

Particle spectrograph

Wave operator and propagator

Quadratic (free) action

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

Diagram illustrating the construction of the source-free constraint matrix for the 2D case. The diagram shows the assembly of the matrix from various terms, including source terms and constraints, leading to a final matrix structure with a green box indicating "No source constraints".

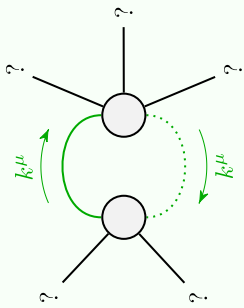
The diagram shows the following components and their assembly:

- Source terms (red boxes):**
 - $\tau_{0+}^{\#1} + \tau_{0+}^{\#2}$ (top left)
 - $\tau_{0+}^{\#1} + \frac{1}{\alpha k^2}$ (top middle)
 - $\tau_{0+}^{\#1} + \tau_{0+}^{\#2}$ (top right)
 - $\tau_{0+}^{\#1} + \frac{1}{(-\alpha + \beta) k^2}$ (bottom left)
 - $\tau_{0+}^{\#1} + \tau_{0+}^{\#2}$ (bottom middle)
 - $\tau_{0+}^{\#1} + \tau_{0+}^{\#2}$ (bottom right)
- Constraint terms (blue boxes):**
 - $\tau_{2+}^{\#1} + \alpha \beta$ (middle left)
 - $\tau_{2+}^{\#1} + \alpha \beta$ (middle right)
 - $\tau_{2+}^{\#1} + \alpha \beta$ (bottom left)
 - $\tau_{2+}^{\#1} + \alpha \beta$ (bottom right)
- Final matrix structure (green box):**
 - $\tau_{2+}^{\#1} + \alpha \beta$ (top left)
 - $\tau_{2+}^{\#1} + \alpha \beta$ (top middle)
 - $\tau_{2+}^{\#1} + \alpha \beta$ (top right)
 - $\tau_{2+}^{\#1} + \alpha \beta$ (bottom left)
 - $\tau_{2+}^{\#1} + \alpha \beta$ (bottom middle)
 - $\tau_{2+}^{\#1} + \alpha \beta$ (bottom right)

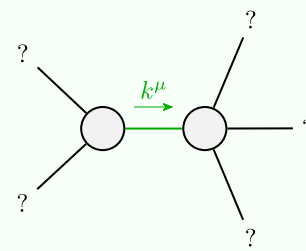
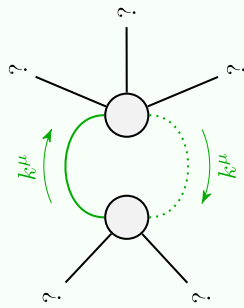
The diagram shows the assembly of the matrix from various terms, including source terms and constraints, leading to a final matrix structure with a green box indicating "No source constraints".

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:	$0 < \frac{6 \alpha + 3 \beta + \sqrt{3} \sqrt{12 \alpha^2 + 12 \alpha \beta + 19 \beta^2 + 64 (\alpha - \beta)^2} p^2}{\alpha (\alpha - \beta)} \quad \&$ $\frac{6 \alpha + 3 \beta + \sqrt{3} \sqrt{12 \alpha^2 + 12 \alpha \beta + 19 \beta^2 + 64 (\alpha - \beta)^2} p^2}{\alpha (\alpha - \beta)} > 0$
Polarisations:	1



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

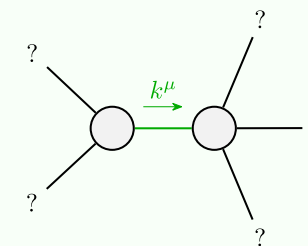
Quadratic pole	$\frac{1}{\alpha} + \frac{5}{\alpha - \beta} > 0$
Pole residue:	
Polarisations:	1

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

(No massive particles)



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

Unitarity conditions

(Unitarity is demonstrably impossible)