Particle spectrograph

Wave operator and propagator

Source constraints

SO(3) irreps	Fundamental fields	Multiplicities
$\tau^{\#2}_{0^+} == 0$	$\partial_\beta\partial_\alpha\tau^{\alpha\beta} == 0$	1
$\tau^{\#1}_{0^+} - 2 i k\,\sigma^{\#1}_{0^+} == 0$	$\partial_\beta\partial_\alpha\tau^{\alpha\beta} == \partial_\beta\partial^\beta\tau^{\alpha}{}_{\alpha} + 2\,\partial_\chi\partial^\chi\partial_\beta\sigma^{\alpha\beta}{}_{\alpha}$	1
$\tau^{\#2\,\alpha}_{1^-} + 2 i k\,\sigma^{\#2\,\alpha}_{1^-} == 0$	$\partial_\chi\partial_\beta\partial^\alpha\tau^{\beta\chi} == \partial_\chi\partial^\chi\partial_\beta\tau^{\alpha\beta} + 2\,\partial_\delta\partial^\delta\partial_\chi\partial_\beta\sigma^{\alpha\beta\chi}$	3
$\tau^{\#1\,\alpha}_{1^-} == 0$	$\partial_\chi\partial_\beta\partial^\alpha\tau^{\beta\chi} == \partial_\chi\partial^\chi\partial_\beta\tau^{\beta\alpha}$	3
$\tau^{\#1\,\alpha\beta}_{1^+} - 2 i k\,\sigma^{\#1\,\alpha\beta}_{1^+} == 0$	$\partial_\chi\partial^\alpha\tau^{\beta\chi} + \partial_\chi\partial^\beta\tau^{\chi\alpha} + \partial_\chi\partial^\chi\tau^{\alpha\beta} + 2\,\partial_\delta\partial_\chi\partial^\alpha\sigma^{\beta\chi\delta} + 2\,\partial_\delta\partial^\delta\partial_\chi\sigma^{\alpha\chi\beta} == \partial_\chi\partial^\alpha\tau^{\chi\beta} + \partial_\chi\partial^\beta\tau^{\alpha\chi} + \partial_\chi\partial^\chi\tau^{\beta\alpha} + 2\,\partial_\delta\partial_\chi\partial^\beta\sigma^{\alpha\chi\delta} + 2\,\partial_\delta\partial^\delta\partial_\chi\sigma^{\beta\chi\alpha}$	3
$2\,\sigma^{\#1\,\alpha\beta}_{1^+} + \sigma^{\#2\,\alpha\beta}_{1^+} == 0$	$\partial_\chi\sigma^{\alpha\beta\chi} + \partial_\chi\sigma^{\beta\chi\alpha} == \partial_\chi\sigma^{\alpha\chi\beta}$	3
$\tau^{\#1\,\alpha\beta}_{2^+} - 2 i k\,\sigma^{\#1\,\alpha\beta}_{2^+} == 0$	$-i(4\,\partial_\delta\partial_\chi\partial^\beta\partial^\alpha\tau^{\chi\delta} + 2\,\partial_\delta\partial^\delta\partial^\beta\partial^\alpha\tau^{\chi}{}_{\chi} - 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\alpha\tau^{\beta\chi} - 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\alpha\tau^{\chi\beta} - 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\beta\tau^{\alpha\chi} - 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\beta\tau^{\chi\alpha} + 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\chi\tau^{\alpha\beta} + 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\chi\tau^{\beta\alpha} + 4 i k^\chi\,\partial_\epsilon\partial_\chi\partial^\beta\partial^\alpha\sigma^{\delta\epsilon}{}_{\delta} - 6 i k^\chi\,\partial_\epsilon\partial_\delta\partial_\chi\partial^\alpha\sigma^{\beta\delta\epsilon} - 6 i k^\chi\,\partial_\epsilon\partial_\delta\partial_\chi\partial^\beta\sigma^{\alpha\delta\epsilon} + 2\,\eta^{\alpha\beta}\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi\tau^{\chi\delta} + 6 i k^\chi\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi\sigma^{\alpha\delta\beta} + 6 i k^\chi\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi\sigma^{\beta\delta\alpha} - 2\,\eta^{\alpha\beta}\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\delta\tau^{\chi}{}_{\chi} - 4 i\,\eta^{\alpha\beta}\,k^\chi\,\partial_\phi\partial^\phi\partial_\epsilon\partial_\chi\sigma^{\delta\epsilon}{}_{\delta}) == 0$	5
Total constraints/gauge generators:		19

Quadratic (free) action

$$
\begin{aligned}
S == \iiiint\Big(\tfrac{1}{3}\big(&3 t_1\,\omega^{\alpha\iota}{}_{\alpha}\,\omega_{\iota}{}^{\theta}{}_{\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\iota\theta}\,(\omega^{\alpha\iota\theta} + 2\,\partial^\theta f^{\alpha\iota}) + t_1\,\omega_{\alpha\theta\iota}\,(\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
\end{aligned}
$$

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

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

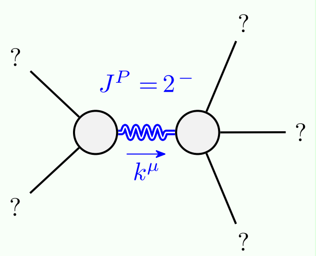
	$\sigma^{\#1}_{2^+\alpha\beta}$	$\tau^{\#1}_{2^+\alpha\beta}$	$\sigma^{\#1}_{2^-\alpha\beta\chi}$
$\sigma^{\#1}_{2^+}{}^\dagger{}^{\alpha\beta}$	$\frac{2}{(1+2k^2)^2 t_1}$	$-\frac{2 i\sqrt{2}\,k}{(1+2k^2)^2 t_1}$	0
$\tau^{\#1}_{2^+}{}^\dagger{}^{\alpha\beta}$	$\frac{2 i\sqrt{2}\,k}{(1+2k^2)^2 t_1}$	$\frac{4k^2}{(1+2k^2)^2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

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

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

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

Massive and massless spectra



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

(No massless particles)

Unitarity conditions

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