Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$\mathcal{S}_{\text{F}} == \iiiint \Big(\tfrac{1}{6}\big(-2 t_1\, \omega_{\iota}{}^{\alpha\iota}\, \omega_{\kappa\alpha}{}^{\kappa} - 2 (t_1 - 2 t_2)\, \omega_{\iota}{}^{\kappa\lambda}\, \omega_{\kappa\lambda}{}^{\iota} + 2 t_1\, \omega_{\kappa\lambda}{}^{\iota}\, \omega^{\kappa\lambda}{}_{\iota} +$$
$$2 t_2\, \omega_{\kappa\lambda}{}^{\iota}\, \omega^{\kappa\lambda}{}_{\iota} + 6 f^{\alpha\beta}\, \tau_{\alpha\beta} + 6\, \omega^{\alpha\beta\chi}\, \sigma_{\alpha\beta\chi} + 4 r_2\, \partial^{\beta}\omega^{\theta\alpha}{}_{\kappa}\, \partial_{\theta}\omega_{\alpha\beta}{}^{\kappa} -$$
$$2 r_2\, \partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\, \partial_{\kappa}\omega^{\alpha\beta\theta} - 4 r_2\, \partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\, \partial_{\kappa}\omega^{\theta\alpha\beta} + 24 r_3\, \partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\, \partial_{\kappa}\omega^{\theta\kappa\lambda} -$$
$$24 r_3\, \partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\, \partial_{\kappa}\omega^{\theta\kappa\lambda} - 2 t_1\, \partial^{\alpha}f_{\theta\kappa}\, \partial^{\kappa}f_{\alpha}{}^{\theta} + t_2\, \partial^{\alpha}f_{\theta\kappa}\, \partial^{\kappa}f_{\alpha}{}^{\theta} -$$
$$4 t_1\, \partial^{\alpha}f_{\kappa\theta}\, \partial^{\kappa}f_{\alpha}{}^{\theta} - t_2\, \partial^{\alpha}f_{\kappa\theta}\, \partial^{\kappa}f_{\alpha}{}^{\theta} - 2 t_1\, \partial^{\alpha}f^{\lambda}{}_{\kappa}\, \partial^{\kappa}f_{\alpha\lambda} + t_2\, \partial^{\alpha}f^{\lambda}{}_{\kappa}\, \partial^{\kappa}f_{\alpha\lambda} +$$
$$2 t_1\, \omega_{\kappa\alpha}{}^{\alpha}\, \partial^{\kappa}f^{\iota}{}_{\iota} + 2 t_1\, \omega_{\kappa\lambda}{}^{\lambda}\, \partial^{\kappa}f^{\iota}{}_{\iota} + 4 t_1\, \partial^{\alpha}f_{\kappa\alpha}\, \partial^{\kappa}f^{\iota}{}_{\iota} - 2 t_1\, \partial_{\kappa}f^{\lambda}{}_{\lambda}\, \partial^{\kappa}f^{\iota}{}_{\iota} +$$
$$2 t_1\, \omega_{\iota\theta\kappa}\, \partial^{\kappa}f^{\iota\theta} + 2 t_2\, \omega_{\iota\theta\kappa}\, \partial^{\kappa}f^{\iota\theta} + 8 t_1\, \omega_{\iota\kappa\theta}\, \partial^{\kappa}f^{\iota\theta} - 4 t_2\, \omega_{\iota\kappa\theta}\, \partial^{\kappa}f^{\iota\theta} -$$
$$2 t_1\, \omega_{\theta\iota\kappa}\, \partial^{\kappa}f^{\iota\theta} - 2 t_2\, \omega_{\theta\iota\kappa}\, \partial^{\kappa}f^{\iota\theta} + 4 t_1\, \omega_{\theta\kappa\iota}\, \partial^{\kappa}f^{\iota\theta} + 4 t_2\, \omega_{\theta\kappa\iota}\, \partial^{\kappa}f^{\iota\theta} -$$
$$2 t_1\, \omega_{\iota\alpha}{}^{\alpha}\, \partial^{\kappa}f^{\iota}{}_{\kappa} - 2 t_1\, \omega_{\iota\lambda}{}^{\lambda}\, \partial^{\kappa}f^{\iota}{}_{\kappa} + 2 t_1\, \partial^{\alpha}f^{\lambda}{}_{\kappa}\, \partial^{\kappa}f_{\lambda\alpha} - t_2\, \partial^{\alpha}f^{\lambda}{}_{\kappa}\, \partial^{\kappa}f_{\lambda\alpha} +$$
$$2 t_1\, \partial_{\kappa}f_{\theta}{}^{\lambda}\, \partial^{\kappa}f_{\lambda}{}^{\theta} - t_2\, \partial_{\kappa}f_{\theta}{}^{\lambda}\, \partial^{\kappa}f_{\lambda}{}^{\theta} + 4 t_1\, \partial_{\kappa}f^{\lambda}{}_{\theta}\, \partial^{\kappa}f_{\lambda}{}^{\theta} + t_2\, \partial_{\kappa}f^{\lambda}{}_{\theta}\, \partial^{\kappa}f_{\lambda}{}^{\theta} -$$
$$2 t_1\, \partial^{\alpha}f^{\lambda}{}_{\alpha}\, \partial^{\kappa}f_{\lambda\kappa} + 2 r_2\, \partial_{\kappa}\omega^{\alpha\beta\theta}\, \partial^{\kappa}\omega_{\alpha\beta\theta} + 4 r_2\, \partial_{\kappa}\omega^{\theta\alpha\beta}\, \partial^{\kappa}\omega_{\alpha\beta\theta} -$$
$$4 r_2\, \partial^{\beta}\omega_{\iota}{}^{\alpha\lambda}\, \partial_{\lambda}\omega_{\alpha\beta}{}^{\iota} + 4 r_2\, \partial^{\beta}\omega_{\iota}{}^{\lambda\alpha}\, \partial_{\lambda}\omega_{\alpha\beta}{}^{\iota} - 24 r_3\, \partial^{\beta}\omega_{\iota}{}^{\lambda\alpha}\, \partial_{\lambda}\omega_{\alpha\beta}{}^{\iota} -$$
$$24 r_3\, \partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\, \partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa} + 24 r_3\, \partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\, \partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa}\big)\Big)[t, x, y, z]\, dz\, dy\, dx\, dt$$

	$\sigma^{\#1}_{1^+}{}_{\alpha\beta}$	$\sigma^{\#2}_{1^+}{}_{\alpha\beta}$	$\tau^{\#1}_{1^+}{}_{\alpha\beta}$	$\sigma^{\#1}_{1^-}{}_{\alpha}$	$\sigma^{\#2}_{1^-}{}_{\alpha}$	$\tau^{\#1}_{1^-}{}_{\alpha}$	$\tau^{\#2}_{1^-}{}_{\alpha}$
$\sigma^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	$\frac{2(t_1+t_2)}{3 t_1 t_2}$	$\frac{\sqrt{2}(t_1-2t_2)}{3(1+k^2) t_1 t_2}$	$\frac{i\sqrt{2}k(t_1-2t_2)}{3(1+k^2) t_1 t_2}$	0	0	0	0
$\sigma^{\#2}_{1^+}{}^\dagger{}^{\alpha\beta}$	$\frac{\sqrt{2}(t_1-2t_2)}{3(1+k^2) t_1 t_2}$	$\frac{t_1+4t_2}{3(1+k^2)^2 t_1 t_2}$	$\frac{i k(t_1+4t_2)}{3(1+k^2)^2 t_1 t_2}$	0	0	0	0
$\tau^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	$-\frac{i\sqrt{2}k(t_1-2t_2)}{3(1+k^2) t_1 t_2}$	$-\frac{i k(t_1+4t_2)}{3(1+k^2)^2 t_1 t_2}$	$\frac{k^2(t_1+4t_2)}{3(1+k^2)^2 t_1 t_2}$	0	0	0	0
$\sigma^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$\frac{6}{(3+4k^2)^2 t_1}$	$\frac{6\sqrt{2}}{(3+4k^2)^2 t_1}$	0	$\frac{12 i k}{(3+4k^2)^2 t_1}$
$\sigma^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$\frac{6\sqrt{2}}{(3+4k^2)^2 t_1}$	$\frac{12}{(3+4k^2)^2 t_1}$	0	$\frac{12 i\sqrt{2} k}{(3+4k^2)^2 t_1}$
$\tau^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	0	0	0	0
$\tau^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$-\frac{12 i k}{(3+4k^2)^2 t_1}$	$-\frac{12 i\sqrt{2} k}{(3+4k^2)^2 t_1}$	0	$\frac{24 k^2}{(3+4k^2)^2 t_1}$

	$\omega^{\#1}_{1^+}{}_{\alpha\beta}$	$\omega^{\#2}_{1^+}{}_{\alpha\beta}$	$f^{\#1}_{1^+}{}_{\alpha\beta}$	$\omega^{\#1}_{1^-}{}_{\alpha}$	$\omega^{\#2}_{1^-}{}_{\alpha}$	$f^{\#1}_{1^-}{}_{\alpha}$	$f^{\#2}_{1^-}{}_{\alpha}$
$\omega^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	$\frac{1}{6}(t_1+4t_2)$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$-\frac{i k(t_1-2t_2)}{3\sqrt{2}}$	0	0	0	0
$\omega^{\#2}_{1^+}{}^\dagger{}^{\alpha\beta}$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{t_1+t_2}{3}$	$\frac{1}{3} i k(t_1+t_2)$	0	0	0	0
$f^{\#1}_{1^+}{}^\dagger{}^{\alpha\beta}$	$\frac{i k(t_1-2t_2)}{3\sqrt{2}}$	$-\frac{1}{3} i k(t_1+t_2)$	$\frac{1}{3} k^2(t_1+t_2)$	0	0	0	0
$\omega^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$\frac{t_1}{6}$	$\frac{t_1}{3\sqrt{2}}$	0	$\frac{i k t_1}{3}$
$\omega^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	0	$\frac{1}{3} i\sqrt{2} k t_1$
$f^{\#1}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	0	0	0	0
$f^{\#2}_{1^-}{}^\dagger{}^{\alpha}$	0	0	0	$-\frac{1}{3} i k t_1$	$-\frac{1}{3} i\sqrt{2} k t_1$	0	$\frac{2k^2 t_1}{3}$

	$\omega^{\#1}_{0^+}$	$f^{\#1}_{0^+}$	$f^{\#2}_{0^+}$	$\omega^{\#1}_{0^-}$
$\omega^{\#1}_{0^+}{}^\dagger$	$6k^2 r_3$	0	0	0
$f^{\#1}_{0^+}{}^\dagger$	0	0	0	0
$f^{\#2}_{0^+}{}^\dagger$	0	0	0	0
$\omega^{\#1}_{0^-}{}^\dagger$	0	0	0	$k^2 r_2 + t_2$

	$\omega^{\#1}_{2^+}{}_{\alpha\beta}$	$f^{\#1}_{2^+}{}_{\alpha\beta}$	$\omega^{\#1}_{2^-}{}_{\alpha\beta\chi}$
$\omega^{\#1}_{2^+}{}^\dagger{}^{\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{i k t_1}{\sqrt{2}}$	0
$f^{\#1}_{2^+}{}^\dagger{}^{\alpha\beta}$	$\frac{i k t_1}{\sqrt{2}}$	$k^2 t_1$	0
$\omega^{\#1}_{2^-}{}^\dagger{}^{\alpha\beta\chi}$	0	0	$\frac{t_1}{2}$

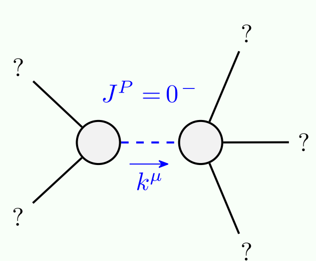
	$\sigma^{\#1}_{0^+}$	$\tau^{\#1}_{0^+}$	$\tau^{\#2}_{0^+}$	$\sigma^{\#1}_{0^-}$
$\sigma^{\#1}_{0^+}{}^\dagger$	$\frac{1}{6k^2 r_3}$	0	0	0
$\tau^{\#1}_{0^+}{}^\dagger$	0	0	0	0
$\tau^{\#2}_{0^+}{}^\dagger$	0	0	0	0
$\sigma^{\#1}_{0^-}{}^\dagger$	0	0	0	$\frac{1}{k^2 r_2 + t_2}$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau^{\#2}_{0^+} == 0$	1
$\tau^{\#1}_{0^+} == 0$	1
$\tau^{\#2}_{1^-}{}^{\alpha} + 2 i k\, \sigma^{\#1}_{1^-}{}^{\alpha} == 0$	3
$\tau^{\#1}_{1^-}{}^{\alpha} == 0$	3
$\sigma^{\#1}_{1^-}{}^{\alpha} == \sigma^{\#2}_{1^-}{}^{\alpha}$	3
$\tau^{\#1}_{1^+}{}^{\alpha\beta} + i k\, \sigma^{\#2}_{1^+}{}^{\alpha\beta} == 0$	3
$\tau^{\#1}_{2^+}{}^{\alpha\beta} - 2 i k\, \sigma^{\#1}_{2^+}{}^{\alpha\beta} == 0$	5
Total constraints:	19

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

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

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