

# Particle spectrograph

## Wave operator and propagator

	$\omega_{2+}^{\#1}{}_{\alpha\beta}$	$f_{2+}^{\#1}{}_{\alpha\beta}$	$\omega_{2-}^{\#1}{}_{\alpha\beta\chi}$
$\omega_{2+}^{\#1}{}_{\dagger}{}^{\alpha\beta}$	0	0	0
$f_{2+}^{\#1}{}_{\dagger}{}^{\alpha\beta}$	0	$2\beta_1 k^2$	0
$\omega_{2-}^{\#1}{}_{\dagger}{}^{\alpha\beta\chi}$	0	0	0

Source constraints/gauge generators	
SO(3) irreps	Multiplicities
$\tau_{0+}^{\#2} == 0$	1
$\sigma_{0+}^{\#1} == 0$	1
$\tau_{1-}^{\#2\alpha} == 0$	3
$\tau_{1-}^{\#1\alpha} == 0$	3
$\sigma_{1-}^{\#2\alpha} == 0$	3
$\sigma_{1-}^{\#1\alpha} == 0$	3
$\tau_{1+}^{\#1\alpha\beta} == 0$	3
$\sigma_{1+}^{\#2\alpha\beta} == 0$	3
$\sigma_{1+}^{\#1\alpha\beta} == 0$	3
$\sigma_{2+}^{\#1\alpha\beta} == 0$	5
$\sigma_{2-}^{\#1\alpha\beta\chi} == 0$	5
Total constraints:	33

Quadratic (free) action

$$S = \iiint \left( f^{\alpha\beta}{}_{\alpha\beta\chi} \tau_{\alpha\beta} + \omega^{\alpha\beta\chi}{}_{\alpha\beta\chi} \sigma_{\alpha\beta\chi} + \beta_1 (-4 \omega^{\chi}{}_{\alpha} \partial_{\beta} f^{\alpha\beta}{}_{\alpha} + 4 \omega^{\chi}{}_{\beta} \partial^{\beta} f^{\alpha}{}_{\alpha} - 2 \partial_{\beta} f^{\chi}{}_{\alpha} \partial^{\beta} f^{\alpha}{}_{\alpha} - 2 \partial_{\beta} f^{\alpha\beta}{}_{\alpha} \partial_{\chi} f^{\chi}{}_{\beta} - 4 f^{\alpha\beta}{}_{\alpha} \partial_{\chi} f^{\chi}{}_{\beta} - \partial_{\beta} \omega^{\chi}{}_{\alpha} \partial^{\beta} \omega^{\chi}{}_{\alpha} - \partial_{\alpha} f^{\alpha\beta}{}_{\beta} \partial^{\chi} f^{\alpha\beta}{}_{\chi} - \partial_{\alpha} f^{\alpha\beta}{}_{\beta} \partial^{\chi} f^{\alpha\beta}{}_{\chi} + 4 f^{\alpha}{}_{\alpha} \partial_{\chi} \omega^{\beta\chi}{}_{\beta} + 4 \omega_{\alpha\chi\beta} \partial^{\chi} f^{\alpha\beta}{}_{\beta} - 2 \partial_{\alpha} f_{\beta\chi} \partial^{\chi} f^{\alpha\beta}{}_{\beta} - \partial_{\alpha} f_{\beta\chi} \partial^{\chi} f^{\alpha\beta}{}_{\beta} + \partial_{\beta} f_{\alpha\chi} \partial^{\chi} f^{\alpha\beta}{}_{\beta} + \partial_{\chi} f_{\alpha\beta} \partial^{\chi} f^{\alpha\beta}{}_{\beta} + \partial_{\chi} f_{\beta\alpha} \partial^{\chi} f^{\alpha\beta}{}_{\beta} \right) + \frac{1}{3} \alpha_3 (4 \partial_{\beta} \omega_{\alpha\chi\delta} - 2 \partial_{\beta} \omega_{\alpha\delta\chi} + 2 \partial_{\beta} \omega_{\chi\delta\alpha} - \partial_{\chi} \omega_{\alpha\beta\delta} + \partial_{\delta} \omega_{\alpha\beta\chi} - 2 \partial_{\delta} \omega_{\alpha\chi\beta}) \partial^{\delta} \omega^{\alpha\beta\chi} [t, x, y, z] dz dy dx dt$$

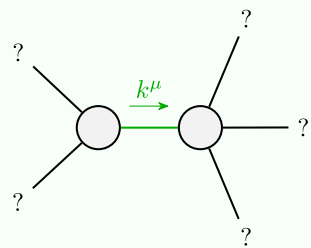
	$\sigma_{2+}^{\#1}{}_{\alpha\beta}$	$\tau_{2+}^{\#1}{}_{\alpha\beta}$	$\sigma_{2-}^{\#1}{}_{\alpha\beta\chi}$
$\sigma_{2+}^{\#1}{}_{\dagger}{}^{\alpha\beta}$	0	0	0
$\tau_{2+}^{\#1}{}_{\dagger}{}^{\alpha\beta}$	0	$\frac{1}{2\beta_1 k^2}$	0
$\sigma_{2-}^{\#1}{}_{\dagger}{}^{\alpha\beta\chi}$	0	0	0

$\omega_{1+}^{\#1}{}_{\dagger}{}^{\alpha\beta}$	0	0	0	0	0	0	0
$\omega_{1+}^{\#2}{}_{\dagger}{}^{\alpha\beta}$	0	0	0	0	0	0	0
$f_{1+}^{\#1}{}_{\dagger}{}^{\alpha\beta}$	0	0	0	0	0	0	0
$\omega_{1-}^{\#1}{}_{\dagger}{}^{\alpha}$	0	0	0	0	0	0	0
$\omega_{1-}^{\#2}{}_{\dagger}{}^{\alpha}$	0	0	0	0	0	0	0
$f_{1-}^{\#1}{}_{\dagger}{}^{\alpha}$	0	0	0	0	0	0	0
$f_{1-}^{\#2}{}_{\dagger}{}^{\alpha}$	0	0	0	0	0	0	0

$\sigma_{0+}^{\#1}{}_{\dagger}$	0	0	0	$\frac{1}{\alpha_3 k^2}$	$\omega_{0+}^{\#1}{}_{\dagger}$	0	0	0	$\alpha_3 k^2$
$\tau_{0+}^{\#2}{}_{\dagger}$	0	0	0	0	$f_{0+}^{\#2}{}_{\dagger}$	0	0	0	0
$\tau_{0+}^{\#1}{}_{\dagger}$	0	$-\frac{1}{4\beta_1 k^2}$	0	0	$f_{0+}^{\#1}{}_{\dagger}$	0	$-4\beta_1 k^2$	0	0
$\sigma_{0-}^{\#1}{}_{\dagger}$	0	0	0	0	$\omega_{0-}^{\#1}{}_{\dagger}$	0	0	0	0

$\sigma_{1+}^{\#1}{}_{\dagger}{}^{\alpha\beta}$	0	0	0	0	$\sigma_{1-}^{\#2}{}_{\dagger}{}^{\alpha}$	0	0	0	0
$\sigma_{1+}^{\#2}{}_{\dagger}{}^{\alpha\beta}$	0	0	0	0	$\sigma_{1-}^{\#1}{}_{\dagger}{}^{\alpha}$	0	0	0	0
$\tau_{1+}^{\#1}{}_{\dagger}{}^{\alpha\beta}$	0	0	0	0	$\tau_{1-}^{\#2}{}_{\dagger}{}^{\alpha}$	0	0	0	0
$\sigma_{1-}^{\#1}{}_{\dagger}{}^{\alpha}$	0	0	0	0	$\sigma_{1-}^{\#2}{}_{\dagger}{}^{\alpha}$	0	0	0	0
$\sigma_{1-}^{\#2}{}_{\dagger}{}^{\alpha}$	0	0	0	0	$\tau_{1-}^{\#1}{}_{\dagger}{}^{\alpha}$	0	0	0	0
$\tau_{1-}^{\#1}{}_{\dagger}{}^{\alpha}$	0	0	0	0	$\tau_{1-}^{\#2}{}_{\dagger}{}^{\alpha}$	0	0	0	0
$\tau_{1-}^{\#2}{}_{\dagger}{}^{\alpha}$	0	0	0	0					

## Massive and massless spectra



Quadratic pole	
Pole residue:	$\frac{1}{\beta_1} > 0$
Polarisations:	2

(No massive particles)

## Unitarity conditions

$\beta_1 > 0$