

# Particle spectrograph

## Wave operator and propagator

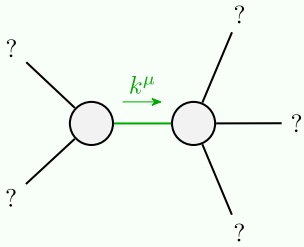
Source constraints		Fundamental fields	Multiplicities
SO(3) irreps			
$\sigma_0^{1-} == 0$		$\epsilon \eta_{\alpha\beta\chi\delta} \partial^\delta \sigma^{\alpha\beta\chi} == 0$	1
$\sigma_0^{1+} == 0$		$\partial_\beta \sigma^{\alpha\beta}_\alpha == 0$	1
$\sigma_1^{2\alpha} == 0$		$\partial_\chi \partial_\beta \sigma^{\alpha\beta\chi} == 0$	3
$\sigma_1^{2\alpha\beta} == 0$		$\partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi} == \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}$	3
$\sigma_2^{1\alpha\beta} == 0$		$3 \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 3 \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta} + 2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \sigma^{\chi\delta}_\chi == 2 \partial_\delta \partial^\beta \partial^\alpha \sigma^{\chi\delta}_\chi + 3 (\partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\chi\beta} + \partial_\delta \partial^\delta \partial_\chi \sigma^{\beta\chi\alpha})$	5
Total constraints/gauge generators:			13

Quadratic (free) action

$$S = \iiint (\omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - \frac{2}{3} r_1 (2 \partial_\beta \omega_{\alpha\beta\theta} - \partial_\beta \omega_{\alpha\theta\beta} + 4 \partial_\beta \omega_{\theta\beta\alpha} + \partial_\theta \omega_{\alpha\beta\theta} - \partial_\theta \omega_{\alpha\theta\beta} - \partial_\theta \omega_{\theta\beta\alpha}) \partial^\theta \omega^{\alpha\beta\theta} + r_5 (\partial_\theta \omega_{\theta\theta}^\kappa \partial^\theta \omega_{\theta\theta}^{\alpha\theta} - \partial_\theta \omega_{\theta\theta}^\kappa \partial^\theta \omega_{\theta\theta}^{\alpha\theta} - (\partial_\alpha \omega_{\theta\theta}^{\alpha\theta} - \partial_\alpha \omega_{\theta\theta}^{\alpha\theta} - 2 \partial^\theta \omega_{\theta\theta}^{\alpha\theta}) (\partial_\kappa \omega_{\theta\theta}^\kappa - \partial_\kappa \omega_{\theta\theta}^\kappa))) [t, x, y, z] dz dy dx dt$$

$\omega_2^{1+} \dagger^{\alpha\beta}$	$\omega_2^{1+} \dagger^{\alpha\beta}$	$\omega_2^{1+} \dagger^{\alpha\beta}$	$\omega_2^{1+} \dagger^{\alpha\beta}$
0	0	0	0
$\omega_2^{1-} \dagger^{\alpha\beta\chi}$	$\omega_2^{1-} \dagger^{\alpha\beta\chi}$	$\omega_2^{1-} \dagger^{\alpha\beta\chi}$	$\omega_2^{1-} \dagger^{\alpha\beta\chi}$
0	0	0	0
$\sigma_2^{1+} \dagger^{\alpha\beta}$	$\sigma_2^{1+} \dagger^{\alpha\beta}$	$\sigma_2^{1+} \dagger^{\alpha\beta}$	$\sigma_2^{1+} \dagger^{\alpha\beta}$
0	0	0	0
$\sigma_2^{1-} \dagger^{\alpha\beta\chi}$	$\sigma_2^{1-} \dagger^{\alpha\beta\chi}$	$\sigma_2^{1-} \dagger^{\alpha\beta\chi}$	$\sigma_2^{1-} \dagger^{\alpha\beta\chi}$
0	0	0	0
$\sigma_0^{1+} \dagger^{\alpha\beta}$	$\sigma_0^{1+} \dagger^{\alpha\beta}$	$\sigma_0^{1+} \dagger^{\alpha\beta}$	$\sigma_0^{1+} \dagger^{\alpha\beta}$
0	0	0	0
$\sigma_0^{1-} \dagger^{\alpha\beta}$	$\sigma_0^{1-} \dagger^{\alpha\beta}$	$\sigma_0^{1-} \dagger^{\alpha\beta}$	$\sigma_0^{1-} \dagger^{\alpha\beta}$
0	0	0	0
$\omega_0^{1+} \dagger^{\alpha\beta}$	$\omega_0^{1+} \dagger^{\alpha\beta}$	$\omega_0^{1+} \dagger^{\alpha\beta}$	$\omega_0^{1+} \dagger^{\alpha\beta}$
0	0	0	0
$\omega_0^{1-} \dagger^{\alpha\beta}$	$\omega_0^{1-} \dagger^{\alpha\beta}$	$\omega_0^{1-} \dagger^{\alpha\beta}$	$\omega_0^{1-} \dagger^{\alpha\beta}$
0	0	0	0
$\sigma_1^{1+} \dagger^{\alpha\beta}$	$\sigma_1^{1+} \dagger^{\alpha\beta}$	$\sigma_1^{1+} \dagger^{\alpha\beta}$	$\sigma_1^{1+} \dagger^{\alpha\beta}$
$\frac{1}{k^2 (2r_1 + r_5)}$	0	0	0
$\sigma_1^{2+} \dagger^{\alpha\beta}$	$\sigma_1^{2+} \dagger^{\alpha\beta}$	$\sigma_1^{2+} \dagger^{\alpha\beta}$	$\sigma_1^{2+} \dagger^{\alpha\beta}$
0	0	0	0
$\sigma_1^{1-} \dagger^\alpha$	$\sigma_1^{1-} \dagger^\alpha$	$\sigma_1^{1-} \dagger^\alpha$	$\sigma_1^{1-} \dagger^\alpha$
0	0	$\frac{1}{k^2 (r_1 + r_5)}$	0
$\sigma_1^{2-} \dagger^\alpha$	$\sigma_1^{2-} \dagger^\alpha$	0	0
$\omega_1^{1+} \dagger^{\alpha\beta}$	$\omega_1^{1+} \dagger^{\alpha\beta}$	$\omega_1^{1+} \dagger^{\alpha\beta}$	$\omega_1^{1+} \dagger^{\alpha\beta}$
$k^2 (2r_1 + r_5)$	0	0	0
$\omega_1^{2+} \dagger^{\alpha\beta}$	$\omega_1^{2+} \dagger^{\alpha\beta}$	$\omega_1^{2+} \dagger^{\alpha\beta}$	$\omega_1^{2+} \dagger^{\alpha\beta}$
0	0	0	0
$\omega_1^{1-} \dagger^\alpha$	$\omega_1^{1-} \dagger^\alpha$	$k^2 (r_1 + r_5)$	0
$\omega_1^{2-} \dagger^\alpha$	$\omega_1^{2-} \dagger^\alpha$	0	0

## Massive and massless spectra



Quadratic pole

Pole residue:  $-\frac{1}{r_1 (r_1 + r_5) (2r_1 + r_5)} > 0$

Polarisations: 2

(No massive particles)

## Unitarity conditions

$$r_1 < 0 \&\& (r_5 < -r_1 \parallel r_5 > -2r_1) \parallel r_1 > 0 \&\& -2r_1 < r_5 < -r_1$$