Particle spectrograph

Wave operator and propagator

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

	$\mathcal{A}^{\#1}_{1^{+}\,\alpha\beta}$	$\mathcal{A}^{\#2}_{1^{+}\,\alpha\beta}$	$f^{\#1}_{1^{+}\,\alpha\beta}$	$\mathcal{A}^{\#1}_{1^{-}\,\alpha}$	$\mathcal{A}^{\#2}_{1^{-}\,\alpha}$	$f^{\#1}_{1^{-}\,\alpha}$	$f^{\#2}_{1^{-}\,\alpha}$
$\mathcal{A}^{\#1}_{1^{+}}\dagger^{\alpha\beta}$	$k^2 (2 r_3 + r_5) - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{i k t_1}{\sqrt{2}}$	0	0	0	0
$\mathcal{A}^{\#2}_{1^{+}}\dagger^{\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$f^{\#1}_{1^{+}}\dagger^{\alpha\beta}$	$\frac{i k t_1}{\sqrt{2}}$	0	0	0	0	0	0
$\mathcal{A}^{\#1}_{1^{-}}\dagger^{\alpha}$	0	0	0	$k^2 (-r_1 + 2 r_3 + r_5) + \frac{t_1}{6}$	$\frac{t_1}{3\sqrt{2}}$	0	$\frac{i k t_1}{3}$
$\mathcal{A}^{\#2}_{1^{-}}\dagger^{\alpha}$	0	0	0	$\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	0	$\frac{1}{3} i \sqrt{2}\, k t_1$
$f^{\#1}_{1^{-}}\dagger^{\alpha}$	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	$\frac{2 k^2 t_1}{3}$

	$\sigma^{\#1}_{1^{+}\,\alpha\beta}$	$\sigma^{\#2}_{1^{+}\,\alpha\beta}$	$\tau^{\#1}_{1^{+}\,\alpha\beta}$	$\sigma^{\#1}_{1^{-}\,\alpha}$	$\sigma^{\#2}_{1^{-}\,\alpha}$	$\tau^{\#1}_{1^{-}\,\alpha}$	$\tau^{\#2}_{1^{-}\,\alpha}$
$\sigma^{\#1}_{1^{+}}\dagger^{\alpha\beta}$	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
$\sigma^{\#2}_{1^{+}}\dagger^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1 + k^2 t_1}$	$\frac{-2 k^2 (2 r_3 + r_5) + t_1}{(1+k^2)^2 t_1^2}$	$\frac{-2 i k^3 (2 r_3 + r_5) + i k t_1}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\tau^{\#1}_{1^{+}}\dagger^{\alpha\beta}$	$\frac{i\sqrt{2}\,k}{t_1 + k^2 t_1}$	$\frac{i (2 k^3 (2 r_3 + r_5) - k t_1)}{(1+k^2)^2 t_1^2}$	$\frac{-2 k^4 (2 r_3 + r_5) + k^2 t_1}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\sigma^{\#1}_{1^{-}}\dagger^{\alpha}$	0	0	0	$\frac{1}{k^2 (-r_1 + 2 r_3 + r_5)}$	$\frac{1}{\sqrt{2}\,(k^2 + 2 k^4)(r_1 - 2 r_3 - r_5)}$	0	$\frac{i}{k (1 + 2 k^2)(r_1 - 2 r_3 - r_5)}$
$\sigma^{\#2}_{1^{-}}\dagger^{\alpha}$	0	0	0	$\frac{1}{\sqrt{2}\,(k^2 + 2 k^4)(r_1 - 2 r_3 - r_5)}$	$\frac{\frac{1}{-r_1 + 2 r_3 + r_5} + \frac{6 k^2}{t_1}}{2 (k + 2 k^3)^2}$	0	$\frac{i (6 k^2 (r_1 - 2 r_3 - r_5) - t_1)}{\sqrt{2}\, k (1 + 2 k^2)^2 (r_1 - 2 r_3 - r_5) t_1}$
$\tau^{\#1}_{1^{-}}\dagger^{\alpha}$	0	0	0	0	0	0	0
$\tau^{\#2}_{1^{-}}\dagger^{\alpha}$	0	0	0	$\frac{i}{k (1 + 2 k^2)(-r_1 + 2 r_3 + r_5)}$	$-\frac{i (6 k^2 (r_1 - 2 r_3 - r_5) - t_1)}{\sqrt{2}\, k (1 + 2 k^2)^2 (r_1 - 2 r_3 - r_5) t_1}$	0	$\frac{\frac{1}{-r_1 + 2 r_3 + r_5} + \frac{6 k^2}{t_1}}{(1 + 2 k^2)^2}$

	$\sigma^{\#1}_{0^{+}}$	$\tau^{\#1}_{0^{+}}$	$\tau^{\#2}_{0^{+}}$	$\sigma^{\#1}_{0^{-}}$
$\sigma^{\#1}_{0^{+}}\dagger$	$\frac{1}{6 k^2 (-r_1 + r_3)}$	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	$-\frac{1}{t_1}$

	$\mathcal{A}^{\#1}_{0^{+}}$	$f^{\#1}_{0^{+}}$	$f^{\#2}_{0^{+}}$	$\mathcal{A}^{\#1}_{0^{-}}$
$\mathcal{A}^{\#1}_{0^{+}}\dagger$	$6 k^2 (-r_1 + r_3)$	0	0	0
$f^{\#1}_{0^{+}}\dagger$	0	0	0	0
$f^{\#2}_{0^{+}}\dagger$	0	0	0	0
$\mathcal{A}^{\#1}_{0^{-}}\dagger$	0	0	0	$-t_1$

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

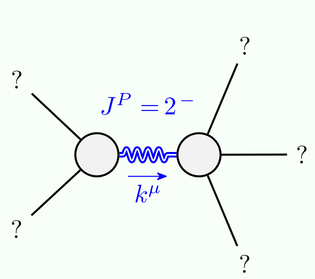
Source constraints

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
$\tau^{\#2\,\alpha}_{1^{-}} + 2 i k\, \sigma^{\#2\,\alpha}_{1^{-}} == 0$	$\partial_\chi\partial_\beta\partial^\alpha \tau^{\beta\chi} == \partial_\chi\partial^\chi\partial_\beta \tau^{\alpha\beta} + 2\, \partial_\delta\partial^\delta\partial_\chi\partial_\beta \sigma^{\alpha\beta\chi}$	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
$\tau^{\#1\,\alpha\beta}_{1^{+}} + i k\, \sigma^{\#2\,\alpha\beta}_{1^{+}} == 0$	$\partial_\chi\partial^\alpha \tau^{\beta\chi} + \partial_\chi\partial^\beta \tau^{\chi\alpha} + \partial_\chi\partial^\chi \tau^{\alpha\beta} +$ $2\, \partial_\delta\partial^\alpha \sigma^{\beta\chi\delta} + 2\, \partial_\delta\partial^\delta \sigma^{\alpha\beta\chi} ==$ $\partial_\chi\partial^\alpha \tau^{\chi\beta} + \partial_\chi\partial^\beta \tau^{\alpha\chi} +$ $\partial_\chi\partial^\chi \tau^{\beta\alpha} + 2\, \partial_\delta\partial_\chi\partial^\beta \sigma^{\alpha\chi\delta}$	3
$\tau^{\#1\,\alpha\beta}_{2^{+}} - 2 i k\, \sigma^{\#1\,\alpha\beta}_{2^{+}} == 0$	$-i (4\, \partial_\delta\partial_\chi\partial^\beta\partial^\alpha \tau^{\chi\delta} + 2\, \partial_\delta\partial^\delta\partial^\beta\partial^\alpha \tau^{\chi}{}_{\chi} -$ $3\, \partial_\delta\partial^\delta\partial_\chi\partial^\alpha \tau^{\beta\chi} - 3\, \partial_\delta\partial^\delta\partial_\chi\partial^\alpha \tau^{\chi\beta} -$ $3\, \partial_\delta\partial^\delta\partial_\chi\partial^\beta \tau^{\alpha\chi} - 3\, \partial_\delta\partial^\delta\partial_\chi\partial^\beta \tau^{\chi\alpha} +$ $3\, \partial_\delta\partial^\delta\partial_\chi\partial^\chi \tau^{\alpha\beta} + 3\, \partial_\delta\partial^\delta\partial_\chi\partial^\chi \tau^{\beta\alpha} +$ $4 i\, k^\chi\, \partial_\epsilon\partial_\chi\partial^\beta\partial^\alpha \sigma^{\delta\epsilon}{}_{\delta} -$ $6 i\, k^\chi\, \partial_\epsilon\partial_\delta\partial_\chi\partial^\alpha \sigma^{\beta\delta\epsilon} -$ $6 i\, k^\chi\, \partial_\epsilon\partial_\delta\partial_\chi\partial^\beta \sigma^{\alpha\delta\epsilon} +$ $2\, \eta^{\alpha\beta}\, \partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi \tau^{\chi\delta} +$ $6 i\, k^\chi\, \partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi \sigma^{\alpha\delta\beta} +$ $6 i\, k^\chi\, \partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi \sigma^{\beta\delta\alpha} -$ $2\, \eta^{\alpha\beta}\, \partial_\epsilon\partial^\epsilon\partial_\delta\partial^\delta \tau^{\chi}{}_{\chi} -$ $4 i\, \eta^{\alpha\beta}\, k^\chi\, \partial_\phi\partial^\phi\partial_\epsilon\partial_\chi \sigma^{\delta\epsilon}{}_{\delta}) == 0$	5
Total constraints/gauge generators:		16

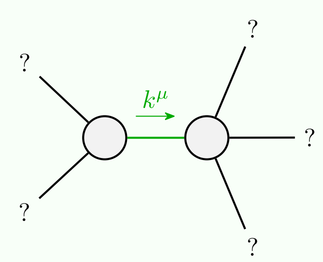
Quadratic (free) action

$$
\begin{aligned}
S == \iiiint(&f^{\alpha\beta}\, \tau_{\alpha\beta} + \mathcal{A}^{\alpha\beta\chi}\, \sigma_{\alpha\beta\chi} + \\
&\tfrac{1}{6} t_1 (2\, \mathcal{A}^{\alpha\iota}{}_{\alpha}\, \mathcal{A}_{\iota}{}^{\theta}{}_{\theta} - 4\, \mathcal{A}_{\alpha}{}^{\theta}{}_{\theta}\, \partial_\iota f^{\alpha\iota} + 4\, \mathcal{A}_{\iota}{}^{\theta}{}_{\theta}\, \partial^\iota f^{\alpha}{}_{\alpha} - 2\, \partial_\iota f^{\theta}{}_{\theta} \\
&\quad \partial^\iota f^{\alpha}{}_{\alpha} - 2\, \partial_\iota f^{\alpha\iota}\, \partial_\theta f_{\alpha}{}^{\theta} + 4\, \partial^\iota f^{\alpha}{}_{\alpha}\, \partial_\theta f_{\iota}{}^{\theta} - 6\, \partial_\alpha f_{\iota\theta}\, \partial^\theta f^{\alpha\iota} - \\
&\quad 3\, \partial_\alpha f_{\theta\iota}\, \partial^\theta f^{\alpha\iota} + 3\, \partial_\iota f_{\alpha\theta}\, \partial^\theta f^{\alpha\iota} + 3\, \partial_\theta f_{\alpha\iota}\, \partial^\theta f^{\alpha\iota} + \\
&\quad 3\, \partial_\theta f_{\iota\alpha}\, \partial^\theta f^{\alpha\iota} + 6\, \mathcal{A}_{\alpha\theta\iota}\, (\mathcal{A}^{\alpha\iota\theta} + 2\, \partial^\theta f^{\alpha\iota})) - \\
&2 r_3 (\partial_\beta \mathcal{A}_{\iota}{}^{\theta}{}_{\theta}\, \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha} + \partial_\iota \mathcal{A}_{\beta}{}^{\theta}{}_{\theta}\, \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha} + \partial_\alpha \mathcal{A}^{\alpha\beta\iota}\, \partial_\theta \mathcal{A}_{\beta}{}^{\theta}{}_{\iota} - \\
&\quad 2\, \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha}\, \partial_\theta \mathcal{A}_{\beta}{}^{\theta}{}_{\iota} + \partial_\alpha \mathcal{A}^{\alpha\beta\iota}\, \partial_\theta \mathcal{A}_{\iota}{}^{\theta}{}_{\beta} - \\
&\quad 2\, \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha}\, \partial_\theta \mathcal{A}_{\iota}{}^{\theta}{}_{\beta} + 2\, \partial_\beta \mathcal{A}_{\iota\theta\alpha}\, \partial^\theta \mathcal{A}^{\alpha\beta\iota}) + \\
&\tfrac{2}{3} r_1 (3\, \partial_\beta \mathcal{A}_{\iota}{}^{\theta}{}_{\theta}\, \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha} + 3\, \partial_\iota \mathcal{A}_{\beta}{}^{\theta}{}_{\theta}\, \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha} + \\
&\quad 3\, \partial_\alpha \mathcal{A}^{\alpha\beta\iota}\, \partial_\theta \mathcal{A}_{\beta}{}^{\theta}{}_{\iota} - 6\, \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha}\, \partial_\theta \mathcal{A}_{\beta}{}^{\theta}{}_{\iota} + \\
&\quad 3\, \partial_\alpha \mathcal{A}^{\alpha\beta\iota}\, \partial_\theta \mathcal{A}_{\iota}{}^{\theta}{}_{\beta} - 6\, \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha}\, \partial_\theta \mathcal{A}_{\iota}{}^{\theta}{}_{\beta} - 2\, \partial_\beta \mathcal{A}_{\alpha\iota\theta} \\
&\quad \partial^\theta \mathcal{A}^{\alpha\beta\iota} + \partial_\beta \mathcal{A}_{\alpha\theta\iota}\, \partial^\theta \mathcal{A}^{\alpha\beta\iota} + 2\, \partial_\beta \mathcal{A}_{\iota\theta\alpha}\, \partial^\theta \mathcal{A}^{\alpha\beta\iota} - \\
&\quad \partial_\iota \mathcal{A}_{\alpha\beta\theta}\, \partial^\theta \mathcal{A}^{\alpha\beta\iota} + \partial_\theta \mathcal{A}_{\alpha\beta\iota}\, \partial^\theta \mathcal{A}^{\alpha\beta\iota} + \partial_\theta \mathcal{A}_{\alpha\iota\beta}\, \partial^\theta \mathcal{A}^{\alpha\beta\iota}) + \\
&r_5 (\partial_\iota \mathcal{A}_{\theta}{}^{\kappa}{}_{\kappa}\, \partial^\theta \mathcal{A}^{\alpha\iota}{}_{\alpha} - \partial_\theta \mathcal{A}_{\iota}{}^{\kappa}{}_{\kappa}\, \partial^\theta \mathcal{A}^{\alpha\iota}{}_{\alpha} - (\partial_\alpha \mathcal{A}^{\alpha\iota\theta} - 2\, \partial^\theta \mathcal{A}^{\alpha\iota}{}_{\alpha}) \\
&\quad (\partial_\kappa \mathcal{A}_{\iota}{}^{\kappa}{}_{\theta} - \partial_\kappa \mathcal{A}_{\theta}{}^{\kappa}{}_{\iota})))[t, x, y, z]\, dz\, dy\, dx\, dt
\end{aligned}
$$

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



Quadratic pole	
Pole residue:	$\frac{1}{(r_1 - 2 r_3 - r_5)\, t_1^2} > 0$
Polarisations:	2

Unitarity conditions

$r_1 < 0$ && $r_5 < r_1 - 2 r_3$ && $t_1 > 0$