

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
$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$\frac{-2k^2 r_5+t_1}{(1+k^2)^2 t_1^2}$	$-\frac{i(2k^3 r_5-kt_1)}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\frac{i\sqrt{2} k}{t_1+k^2 t_1}$	$\frac{i(2k^3 r_5-kt_1)}{(1+k^2)^2 t_1^2}$	$\frac{-2k^4 r_5+k^2 t_1}{(1+k^2)^2 t_1^2}$	0	0	0	0
0	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2 t_1}$	0	$\frac{2ik}{t_1+2k^2 t_1}$
0	0	0	0	0	$-\frac{\sqrt{2}}{t_1+2k^2 t_1}$	$-\frac{i\sqrt{2} k(2k^2 r_5-t_1)}{(t_1+2k^2 t_1)^2}$
0	0	0	0	0	0	0
0	0	0	$-\frac{2ik}{t_1+2k^2 t_1}$	$\frac{i\sqrt{2} k(2k^2 r_5-t_1)}{(t_1+2k^2 t_1)^2}$	0	$\frac{-4k^4 r_5+2k^2 t_1}{(t_1+2k^2 t_1)^2}$

Quadratic (free) action

$$S=$$

$$\iiint [(f^{\alpha\beta} \tau_{\alpha\beta} + \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} + \frac{1}{2} t_1 (2 \omega^{\alpha i} \omega_{\alpha}{}^{\theta} \omega_{\theta}{}^{\prime} f_{\theta}^{\alpha i} + 4 \omega_{\theta}{}^{\theta} \partial_{\theta} f_{\alpha}^{\alpha i} -$$

$$2 \partial_{\theta} f_{\theta}^{\alpha} \partial_{\theta} f_{\alpha}^{\alpha} - 2 \partial_{\theta} f_{\alpha}^{\alpha i} \partial_{\theta} f_{\theta}^{\alpha} + 4 \partial_{\theta} f_{\alpha}^{\alpha} \partial_{\theta} f_{\theta}^{\theta} - 2 \partial_{\alpha} f_{\theta}^{\theta} \partial_{\theta} f_{\alpha}^{\alpha i} - \partial_{\alpha} f_{\theta}^{\theta} \partial_{\theta} f_{\alpha}^{\alpha i} +$$

$$\partial_{\theta} f_{\alpha\theta} \partial_{\theta} f_{\alpha}^{\alpha i} + \partial_{\theta} f_{\alpha i} \partial_{\theta} f_{\alpha}^{\alpha i} + \partial_{\theta} f_{\alpha}^{\alpha i} \partial_{\theta} f_{\alpha}^{\alpha i} + 2 \omega_{\alpha\theta i} (\omega^{\alpha i\theta} + 2 \partial_{\theta} f_{\alpha}^{\alpha i})) +$$

$$\frac{1}{3} r_2 (4 \partial_{\beta} \omega_{\alpha i \theta} - 2 \partial_{\beta} \omega_{\alpha\theta i} + 2 \partial_{\beta} \omega_{\theta\alpha i} - \partial_{\theta} \omega_{\alpha\beta i} + \partial_{\theta} \omega_{\alpha\beta i} - 2 \partial_{\theta} \omega_{\alpha i \beta}) \partial_{\theta} \omega^{\alpha\beta i} +$$

$$r_5 (\partial_{\theta} \omega_{\theta}{}^{\kappa} \partial_{\kappa} \omega_{\alpha}^{\theta} \omega_{\alpha}^{\kappa} - \partial_{\theta} \omega_{\alpha}{}^{\kappa} \partial_{\kappa} \omega_{\theta}^{\theta} \omega_{\alpha}^{\alpha i} - (\partial_{\alpha} \omega^{\alpha i \theta} - 2 \partial_{\theta} \omega_{\alpha}^{\alpha i}) (\partial_{\kappa} \omega_{\theta}{}^{\kappa} - \partial_{\kappa} \omega_{\theta}^{\kappa}))]$$

$$t, x, y, z] dz dy dx dt$$

$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1-}^{\#1} \dagger^{\alpha}$	$\omega_{1-}^{\#2} \dagger^{\alpha}$	$f_{1-}^{\#1} \dagger^{\alpha}$	$f_{1-}^{\#2} \dagger^{\alpha}$
$k^2 r_5 - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{ik t_1}{\sqrt{2}}$	0	0	0	0
$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$\frac{ik t_1}{\sqrt{2}}$	0	0	0	0	0	0
0	0	0	$k^2 r_5 - \frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0	$i k t_1$
0	0	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
0	0	0	0	0	0	0
0	0	0	$-i k t_1$	0	0	0

$\sigma_{2+}^{\#1} \dagger^{\alpha\beta}$	$\tau_{2+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{2-}^{\#1} \dagger^{\alpha\beta\chi}$
$\frac{2}{(1+2k^2)^2 t_1}$	$-\frac{2i\sqrt{2} k}{(1+2k^2)^2 t_1}$	0
$\frac{2i\sqrt{2} k}{(1+2k^2)^2 t_1}$	$\frac{4k^2}{(1+2k^2)^2 t_1}$	0
0	0	$\frac{2}{t_1}$

$\omega_{2+}^{\#1} \dagger^{\alpha\beta}$	$f_{2+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{2-}^{\#1} \dagger^{\alpha\beta\chi}$
$\frac{t_1}{2}$	$-\frac{ik t_1}{\sqrt{2}}$	0
$\frac{ik t_1}{\sqrt{2}}$	$k^2 t_1$	0
0	0	$\frac{t_1}{2}$

$\omega_{0+}^{\#1} \dagger$	$f_{0+}^{\#1} \dagger$	$f_{0+}^{\#2} \dagger$	$\omega_{0-}^{\#1} \dagger$
$-t_1$	$i\sqrt{2} k t_1$	0	0
$-i\sqrt{2} k t_1$	$-2k^2 t_1$	0	0
0	0	0	0
0	0	0	$k^2 r_2 - t_1$

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
$\tau_{1+}^{\#1\alpha\beta} + i k \sigma_{1+}^{\#2\alpha\beta} == 0$	3
$\tau_{2+}^{\#1\alpha\beta} - 2 i k \sigma_{2+}^{\#1\alpha\beta} == 0$	5
Total constraints:	16

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

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