

# Particle spectrograph

## Wave operator and propagator

Quadratic (free) action

$$S_F == \iiint \left( \frac{1}{2} (2 \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - (r_3 + 2r_5) \partial_\mu \omega_\lambda^{\kappa\lambda} \partial^\mu \omega_\lambda^\alpha + r_3 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega_\lambda^{\theta\kappa\lambda} - 2r_5 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega_\lambda^{\theta\kappa\lambda} - \partial_\kappa \omega^{\theta\kappa\lambda} - r_3 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\lambda^{\theta\kappa\lambda} + 2r_5 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\lambda^{\theta\kappa\lambda} - r_3 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega_\lambda^{\theta\kappa\lambda} + 4r_5 \partial_\theta \omega_\lambda^\alpha \partial_\kappa \omega_\lambda^{\theta\kappa\lambda} - 2r_5 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega_\lambda^{\theta\kappa\lambda} + 2r_5 \partial_\alpha \omega_\lambda^\alpha \partial_\theta \omega_\lambda^{\theta\kappa\lambda} + 8r_3 \partial^\beta \omega_\lambda^\alpha \partial_\lambda \omega_\alpha^\beta - r_3 \partial_\alpha \omega_\lambda^\alpha \partial^\lambda \omega_\lambda^{\theta\kappa} + 2r_5 \partial_\alpha \omega_\lambda^\alpha \partial^\lambda \omega_\lambda^{\theta\kappa} + r_3 \partial_\theta \omega_\lambda^\alpha \partial^\lambda \omega_\lambda^{\theta\kappa} - 2r_5 \partial_\theta \omega_\lambda^\alpha \partial^\lambda \omega_\lambda^{\theta\kappa} ) [t, x, y, z] dz dy dx dt \right)$$

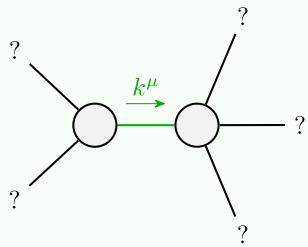
$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$	$\sigma_{1^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1^+}^{\#2} \dagger^{\alpha\beta}$	$\sigma_{1^-}^{\#1} \dagger^\alpha$	$\sigma_{1^-}^{\#2} \dagger^\alpha$
$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$	$\sigma_{1^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1^+}^{\#2} \dagger^{\alpha\beta}$	$\sigma_{1^-}^{\#1} \dagger^\alpha$	$\sigma_{1^-}^{\#2} \dagger^\alpha$
$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$	$\sigma_{1^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1^+}^{\#2} \dagger^{\alpha\beta}$	$\sigma_{1^-}^{\#1} \dagger^\alpha$	$\sigma_{1^-}^{\#2} \dagger^\alpha$
$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$	$\sigma_{1^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1^+}^{\#2} \dagger^{\alpha\beta}$	$\sigma_{1^-}^{\#1} \dagger^\alpha$	$\sigma_{1^-}^{\#2} \dagger^\alpha$
$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$	$\sigma_{1^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1^+}^{\#2} \dagger^{\alpha\beta}$	$\sigma_{1^-}^{\#1} \dagger^\alpha$	$\sigma_{1^-}^{\#2} \dagger^\alpha$
$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$	$\sigma_{1^+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1^+}^{\#2} \dagger^{\alpha\beta}$	$\sigma_{1^-}^{\#1} \dagger^\alpha$	$\sigma_{1^-}^{\#2} \dagger^\alpha$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\sigma_0^{\#1} == 0$	1
$\sigma_{0^+}^{\#1} == 0$	1
$\sigma_{1^-}^{\#2\alpha} == 0$	3
$\sigma_{1^+}^{\#2\alpha\beta} == 0$	3
$\sigma_{2^-}^{\#1\alpha\beta\chi} == 0$	5
Total constraints:	13

$\omega_{0^+}^{\#1} \dagger$	$\omega_{0^+}^{\#1} \dagger$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$
$\omega_{0^+}^{\#1} \dagger$	$\omega_{0^+}^{\#1} \dagger$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$
$\omega_{0^+}^{\#1} \dagger$	$\omega_{0^+}^{\#1} \dagger$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$
$\omega_{0^+}^{\#1} \dagger$	$\omega_{0^+}^{\#1} \dagger$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$
$\omega_{0^+}^{\#1} \dagger$	$\omega_{0^+}^{\#1} \dagger$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$
$\omega_{0^+}^{\#1} \dagger$	$\omega_{0^+}^{\#1} \dagger$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2^+}^{\#1} \dagger^{\alpha\beta\chi}$

## Massive and massless spectra



Quadratic pole

Pole residue:	$-\frac{1}{r_3(2r_3+r_5)(r_3+2r_5)} > 0$
Polarisations:	2

(No massive particles)

## Unitarity conditions

$$r_3 < 0 \&\& (r_5 < -\frac{r_3}{2} \parallel r_5 > -2r_3) \parallel r_3 > 0 \&\& -2r_3 < r_5 < -\frac{r_3}{2}$$