Particle spectrograph

Wave operator and propagator

Quadratic (free) action

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

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

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

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

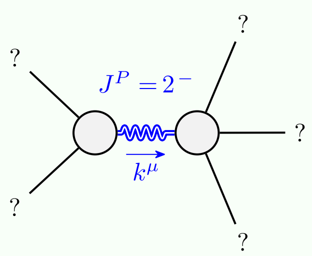
	$\omega^{\#1}_{0^+}\dagger$	$f^{\#1}_{0^+}\dagger$	$f^{\#2}_{0^+}\dagger$	$\omega^{\#1}_{0^-}\dagger$
$\omega^{\#1}_{0^-}$	0	0	0	k^2r_2
$f^{\#2}_{0^+}$	0	0	0	0
$f^{\#1}_{0^+}$	$i\sqrt{2}kt_1$	$-2k^2t_1$	0	0
$\omega^{\#1}_{0^+}$	$-t_1$	$-i\sqrt{2}kt_1$	0	0

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

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

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

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

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