Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$S_F = \int\int\int\int \left(\tfrac{1}{6}\left(-6t_1\,\omega_{\iota}^{\alpha\prime}\,\omega_{\kappa\alpha}^{\ \kappa} - 2\left(t_1-2t_2\right)\omega_{\iota}^{\kappa\lambda}\,\omega_{\kappa\lambda}^{\ \prime} + 2t_1\,\omega_{\kappa\lambda}^{\ \prime}\,\omega^{\kappa\lambda}{}_{\iota}^{\prime} + 2t_2\,\omega_{\kappa\lambda}^{\ \prime}\,\omega^{\kappa\lambda}{}_{\iota}^{\prime} + 6\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} + 12r_1\,\partial_{\iota}\omega^{\kappa\lambda}{}_{\kappa}\,\partial^{\prime}\omega_{\lambda}^{\ \alpha} - 4r_1\,\partial^{\beta}\omega^{\theta\alpha}{}_{\kappa}\,\partial_{\theta}\omega_{\alpha\beta}^{\ \ \kappa} - 4r_1\,\partial_{\theta}\omega_{\alpha\beta}^{\ \ \kappa}\,\partial_{\kappa}\omega^{\alpha\beta\theta} + 12r_1\,\partial_{\iota}\omega_{\lambda}^{\ \alpha}{}_{\theta}\,\partial_{\kappa}\omega^{\theta\kappa\lambda} + 4r_1\,\partial_{\theta}\omega_{\lambda}^{\ \alpha}{}_{\kappa}\,\partial_{\alpha}\omega^{\kappa\lambda\theta} - 24r_1\,\partial_{\theta}\omega_{\lambda}^{\ \alpha}{}_{\alpha}\,\partial_{\kappa}\omega^{\kappa\lambda\theta} + 12r_1\,\partial_{\theta}\omega_{\lambda}^{\ \alpha}{}_{\alpha}\,\partial_{\kappa}\omega^{\kappa\lambda\theta} - 2t_1\,\partial^{\alpha}f_{\theta\kappa}\,\partial^{\kappa}f_{\alpha}^{\ \theta} + t_2\,\partial^{\alpha}f_{\theta\kappa}\,\partial^{\kappa}f_{\alpha}^{\ \theta} - 4t_1\,\partial^{\alpha}f_{\kappa\theta}\,\partial^{\kappa}f_{\alpha}^{\ \theta} - t_2\,\partial^{\alpha}f_{\kappa\theta}\,\partial^{\kappa}f_{\alpha}^{\ \theta} - 2t_1\,\partial^{\alpha}f_{\kappa}^{\ \lambda}\,\partial^{\kappa}f_{\alpha\lambda} + 6t_1\,\omega_{\kappa\alpha}^{\ \ \alpha}\,\partial^{\kappa}f_{\iota}^{\prime} + 6t_1\,\omega_{\kappa\lambda}^{\ \ \lambda}\,\partial^{\kappa}f_{\iota}^{\prime} + 2t_1\,\partial^{\alpha}f_{\kappa}^{\ \lambda}\,\partial^{\kappa}f_{\alpha\lambda} + t_2\,\partial^{\alpha}f_{\kappa}^{\ \lambda}\,\partial^{\kappa}f_{\alpha\lambda} - 6t_1\,\partial_{\kappa}f_{\lambda}^{\ \lambda}\,\partial^{\kappa}f_{\iota}^{\prime} + 12t_1\,\partial^{\alpha}f_{\kappa\alpha}\,\partial^{\kappa}f_{\iota}^{\prime} + 2t_1\,\omega_{\iota\theta\kappa}\,\partial^{\kappa}f^{\iota\theta} + 2t_2\,\omega_{\iota\theta\kappa}\,\partial^{\kappa}f^{\iota\theta} + 8t_1\,\omega_{\iota\kappa\theta}\,\partial^{\kappa}f^{\iota\theta} - 4t_2\,\omega_{\iota\kappa\theta}\,\partial^{\kappa}f^{\iota\theta} - 2t_1\,\omega_{\theta\iota\kappa}\,\partial^{\kappa}f^{\iota\theta} - 2t_2\,\omega_{\theta\iota\kappa}\,\partial^{\kappa}f^{\iota\theta} + 4t_1\,\omega_{\theta\kappa\iota}\,\partial^{\kappa}f^{\iota\theta} + 4t_2\,\omega_{\theta\kappa\iota}\,\partial^{\kappa}f^{\iota\theta} - 6t_1\,\omega_{\iota\alpha}^{\ \ \alpha}\,\partial^{\kappa}f^{\prime}{}_{\kappa} - 6t_1\,\omega_{\iota\lambda}^{\ \ \lambda}\,\partial^{\kappa}f^{\prime}{}_{\kappa} + 2t_1\,\partial^{\alpha}f^{\lambda}{}_{\kappa}\,\partial^{\kappa}f_{\lambda\alpha} - t_2\,\partial^{\alpha}f^{\lambda}{}_{\kappa}\,\partial^{\kappa}f_{\lambda\alpha} + 2t_1\,\partial_{\kappa}f^{\lambda}{}_{\theta}\,\partial^{\kappa}f_{\lambda}^{\ \theta} - t_2\,\partial_{\kappa}f^{\lambda}{}_{\theta}\,\partial^{\kappa}f_{\lambda}^{\ \theta} + 4t_1\,\partial_{\kappa}f^{\lambda}{}_{\theta}\,\partial^{\kappa}f_{\lambda}^{\ \theta} + t_2\,\partial_{\kappa}f^{\lambda}{}_{\theta}\,\partial^{\kappa}f_{\lambda}^{\ \theta} - 6t_1\,\partial^{\alpha}f^{\lambda}{}_{\alpha}\,\partial^{\kappa}f_{\lambda\kappa} + 4r_1\,\partial_{\kappa}\omega^{\alpha\beta\theta}\,\partial^{\kappa}\omega_{\alpha\beta\theta} - 4r_1\,\partial_{\kappa}\omega^{\theta\alpha\beta}\,\partial^{\kappa}\omega_{\alpha\beta\theta} - 16r_1\,\partial^{\beta}\omega_{\iota}^{\lambda\alpha}\,\partial_{\lambda}\omega_{\alpha\beta}^{\ \ \prime} - 16r_1\,\partial^{\beta}\omega_{\iota}^{\alpha\lambda}\,\partial_{\lambda}\omega_{\alpha\beta}^{\ \ \prime} + 12r_1\,\partial_{\alpha}\omega_{\lambda}^{\ \alpha}{}_{\theta}\,\partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa} + 12r_1\,\partial_{\theta}\omega_{\lambda}^{\ \alpha}{}_{\alpha}\,\partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa}\right))[t,x,y,z]\,dz\,dy\,dx\,dt$$

$\sigma_1^{\#1}{}_{+}^{\alpha\beta\dagger}$

	$\sigma_1^{\#1}{}_{-}^{\alpha}$	$\sigma_1^{\#2}{}_{-}^{\alpha}$	$\tau_1^{\#1}{}_{-}^{\alpha}$	$\tau_1^{\#2}{}_{-}^{\alpha}$
$\tau_1^{\#1}{}_{+}^{\alpha\beta}$	$\frac{i\sqrt{2}\,k\left(t_1-2t_2\right)}{3\left(1+k^2\right)t_1\,t_2}$	0	0	0
$\tau_1^{\#2}{}_{+}^{\alpha\beta}$	$\frac{ik\left(t_1+4t_2\right)}{3\left(1+k^2\right)^2t_1\,t_2}$	0	0	0
$\sigma_1^{\#1}{}_{+}^{\alpha\beta}$	$\frac{k^2\left(t_1+4t_2\right)}{3\left(1+k^2\right)^2t_1\,t_2}$	0	0	0
$\sigma_1^{\#2}{}_{+}^{\alpha\beta}$	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	0	$\frac{2ik}{t_1+2k^2t_1}$
$\tau_1^{\#1}{}_{+}^{\alpha\beta}$	0	$\frac{2k^2r_1+t_1}{\left(t_1+2k^2t_1\right)^2}$	0	$\frac{i\sqrt{2}\,k\left(2k^2r_1+t_1\right)}{\left(t_1+2k^2t_1\right)^2}$
$\tau_1^{\#2}{}_{+}^{\alpha\beta}$	0	$-\frac{i\sqrt{2}\,k}{t_1+2k^2t_1}$	0	$\frac{2k^2\left(2k^2r_1+t_1\right)}{\left(t_1+2k^2t_1\right)^2}$

$\omega_1^{\#1}{}_{+}^{\alpha\beta\dagger}$

	$\omega_1^{\#1}{}_{-}^{\alpha}$	$\omega_1^{\#2}{}_{-}^{\alpha}$	$f_1^{\#1}{}_{-}^{\alpha}$	$f_1^{\#2}{}_{-}^{\alpha}$
$f_1^{\#1}{}_{+}^{\alpha\beta}$	0	0	0	0
$\omega_1^{\#1}{}_{+}^{\alpha\beta}$	0	0	0	0
$\omega_1^{\#2}{}_{+}^{\alpha\beta}$	0	0	0	0
$f_1^{\#1}{}_{+}^{\alpha\beta}$	0	0	0	0

$\omega_2^{\#1}{}_{+}^{\alpha\beta\dagger}$

	$f_2^{\#1}{}_{+}^{\alpha\beta}$	$\omega_2^{\#1}{}_{-}^{\alpha\beta\chi}$
$\omega_2^{\#1}{}_{+}^{\alpha\beta}$	$\frac{t_1}{2}$	0
$f_2^{\#1}{}_{+}^{\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	0
$\omega_2^{\#1}{}_{+}^{\alpha\beta\chi}$	0	$k^2r_1+\frac{t_1}{2}$

$\omega_0^{\#1}{}_{+}^{\dagger}$

	$\omega_0^{\#1}{}_{+}$	$f_0^{\#1}{}_{+}$	$f_0^{\#2}{}_{+}$	$\omega_0^{\#1}{}_{-}$
$\omega_0^{\#1}{}_{+}^{\dagger}$	$-t_1$	$i\sqrt{2}\,kt_1$	0	0
$f_0^{\#1}{}_{+}^{\dagger}$	$-i\sqrt{2}\,kt_1$	$-2k^2t_1$	0	0
$f_0^{\#2}{}_{+}^{\dagger}$	0	0	0	0
$\omega_0^{\#1}{}_{-}^{\dagger}$	0	0	0	t_2

$\sigma_2^{\#1}{}_{+}^{\alpha\beta\dagger}$

	$\tau_2^{\#1}{}_{+}^{\alpha\beta}$	$\sigma_2^{\#1}{}_{-}^{\alpha\beta\chi}$
$\sigma_2^{\#1}{}_{+}^{\alpha\beta}$	$\frac{2}{\left(1+2k^2\right)^2t_1}$	0
$\tau_2^{\#1}{}_{+}^{\alpha\beta}$	$\frac{2i\sqrt{2}\,k}{\left(1+2k^2\right)^2t_1}$	0
$\sigma_2^{\#1}{}_{-}^{\alpha\beta\chi}$	0	$\frac{2}{2k^2r_1+t_1}$

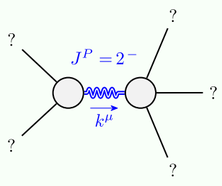
$\tau_0^{\#1}{}_{+}^{\dagger}$

	$\tau_0^{\#2}{}_{+}$	$\tau_0^{\#1}{}_{+}$	$\sigma_0^{\#1}{}_{+}$	$\sigma_0^{\#1}{}_{-}$
$\sigma_0^{\#1}{}_{+}^{\dagger}$	0	$-\frac{i\sqrt{2}\,k}{\left(1+2k^2\right)^2t_1}$	0	0
$\tau_0^{\#1}{}_{+}^{\dagger}$	0	$-\frac{2k^2}{\left(1+2k^2\right)^2t_1}$	0	0
$\tau_0^{\#2}{}_{+}^{\dagger}$	0	0	0	0
$\sigma_0^{\#1}{}_{-}^{\dagger}$	0	0	0	$\frac{1}{t_2}$

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

Massive and massless spectra



Massive particle	
Pole residue:	$-\frac{1}{r_1} > 0$
Polarisations:	5
Square mass:	$-\frac{t_1}{2r_1} > 0$
Spin:	2
Parity:	Odd

(No massless particles)

Unitarity conditions

$r_1 < 0 \;\&\&\; t_1 > 0$