

# Particle spectrograph

## Wave operator and propagator

Quadratic (free) action

$$S = \int \int \int \int (\phi \rho + h^{\alpha\beta} \mathcal{T}_{\alpha\beta} + \beta \partial_\alpha \phi \partial^\alpha \phi + \frac{1}{2} \alpha (\partial_\beta h^\chi_\chi \partial^\beta h^\alpha_\alpha + 2 \partial_\alpha h^{\alpha\beta} \partial_\chi h^\chi_\beta - 2 \partial^\beta h^\alpha_\alpha \partial_\chi h^\chi_\beta - \partial_\chi h^\chi_\beta \partial^\chi h^{\alpha\beta})) [t, x, y, z] dz dy dx dt$$

Source constraints

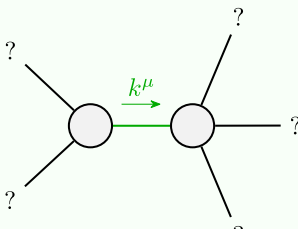
SO(3) irreps	Fundamental fields	Multiplicities
$\mathcal{T}^{#2}_{0+} = 0$	$\partial_\beta \partial_\alpha \mathcal{T}^{\alpha\beta} = 0$	1
$\mathcal{T}^{#1\alpha}_{1-} = 0$	$\partial_\chi \partial_\beta \partial^\alpha \mathcal{T}^{\beta\chi} = \partial_\chi \partial^\chi \partial_\beta \mathcal{T}^{\alpha\beta}$	3
Total constraints/gauge generators:		4

$$\begin{matrix} \mathcal{T}^{#1}_{2+} \alpha\beta \\ \mathcal{T}^{#1}_{2+} \dagger \alpha\beta \end{matrix} \begin{bmatrix} -\frac{2}{\alpha k^2} \end{bmatrix} \begin{matrix} h^{#1}_{2+} \alpha\beta \\ h^{#1}_{2+} \dagger \alpha\beta \end{matrix} \begin{bmatrix} -\frac{\alpha k^2}{2} \end{bmatrix} \begin{matrix} \mathcal{T}^{#1}_{1-} \alpha \\ \mathcal{T}^{#1}_{1-} \dagger \alpha \end{matrix} \begin{bmatrix} 0 \end{bmatrix} \begin{matrix} h^{#1}_{1-} \alpha \\ h^{#1}_{1-} \dagger \alpha \end{matrix} \begin{bmatrix} 0 \end{bmatrix}$$

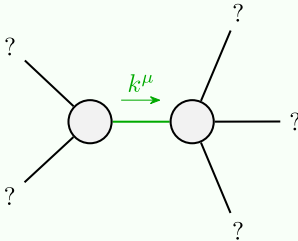
$$\begin{matrix} \mathcal{T}^{#1}_{0+} & \mathcal{T}^{#2}_{0+} & \rho^{#1}_{0+} \\ \mathcal{T}^{#1}_{0+} \dagger & \begin{bmatrix} \frac{1}{\alpha k^2} & 0 & 0 \end{bmatrix} \\ \mathcal{T}^{#2}_{0+} \dagger & \begin{bmatrix} 0 & 0 & 0 \end{bmatrix} \\ \rho^{#1}_{0+} \dagger & \begin{bmatrix} 0 & 0 & \frac{1}{\beta k^2} \end{bmatrix} \end{matrix}$$

$$\begin{matrix} h^{#1}_{0+} & h^{#2}_{0+} & \phi^{#1}_{0+} \\ h^{#1}_{0+} \dagger & \begin{bmatrix} \alpha k^2 & 0 & 0 \end{bmatrix} \\ h^{#2}_{0+} \dagger & \begin{bmatrix} 0 & 0 & 0 \end{bmatrix} \\ \phi^{#1}_{0+} \dagger & \begin{bmatrix} 0 & 0 & \beta k^2 \end{bmatrix} \end{matrix}$$

## Massive and massless spectra



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



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

(No massive particles)

## Unitarity conditions

$$\alpha < 0 \ \&\& \ \beta > 0$$