

Particle spectrograph

Wave operator and propagator

$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1+}^{\#1} \dagger^{\alpha}$	$\sigma_{1+}^{\#2} \dagger^{\alpha}$	$\tau_{1+}^{\#1} \dagger^{\alpha}$	$\tau_{1+}^{\#2} \dagger^{\alpha}$
0	$-\frac{\sqrt{2}}{t_1+k^2}t_1$	$-\frac{i\sqrt{2}k}{t_1+k^2}t_1$	0	0	0	0
$-\frac{\sqrt{2}}{t_1+k^2}t_1$	$\frac{1}{(1+k^2)^2}t_1$	$\frac{ik}{(1+k^2)^2}t_1$	0	0	0	0
$\frac{i\sqrt{2}k}{t_1+k^2}t_1$	$-\frac{ik}{(1+k^2)^2}t_1$	$\frac{k^2}{(1+k^2)^2}t_1$	0	0	0	0
0	0	0	$\frac{2(t_1+t_3)}{3t_1t_3}$	$-\frac{\sqrt{2}(t_1-2t_3)}{3(1+2k^2)t_1t_3}$	0	$-\frac{2ikt_1-4ikt_3}{3t_1t_3+6k^2t_1t_3}$
0	0	0	$-\frac{\sqrt{2}(t_1-2t_3)}{3(1+2k^2)t_1t_3}$	$\frac{t_1+4t_3}{3(1+2k^2)^2t_1t_3}$	0	$\frac{i\sqrt{2}k(t_1+4t_3)}{3(1+2k^2)^2t_1t_3}$
0	0	0	0	0	0	0
0	0	0	$\frac{2ikt_1-4ikt_3}{3t_1t_3+6k^2t_1t_3}$	$-\frac{i\sqrt{2}k(t_1+4t_3)}{3(1+2k^2)^2t_1t_3}$	0	$\frac{2k^2(t_1+4t_3)}{3(1+2k^2)^2t_1t_3}$

$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1+}^{\#1} \dagger^{\alpha}$	$\omega_{1+}^{\#2} \dagger^{\alpha}$	$f_{1+}^{\#1} \dagger^{\alpha}$	$f_{1+}^{\#2} \dagger^{\alpha}$
$-\frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{ikt_1}{\sqrt{2}}$	0	0	0	0
$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$\frac{ikt_1}{\sqrt{2}}$	0	0	0	0	0	0
0	0	0	$\frac{1}{6}(t_1+4t_3)$	$\frac{t_1-2t_3}{3\sqrt{2}}$	0	$\frac{1}{3}ik(t_1-2t_3)$
0	0	0	$\frac{t_1-2t_3}{3\sqrt{2}}$	$\frac{t_1+t_3}{3}$	0	$\frac{1}{3}i\sqrt{2}k(t_1+t_3)$
0	0	0	0	0	0	0
0	0	0	$-\frac{1}{3}ik(t_1-2t_3)$	$-\frac{1}{3}i\sqrt{2}k(t_1+t_3)$	0	$\frac{2}{3}k^2(t_1+t_3)$

Quadratic (free) action

$$S = \iiint (\frac{1}{6} (2 \omega_{\alpha}^{\alpha 1} (t_1 \omega_{\theta}^{\theta} - 2 t_3 \omega_{\kappa}^{\kappa}) + 6 f^{\alpha \beta} \tau_{\alpha \beta} + 6 \omega^{\alpha \beta \chi} \sigma_{\alpha \beta \chi} - 4 t_1 \omega_{\alpha}^{\theta} \partial_{\theta} f^{\alpha 1} + 8 t_3 \omega_{\kappa}^{\kappa} \partial_{\kappa} f^{\alpha 1} + 4 t_1 \omega_{\theta}^{\theta} \partial_{\theta} f^{\alpha} - 8 t_3 \omega_{\kappa}^{\kappa} \partial_{\kappa} f^{\alpha} - 2 t_1 \partial_{\theta} f_{\theta}^{\theta} \partial_{\theta} f_{\alpha}^{\alpha} + 4 t_3 \partial_{\theta} f_{\kappa}^{\kappa} \partial_{\kappa} f_{\alpha}^{\alpha} - 2 t_1 \partial_{\theta} f_{\theta}^{\alpha 1} \partial_{\theta} f_{\alpha}^{\theta} + 4 t_1 \partial_{\theta} f_{\alpha}^{\theta} \partial_{\theta} f_{\theta}^{\theta} - 6 t_1 \partial_{\alpha} f_{\theta}^{\theta} \partial_{\theta} f_{\theta}^{\alpha 1} - 3 t_1 \partial_{\alpha} f_{\theta}^{\alpha 1} \partial_{\theta} f_{\alpha}^{\alpha 1} + 3 t_1 \partial_{\theta} f_{\alpha \theta}^{\alpha \theta} \partial_{\theta} f_{\alpha}^{\alpha 1} + 3 t_1 \partial_{\theta} f_{\alpha}^{\theta} \partial_{\theta} f_{\alpha}^{\alpha 1} + 3 t_1 \partial_{\theta} f_{\alpha}^{\theta} \partial_{\theta} f_{\alpha}^{\alpha 1} + 3 t_1 \partial_{\theta} f_{\alpha}^{\theta} \partial_{\theta} f_{\alpha}^{\alpha 1} - 3 t_1 \partial_{\theta} f_{\alpha}^{\theta} \partial_{\theta} f_{\alpha}^{\alpha 1} + 6 t_1 \omega_{\alpha \theta}^{\alpha \beta 1} + 6 t_1 \omega_{\alpha \theta}^{\alpha \beta 1} (\omega^{\alpha \theta} + 2 \partial^{\theta} f^{\alpha 1}) + 8 r_2 \partial_{\beta} \omega_{\alpha \theta}^{\alpha \beta 1} \partial^{\theta} \omega^{\alpha \beta 1} - 4 r_2 \partial_{\beta} \omega_{\alpha \theta}^{\alpha \beta 1} \partial^{\theta} \omega^{\alpha \beta 1} + 4 r_2 \partial_{\beta} \omega_{\theta \alpha}^{\alpha \beta 1} \partial^{\theta} \omega^{\alpha \beta 1} - 2 r_2 \partial_{\theta} \omega_{\alpha \beta \theta}^{\alpha \beta 1} \partial^{\theta} \omega^{\alpha \beta 1} + 2 r_2 \partial_{\theta} \omega_{\alpha \beta \theta}^{\alpha \beta 1} \partial^{\theta} \omega^{\alpha \beta 1} - 4 r_2 \partial_{\theta} \omega_{\alpha \beta \theta}^{\alpha \beta 1} \partial^{\theta} \omega^{\alpha \beta 1} + 4 t_3 \partial_{\theta} f_{\alpha}^{\alpha 1} \partial_{\kappa} f_{\alpha}^{\kappa} - 8 t_3 \partial_{\theta} f_{\alpha}^{\kappa} \partial_{\kappa} f_{\alpha}^{\alpha 1}) [t, x, y, z] dz dy dx dt$$

$\sigma_{2+}^{\#1} \dagger^{\alpha\beta}$

$\tau_{2+}^{\#1} \dagger^{\alpha\beta}$

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

$\frac{2}{(1+2k^2)^2}t_1$

$-\frac{2i\sqrt{2}k}{(1+2k^2)^2}t_1$

0

$\frac{2i\sqrt{2}k}{(1+2k^2)^2}t_1$

$\frac{4k^2}{(1+2k^2)^2}t_1$

0

Source constraints/gauge generators

SO(3) irreps

Multiplicities

$\tau_{0+}^{\#2} == 0$

1

$\tau_{0+}^{\#1} - 2ik\sigma_{0+}^{\#1} == 0$

1

$\tau_{1+}^{\#2\alpha} + 2ik\sigma_{1+}^{\#2\alpha} == 0$

3

$\tau_{1+}^{\#1\alpha} == 0$

3

$\tau_{1+}^{\#1\alpha\beta} + ik\sigma_{1+}^{\#2\alpha\beta} == 0$

3

$\tau_{2+}^{\#1\alpha\beta} - 2ik\sigma_{2+}^{\#1\alpha\beta} == 0$

5

Total constraints:

16

$\omega_{2+}^{\#1} \dagger^{\alpha\beta}$

$f_{2+}^{\#1} \dagger^{\alpha\beta}$

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

$\frac{t_1}{2}$

$-\frac{ikt_1}{\sqrt{2}}$

0

$\frac{ikt_1}{\sqrt{2}}$

k^2t_1

0

$\omega_{0+}^{\#1} \dagger$

$f_{0+}^{\#1} \dagger$

$f_{0+}^{\#2} \dagger$

$\omega_{0+}^{\#1} \dagger$

t_3

$-i\sqrt{2}kt_3$

0

0

$i\sqrt{2}kt_3$

$2k^2t_3$

0

0

0

0

0

0

$\sigma_{0+}^{\#1} \dagger$

$\tau_{0+}^{\#2} \dagger$

$\tau_{0+}^{\#1} \dagger$

$\sigma_{0+}^{\#1} \dagger$

0

0

0

$\frac{1}{k^2r_2-t_1}$

$-\frac{i\sqrt{2}k}{(1+2k^2)^2}t_3$

$\frac{2k^2}{(1+2k^2)^2}t_3$

0

0

$\frac{1}{(1+2k^2)^2}t_3$

$\frac{i\sqrt{2}k}{(1+2k^2)^2}t_3$

0

0

Massive and massless spectra

Massive particle

Pole residue:

$-\frac{1}{r_2} > 0$

Polarisations:

1

Square mass:

$\frac{t_1}{r_2} > 0$

Spin:

0

Parity:

Odd

(No massless particles)

Unitarity conditions

$r_2 < 0 \&\& t_1 < 0$