

Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$S = \iiint [(\omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - 2r_3 (\partial_\beta \omega_{,\theta}^\theta \partial_\theta \omega_{,\beta}^\theta \partial_\theta \omega_{,\theta}^\theta + \partial_\theta \omega_{,\beta}^\theta \partial_\theta \omega_{,\theta}^\theta + \partial_\alpha \omega_{,\theta}^\alpha \partial_\theta \omega_{,\beta}^\theta - 2\partial_\alpha \omega_{,\beta}^{\alpha\beta} \partial_\theta \omega_{,\theta}^\theta - 2\partial_\theta \omega_{,\beta}^{\alpha\beta} \partial_\theta \omega_{,\theta}^\theta + 2\partial_\beta \omega_{,\theta\alpha}^\theta \partial_\theta \omega_{,\theta}^{\alpha\beta}) + \frac{2}{3} r_1 (3\partial_\beta \omega_{,\theta}^\theta \partial_\theta \omega_{,\theta}^\theta + 3\partial_\theta \omega_{,\beta}^\theta \partial_\theta \omega_{,\theta}^\theta + 3\partial_\alpha \omega_{,\theta}^{\alpha\beta} \partial_\theta \omega_{,\beta}^\theta - 6\partial_\theta \omega_{,\beta}^\theta \partial_\theta \omega_{,\theta}^{\alpha\beta} \partial_\alpha \omega_{,\theta}^\theta + 3\partial_\alpha \omega_{,\theta}^{\alpha\beta} \partial_\theta \omega_{,\beta}^\theta - 6\partial_\theta \omega_{,\beta}^\theta \partial_\theta \omega_{,\alpha\theta}^{\alpha\beta} + \partial_\beta \omega_{,\alpha\theta}^\theta \partial_\theta \omega_{,\theta}^{\alpha\beta} + 2\partial_\beta \omega_{,\theta\alpha}^\theta \partial_\theta \omega_{,\theta}^{\alpha\beta}) + 2\partial_\beta \omega_{,\theta\alpha}^\theta \partial_\theta \omega_{,\theta}^{\alpha\beta} - \partial_\theta \omega_{,\alpha\beta\theta}^\theta \partial_\theta \omega_{,\theta}^{\alpha\beta} + \partial_\theta \omega_{,\alpha\beta}^\theta \partial_\theta \omega_{,\theta}^{\alpha\beta} + \partial_\theta \omega_{,\alpha\beta}^\theta \partial_\theta \omega_{,\theta}^{\alpha\beta}) + r_5 (\partial_\theta \omega_{,\theta}^\kappa \partial_\kappa \omega_{,\theta}^{\alpha\iota} - \partial_\theta \omega_{,\kappa}^\kappa \partial_\theta \omega_{,\theta}^{\alpha\iota} - (\partial_\alpha \omega_{,\kappa}^{\alpha\iota\theta} - 2\partial_\theta \omega_{,\theta}^{\alpha\iota} - \partial_\kappa \omega_{,\theta}^\kappa - \partial_\kappa \omega_{,\theta}^\kappa))] dt, x, y, z] dz dy dx$$

$$\begin{array}{c}
 \begin{array}{cc}
 \omega_{2+}^{\#1} \alpha\beta & \omega_{2-}^{\#1} \alpha\beta\chi \\
 \omega_{2+}^{\#1} \dagger\alpha\beta & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array} \\
 \omega_{2-}^{\#1} \dagger\alpha\beta\chi & \begin{array}{|c|c|} \hline 0 & k^2 r_1 \\ \hline \end{array}
 \end{array}
 \quad
 \begin{array}{cc}
 \sigma_{2+}^{\#1} \alpha\beta & \sigma_{2-}^{\#1} \alpha\beta\chi \\
 \sigma_{2+}^{\#1} \dagger\alpha\beta & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array} \\
 \sigma_{2-}^{\#1} \dagger\alpha\beta\chi & \begin{array}{|c|c|} \hline 0 & \frac{1}{k^2 r_1} \\ \hline \end{array}
 \end{array}
 \quad
 \begin{array}{cc}
 \omega_0^{\#1} & \omega_0^{\#1} \\
 \omega_0^{\#1} \dagger & \begin{array}{|c|c|} \hline 6k^2(-r_1+r_3) & 0 \\ \hline \end{array} \\
 \omega_0^{\#1} \dagger & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array}
 \end{array}
 \end{array}$$

$$\begin{array}{cccc}
 \omega_{1+}^{\#1} \alpha\beta & \omega_{1+}^{\#2} \alpha\beta & \omega_{1-}^{\#1} \alpha & \omega_{1-}^{\#2} \alpha \\
 \omega_{1+}^{\#1} \dagger\alpha\beta & \begin{array}{|c|c|} \hline k^2(2r_3+r_5) & 0 \\ \hline \end{array} & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array} & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array} \\
 \omega_{1+}^{\#2} \dagger\alpha\beta & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array} & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array} & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array} \\
 \omega_{1-}^{\#1} \dagger\alpha & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array} & \begin{array}{|c|c|} \hline k^2(-r_1+2r_3+r_5) & 0 \\ \hline \end{array} & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array} \\
 \omega_{1-}^{\#2} \dagger\alpha & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array} & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array} & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array}
 \end{array}$$

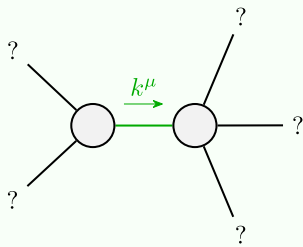
$$\begin{array}{cc}
 \sigma_0^{\#1} & \sigma_0^{\#1} \\
 \sigma_0^{\#1} \dagger & \begin{array}{|c|c|} \hline \frac{1}{6k^2(-r_1+r_3)} & 0 \\ \hline \end{array} \\
 \sigma_0^{\#1} \dagger & \begin{array}{|c|c|} \hline 0 & 0 \\ \hline \end{array}
 \end{array}$$

Source constraints/gauge generators	
SO(3) irreps	Multiplicities
$\sigma_0^{\#1} == 0$	1
$\sigma_1^{\#2\alpha} == 0$	3
$\sigma_1^{\#2\alpha\beta} == 0$	3
$\sigma_2^{\#1\alpha\beta} == 0$	5
Total constraints: 12	

	$\sigma_{0+}^{\#1}$	$\sigma_{0-}^{\#1}$
$\sigma_{0+}^{\#1} \dagger$	$\frac{1}{6k^2(-r_1+r_3)}$	0
$\sigma_{0-}^{\#1} \dagger$	0	0

$\sigma_{1+}^{\#1} + \alpha\beta$	$\frac{1}{k^2(2r_3+r_5)}$	$\sigma_{1+}^{\#2}$	$\sigma_{1-}^{\#1} \alpha$	$\sigma_{1-}^{\#2} \alpha$
$\sigma_{1+}^{\#2} + \alpha\beta$	0	0	0	0
$\sigma_{1-}^{\#1} + \alpha$	0	0	$\frac{1}{k^2(-r_1+2r_3+r_5)}$	0
$\sigma_{1-}^{\#2} + \alpha$	0	0	0	0

Massive and massless spectra



Quadratic pole	
Pole residue:	$\frac{1}{r_1 (r_1 - 2 r_3 - r_5) (2 r_3 + r_5)} > 0$
Polarisations:	2

(No massive particles)

Unitarity conditions

$$r_1 < 0 \&\& (r_5 < r_1 - 2r_3 \parallel r_5 > -2r_3) \parallel r_1 > 0 \&\& -2r_3 < r_5 < r_1 - 2r_3$$