Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$\mathcal{S}_F == \iiint\Big(\tfrac{1}{6}\big(-6t_1\,\omega_l^{\alpha\prime}\,\omega_{\kappa\alpha}^{\ \ \kappa} - 6t_1\,\omega_l^{\alpha\prime}\,\omega_{\kappa\alpha}^{\ \ \kappa\prime} + 6\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} - 6\,r_5\,\partial_l\omega^{\kappa\lambda}{}_\kappa\big)\,\partial^l\omega_\lambda^{\ \alpha}{}_\alpha + 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^{\theta\alpha\beta} - 4\,r_2\,\partial_\theta\omega_{\alpha\beta}^{\ \ \kappa}\,\partial_\kappa\omega^{\theta\alpha\beta} - 6\,r_5\,\partial_\alpha\omega_\lambda^{\ \alpha}{}_\theta\,\partial_\kappa\omega^{\theta\kappa\lambda} - 6\,r_5\,\partial_\alpha\omega_\lambda^{\ \alpha}{}_\theta\,\partial_\kappa\omega^{\kappa\lambda\theta} + 12\,r_5\,\partial_\theta\omega_\lambda^{\ \alpha}{}_\alpha\,\partial_\kappa\omega^{\kappa\lambda\theta} - 3\,t_1\,\partial^\alpha f_{\theta\kappa}\,\partial^\kappa f_\alpha^{\ \theta} - 3\,t_1\,\partial^\alpha f_{\kappa\theta}\,\partial^\kappa f_\alpha^{\ \theta} + 6\,t_1\,\omega_{\kappa\alpha}^{\ \ \alpha}\,\partial^\kappa f_l' + 6\,t_1\,\omega_{\kappa\lambda}^{\ \ \lambda}\,\partial^\kappa f_l' - 12\,t_1\,\omega_{l\kappa\theta}\,\partial^\kappa f'^\theta - 6\,t_1\,\omega_{l\alpha}^{\ \ \alpha}\,\partial^\kappa f_\kappa' + 3\,t_1\,\partial_\kappa f_\theta^{\ \lambda}\,\partial^\kappa f_\lambda^{\ \theta} + 3\,t_1\,\partial_\kappa f_\lambda^{\ \theta}\,\partial^\kappa f_\theta^{\ \lambda} + 4\,r_2\,\partial_\kappa\omega^{\theta\alpha\beta}\,\partial^\kappa\omega_{\alpha\beta\theta} - 4\,r_2\,\partial^\beta\omega_l^{\alpha\lambda}\,\partial_\lambda\omega_{\alpha\beta}' + 6\,r_5\,\partial_\alpha\omega_\lambda^{\ \alpha}{}_\theta\,\partial^\lambda\omega^{\theta\kappa}{}_\kappa - 6\,r_5\,\partial_\theta\omega_\lambda^{\ \alpha}{}_\alpha\,\partial^\lambda\omega^{\theta\kappa}{}_\kappa\Big)[t,\,x,\,y,\,z]\,dz\,dy\,dx\,dt$$

	$\sigma_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^+}^{\#2}{}_{\alpha\beta}$	$\tau_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^-}^{\#1}{}_{\alpha}$	$\sigma_{1^-}^{\#2}{}_{\alpha}$	$\tau_{1^-}^{\#1}{}_{\alpha}$	$\tau_{1^-}^{\#2}{}_{\alpha}$
$\sigma_{1^+}^{\#1\,\dagger}{}^{\alpha\beta}$	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
$\sigma_{1^+}^{\#2\,\dagger}{}^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$-\frac{-2k^2 r_5+t_1}{(1+k^2)^2 t_1^2}$	$-\frac{i(2k^3 r_5-k t_1)}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\tau_{1^+}^{\#1\,\dagger}{}^{\alpha\beta}$	$\frac{i\sqrt{2}\,k}{t_1+k^2 t_1}$	$\frac{-2k^4 r_5+2k^2 t_1}{(1+k^2)^2 t_1^2}$	$\frac{i(2k^3 r_5-k t_1)}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\sigma_{1^-}^{\#1\,\dagger}{}^{\alpha}$	0	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2 t_1}$	0	$\frac{2ik}{t_1+2k^2 t_1}$
$\sigma_{1^-}^{\#2\,\dagger}{}^{\alpha}$	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2 t_1}$	$\frac{-2k^2 r_5+t_1}{(1+2k^2)^2 t_1^2}$	$-\frac{i\sqrt{2}\,k(2k^2 r_5-t_1)}{(1+2k^2)^2 t_1^2}$	0
$\tau_{1^-}^{\#1\,\dagger}{}^{\alpha}$	0	0	0	0	0	0	$\frac{-4k^4 r_5+2k^2 t_1}{(1+2k^2)^2 t_1^2}$
$\tau_{1^-}^{\#2\,\dagger}{}^{\alpha}$	0	0	0	$-\frac{2ik}{t_1+2k^2 t_1}$	$\frac{i\sqrt{2}\,k(2k^2 r_5-t_1)}{(1+2k^2)^2 t_1^2}$	$\frac{-4k^4 r_5+2k^2 t_1}{(1+2k^2)^2 t_1^2}$	0

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1\,\dagger}$	$-\frac{1}{(1+2k^2)^2 t_1}$	$\frac{i\sqrt{2}\,k}{(1+2k^2)^2 t_1}$	0	0
$\tau_{0^+}^{\#1\,\dagger}$	$-\frac{i\sqrt{2}\,k}{(1+2k^2)^2 t_1}$	$-\frac{2k^2}{(1+2k^2)^2 t_1}$	0	0
$\tau_{0^+}^{\#2\,\dagger}$	0	0	0	0
$\sigma_{0^-}^{\#1\,\dagger}$	0	0	0	$\frac{1}{k^2 r_2 - t_1}$

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

	$\omega_{2^+}^{\#1}{}_{\alpha\beta}$	$f_{2^+}^{\#1}{}_{\alpha\beta}$	$\omega_{2^-}^{\#1}{}_{\alpha\beta\chi}$
$\omega_{2^+}^{\#1\,\dagger}{}^{\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	0
$f_{2^+}^{\#1\,\dagger}{}^{\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	$k^2 t_1$	0
$\omega_{2^-}^{\#1\,\dagger}{}^{\alpha\beta\chi}$	0	0	$\frac{t_1}{2}$

	$\omega_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^+}^{\#2}{}_{\alpha\beta}$	$f_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^-}^{\#1}{}_{\alpha}$	$\omega_{1^-}^{\#2}{}_{\alpha}$	$f_{1^-}^{\#1}{}_{\alpha}$	$f_{1^-}^{\#2}{}_{\alpha}$
$\omega_{1^+}^{\#1\,\dagger}{}^{\alpha\beta}$	$k^2 r_5 - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$\frac{ikt_1}{\sqrt{2}}$	0	$\frac{t_1}{\sqrt{2}}$	0	ikt_1
$\omega_{1^+}^{\#2\,\dagger}{}^{\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
$f_{1^+}^{\#1\,\dagger}{}^{\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega_{1^-}^{\#1\,\dagger}{}^{\alpha}$	0	0	0	$k^2 r_5 - \frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0	$-ikt_1$
$\omega_{1^-}^{\#2\,\dagger}{}^{\alpha}$	0	0	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
$f_{1^-}^{\#1\,\dagger}{}^{\alpha}$	0	0	0	$-ikt_1$	0	0	0
$f_{1^-}^{\#2\,\dagger}{}^{\alpha}$	0	0	0	0	0	0	0

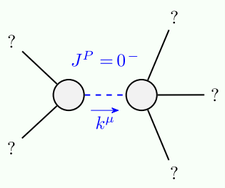
	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1\,\dagger}$	0	0	0	0
$f_{0^+}^{\#1\,\dagger}$	0	0	0	0
$f_{0^+}^{\#2\,\dagger}$	0	0	0	0
$\omega_{0^-}^{\#1\,\dagger}$	0	0	0	$k^2 r_2 - t_1$

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

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

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