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

Quadratic (free) action

$$
\begin{aligned}
S == \iiiint\Big(\tfrac{1}{6}\,(&2\,t_1\,\mathcal{A}^{\alpha\prime}{}_\alpha\,\mathcal{A}_\prime{}^\theta{}_\theta + 6\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\mathcal{A}^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} - 4\,t_1\,\mathcal{A}_\alpha{}^\theta{}_\theta\,\partial_\iota f^{\alpha\prime} + \\
&4\,t_1\,\mathcal{A}_\prime{}^\theta{}_\theta\,\partial^\prime f^\alpha{}_\alpha - 2\,t_1\,\partial_\iota f^\theta{}_\theta\,\partial^\prime f^\alpha{}_\alpha - 24\,r_3\,\partial_\beta\mathcal{A}_\prime{}^\theta{}_\theta\,\partial^\prime\mathcal{A}^{\alpha\beta}{}_\alpha - \\
&2\,t_1\,\partial_\iota f^{\alpha\prime}\,\partial_\theta f_\alpha{}^\theta + 4\,t_1\,\partial^\prime f^\alpha{}_\alpha\,\partial_\theta f_\prime{}^\theta - 24\,r_3\,\partial_\alpha\mathcal{A}^{\alpha\beta\prime} \\
&\partial_\theta\mathcal{A}_\prime{}^\theta{}_\beta + 48\,r_3\,\partial^\prime\mathcal{A}^{\alpha\beta}{}_\alpha\,\partial_\theta\mathcal{A}_\prime{}^\theta{}_\beta - 6\,t_1\,\partial_\alpha f_\prime{}^\theta\,\partial_\theta f^{\alpha\prime} - \\
&3\,t_1\,\partial_\alpha f_{\theta\prime}\,\partial^\theta f^{\alpha\prime} + 3\,t_1\,\partial_\iota f_{\alpha\theta}\,\partial^\theta f^{\alpha\prime} + 3\,t_1\,\partial_\theta f_{\alpha\prime}\,\partial^\theta f^{\alpha\prime} + \\
&3\,t_1\,\partial_\theta f_{\prime\alpha}\,\partial^\theta f^{\alpha\prime} + 6\,t_1\,\mathcal{A}_{\alpha\theta\prime}\,(\mathcal{A}^{\alpha\prime\theta} + 2\,\partial^\theta f^{\alpha\prime}) + \\
&8\,r_2\,\partial_\beta\mathcal{A}_{\alpha\prime\theta}\,\partial^\theta\mathcal{A}^{\alpha\beta\prime} - 4\,r_2\,\partial_\beta\mathcal{A}_{\alpha\theta\prime}\,\partial^\theta\mathcal{A}^{\alpha\beta\prime} + \\
&4\,r_2\,\partial_\beta\mathcal{A}_{\prime\theta\alpha}\,\partial^\theta\mathcal{A}^{\alpha\beta\prime} - 24\,r_3\,\partial_\beta\mathcal{A}_{\prime\theta\alpha}\,\partial^\theta\mathcal{A}^{\alpha\beta\prime} - \\
&2\,r_2\,\partial_\iota\mathcal{A}_{\alpha\beta\theta}\,\partial^\theta\mathcal{A}^{\alpha\beta\prime} + 2\,r_2\,\partial_\theta\mathcal{A}_{\alpha\beta\prime}\,\partial^\theta\mathcal{A}^{\alpha\beta\prime} - \\
&4\,r_2\,\partial_\theta\mathcal{A}_{\alpha\prime\beta}\,\partial^\theta\mathcal{A}^{\alpha\beta\prime}\Big))[t,\,x,\,y,\,z]\,dz\,dy\,dx\,dt
\end{aligned}
$$

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

	$\mathcal{A}^{\#1}_{1^+\,\alpha\beta}$	$\mathcal{A}^{\#2}_{1^+\,\alpha\beta}$	$f^{\#1}_{1^+\,\alpha\beta}$	$\mathcal{A}^{\#1}_{1^-\,\alpha}$	$\mathcal{A}^{\#2}_{1^-\,\alpha}$	$f^{\#1}_{1^-\,\alpha}$	$f^{\#2}_{1^-\,\alpha}$
$\mathcal{A}^{\#1}_{1^+}\dagger^{\alpha\beta}$	$-\frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{ikt_1}{\sqrt{2}}$	0	0	0	0
$\mathcal{A}^{\#2}_{1^+}\dagger^{\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$f^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	0	0	0	0	0	0
$\mathcal{A}^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{t_1}{6}$	$\frac{t_1}{3\sqrt{2}}$	0	$\frac{ikt_1}{3}$
$\mathcal{A}^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	0	$\frac{1}{3}i\sqrt{2}\,kt_1$
$f^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	0	0	0	0
$f^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$-\frac{1}{3}ikt_1$	$-\frac{1}{3}i\sqrt{2}\,kt_1$	0	$\frac{2k^2 t_1}{3}$

	$\mathcal{A}^{\#1}_{0^+}\dagger$	$f^{\#2}_{0^+}\dagger$	$f^{\#1}_{0^+}\dagger$	$\mathcal{A}^{\#1}_{0^+}\dagger$
$\mathcal{A}^{\#1}_{0^+}$	0	0	0	$6k^2 r_3$
$f^{\#1}_{0^+}$	0	0	0	0
$f^{\#2}_{0^+}$	0	0	0	0
$\mathcal{A}^{\#1}_{0^+}$	$k^2 r_2 - t_1$	0	0	0

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

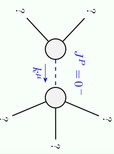
	$\mathcal{A}^{\#1}_{2^+}\dagger^{\alpha\beta\chi}$	$f^{\#1}_{2^+}\dagger^{\alpha\beta}$	$\mathcal{A}^{\#1}_{2^+}\dagger^{\alpha\beta}$
$\mathcal{A}^{\#1}_{2^+\,\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	$-\frac{t_1}{2}$
$f^{\#1}_{2^+\,\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	$k^2 t_1$	$-\frac{ikt_1}{\sqrt{2}}$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

	$\sigma^{\#1}_{0^+}\dagger$	$\tau^{\#2}_{0^+}\dagger$	$\tau^{\#1}_{0^+}\dagger$	$\sigma^{\#1}_{0^+}\dagger$
$\sigma^{\#1}_{0^+}$	0	0	0	$\frac{1}{6k^2 r_3}$
$\tau^{\#1}_{0^+}$	0	0	0	0
$\tau^{\#2}_{0^+}$	0	0	0	0
$\sigma^{\#1}_{0^-}$	$\frac{1}{k^2 r_2 - t_1}$	0	0	0

(No massless particles)

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



Unitarity conditions

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