Particle spectrograph

Wave operator and propagator

Source constraints

SO(3) irreps	Fundamental fields	Multiplicities
$\sigma^{\#1}_{0^+} == 0$	$\partial_\beta \sigma^{\alpha\beta}{}_{\alpha} == 0$	1
$\tau^{\#1}_{0^+} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau^{\alpha}{}_{\alpha}$	1
$\tau^{\#2}_{0^+} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$	1
$\tau^{\#2}_{1^-}{}^{\alpha} + 2 i k\, \sigma^{\#1}_{1^-}{}^{\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} + 2 (\partial_\delta \partial^\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi}{}_{\beta} - \partial_\delta \partial^\delta \partial_\chi \partial_\beta \sigma^{\alpha\beta\chi} + \partial_\delta \partial^\delta \partial_\chi \partial^\chi \sigma^{\alpha\beta}{}_{\beta}) == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta}$	3
$\tau^{\#1}_{1^-}{}^{\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\beta\alpha}$	3
$\sigma^{\#1}_{1^-}{}^{\alpha} == \sigma^{\#2}_{1^-}{}^{\alpha}$	$\partial_\chi \partial^\alpha \sigma^{\beta\chi}{}_{\beta} + \partial_\chi \partial^\chi \sigma^{\alpha\beta}{}_{\beta} == 0$	3
$\tau^{\#1}_{1^+}{}^{\alpha\beta} + i k\, \sigma^{\#2}_{1^+}{}^{\alpha\beta} == 0$	$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\beta \tau^{\chi\alpha} + \partial_\chi \partial^\chi \tau^{\alpha\beta} + 2 \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2 \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi} == \partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha\chi} + \partial_\chi \partial^\chi \tau^{\beta\alpha} + 2 \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}$	3
$\tau^{\#1}_{2^+}{}^{\alpha\beta} - 2 i k\, \sigma^{\#1}_{2^+}{}^{\alpha\beta} == 0$	$-i (4 \partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2 \partial_\delta \partial^\delta \partial^\beta \partial^\alpha \tau^{\chi}{}_{\chi} - 3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi} - 3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} - 3 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi} - 3 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha} + 3 \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3 \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\beta\alpha} + 4 i k^\chi \partial_\epsilon \partial_\chi \partial^\beta \partial^\alpha \sigma^{\delta\epsilon}{}_{\delta} - 6 i k^\chi \partial_\epsilon \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon} - 6 i k^\chi \partial_\epsilon \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon} + 2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} + 6 i k^\chi \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\alpha\delta\beta} + 6 i k^\chi \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\beta\delta\alpha} - 2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \tau^{\chi}{}_{\chi} - 4 i \eta^{\alpha\beta} k^\chi \partial_\phi \partial^\phi \partial_\epsilon \partial_\chi \sigma^{\delta\epsilon}{}_{\delta}) == 0$	5
Total constraints/gauge generators:		20

Quadratic (free) action

$$\mathcal{S} == \iiiint \Big(\tfrac{1}{6} \big(2 t_1 \mathcal{A}^{\alpha\iota}{}_{\alpha} \mathcal{A}_{\iota}{}^{\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\iota} + 4 t_1 \mathcal{A}_{\iota}{}^{\theta}{}_{\theta} \partial^\iota f^{\alpha}{}_{\alpha} - 2 t_1 \partial_\iota f^{\theta}{}_{\theta} \partial^\iota f^{\alpha}{}_{\alpha} - 6 r_1 \partial_\beta \mathcal{A}_{\iota}{}^{\theta}{}_{\theta} \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha} + 6 r_1 \partial_\iota \mathcal{A}_{\beta}{}^{\theta}{}_{\theta} \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha} - 2 t_1 \partial_\iota f^{\alpha\iota} \partial_\theta f_{\alpha}{}^{\theta} + 4 t_1 \partial^\iota f^{\alpha}{}_{\alpha} \partial_\theta f_{\iota}{}^{\theta} + 6 r_1 \partial_\alpha \mathcal{A}^{\alpha\beta\iota} \partial_\theta \mathcal{A}_{\beta}{}^{\theta}{}_{\iota} - 12 r_1 \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha} \partial_\theta \mathcal{A}_{\beta}{}^{\theta}{}_{\iota} - 6 r_1 \partial_\alpha \mathcal{A}^{\alpha\beta\iota} \partial_\theta \mathcal{A}_{\iota}{}^{\theta}{}_{\beta} + 12 r_1 \partial^\iota \mathcal{A}^{\alpha\beta}{}_{\alpha} \partial_\theta \mathcal{A}_{\iota}{}^{\theta}{}_{\beta} - 6 t_1 \partial_\alpha f_{\iota\theta} \partial^\theta f^{\alpha\iota} - 3 t_1 \partial_\alpha f_{\theta\iota} \partial^\theta f^{\alpha\iota} + 3 t_1 \partial_\iota f_{\alpha\theta} \partial^\theta f^{\alpha\iota} + 3 t_1 \partial_\theta f_{\alpha\iota} \partial^\theta f^{\alpha\iota} + 3 t_1 \partial_\theta f_{\iota\alpha} \partial^\theta f^{\alpha\iota} + 6 t_1 \mathcal{A}_{\alpha\theta\iota} (\mathcal{A}^{\alpha\iota\theta} + 2 \partial^\theta f^{\alpha\iota}) - 8 r_1 \partial_\beta \mathcal{A}_{\alpha\iota\theta} \partial^\theta \mathcal{A}^{\alpha\beta\iota} + 4 r_1 \partial_\beta \mathcal{A}_{\alpha\theta\iota} \partial^\theta \mathcal{A}^{\alpha\beta\iota} - 16 r_1 \partial_\beta \mathcal{A}_{\iota\theta\alpha} \partial^\theta \mathcal{A}^{\alpha\beta\iota} - 4 r_1 \partial_\iota \mathcal{A}_{\alpha\beta\theta} \partial^\theta \mathcal{A}^{\alpha\beta\iota} + 4 r_1 \partial_\theta \mathcal{A}_{\alpha\beta\iota} \partial^\theta \mathcal{A}^{\alpha\beta\iota} + 4 r_1 \partial_\theta \mathcal{A}_{\alpha\iota\beta} \partial^\theta \mathcal{A}^{\alpha\beta\iota}\big)\Big)[t, x, y, z]\, dz\, dy\, dx\, dt$$

	$\sigma^{\#1}_{1^+}{}_{\alpha\beta}$	$\sigma^{\#2}_{1^+}{}_{\alpha\beta}$	$\tau^{\#1}_{1^+}{}_{\alpha\beta}$	$\sigma^{\#1}_{1^-}{}_{\alpha}$	$\sigma^{\#2}_{1^-}{}_{\alpha}$	$\tau^{\#1}_{1^-}{}_{\alpha}$	$\tau^{\#2}_{1^-}{}_{\alpha}$
$\sigma^{\#1}_{1^+}\dagger^{\alpha\beta}$	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
$\sigma^{\#2}_{1^+}\dagger^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$\frac{-2k^2 r_1+t_1}{(1+k^2)^2 t_1^2}$	$-\frac{i(2k^3 r_1-k t_1)}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\tau^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{i\sqrt{2}k}{t_1+k^2 t_1}$	$\frac{i(2k^3 r_1-k t_1)}{(1+k^2)^2 t_1^2}$	$\frac{-2k^4 r_1+k^2 t_1}{(1+k^2)^2 t_1^2}$	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	$\frac{12 i k}{(3+4k^2)^2 t_1}$
$\sigma^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{6\sqrt{2}}{(3+4k^2)^2 t_1}$	$\frac{12}{(3+4k^2)^2 t_1}$	0	$\frac{12 i\sqrt{2}k}{(3+4k^2)^2 t_1}$
$\tau^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	0	0	0	0
$\tau^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$-\frac{12 i k}{(3+4k^2)^2 t_1}$	$-\frac{12 i\sqrt{2}k}{(3+4k^2)^2 t_1}$	0	$\frac{24 k^2}{(3+4k^2)^2 t_1}$

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

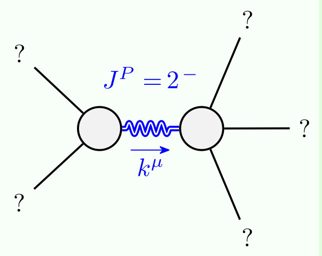
	$\mathcal{A}^{\#1}_{0^+}$	$f^{\#1}_{0^+}$	$f^{\#2}_{0^+}$	$\mathcal{A}^{\#1}_{0^-}$
$\mathcal{A}^{\#1}_{0^+}\dagger$	0	0	0	0
$f^{\#1}_{0^+}\dagger$	0	0	0	0
$f^{\#2}_{0^+}\dagger$	0	0	0	0
$\mathcal{A}^{\#1}_{0^-}\dagger$	0	0	0	$-t_1$

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

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

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

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

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