Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$
\begin{aligned}
S == \iiiint \Big(&\tfrac{1}{6}\,(2\,t_1\;\omega^{\alpha\imath}{}_{\alpha}\;\omega_{\imath}{}^{\theta}{}_{\theta} + 6\;f^{\alpha\beta}\;\tau_{\alpha\beta} + 6\;\omega^{\alpha\beta\chi}\;\sigma_{\alpha\beta\chi} - 4\,t_1\;\omega_{\alpha}{}^{\theta}{}_{\theta}\;\partial_{\imath} f^{\alpha\imath} + 4\,t_1\;\omega_{\imath}{}^{\theta}{}_{\theta}\\
&\partial^{\imath} f^{\alpha}{}_{\alpha} - 2\,t_1\,\partial_{\imath} f^{\theta}{}_{\theta}\,\partial^{\imath} f^{\alpha}{}_{\alpha} - 24\,r_3\,\partial_{\beta}\omega_{\imath}{}^{\theta}{}_{\theta}\,\partial^{\imath}\omega^{\alpha\beta}{}_{\alpha} - 2\,t_1\,\partial_{\imath} f^{\alpha\imath}\,\partial_{\theta} f_{\alpha}{}^{\theta} +\\
&4\,t_1\,\partial^{\imath} f^{\alpha}{}_{\alpha}\,\partial_{\theta} f_{\imath}{}^{\theta} - 24\,r_3\,\partial_{\alpha}\omega^{\alpha\beta\imath}\,\partial_{\theta}\omega_{\imath}{}^{\theta}{}_{\beta} + 48\,r_3\,\partial^{\imath}\omega^{\alpha\beta}{}_{\alpha}\,\partial_{\theta}\omega_{\imath}{}^{\theta}{}_{\beta} + 4\,t_1\;\omega_{\imath\theta\alpha}\,\partial^{\theta} f^{\alpha\imath} +\\
&4\,t_2\;\omega_{\imath\theta\alpha}\,\partial^{\theta} f^{\alpha\imath} - 4\,t_1\,\partial_{\alpha} f_{\imath\theta}\,\partial^{\theta} f^{\alpha\imath} + 2\,t_2\,\partial_{\alpha} f_{\imath\theta}\,\partial^{\theta} f^{\alpha\imath} - 4\,t_1\,\partial_{\alpha} f_{\theta\imath}\,\partial^{\theta} f^{\alpha\imath} -\\
&t_2\,\partial_{\alpha} f_{\theta\imath}\,\partial^{\theta} f^{\alpha\imath} + 2\,t_1\,\partial_{\imath} f_{\alpha\theta}\,\partial^{\theta} f^{\alpha\imath} - t_2\,\partial_{\imath} f_{\alpha\theta}\,\partial^{\theta} f^{\alpha\imath} + 4\,t_1\,\partial_{\theta} f_{\alpha\imath}\,\partial^{\theta} f^{\alpha\imath} + t_2\,\partial_{\theta} f_{\alpha\imath}\\
&\partial^{\theta} f^{\alpha\imath} + 2\,t_1\,\partial_{\theta} f_{\imath\alpha}\,\partial^{\theta} f^{\alpha\imath} - t_2\,\partial_{\theta} f_{\imath\alpha}\,\partial^{\theta} f^{\alpha\imath} + 2\,(t_1 + t_2)\;\omega_{\alpha\imath\theta}\,(\omega^{\alpha\imath\theta} + 2\,\partial^{\theta} f^{\alpha\imath}) +\\
&2\;\omega_{\alpha\theta\imath}\,((t_1 - 2\,t_2)\;\omega^{\alpha\imath\theta} + 2\,(2\,t_1 - t_2)\,\partial^{\theta} f^{\alpha\imath}) + 8\,r_2\,\partial_{\beta}\omega_{\alpha\imath\theta}\,\partial^{\theta}\omega^{\alpha\beta\imath} -\\
&4\,r_2\,\partial_{\beta}\omega_{\alpha\theta\imath}\,\partial^{\theta}\omega^{\alpha\beta\imath} + 4\,r_2\,\partial_{\beta}\omega_{\imath\theta\alpha}\,\partial^{\theta}\omega^{\alpha\beta\imath} - 24\,r_3\,\partial_{\beta}\omega_{\imath\theta\alpha}\,\partial^{\theta}\omega^{\alpha\beta\imath} - 2\,r_2\,\partial_{\imath}\omega_{\alpha\beta\theta}\\
&\partial^{\theta}\omega^{\alpha\beta\imath} + 2\,r_2\,\partial_{\theta}\omega_{\alpha\beta\imath}\,\partial^{\theta}\omega^{\alpha\beta\imath} - 4\,r_2\,\partial_{\theta}\omega_{\alpha\imath\beta}\,\partial^{\theta}\omega^{\alpha\beta\imath}\Big)[t, x, y, z]\,dz\,dy\,dx\,dt
\end{aligned}
$$

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

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

Source constraints/gauge generators

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

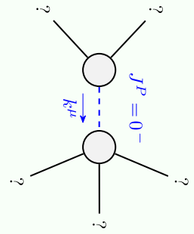
	$\omega^{\#1}_{0^+}{}^{\dagger}$	$f^{\#2}_{0^+}{}^{\dagger}$	$f^{\#1}_{0^+}{}^{\dagger}$	$\omega^{\#1}_{0^+}{}^{\dagger}$
$\omega^{\#1}_{0^+}$	0	0	0	$6\,k^2\,r_3$
$f^{\#1}_{0^+}$	0	0	0	0
$f^{\#2}_{0^+}$	0	0	0	0
$\omega^{\#1}_{0^-}$	$k^2\,r_2 + t_2$	0	0	0

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

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

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

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

$r_2 < 0 \;\&\&\; t_2 > 0$