Particle spectrograph

Wave operator and propagator

Source constraints		
SO(3) irreps	Fundamental fields	Multiplicities
$\sigma_{0^+}^{\#1} == 0$	$\partial_\beta \sigma^{\alpha\beta}{}_\alpha == 0$	1
$\tau_{0^+}^{\#1} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau^\alpha{}_\alpha$	1
$\tau_{0^+}^{\#2} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$	1
$\tau_{1^-}^{\#2\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta}$	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
$\sigma_{1^-}^{\#2\alpha} == 0$	$\partial_\chi \partial_\beta \sigma^{\alpha\beta\chi} == 0$	3
$\tau_{1^+}^{\#1\alpha\beta} + i\,k\,\sigma_{1^+}^{\#2\alpha\beta} == 0$	$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\beta \tau^{\chi\alpha} + \partial_\chi \partial^\chi \tau^{\alpha\beta} +$ $2\,\partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2\,\partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi} ==$ $\partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha\chi} +$ $\partial_\chi \partial^\chi \tau^{\beta\alpha} + 2\,\partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}$	3
$\sigma_{2^-}^{\#1\alpha\beta\chi} == 0$	$3\,\partial_\epsilon \partial_\delta \partial^\chi \partial^\alpha \sigma^{\beta\delta\epsilon} + 3\,\partial_\epsilon \partial^\epsilon \partial^\chi \partial^\alpha \sigma^{\beta\delta}{}_\delta +$ $2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\beta \sigma^{\alpha\chi\delta} + 4\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\beta \sigma^{\alpha\delta\chi} +$ $2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\beta \sigma^{\chi\delta\alpha} + 4\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \sigma^{\alpha\beta\delta} +$ $2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \sigma^{\alpha\delta\beta} + 2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \sigma^{\beta\chi\alpha} +$ $3\,\eta^{\beta\chi}\,\partial_\phi \partial^\phi \partial_\epsilon \partial^\alpha \sigma^{\delta\epsilon}{}_\delta +$ $3\,\eta^{\alpha\chi}\,\partial_\phi \partial^\phi \partial_\epsilon \partial_\delta \sigma^{\beta\delta\epsilon} +$ $3\,\eta^{\beta\chi}\,\partial_\phi \partial^\phi \partial_\epsilon \partial^\epsilon \sigma^{\alpha\delta}{}_\delta ==$ $3\,\partial_\epsilon \partial_\delta \partial^\chi \partial^\beta \sigma^{\alpha\delta\epsilon} + 3\,\partial_\epsilon \partial^\epsilon \partial^\chi \partial^\beta \sigma^{\alpha\delta}{}_\delta +$ $2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\beta\chi\delta} + 4\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\beta\delta\chi} +$ $2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\alpha \sigma^{\chi\delta\beta} + 2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\chi \sigma^{\beta\delta\alpha} +$ $4\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \sigma^{\alpha\beta\chi} + 2\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \sigma^{\alpha\chi\beta} +$ $3\,\eta^{\alpha\chi}\,\partial_\phi \partial^\phi \partial_\epsilon \partial^\beta \sigma^{\delta\epsilon}{}_\delta +$ $3\,\eta^{\beta\chi}\,\partial_\phi \partial^\phi \partial_\epsilon \partial_\delta \sigma^{\alpha\delta\epsilon} +$ $3\,\eta^{\alpha\chi}\,\partial_\phi \partial^\phi \partial_\epsilon \partial^\epsilon \sigma^{\beta\delta}{}_\delta$	5
$\tau_{2^+}^{\#1\alpha\beta} == 0$	$4\,\partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2\,\partial_\delta \partial^\delta \partial^\beta \partial^\alpha \tau^\chi{}_\chi +$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\beta\alpha} +$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} ==$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi} + 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} +$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi} + 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha} +$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \tau^\chi{}_\chi$	5
Total constraints/gauge generators:		25

Quadratic (free) action

$$\begin{aligned}\mathcal{S} == &\iiiint \Big(\tfrac{1}{6}\big(6\, f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\mathcal{A}^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} - 3\,r_3\,\partial_\beta \mathcal{A}_\iota{}^\theta{}_\theta\,\partial^\iota \mathcal{A}^{\alpha\beta}{}_\alpha - 3\,r_3\,\partial_\iota \mathcal{A}_\beta{}^\theta{}_\theta\,\partial^\iota \mathcal{A}^{\alpha\beta}{}_\alpha -\\ &3\,r_3\,\partial_\alpha \mathcal{A}^{\alpha\beta\iota}\,\partial_\theta \mathcal{A}_\beta{}^\theta{}_\iota + 6\,r_3\,\partial^\iota \mathcal{A}^{\alpha\beta}{}_\alpha\,\partial_\theta \mathcal{A}_\beta{}^\theta{}_\iota -\\ &3\,r_3\,\partial_\alpha \mathcal{A}^{\alpha\beta\iota}\,\partial_\theta \mathcal{A}_\iota{}^\theta{}_\beta + 6\,r_3\,\partial^\iota \mathcal{A}^{\alpha\beta}{}_\alpha\,\partial_\theta \mathcal{A}_\iota{}^\theta{}_\beta +\\ &4\,t_2\,\mathcal{A}_{\iota\theta\alpha}\,\partial^\theta f^{\alpha\iota} + 2\,t_2\,\partial_\alpha f_{\iota\theta}\,\partial^\theta f^{\alpha\iota} - t_2\,\partial_\alpha f_{\theta\iota}\,\partial^\theta f^{\alpha\iota} -\\ &t_2\,\partial_\iota f_{\alpha\theta}\,\partial^\theta f^{\alpha\iota} + t_2\,\partial_\theta f_{\alpha\iota}\,\partial^\theta f^{\alpha\iota} - t_2\,\partial_\theta f_{\iota\alpha}\,\partial^\theta f^{\alpha\iota} -\\ &4\,t_2\,\mathcal{A}_{\alpha\theta\iota}\,(\mathcal{A}^{\alpha\iota\theta} + \partial^\theta f^{\alpha\iota}) + 2\,t_2\,\mathcal{A}_{\alpha\iota\theta}\,(\mathcal{A}^{\alpha\iota\theta} + 2\,\partial^\theta f^{\alpha\iota}) -\\ &24\,r_3\,\partial_\beta \mathcal{A}_{\iota\theta\alpha}\,\partial^\theta \mathcal{A}^{\alpha\beta\iota} + 6\,r_5\,\partial_\iota \mathcal{A}_\theta{}^\kappa{}_\kappa\,\partial^\theta \mathcal{A}^{\alpha\iota}{}_\alpha -\\ &6\,r_5\,\partial_\theta \mathcal{A}_\iota{}^\kappa{}_\kappa\,\partial^\theta \mathcal{A}^{\alpha\iota}{}_\alpha - 6\,r_5\,\partial_\alpha \mathcal{A}^{\alpha\iota\theta}\,\partial_\kappa \mathcal{A}_\iota{}^\kappa{}_\theta +\\ &12\,r_5\,\partial^\theta \mathcal{A}^{\alpha\iota}{}_\alpha\,\partial_\kappa \mathcal{A}_\iota{}^\kappa{}_\theta + 6\,r_5\,\partial_\alpha \mathcal{A}^{\alpha\iota\theta}\,\partial_\kappa \mathcal{A}_\theta{}^\kappa{}_\iota -\\ &12\,r_5\,\partial^\theta \mathcal{A}^{\alpha\iota}{}_\alpha\,\partial_\kappa \mathcal{A}_\theta{}^\kappa{}_\iota\big)\Big)[t,x,y,z]\,dz\,dy\,dx\,dt\end{aligned}$$

	$\sigma_{1^+\alpha\beta}^{\#1}$	$\sigma_{1^+\alpha\beta}^{\#2}$	$\tau_{1^+\alpha\beta}^{\#1}$	$\sigma_{1^-\alpha}^{\#1}$	$\sigma_{1^-\alpha}^{\#2}$	$\tau_{1^-\alpha}^{\#1}$	$\tau_{1^-\alpha}^{\#2}$
$\sigma_{1^+}^{\#1}\dagger^{\alpha\beta}$	$\frac{1}{k^2(2r_3+r_5)}$	$-\frac{\sqrt{2}}{k^2(1+k^2)(2r_3+r_5)}$	$-\frac{i\sqrt{2}}{k(1+k^2)(2r_3+r_5)}$	0	0	0	0
$\sigma_{1^+}^{\#2}\dagger^{\alpha\beta}$	$-\frac{\sqrt{2}}{k^2(1+k^2)(2r_3+r_5)}$	$\frac{3k^2(2r_3+r_5)+2t_2}{(k+k^3)^2(2r_3+r_5)t_2}$	$\frac{i(3k^2(2r_3+r_5)+2t_2)}{k(1+k^2)^2(2r_3+r_5)t_2}$	0	0	0	0
$\tau_{1^+}^{\#1}\dagger^{\alpha\beta}$	$\frac{i\sqrt{2}}{k(1+k^2)(2r_3+r_5)}$	$-\frac{i(3k^2(2r_3+r_5)+2t_2)}{k(1+k^2)^2(2r_3+r_5)t_2}$	$\frac{3k^2(2r_3+r_5)+2t_2}{(1+k^2)^2(2r_3+r_5)t_2}$	0	0	0	0
$\sigma_{1^-}^{\#1}\dagger^{\alpha}$	0	0	0	$\frac{2}{k^2(r_3+2r_5)}$	0	0	0
$\sigma_{1^-}^{\#2}\dagger^{\alpha}$	0	0	0	0	0	0	0
$\tau_{1^-}^{\#1}\dagger^{\alpha}$	0	0	0	0	0	0	0
$\tau_{1^-}^{\#2}\dagger^{\alpha}$	0	0	0	0	0	0	0

	$\mathcal{A}_{1^+\alpha\beta}^{\#1}$	$\mathcal{A}_{1^+\alpha\beta}^{\#2}$	$f_{1^+\alpha\beta}^{\#1}$	$\mathcal{A}_{1^-\alpha}^{\#1}$	$\mathcal{A}_{1^-\alpha}^{\#2}$	$f_{1^-\alpha}^{\#1}$	$f_{1^-\alpha}^{\#2}$
$\mathcal{A}_{1^+}^{\#1}\dagger^{\alpha\beta}$	$k^2(2r_3+r_5)+\frac{2t_2}{3}$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{1}{3}i\sqrt{2}\,k t_2$	0	0	0	0
$\mathcal{A}_{1^+}^{\#2}\dagger^{\alpha\beta}$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{t_2}{3}$	$\frac{i k t_2}{3}$	0	0	0	0
$f_{1^+}^{\#1}\dagger^{\alpha\beta}$	$-\frac{1}{3}i\sqrt{2}\,k t_2$	$-\frac{1}{3}i k t_2$	$\frac{k^2 t_2}{3}$	0	0	0	0
$\mathcal{A}_{1^-}^{\#1}\dagger^{\alpha}$	0	0	0	$\frac{1}{2}k^2(r_3+2r_5)$	0	0	0
$\mathcal{A}_{1^-}^{\#2}\dagger^{\alpha}$	0	0	0	0	0	0	0
$f_{1^-}^{\#1}\dagger^{\alpha}$	0	0	0	0	0	0	0
$f_{1^-}^{\#2}\dagger^{\alpha}$	0	0	0	0	0	0	0

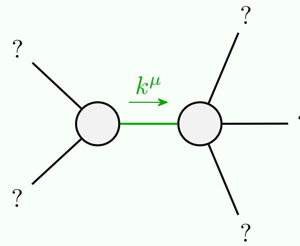
	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1}\dagger$	0	0	0	0
$\tau_{0^+}^{\#1}\dagger$	0	0	0	0
$\tau_{0^+}^{\#2}\dagger$	0	0	0	0
$\sigma_{0^-}^{\#1}\dagger$	0	0	0	$\frac{1}{t_2}$

	$\mathcal{A}_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\mathcal{A}_{0^-}^{\#1}$
$\mathcal{A}_{0^+}^{\#1}\dagger$	0	0	0	0
$f_{0^+}^{\#1}\dagger$	0	0	0	0
$f_{0^+}^{\#2}\dagger$	0	0	0	0
$\mathcal{A}_{0^-}^{\#1}\dagger$	0	0	0	t_2

	$\mathcal{A}_{2^+\alpha\beta}^{\#1}$	$f_{2^+\alpha\beta}^{\#1}$	$\mathcal{A}_{2^-\alpha\beta\chi}^{\#1}$
$\mathcal{A}_{2^+}^{\#1}\dagger^{\alpha\beta}$	$-\frac{3k^2 r_3}{2}$	0	0
$f_{2^+}^{\#1}\dagger^{\alpha\beta}$	0	0	0
$\mathcal{A}_{2^-}^{\#1}\dagger^{\alpha\beta\chi}$	0	0	0

	$\sigma_{2^+\alpha\beta}^{\#1}$	$\tau_{2^+\alpha\beta}^{\#1}$	$\sigma_{2^-\alpha\beta\chi}^{\#1}$
$\sigma_{2^+}^{\#1}\dagger^{\alpha\beta}$	$-\frac{2}{3k^2 r_3}$	0	0
$\tau_{2^+}^{\#1}\dagger^{\alpha\beta}$	0	0	0
$\sigma_{2^-}^{\#1}\dagger^{\alpha\beta\chi}$	0	0	0

Massive and massless spectra



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

(No massive particles)

Unitarity conditions

$r_3 < 0\;\&\&\;(r_5 < -\frac{r_3}{2}\;\|\;r_5 > -2r_3)\;\|\;r_3 > 0\;\&\&\;-2r_3 < r_5 < -\frac{r_3}{2}$