Particle spectrograph

Wave operator and propagator

Quadratic (free) action

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

	$\sigma^{\#1}_{1^+}{}_{\alpha\beta}$	$\sigma^{\#2}_{1^+}{}_{\alpha\beta}$	$\tau^{\#1}_{1^+}{}_{\alpha\beta}$	$\sigma^{\#1}_{1^-}{}_{\alpha}$	$\sigma^{\#2}_{1^-}{}_{\alpha}$	$\tau^{\#1}_{1^-}{}_{\alpha}$	$\tau^{\#2}_{1^-}{}_{\alpha}$
$\sigma^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{6}{(3+k^2)^2 t_2}$	$\frac{3\sqrt{2}}{(3+k^2)^2 t_2}$	$\frac{3 i \sqrt{2}\, k}{(3+k^2)^2 t_2}$	0	0	0	0
$\sigma^{\#2}_{1^+}\dagger^{\alpha\beta}$	$\frac{3\sqrt{2}}{(3+k^2)^2 t_2}$	$\frac{3}{(3+k^2)^2 t_2}$	$\frac{3 i k}{(3+k^2)^2 t_2}$	0	0	0	0
$\tau^{\#1}_{1^+}\dagger^{\alpha\beta}$	$-\frac{3 i \sqrt{2}\, k}{(3+k^2)^2 t_2}$	$-\frac{3 i k}{(3+k^2)^2 t_2}$	$\frac{3 k^2}{(3+k^2)^2 t_2}$	0	0	0	0
$\sigma^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	$-\frac{1}{k^2 r_1}$	$-\frac{\sqrt{2}}{k^2 r_1+2 k^4 r_1}$	0	$-\frac{2 i}{k r_1+2 k^3 r_1}$
$\sigma^{\#2}_{1^-}\dagger^{\alpha}$	0	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	$\frac{i \sqrt{2}\,(3 k^2 r_1-2 t_3)}{k (1+2 k^2)^2 r_1 t_3}$
$\tau^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	0	0	0	0
$\tau^{\#2}_{1^-}\dagger^{\alpha}$	0	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	$\frac{6 k^2 r_1-4 t_3}{(1+2 k^2)^2 r_1 t_3}$

	$\omega^{\#1}_{1^+}{}_{\alpha\beta}$	$\omega^{\#2}_{1^+}{}_{\alpha\beta}$	$f^{\#1}_{1^+}{}_{\alpha\beta}$	$\omega^{\#1}_{1^-}{}_{\alpha}$	$\omega^{\#2}_{1^-}{}_{\alpha}$	$f^{\#1}_{1^-}{}_{\alpha}$	$f^{\#2}_{1^-}{}_{\alpha}$
$\omega^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{2 t_2}{3}$	$\frac{\sqrt{2}\, t_2}{3}$	$\frac{1}{3} i \sqrt{2}\, k t_2$	0	0	0	0
$\omega^{\#2}_{1^+}\dagger^{\alpha\beta}$	$\frac{\sqrt{2}\, t_2}{3}$	$\frac{t_2}{3}$	$\frac{i k t_2}{3}$	0	0	0	0
$f^{\#1}_{1^+}\dagger^{\alpha\beta}$	$-\frac{1}{3} i \sqrt{2}\, k t_2$	$-\frac{1}{3} i k t_2$	$\frac{k^2 t_2}{3}$	0	0	0	0
$\omega^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	$-k^2 r_1 + \frac{2 t_3}{3}$	$-\frac{\sqrt{2}\, t_3}{3}$	0	$-\frac{2}{3} i k t_3$
$\omega^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$-\frac{\sqrt{2}\, t_3}{3}$	$\frac{t_3}{3}$	0	$\frac{1}{3} i \sqrt{2}\, k t_3$
$f^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	0	0	0	0
$f^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{2 i k t_3}{3}$	$-\frac{1}{3} i \sqrt{2}\, k t_3$	0	$\frac{2 k^2 t_3}{3}$

	$\omega^{\#1}_{2^+}{}_{\alpha\beta}$	$f^{\#1}_{2^+}{}_{\alpha\beta}$	$\omega^{\#1}_{2^-}{}_{\alpha\beta\chi}$
$\omega^{\#1}_{2^+}\dagger^{\alpha\beta}$	0	0	0
$f^{\#1}_{2^+}\dagger^{\alpha\beta}$	0	0	0
$\omega^{\#1}_{2^-}\dagger^{\alpha\beta\chi}$	0	0	$k^2 r_1$

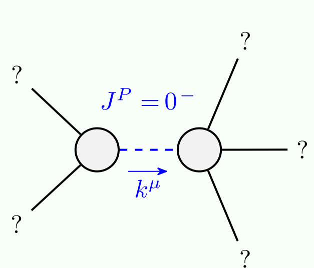
	$\sigma^{\#1}_{2^+}{}_{\alpha\beta}$	$\tau^{\#1}_{2^+}{}_{\alpha\beta}$	$\sigma^{\#1}_{2^-}{}_{\alpha\beta\chi}$
$\sigma^{\#1}_{2^+}\dagger^{\alpha\beta}$	0	0	0
$\tau^{\#1}_{2^+}\dagger^{\alpha\beta}$	0	0	0
$\sigma^{\#1}_{2^-}\dagger^{\alpha\beta\chi}$	0	0	$\frac{1}{k^2 r_1}$

	$\omega^{\#1}_{0^+}$	$f^{\#1}_{0^+}$	$f^{\#2}_{0^+}$	$\omega^{\#1}_{0^-}$
$\omega^{\#1}_{0^+}\dagger$	t_3	$-i \sqrt{2}\, k t_3$	0	0
$f^{\#1}_{0^+}\dagger$	$i \sqrt{2}\, k t_3$	$2 k^2 t_3$	0	0
$f^{\#2}_{0^+}\dagger$	0	0	0	0
$\omega^{\#1}_{0^-}\dagger$	0	0	0	$k^2 r_2 + t_2$

Source constraints/gauge generators	
SO(3) irreps	Multiplicities
$\tau^{\#2}_{0^+} == 0$	1
$\tau^{\#1}_{0^+} - 2 i k\, \sigma^{\#1}_{0^+} == 0$	1
$\tau^{\#2}_{1^-}{}^{\alpha} + 2 i k\, \sigma^{\#2}_{1^-}{}^{\alpha} == 0$	3
$\tau^{\#1}_{1^-}{}^{\alpha} == 0$	3
$\tau^{\#1}_{1^+}{}^{\alpha\beta} + i k\, \sigma^{\#1}_{1^+}{}^{\alpha\beta} == 0$	3
$\sigma^{\#1}_{1^+}{}^{\alpha\beta} == \sigma^{\#2}_{1^+}{}^{\alpha\beta}$	3
$\tau^{\#1}_{2^+}{}^{\alpha\beta} == 0$	5
$\sigma^{\#1}_{2^+}{}^{\alpha\beta} == 0$	5
Total constraints:	24

	$\sigma^{\#1}_{0^+}$	$\tau^{\#1}_{0^+}$	$\tau^{\#2}_{0^+}$	$\sigma^{\#1}_{0^-}$
$\sigma^{\#1}_{0^+}\dagger$	$\frac{1}{(1+2 k^2)^2 t_3}$	$-\frac{i \sqrt{2}\, k}{(1+2 k^2)^2 t_3}$	0	0
$\tau^{\#1}_{0^+}\dagger$	$\frac{i \sqrt{2}\, k}{(1+2 k^2)^2 t_3}$	$\frac{2 k^2}{(1+2 k^2)^2 t_3}$	0	0
$\tau^{\#2}_{0^+}\dagger$	0	0	0	0
$\sigma^{\#1}_{0^-}\dagger$	0	0	0	$\frac{1}{k^2 r_2 + t_2}$

Massive and massless spectra



Massive particle	
Pole residue:	$-\frac{1}{r_2} > 0$
Polarisations:	1
Square mass:	$-\frac{t_2}{r_2} > 0$
Spin:	0
Parity:	Odd

(No massless particles)

Unitarity conditions

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