0
$\mathcal{A}^{#2}_1 +^{\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0
$f^{#1}_1 +^{\alpha\beta}$	$\frac{ik t_1}{\sqrt{2}}$	0	0	0	0	0
$\mathcal{A}^{#1}_1 -^{\alpha}$	0	0	$k^2r_5 + \frac{t_1}{6}$	$\frac{t_1}{3\sqrt{2}}$	0	$\frac{ik t_1}{3}$
$\mathcal{A}^{#2}_1 -^{\alpha}$	0	0	$\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	0	$\frac{1}{3}i\sqrt{2}kt_1$
$f^{#1}_1 -^{\alpha}$	0	0	0	0	0	0
$f^{#2}_1 -^{\alpha}$	0	0	$-\frac{1}{3}ik t_1$	$-\frac{1}{3}i\sqrt{2}kt_1$	0	$\frac{2k^2t_1}{3}$
$\mathcal{A}^{#1}_2 +^{\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{ik t_1}{\sqrt{2}}$	0	0	0	0
$f^{#1}_2 +^{\alpha\beta}$	$\frac{ik t_1}{\sqrt{2}}$	k^2t_1	0	0	0	0
$\mathcal{A}^{#1}_2 -^{\alpha\beta\chi}$	0	0	$\frac{t_1}{2}$	0	$-t_1$	0
$\sigma^{#1}_2 +^{\alpha\beta}$	$\frac{2}{(1+2k^2)^2}t_1$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2}t_1$	0	0	0	0
$\tau^{#1}_2 +^{\alpha\beta}$	$\frac{2i\sqrt{2}k}{(1+2k^2)^2}t_1$	$\frac{4k^2}{(1+2k^2)^2}t_1$	0	0	0	0
$\sigma^{#1}_2 -^{\alpha\beta\chi}$	0	$\frac{1}{t_1}$	0	0	0	$\frac{1}{t_1}$
$\sigma^{#1}_0 +^{\alpha\beta}$	0	0	0	0	0	0
$\tau^{#1}_0 +^{\alpha\beta}$	0	0	0	0	0	0
$\tau^{#2}_0 +^{\alpha\beta}$	0	0	0	0	0	0
$\sigma^{#1}_0 -^{\alpha\beta}$	0	0	0	0	0	$-\frac{1}{t_1}$

Massive and massless spectra



Quadratic pole

Pole residue: $-\frac{1}{r_5 t_1^2} > 0$

Polarisations: 2

(No massive particles)

Unitarity conditions

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