

# Wave operator and propagator

[illegible][illegible]

## Quadratic (free) action

§ 11

$$\begin{aligned} & \int \int \int \int \left( \frac{1}{8} (8 h^{\alpha\beta} \mathcal{T}_{\alpha\beta} - 4 \Gamma^{\alpha\beta\chi} (a_0 \Gamma_{\beta\chi\alpha} - 2 \Delta_{\alpha\beta\chi} + a_0 \partial_\beta h_{\alpha\chi}) + 2 a_0 \Gamma^{\alpha\beta} \Gamma_{\alpha}^{\gamma\delta} h_{\gamma\delta}^{\chi} - \right. \\ & 2 a_0 h^{\chi} \partial_\beta \Gamma_{\alpha}^{\gamma\delta} h_{\gamma}^{\beta} + 2 a_0 h^{\chi} \partial_\beta \Gamma^{\alpha\beta} - 4 a_0 h_{\alpha\chi} \partial_\beta \Gamma^{\alpha\beta\chi} + \\ & 4 a_0 h^{\alpha\beta} \partial_\beta \partial_\alpha h^{\chi} - a_0 \partial_\beta h^{\chi} \partial_\beta h^{\alpha} - 4 a_0 \partial_\alpha h^{\alpha\beta} \partial_\chi h_{\beta}^{\chi} + \\ & 4 a_0 \partial^\beta h^{\alpha} \partial_\chi h_{\beta}^{\chi} + 2 a_0 \Gamma^{\alpha\beta} \Gamma_{\beta\chi}^{\gamma\delta} (2 \Gamma_{\beta\chi}^{\gamma\delta} - \partial_\beta h_{\chi}^{\gamma\delta} + 2 \partial_\chi h_{\beta}^{\gamma\delta}) - \\ & 8 a_0 h^{\alpha\beta} \partial_\chi \partial_\beta h_{\alpha}^{\chi} + 2 a_0 h^{\alpha} \partial_\chi \partial_\beta h^{\beta\chi} + \\ & 4 a_0 h^{\alpha\beta} \partial_\chi \partial^\chi h_{\alpha\beta} - 2 a_0 h^{\alpha} \partial_\chi \partial^\chi h_{\beta}^{\beta} - \\ & 2 a_0 \partial_\beta h_{\alpha\chi} \partial^\chi h^{\alpha\beta} + 3 a_0 \partial_\chi h_{\alpha\beta} \partial^\chi h^{\alpha\beta} + \\ & \left. 4 a_0 h_{\beta\gamma} \partial^\chi \Gamma_{\alpha}^{\gamma\delta} \right) [t, x, y, z] dz dy dx dt \end{aligned}$$

## Source constraints

SO(3) irreps	Fundamental fields	Multiplicities
$\mathcal{T}_0^{\#2} = 0$	$\partial_\beta \partial_\alpha \mathcal{T}^{\alpha\beta} = 0$	1
$\Delta_{0+}^{\#3} + 2 \Delta_{0+}^{\#4} + 3 \Delta_{0+}^{\#2} = 0$	$\partial_\alpha \Delta^{\alpha\beta}{}_\beta = 0$	1
$\mathcal{T}_1^{\#1\alpha} = 0$	$\partial_\chi \partial_\beta \partial^\alpha \mathcal{T}^{\beta\chi} = \partial_\chi \partial^\alpha \partial_\beta \mathcal{T}^{\alpha\beta}$	3
$2 \Delta_1^{\#6\alpha} + \Delta_1^{\#4\alpha} + 2 \Delta_1^{\#5\alpha} + \Delta_1^{\#3\alpha} = 0$	$\partial_\beta \partial^\alpha \Delta^{\beta\chi}{}_\chi = \partial_\chi \partial^\alpha \Delta^{\alpha\beta}{}_\beta$	3
Total constraints/gauge generators:		8

	$\Delta_0^{\#1} \uparrow$	$\Delta_0^{\#2} \uparrow$	$\Delta_0^{\#3} \uparrow$	$\Delta_0^{\#4} \uparrow$	$\mathcal{T}_0^{\#1} \uparrow$	$\mathcal{T}_0^{\#2} \uparrow$	$\mathcal{T}_0^{\#3} \uparrow$	$\Delta_0^{\#1} \uparrow$
$\Delta_0^{\#1} \uparrow$	$-\frac{2}{a_0}$	0	0	0	0	0	0	0
$\Delta_0^{\#2} \uparrow$	0	$-\frac{3}{4a_0}$	$\frac{5}{4a_0}$	$-\frac{1}{2\sqrt{2}a_0}$	0	0	0	0
$\Delta_0^{\#3} \uparrow$	0	$\frac{5}{4a_0}$	$-\frac{3}{4a_0}$	$-\frac{1}{2\sqrt{2}a_0}$	0	0	0	0
$\Delta_0^{\#4} \uparrow$	0	$-\frac{1}{2\sqrt{2}a_0}$	$-\frac{1}{2\sqrt{2}a_0}$	$\frac{1}{2a_0}$	0	0	0	0
$\mathcal{T}_0^{\#1} \uparrow$	0	0	0	0	$\frac{4}{a_0 k^2}$	0	0	0
$\mathcal{T}_0^{\#2} \uparrow$	0	0	0	0	0	0	0	0
$\Delta_0^{\#1} \uparrow$	0	0	0	0	0	0	$-\frac{2}{a_0}$	$a_0$

$\Delta_{2+}^{\#1} \dagger \alpha\beta$	$\frac{4}{a_0}$	0	0	0	$\mathcal{T}_{2+}^{\#1} \alpha\beta$	0	0	0	$\Delta_{2-}^{\#2} \alpha\beta\chi$	$\Delta_{2-}^{\#2} \alpha\beta\chi$
$\Delta_{2+}^{\#2} \dagger \alpha\beta$	0	$-\frac{2}{a_0}$	0	0	0	0	0	0	0	0
$\Delta_{2+}^{\#3} \dagger \alpha\beta$	0	0	$\frac{4}{a_0}$	0	0	0	0	0	0	0
$\mathcal{T}_{2+}^{\#1} \dagger \alpha\beta$	0	0	0	$-\frac{8}{a_0 k^2}$	0	0	0	0	0	0
$\Delta_{2-}^{\#1} \dagger \alpha\beta\chi$	0	0	0	0	0	0	0	$\frac{4}{a_0}$	0	0
$\Delta_{2-}^{\#2} \dagger \alpha\beta\chi$	0	0	0	0	0	0	0	0	$\frac{4}{a_0}$	$\frac{4}{a_0}$

$\Gamma_{0+}^{\#1}$	$\Gamma_{0+}^{\#2}$	$\Gamma_{0+}^{\#3}$	$\Gamma_{0+}^{\#4}$	$h_{0+}^{\#1}$	$h_{0+}^{\#2}$	$\Gamma_{0+}^{\#1}$
$-\frac{a_0}{2}$	0	0	0	0	0	0
0	0	$\frac{a_0}{2}$	$-\frac{a_0}{2\sqrt{2}}$	0	0	0
0	$\frac{a_0}{2}$	0	$-\frac{a_0}{2\sqrt{2}}$	0	0	0
0	$-\frac{a_0}{2\sqrt{2}}$	$-\frac{a_0}{2\sqrt{2}}$	$\frac{a_0}{2}$	0	0	0
0	0	0	0	$\frac{a_0 k^2}{4}$	0	0
0	0	0	0	0	0	0
0	0	0	0	0	0	$-\frac{a_0}{2}$

  

$\Gamma_{2+}^{\#1} \alpha\beta$	$\Gamma_{2+}^{\#2} \alpha\beta$	$\Gamma_{2+}^{\#3} \alpha\beta$	$h_{2+}^{\#1} \alpha\beta$	$\Gamma_{2+}^{\#1} \alpha\beta\chi$	$\Gamma_{2+}^{\#2} \alpha\beta\chi$
$\Gamma_{2+}^{\#1} \alpha\beta$	$\frac{a_0}{4}$	0	0	0	0
$\Gamma_{2+}^{\#2} \alpha\beta$	0	$-\frac{a_0}{2}$	0	0	0
$\Gamma_{2+}^{\#3} \alpha\beta$	0	0	$\frac{a_0}{4}$	0	0
$h_{2+}^{\#1} \alpha\beta$	0	0	0	$-\frac{a_0 k^2}{8}$	0
$\Gamma_{2+}^{\#1} \alpha\beta\chi$	0	0	0	0	$\frac{a_0}{4}$
$\Gamma_{2+}^{\#2} \alpha\beta\chi$	0	0	0	0	$\frac{a_0}{4}$

Quadratic pole	
Pole residue:	$-\frac{1}{a_0} > 0$
Polarisations:	2

(No massive particles)

$$a_0 < 0$$
