# Particle spectrograph

## Wave operator and propagator

Quadratic (free) action

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

| | $\mathcal{T}^{\#1}_{0^+}$ | $\mathcal{T}^{\#2}_{0^+}$ |
|---|---|---|
| $\mathcal{T}^{\#1}_{0^+}\,\dagger$ | $\frac{1}{\frac{\beta(\beta-4\gamma)}{\beta-\gamma}+\alpha k^2}$ | $\frac{\sqrt{3}\,\gamma}{\beta(\beta-4\gamma)+\alpha(\beta-\gamma)k^2}$ |
| $\mathcal{T}^{\#2}_{0^+}\,\dagger$ | $\frac{\sqrt{3}\,\gamma}{\beta(\beta-4\gamma)+\alpha(\beta-\gamma)k^2}$ | $\frac{1}{\beta+\gamma(-1-\frac{3\gamma}{\beta-3\gamma+\alpha k^2})}$ |

| | $h^{\#1}_{0^+}$ | $h^{\#2}_{0^+}$ |
|---|---|---|
| $h^{\#1}_{0^+}\,\dagger$ | $\beta-3\gamma+\alpha k^2$ | $-\sqrt{3}\,\gamma$ |
| $h^{\#2}_{0^+}\,\dagger$ | $-\sqrt{3}\,\gamma$ | $\beta-\gamma$ |

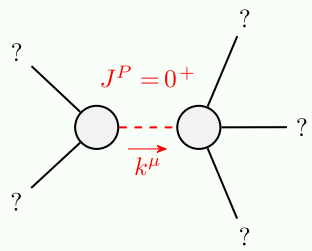
| | $\mathcal{T}^{\#1}_{2^+\,\alpha\beta}$ |
|---|---|
| $\mathcal{T}^{\#1}_{2^+}\,\dagger^{\alpha\beta}$ | $\frac{1}{\beta-\frac{\alpha k^2}{2}}$ |

| | $h^{\#1}_{2^+\,\alpha\beta}$ |
|---|---|
| $h^{\#1}_{2^+}\,\dagger^{\alpha\beta}$ | $\beta-\frac{\alpha k^2}{2}$ |

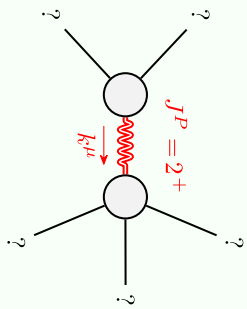
| | $\mathcal{T}^{\#1}_{1^-\,\alpha}$ | $h^{\#1}_{1^-\,\alpha}$ |
|---|---|---|
| $\mathcal{T}^{\#1}_{1^-}\,\dagger^{\alpha}$ | $\frac{1}{\beta}$ | $\beta$ |

(No source constraints)

## Massive and massless spectra




| Massive particle | |
|---|---|
| Pole residue: | $\frac{\beta^2-2\beta\gamma+4\gamma^2}{\alpha(\beta-\gamma)^2} > 0$ |
| Polarisations: | 1 |
| Square mass: | $-\frac{\beta(\beta-4\gamma)}{\alpha(\beta-\gamma)} > 0$ |
| Spin: | 0 |
| Parity: | Even |




| Massive particle | |
|---|---|
| Pole residue: | $-\frac{2}{\alpha} > 0$ |
| Polarisations: | 5 |
| Square mass: | $\frac{2\beta}{\alpha} > 0$ |
| Spin: | 2 |
| Parity: | Even |

(No massless particles)

## Unitarity conditions

(Unitarity is demonstrably impossible)