

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

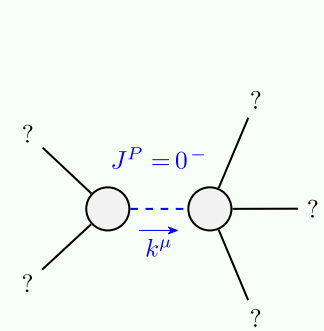
	$\sigma_1^{\#1} + \alpha\beta$	$\sigma_1^{\#2} + \alpha\beta$	$\tau_1^{\#1} + \alpha\beta$	$\sigma_1^{\#1} - \alpha$	$\sigma_1^{\#2} - \alpha$	$\tau_1^{\#1} - \alpha$	$\tau_1^{\#2} - \alpha$
$\sigma_1^{\#1} + \alpha\beta$	0	$-\frac{\sqrt{2}}{t_1 + k^2 t_1}$	$-\frac{i\sqrt{2}k}{t_1 + k^2 t_1}$	0	0	0	0
$\sigma_1^{\#2} + \alpha\beta$	$-\frac{\sqrt{2}}{t_1 + k^2 t_1}$	$\frac{-2k^2 r_5 + t_1}{(1+k^2)^2 t_1^2}$	$-\frac{i(2k^3 r_5 - kt_1)}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\tau_1^{\#1} + \alpha\beta$	$\frac{i\sqrt{2}k}{t_1 + k^2 t_1}$	$\frac{i(2k^3 r_5 - kt_1)}{(1+k^2)^2 t_1^2}$	$\frac{-2k^4 r_5 + k^2 t_1}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\sigma_1^{\#1} + \alpha$	0	0	0	0	$\frac{\sqrt{2}}{t_1 + 2k^2 t_1}$	0	$\frac{2ik}{t_1 + 2k^2 t_1}$
$\sigma_1^{\#2} + \alpha$	0	0	0	$\frac{\sqrt{2}}{t_1 + 2k^2 t_1}$	$\frac{-2k^2 r_5 + t_1}{(t_1 + 2k^2 t_1)^2}$	0	$-\frac{i\sqrt{2}k(2k^2 r_5 - t_1)}{(t_1 + 2k^2 t_1)^2}$
$\tau_1^{\#1} + \alpha$	0	0	0	0	0	0	0
$\tau_1^{\#2} + \alpha$	0	0	0	$-\frac{2ik}{t_1 + 2k^2 t_1}$	$\frac{i\sqrt{2}k(2k^2 r_5 - t_1)}{(t_1 + 2k^2 t_1)^2}$	0	$\frac{-4k^4 r_5 + 2k^2 t_1}{(t_1 + 2k^2 t_1)^2}$

Quadratic (free) action

$$S = \int \int \int \int (f^{\alpha\beta} \tau_{\alpha\beta} + \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} + \frac{1}{2} t_1 (2 \omega^{\alpha\iota}{}_{\alpha} \omega^{\theta}{}_{\iota\theta} - 4 \omega^{\theta}{}_{\alpha\theta} \omega^{\alpha\iota}{}_{\iota} \partial_{\iota} f^{\alpha\iota} + 4 \omega^{\theta}{}_{\iota\theta} \omega^{\alpha\iota}{}_{\iota} \partial_{\iota} f^{\alpha}{}_{\alpha} - 2 \partial_{\iota} f^{\theta}{}_{\theta} \partial_{\iota} f^{\alpha}{}_{\alpha} - 2 \partial_{\iota} f^{\alpha\iota}{}_{\alpha} \partial_{\theta} f^{\theta}{}_{\alpha} + 4 \partial_{\iota} f^{\alpha}{}_{\alpha} \partial_{\theta} f^{\theta}{}_{\iota} - 2 \partial_{\alpha} f^{\iota\theta} \partial_{\theta} f^{\alpha\iota} - \partial_{\alpha} f^{\iota\theta} \partial^{\theta} f^{\alpha\iota} + \partial_{\theta} f^{\alpha\theta} \partial^{\theta} f^{\alpha\iota} + \partial_{\theta} f^{\alpha\theta} \partial^{\theta} f^{\alpha\iota}) + \partial_{\theta} f^{\iota\alpha} \partial^{\theta} f^{\alpha\iota} + 2 \omega^{\alpha\theta\iota} (\omega^{\alpha\iota\theta} + 2 \partial^{\theta} f^{\alpha\iota})) + \frac{1}{3} r_2 (4 \partial_{\beta} \omega^{\alpha\iota\theta} - 2 \partial_{\beta} \omega^{\alpha\theta\iota} + 2 \partial_{\beta} \omega^{\iota\theta\alpha} - \partial_{\iota} \omega^{\alpha\beta\theta} + \partial_{\theta} \omega^{\alpha\beta\iota} - 2 \partial_{\theta} \omega^{\alpha\iota\beta}) \partial^{\theta} \omega^{\alpha\beta\iota} + r_5 (\partial_{\iota} \omega^{\kappa}{}_{\theta\kappa} \partial^{\theta} \omega^{\alpha\iota}{}_{\alpha} - \partial_{\theta} \omega^{\kappa}{}_{\alpha} \partial^{\theta} \omega^{\alpha\iota}{}_{\kappa} - (\partial_{\alpha} \omega^{\alpha\iota\theta} - 2 \partial^{\theta} \omega^{\iota\alpha}{}_{\alpha}) (\partial_{\kappa} \omega^{\kappa}{}_{\theta} - \partial_{\kappa} \omega^{\theta}{}_{\iota})) [t, x, y, z] dz dy dx dt$$

[illegible]

# 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

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