

Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$S = \int \int \int \int (\frac{1}{6} (-4 t_3 \omega_{\alpha}^{\alpha i} \omega_{\alpha}^{\kappa} + 6 f^{\alpha \beta} \tau_{\alpha \beta} + 6 \omega^{\alpha \beta \chi} \sigma_{\alpha \beta \chi} + 8 t_3 \omega_{\alpha}^{\kappa} \partial_i f^{\alpha i} - 8 t_3 \omega_{\alpha}^{\kappa} \partial_i f^{\alpha i} + \partial_i f^{\alpha} \omega_{\alpha}^{\kappa} + 4 t_3 \partial_i f^{\kappa} \partial_i f^{\alpha} - 12 r_1 \partial_{\beta} \omega_{\beta}^{\theta} \partial_i \omega_{\beta}^{\alpha \beta} + 12 r_1 \partial_i \omega_{\beta}^{\theta} \partial_i \omega_{\beta}^{\alpha \beta} + 12 r_1 \partial_{\alpha} \omega^{\alpha \beta i} \partial_{\theta} \omega_{\beta}^{\theta} - 24 r_1 \partial_i \omega_{\beta}^{\alpha \beta} \partial_{\theta} \omega_{\beta}^{\theta} - 12 r_1 \partial_{\alpha} \omega^{\alpha \beta i} \partial_{\theta} \omega_{\beta}^{\theta} + 24 r_1 \partial_i \omega_{\alpha}^{\alpha \beta} \partial_{\theta} \omega_{\beta}^{\theta} + 4 t_2 \omega_{\beta}^{\theta} \partial_{\theta} f^{\alpha i} + 2 t_2 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha i} - t_2 \partial_{\alpha} f_{\theta i} \partial^{\theta} f^{\alpha i} - t_2 \partial_i f_{\alpha \theta} \partial^{\theta} f^{\alpha i} + t_2 \partial_{\theta} f_{\alpha i} \partial^{\theta} f^{\alpha i} - t_2 \partial_{\theta} f_{i \alpha} \partial^{\theta} f^{\alpha i} - 4 t_2 \omega_{\alpha \theta i} (\omega^{\alpha i \theta} + \partial^{\theta} f^{\alpha i}) + 2 t_2 \omega_{\alpha i \theta} (\omega^{\alpha i \theta} + 2 \partial^{\theta} f^{\alpha i}) - 8 r_1 \partial_{\beta} \omega_{\alpha i \theta} \partial^{\theta} \omega_{\alpha i \theta}^{\alpha \beta i} + 8 r_2 \partial_{\beta} \omega_{\alpha i \theta} \partial^{\theta} \omega_{\alpha i \theta}^{\alpha \beta i} + 4 r_1 \partial_{\beta} \omega_{\alpha \theta i} \partial^{\theta} \omega_{\alpha \theta i}^{\alpha \beta i} - 4 r_2 \partial_{\beta} \omega_{\alpha \theta i} \partial^{\theta} \omega_{\alpha \theta i}^{\alpha \beta i} - 16 r_1 \partial_{\beta} \omega_{i \theta \alpha} \partial^{\theta} \omega_{i \theta \alpha}^{\alpha \beta i} + 4 r_2 \partial_{\beta} \omega_{i \theta \alpha} \partial^{\theta} \omega_{i \theta \alpha}^{\alpha \beta i} - 4 r_1 \partial_i \omega_{\alpha \beta \theta} \partial^{\theta} \omega_{\alpha \beta i}^{\alpha \beta i} - 2 r_2 \partial_i \omega_{\alpha \beta \theta} \partial^{\theta} \omega_{\alpha \beta i}^{\alpha \beta i} + 4 r_1 \partial_{\theta} \omega_{\alpha \beta i} \partial^{\theta} \omega_{\alpha \beta i}^{\alpha \beta i} + 2 r_2 \partial_{\theta} \omega_{\alpha \beta i} \partial^{\theta} \omega_{\alpha \beta i}^{\alpha \beta i} + 4 r_1 \partial_{\theta} \omega_{\alpha i \beta} \partial^{\theta} \omega_{\alpha i \beta}^{\alpha \beta i} - 4 r_2 \partial_{\theta} \omega_{\alpha i \beta} \partial^{\theta} \omega_{\alpha i \beta}^{\alpha \beta i} - 4 r_1 \partial_{\theta} \omega_{\alpha i \beta} \partial^{\theta} \omega_{\alpha i \beta}^{\alpha \beta i} - 8 t_3 \partial_i f^{\alpha} \partial_{\kappa} f_{\alpha}^{\kappa} - 8 t_3 \partial_i f^{\alpha} \partial_{\kappa} f_{\alpha}^{\kappa})) [t, x, y, z] dz dy dx dt$$

$\sigma_{1+}^{\#1} + \alpha \beta$	$\sigma_{1+}^{\#2} + \alpha \beta$	$\tau_{1+}^{\#1} + \alpha \beta$	$\sigma_{1-}^{\#1} - \alpha$	$\sigma_{1-}^{\#2} - \alpha$	$\tau_{1-}^{\#1} - \alpha$	$\tau_{1-}^{\#2} - \alpha$
$\frac{6}{(3+k^2)^2 t_2}$	$\frac{3 \sqrt{2}}{(3+k^2)^2 t_2}$	$\frac{3 i \sqrt{2} k}{(3+k^2)^2 t_2}$	0	0	0	0
$\frac{3 \sqrt{2}}{(3+k^2)^2 t_2}$	$\frac{3}{(3+k^2)^2 t_2}$	$\frac{3 i k}{(3+k^2)^2 t_2}$	0	0	0	0
$\tau_{1+}^{\#1} + \alpha \beta$	$-\frac{3 i \sqrt{2} k}{(3+k^2)^2 t_2}$	$-\frac{3 k^2}{(3+k^2)^2 t_2}$	0	0	0	0
$\sigma_{1-}^{\#1} + \alpha$	0	0	$-\frac{1}{k^2 r_1}$	$-\frac{\sqrt{2}}{k^2 r_1 + 2 k^4 r_1}$	0	$-\frac{2 i}{k r_1 + 2 k^3 r_1}$
$\sigma_{1-}^{\#2} + \alpha$	0	0	$-\frac{\sqrt{2}}{k^2 r_1 + 2 k^4 r_1}$	$\frac{3 k^2 r_1 - 2 t_3}{(k + 2 k^3)^2 r_1 t_3}$	0	$\frac{i \sqrt{2} (3 k^2 r_1 - 2 t_3)}{k (1 + 2 k^2)^2 r_1 t_3}$
$\tau_{1-}^{\#1} + \alpha$	0	0	0	0	0	0
$\tau_{1-}^{\#2} + \alpha$	0	0	$\frac{2 i}{k r_1 + 2 k^3 r_1}$	$-\frac{i \sqrt{2} (3 k^2 r_1 - 2 t_3)}{k (1 + 2 k^2)^2 r_1 t_3}$	0	$\frac{6 k^2 r_1 - 4 t_3}{(1 + 2 k^2)^2 r_1 t_3}$

$\omega_{1+}^{\#1} + \alpha \beta$	$\omega_{1+}^{\#2} + \alpha \beta$	$f_{1+}^{\#1} + \alpha \beta$	$\omega_{1-}^{\#1} - \alpha$	$\omega_{1-}^{\#2} - \alpha$	$f_{1-}^{\#1} - \alpha$	$f_{1-}^{\#2} - \alpha$
$\frac{2 t_2}{3}$	$\frac{\sqrt{2} t_2}{3}$	$\frac{1}{3} i \sqrt{2} k t_2$	0	0	0	0
$\omega_{1+}^{\#2} + \alpha \beta$	$\frac{\sqrt{2} t_2}{3}$	$\frac{i k t_2}{3}$	0	0	0	0
$f_{1+}^{\#1} + \alpha \beta$	$-\frac{1}{3} i \sqrt{2} k t_2$	$\frac{k^2 t_2}{3}$	0	0	0	0
$\omega_{1-}^{\#1} + \alpha$	0	0	$-k^2 r_1 + \frac{2 t_3}{3}$	$-\frac{\sqrt{2} t_3}{3}$	0	$-\frac{2}{3} i k t_3$
$\omega_{1-}^{\#2} + \alpha$	0	0	$-\frac{\sqrt{2} t_3}{3}$	$\frac{t_3}{3}$	0	$\frac{1}{3} i \sqrt{2} k t_3$
$f_{1-}^{\#1} + \alpha$	0	0	0	0	0	0
$f_{1-}^{\#2} + \alpha$	0	0	$\frac{2 i k t_3}{3}$	$-\frac{1}{3} i \sqrt{2} k t_3$	0	$\frac{2 k^2 t_3}{3}$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau_{0+}^{\#2} == 0$	1
$\tau_{0+}^{\#1} - 2 i k \sigma_{0+}^{\#1} == 0$	1
$\tau_{1-}^{\#2 \alpha} + 2 i k \sigma_{1-}^{\#2 \alpha} == 0$	3
$\tau_{1-}^{\#1 \alpha} == 0$	3
$\tau_{1+}^{\#1 \alpha \beta} + i k \sigma_{1+}^{\#1 \alpha \beta} == 0$	3
$\sigma_{1+}^{\#1 \alpha \beta} == \sigma_{1+}^{\#2 \alpha \beta}$	3
$\tau_{2+}^{\#1 \alpha \beta} == 0$	5
$\sigma_{2+}^{\#1 \alpha \beta} == 0$	5
Total constraints:	24

$\omega_{2+}^{\#1} + \alpha \beta$ $f_{2+}^{\#1} + \alpha \beta$ $\omega_{2-}^{\#1} - \alpha \beta \chi$

0	0	0
0	0	0
0	0	$k^2 r_1$

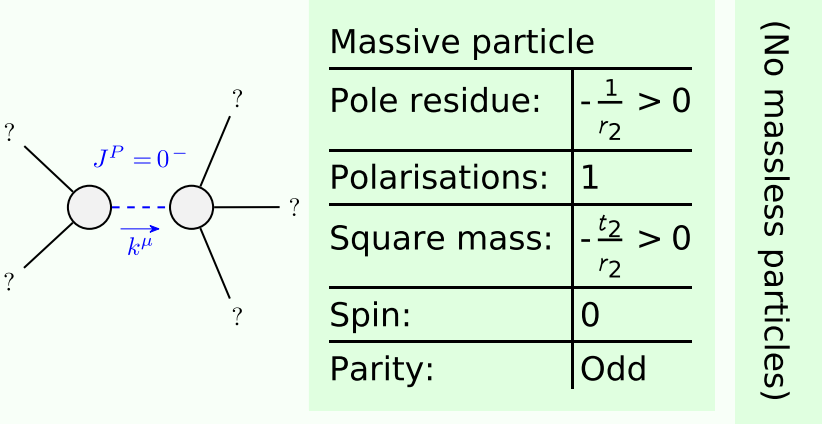
 $\sigma_{2+}^{\#1} + \alpha \beta \chi$ $\tau_{2+}^{\#1} + \alpha \beta$ $\sigma_{2+}^{\#1} - \alpha \beta \chi$

0	0	0
0	0	0
$\frac{1}{k^2 r_1}$	0	0

$\sigma_{0+}^{\#1} +$	$\tau_{0+}^{\#1} +$	$\tau_{0+}^{\#2} +$	$\sigma_{0-}^{\#1} -$
$\frac{1}{(1+2 k^2)^2 t_3}$	$-\frac{i \sqrt{2} k}{(1+2 k^2)^2 t_3}$	0	0
$\tau_{0+}^{\#1} +$	$\frac{i \sqrt{2} k}{(1+2 k^2)^2 t_3}$	0	0
$\tau_{0+}^{\#2} +$	0	0	0
$\sigma_{0-}^{\#1} +$	0	0	$\frac{1}{k^2 r_2 + t_2}$

$\omega_{0+}^{\#1} +$	$f_{0+}^{\#1} +$	$f_{0+}^{\#2} +$	$\omega_{0-}^{\#1} -$
t_3	$-i \sqrt{2} k t_3$	0	0
$f_{0+}^{\#1} +$	$i \sqrt{2} k t_3$	0	0
$f_{0+}^{\#2} +$	0	0	0
$\omega_{0-}^{\#1} +$	0	0	$k^2 r_2 + t_2$

Massive and massless spectra



Unitarity conditions

$r_2 < 0 \&\& t_2 > 0$