

Particle spectrograph

Wave operator and propagator

Quadratic (free) action

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

$\mathcal{T}_{+0}^{\#2+}$

$0$

$\frac{1}{\alpha(\beta)k^2}$

$\mathcal{T}_{+0}^{\#1+}$

$\frac{1}{\alpha k^2}$

$0$

$\mathcal{T}_{+0}^{\#1+}$

$0$

$\frac{1}{\alpha k^2}$

$\mathcal{T}_{+0}^{\#2+}$

$0$

$\frac{1}{\alpha(\beta)k^2}$

$h_{+0}^{\#1+}$

$\alpha k^2$

$0$

$h_{+0}^{\#2+}$

$0$

$(-\alpha + \beta) k^2$

(No source constraints)

$h_{+1}^{\#1+}$

$\frac{1}{2} (-\alpha + \beta) k^2$

$0$

$\mathcal{T}_{+1}^{\#1+}$

$-\frac{2}{(\alpha\beta)k^2}$

$0$

$\mathcal{T}_{+1}^{\#2+}$

$-\frac{2}{\alpha k^2}$

$0$

$h_{+1}^{\#1+}$

$0$

$0$

$h_{+1}^{\#2+}$

$0$

$(-\alpha + \beta) k^2$

$h_{+2}^{\#1+}$

$-\frac{\alpha k^2}{2}$

$0$

$\mathcal{T}_{+2}^{\#1+}$

$0$

$0$

$\mathcal{T}_{+2}^{\#2+}$

$0$

$0$

$h_{+2}^{\#1+}$

$0$

$0$

$h_{+2}^{\#2+}$

$0$

$0$

Massive and massless spectra

Quartic pole

Pole residue:  $0 < \frac{6\alpha + 3\beta - \sqrt{3} \sqrt{12\alpha^2 + 12\alpha\beta + 19\beta^2 + 64(\alpha-\beta)^2} p^2}{\alpha(\alpha-\beta)} \&\& \frac{6\alpha + 3\beta - \sqrt{3} \sqrt{12\alpha^2 + 12\alpha\beta + 19\beta^2 + 64(\alpha-\beta)^2} p^2}{\alpha(\alpha-\beta)} > 0$

Polarisations: 1

Quartic pole

Pole residue:  $0 < \frac{6\alpha + 3\beta + \sqrt{3} \sqrt{12\alpha^2 + 12\alpha\beta + 19\beta^2 + 64(\alpha-\beta)^2} p^2}{\alpha(\alpha-\beta)} \&\& \frac{6\alpha + 3\beta + \sqrt{3} \sqrt{12\alpha^2 + 12\alpha\beta + 19\beta^2 + 64(\alpha-\beta)^2} p^2}{\alpha(\alpha-\beta)} > 0$

Polarisations: 1

Quadratic pole

Pole residue:  $-\frac{2\alpha + \beta + \sqrt{20\alpha^2 - 36\alpha\beta + 17\beta^2}}{\alpha(\alpha-\beta)} > 0$

Polarisations: 1

Quadratic pole

Pole residue:  $-\frac{1}{\alpha} + \frac{5}{-\alpha + \beta} > 0$

Polarisations: 1

Quadratic pole

Pole residue:  $\frac{1}{\alpha} + \frac{1}{\alpha-\beta} > 0$

Polarisations: 2

Quadratic pole

Pole residue:  $\frac{1}{\alpha} + \frac{5}{\alpha-\beta} > 0$

Polarisations: 1

Hexic pole

Pole residue:  $0 < \frac{2\alpha + \beta}{\alpha^2 - \alpha\beta} \&\& \frac{2\alpha + \beta}{\alpha^2 - \alpha\beta} > 0$

Polarisations: 1

Quartic pole

Pole residue:  $0 < \frac{\beta}{\alpha^2 - \alpha\beta} \&\& \frac{\beta}{\alpha^2 - \alpha\beta} > 0$

Polarisations: 2

Quadratic pole

Pole residue:  $-\frac{1}{\alpha} + \frac{1}{-\alpha + \beta} > 0$

Polarisations: 2

Unitarity conditions

(Unitarity is demonstrably impossible)