Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$
\begin{aligned}
S_{\mathrm{F}} == & \iiiint\Big(\tfrac{1}{3}\big(-3t_1\,\omega_{\iota}^{\ \alpha\iota}\,\omega_{\kappa\alpha}^{\ \ \kappa}-t_1\,\omega_{\iota}^{\ \kappa\lambda}\,\omega_{\kappa\lambda}^{\ \ \iota}+t_1\,\omega_{\kappa\lambda}^{\ \ \iota}\,\omega^{\kappa\lambda}_{\ \ \iota}+3\,f^{\alpha\beta}\,\tau_{\alpha\beta}+3\,\omega^{\alpha\beta\chi}\\
&\sigma_{\alpha\beta\chi}+6r_1\,\partial_{\iota}\omega^{\kappa\lambda}_{\ \ \kappa}\partial^{\iota}\omega_{\lambda\ \alpha}^{\ \alpha}-2r_1\,\partial^{\beta}\omega^{\theta\alpha}_{\ \ \kappa}\partial_{\theta}\omega_{\alpha\beta}^{\ \ \kappa}+2r_2\,\partial^{\beta}\omega^{\theta\alpha}_{\ \ \kappa}\partial_{\theta}\omega_{\alpha\beta}^{\ \ \kappa}-\\
&2r_1\,\partial_{\theta}\omega_{\alpha\beta}^{\ \ \kappa}\partial_{\kappa}\omega^{\alpha\beta\theta}-r_2\,\partial_{\theta}\omega_{\alpha\beta}^{\ \ \kappa}\partial_{\kappa}\omega^{\alpha\beta\theta}+2r_1\,\partial_{\theta}\omega_{\alpha\beta}^{\ \ \kappa}\partial_{\kappa}\omega^{\theta\alpha\beta}-\\
&2r_2\,\partial_{\theta}\omega_{\alpha\beta}^{\ \ \kappa}\partial_{\kappa}\omega^{\theta\alpha\beta}+6r_1\,\partial_{\alpha}\omega_{\lambda\ \theta}^{\ \alpha}\partial_{\kappa}\omega^{\theta\kappa\lambda}-6r_1\,\partial_{\theta}\omega_{\lambda\ \alpha}^{\ \alpha}\partial_{\kappa}\omega^{\theta\kappa\lambda}+\\
&6r_1\,\partial_{\alpha}\omega_{\lambda\ \theta}^{\ \alpha}\partial_{\kappa}\omega^{\kappa\lambda\theta}-12r_1\,\partial_{\theta}\omega_{\lambda\ \alpha}^{\ \alpha}\partial_{\kappa}\omega^{\kappa\lambda\theta}-t_1\,\partial^{\alpha}f_{\theta\kappa}\partial^{\kappa}f_{\alpha}^{\ \theta}-2t_1\,\partial^{\alpha}f_{\kappa\theta}\partial^{\kappa}f_{\alpha}^{\ \theta}-\\
&t_1\,\partial^{\alpha}f^{\lambda}_{\ \kappa}\partial^{\kappa}f_{\alpha\lambda}+3t_1\,\omega_{\kappa\alpha}^{\ \ \alpha}\partial^{\kappa}f^{\iota}_{\ \iota}+3t_1\,\omega_{\kappa\lambda}^{\ \ \lambda}\partial^{\kappa}f^{\iota}_{\ \iota}+6t_1\,\partial^{\alpha}f_{\kappa\alpha}\partial^{\kappa}f^{\iota}_{\ \iota}-\\
&3t_1\,\partial_{\kappa}f^{\lambda}_{\ \lambda}\partial^{\kappa}f^{\iota}_{\ \iota}+t_1\,\omega_{\iota\theta\kappa}\partial^{\kappa}f^{\iota\theta}+4t_1\,\omega_{\iota\kappa\theta}\partial^{\kappa}f^{\iota\theta}-t_1\,\omega_{\theta\iota\kappa}\partial^{\kappa}f^{\iota\theta}+\\
&2t_1\,\omega_{\theta\kappa\iota}\partial^{\kappa}f^{\iota\theta}-3t_1\,\omega_{\iota\alpha}^{\ \ \alpha}\partial^{\kappa}f^{\iota}_{\ \kappa}-3t_1\,\omega_{\iota\lambda}^{\ \ \lambda}\partial^{\kappa}f^{\iota}_{\ \kappa}+t_1\,\partial^{\alpha}f^{\lambda}_{\ \kappa}\partial^{\kappa}f_{\lambda\alpha}+\\
&t_1\,\partial_{\kappa}f_{\theta}^{\ \lambda}\partial^{\kappa}f_{\lambda}^{\ \theta}+2t_1\,\partial_{\kappa}f_{\theta}^{\ \lambda}\partial^{\kappa}f_{\lambda}^{\ \theta}-3t_1\,\partial^{\alpha}f^{\lambda}_{\ \alpha}\partial^{\kappa}f_{\lambda\kappa}+2r_1\,\partial_{\kappa}\omega^{\alpha\beta\theta}\partial^{\kappa}\omega_{\alpha\beta\theta}+\\
&r_2\,\partial_{\kappa}\omega^{\alpha\beta\theta}\partial^{\kappa}\omega_{\alpha\beta\theta}-2r_1\,\partial_{\kappa}\omega^{\theta\alpha\beta}\partial^{\kappa}\omega_{\alpha\beta\theta}+2r_2\,\partial_{\kappa}\omega^{\theta\alpha\beta}\partial^{\kappa}\omega_{\alpha\beta\theta}+2r_1\,\partial^{\beta}\omega^{\alpha\lambda}_{\ \ \iota}\\
&\partial_{\lambda}\omega_{\alpha\beta}^{\ \ \iota}-2r_2\,\partial^{\beta}\omega^{\alpha\lambda}_{\ \ \iota}\partial_{\lambda}\omega_{\alpha\beta}^{\ \ \iota}-8r_1\,\partial^{\beta}\omega^{\lambda\alpha}_{\ \ \iota}\partial_{\lambda}\omega_{\alpha\beta}^{\ \ \iota}+2r_2\,\partial^{\beta}\omega^{\lambda\alpha}_{\ \ \iota}\partial_{\lambda}\omega_{\alpha\beta}^{\ \ \iota}-\\
&6r_1\,\partial_{\alpha}\omega_{\lambda\ \theta}^{\ \alpha}\partial^{\lambda}\omega^{\theta\kappa}_{\ \ \kappa}+6r_1\,\partial_{\theta}\omega_{\lambda\ \alpha}^{\ \alpha}\partial^{\lambda}\omega^{\theta\kappa}_{\ \ \kappa}\big)\Big)[t,x,y,z]\,dz\,dy\,dx\,dt
\end{aligned}
$$

	$\sigma^{\#1}_{1^+\alpha\beta}$	$\sigma^{\#2}_{1^+\alpha\beta}$	$\tau^{\#1}_{1^+\alpha\beta}$	$\sigma^{\#1}_{1^-\alpha}$	$\sigma^{\#2}_{1^-\alpha}$	$\tau^{\#1}_{1^-\alpha}$	$\tau^{\#2}_{1^-\alpha}$
$\sigma^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{6}{(3+2k^2)^2 t_1}$	$-\frac{6\sqrt{2}}{(3+2k^2)^2 t_1}$	$-\frac{6i\sqrt{2}k}{(3+2k^2)^2 t_1}$	0	0	0	0
$\sigma^{\#2}_{1^+}\dagger^{\alpha\beta}$	$-\frac{6\sqrt{2}}{(3+2k^2)^2 t_1}$	$\frac{12}{(3+2k^2)^2 t_1}$	$\frac{12ik}{(3+2k^2)^2 t_1}$	0	0	0	0
$\tau^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{6i\sqrt{2}k}{(3+2k^2)^2 t_1}$	$-\frac{12ik}{(3+2k^2)^2 t_1}$	$\frac{12k^2}{(3+2k^2)^2 t_1}$	0	0	0	0
$\sigma^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	0	$\frac{2ik}{t_1+2k^2t_1}$
$\sigma^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{2k^2r_1+t_1}{(t_1+2k^2t_1)^2}$	0	$\frac{i\sqrt{2}k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$
$\tau^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	0	0	0	0
$\tau^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$-\frac{2ik}{t_1+2k^2t_1}$	$-\frac{i\sqrt{2}k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$	0	$\frac{2k^2(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$

	$\sigma^{\#1}_{0^+}$	$\tau^{\#1}_{0^+}$	$\tau^{\#2}_{0^+}$	$\sigma^{\#1}_{0^-}$
$\sigma^{\#1}_{0^+}\dagger$	$-\frac{1}{(1+2k^2)^2 t_1}$	$\frac{i\sqrt{2}k}{(1+2k^2)^2 t_1}$	0	0
$\tau^{\#1}_{0^+}\dagger$	$-\frac{i\sqrt{2}k}{(1+2k^2)^2 t_1}$	$-\frac{2k^2}{(1+2k^2)^2 t_1}$	0	0
$\tau^{\#2}_{0^+}\dagger$	0	0	0	0
$\sigma^{\#1}_{0^-}\dagger$	0	0	0	$\frac{1}{k^2 r_2}$

	$\sigma^{\#1}_{2^+\alpha\beta}$	$\tau^{\#1}_{2^+\alpha\beta}$	$\sigma^{\#1}_{2^-\alpha\beta\chi}$
$\sigma^{\#1}_{2^+}\dagger^{\alpha\beta}$	$\frac{2}{(1+2k^2)^2 t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2 t_1}$	0
$\tau^{\#1}_{2^+}\dagger^{\alpha\beta}$	$\frac{2i\sqrt{2}k}{(1+2k^2)^2 t_1}$	$\frac{4k^2}{(1+2k^2)^2 t_1}$	0
$\sigma^{\#1}_{2^-}\dagger^{\alpha\beta\chi}$	0	0	$\frac{2}{2k^2r_1+t_1}$

	$\omega^{\#1}_{1^+\alpha\beta}$	$\omega^{\#2}_{1^+\alpha\beta}$	$f^{\#1}_{1^+\alpha\beta}$	$\omega^{\#1}_{1^-\alpha}$	$\omega^{\#2}_{1^-\alpha}$	$f^{\#1}_{1^-\alpha}$	$f^{\#2}_{1^-\alpha}$
$\omega^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{t_1}{6}$	$-\frac{t_1}{3\sqrt{2}}$	$\frac{ikt_1}{3\sqrt{2}}$	0	0	0	0
$\omega^{\#2}_{1^+}\dagger^{\alpha\beta}$	$-\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	$\frac{ikt_1}{3}$	0	0	0	0
$f^{\#1}_{1^+}\dagger^{\alpha\beta}$	$-\frac{ikt_1}{3\sqrt{2}}$	$-\frac{1}{3}ikt_1$	$\frac{k^2t_1}{3}$	0	0	0	0
$\omega^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	$-k^2r_1-\frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0	ikt_1
$\omega^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
$f^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	0	0	0	0
$f^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$-ikt_1$	0	0	0

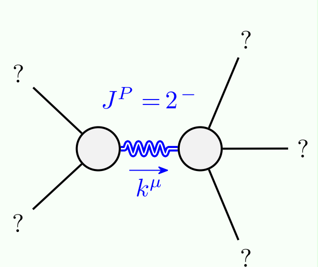
	$\omega^{\#1}_{2^+\alpha\beta}$	$f^{\#1}_{2^+\alpha\beta}$	$\omega^{\#1}_{2^-\alpha\beta\chi}$
$\omega^{\#1}_{2^+}\dagger^{\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	0
$f^{\#1}_{2^+}\dagger^{\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	k^2t_1	0
$\omega^{\#1}_{2^-}\dagger^{\alpha\beta\chi}$	0	0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

	$\omega^{\#1}_{0^+}$	$f^{\#1}_{0^+}$	$f^{\#2}_{0^+}$	$\omega^{\#1}_{0^-}$
$\omega^{\#1}_{0^+}\dagger$	$-t_1$	$i\sqrt{2}\,kt_1$	0	0
$f^{\#1}_{0^+}\dagger$	$-i\sqrt{2}\,kt_1$	$-2k^2t_1$	0	0
$f^{\#2}_{0^+}\dagger$	0	0	0	0
$\omega^{\#1}_{0^-}\dagger$	0	0	0	k^2r_2

Source constraints/gauge generators

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

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

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