

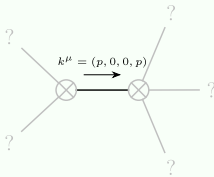
Particle spectrograph

Wave operator and propagator

$$S = \iiint (\phi \rho + \alpha \partial_a \phi \partial^a \phi)[t, x, y, z] d^3x \quad (\text{No source constraints})$$

$$\begin{array}{cc} \begin{array}{c} \#1 \\ 0^+ \end{array} \phi^+ & \begin{array}{c} \#1 \\ 0^+ \end{array} \rho^+ \\ \begin{array}{c} \#1 \\ 0^+ \end{array} \phi^+ & \begin{array}{c} \alpha k^2 \end{array} \\ \begin{array}{c} \#1 \\ 0^+ \end{array} \phi^+ & \begin{array}{c} \alpha k^2 \end{array} \\ \begin{array}{c} \#1 \\ 0^+ \end{array} \phi^+ & \begin{array}{c} \alpha k^2 \end{array} \end{array}$$

Massive and massless spectra



Massless particle

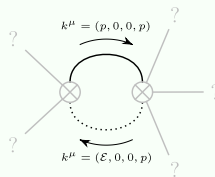
Join[{}, Gather [

```
Pole residue: {{1}, {1}}.Replace[Symbol[  
MapThread[#1 → #2 &, {Tally[First[Symbol[]]], {}}], {2}].{1}, {1}} > 0
```

Polarisations: 1

(No particles)

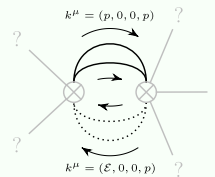
Unitarity conditions



Quartic pol

```
Pole residue: 0 < { {1}, {1} }.Replace[Symbol[],  
    MapThread[#1 → #2 &, {Tally[First[Symbol[]]], {}}], {2}].{ {1}, {1} } &&  
    { {1}, {1} }.Replace[Symbol[], MapThread[#1 → #2 &, {Tally[First[Symbol[]]], {}}],  
    {2}].{ {1}, {1} } > 0
```

Polarisations: 1



Hexic pol

```
Pole residue: 0 < {{1}}, {1}}.Replace[Symbol[],  
MapThread[#1 → #2 &, {Tally[First[Symbol[]]], {}}], {2}].{{1}}, {1}} &&  
{{1}}, {1}}.Replace[Symbol[], MapThread[#1 → #2 &, {Tally[First[Symbol[]]], {}}],  
{2}].{{1}}, {1}} > 0
```

Polarisations: 1