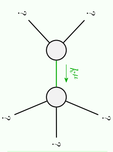
Particle spectrograph

Wave operator and propagator

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

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

Source constraints

SO(3) irreps	Fundamental fields	Multiplicities
$\tau_0^{\#2} == 0$	$\partial_\beta\partial_\alpha\tau^{\alpha\beta} == 0$	1
$\tau_{0^+}^{\#1} - 2\,i\,k\,\sigma_{0^+}^{\#1} == 0$	$\partial_\beta\partial_\alpha\tau^{\alpha\beta} == \partial_\beta\partial^\beta\tau^\alpha{}_\alpha + 2\,\partial_\chi\partial^\chi\partial_\beta\sigma^{\alpha\beta}{}_\alpha$	1
$\tau_{1^-}^{\#2\,\alpha} + 2\,i\,k\;\sigma_{1^-}^{\#2\,\alpha} == 0$	$\partial_\chi\partial_\beta\partial^\alpha\tau^{\beta\chi} == \partial_\chi\partial^\chi\partial_\beta\tau^{\alpha\beta} + 2\,\partial_\delta\partial^\delta\partial_\chi\partial_\beta\sigma^{\alpha\beta\chi}$	3
$\tau_{1^-}^{\#1\,\alpha} == 0$	$\partial_\chi\partial_\beta\partial^\alpha\tau^{\beta\chi} == \partial_\chi\partial^\chi\partial_\beta\tau^{\beta\alpha}$	3
$\tau_{1^+}^{\#1\,\alpha\beta} == 0$	$\partial_\chi\partial^\alpha\tau^{\beta\chi} + \partial_\chi\partial^\beta\tau^{\chi\alpha} + \partial_\chi\partial^\chi\tau^{\alpha\beta} == \partial_\chi\partial^\alpha\tau^{\chi\beta} + \partial_\chi\partial^\beta\tau^{\alpha\chi} + \partial_\chi\partial^\chi\tau^{\beta\alpha}$	3
$\sigma_{1^+}^{\#2\,\alpha\beta} == 0$	$\partial_\delta\partial_\chi\partial^\alpha\sigma^{\beta\chi\delta} + \partial_\delta\partial^\delta\partial_\chi\sigma^{\alpha\beta\chi} == \partial_\delta\partial_\chi\partial^\beta\sigma^{\alpha\chi\delta}$	3
$\sigma_{2^-}^{\#1\,\alpha\beta\chi} == 0$	$3\,\partial_\epsilon\partial_\delta\partial^\chi\partial^\alpha\sigma^{\beta\delta\epsilon} + 3\,\partial_\epsilon\partial^\epsilon\partial^\chi\partial^\alpha\sigma^{\beta\delta}{}_\delta + 2\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\beta\sigma^{\alpha\chi\delta} + 4\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\beta\sigma^{\alpha\delta\chi} + 2\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\chi\sigma^{\alpha\beta\delta} + 4\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\chi\sigma^{\alpha\delta\beta} + 2\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\delta\sigma^{\beta\chi\alpha} + 3\,\eta^{\beta\chi}\,\partial_\phi\partial^\phi\partial_\epsilon\partial^\alpha\sigma^{\delta\epsilon}{}_\delta + 3\,\eta^{\alpha\chi}\,\partial_\phi\partial^\phi\partial_\epsilon\partial_\delta\sigma^{\beta\delta\epsilon} + 3\,\eta^{\beta\chi}\,\partial_\phi\partial^\phi\partial_\epsilon\partial^\epsilon\sigma^{\alpha\delta}{}_\delta == 3\,\partial_\epsilon\partial_\delta\partial^\chi\partial^\beta\sigma^{\alpha\delta\epsilon} + 3\,\partial_\epsilon\partial^\epsilon\partial^\chi\partial^\beta\sigma^{\alpha\delta}{}_\delta + 2\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\alpha\sigma^{\beta\chi\delta} + 4\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\alpha\sigma^{\beta\delta\chi} + 2\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\chi\sigma^{\beta\delta\alpha} + 2\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\delta\sigma^{\alpha\chi\beta} + 4\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\delta\sigma^{\alpha\beta\chi} + 3\,\eta^{\alpha\chi}\,\partial_\phi\partial^\phi\partial_\epsilon\partial^\beta\sigma^{\delta\epsilon}{}_\delta + 3\,\eta^{\beta\chi}\,\partial_\phi\partial^\phi\partial_\epsilon\partial_\delta\sigma^{\alpha\delta\epsilon} + 3\,\eta^{\alpha\chi}\,\partial_\phi\partial^\phi\partial_\epsilon\partial^\epsilon\sigma^{\beta\delta}{}_\delta$	5
$\tau_{2^+}^{\#1\,\alpha\beta} == 0$	$4\,\partial_\delta\partial_\chi\partial^\beta\partial^\alpha\tau^{\chi\delta} + 2\,\partial_\delta\partial^\delta\partial^\beta\partial^\alpha\tau^\chi{}_\chi + 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\chi\tau^{\alpha\beta} + 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\chi\tau^{\beta\alpha} + 2\,\eta^{\alpha\beta}\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi\tau^{\chi\delta} == 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\alpha\tau^{\beta\chi} + 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\beta\tau^{\alpha\chi} + 2\,\eta^{\alpha\beta}\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\delta\tau^\chi{}_\chi$	5
Total constraints/gauge generators:		24

Quadratic (free) action

$$\begin{aligned}\mathcal{S} == \iiint\Big(\tfrac{1}{6}\,(&-4\,t_3\;\omega^{\alpha\prime}{}_\alpha\;\omega_\prime{}^\kappa{}_\kappa + 6\,f^{\alpha\beta}\;\tau_{\alpha\beta} + 6\;\omega^{\alpha\beta\chi}\;\sigma_{\alpha\beta\chi} + 8\,t_3\;\omega_\alpha{}^\kappa{}_\kappa\,\partial_\prime f^{\alpha\prime} - \\ &8\,t_3\;\omega_\prime{}^\kappa{}_\kappa\,\partial^\prime f^\alpha{}_\alpha + 4\,t_3\,\partial_\prime f^\kappa{}_\kappa\,\partial^\prime f^\alpha{}_\alpha - 3\,r_3\,\partial_\beta\omega_\prime{}^\theta{}_\theta\,\partial^\prime\omega^{\alpha\beta}{}_\alpha - \\ &3\,r_3\,\partial_\prime\omega_\beta{}^\theta{}_\theta\,\partial^\prime\omega^{\alpha\beta}{}_\alpha - 3\,r_3\,\partial_\alpha\omega^{\alpha\beta\prime}\,\partial_\theta\omega_\beta{}^\theta{}_\prime + \\ &6\,r_3\,\partial^\prime\omega^{\alpha\beta}{}_\alpha\,\partial_\theta\omega_\beta{}^\theta{}_\prime - 3\,r_3\,\partial_\alpha\omega^{\alpha\beta\prime}\,\partial_\theta\omega_\prime{}^\theta{}_\beta + \\ &6\,r_3\,\partial^\prime\omega^{\alpha\beta}{}_\alpha\,\partial_\theta\omega_\prime{}^\theta{}_\beta + 8\,r_2\,\partial_\beta\omega_{\alpha\prime\theta}\,\partial^\theta\omega^{\alpha\beta\prime} - \\ &4\,r_2\,\partial_\beta\omega_{\alpha\theta\prime}\,\partial^\theta\omega^{\alpha\beta\prime} + 4\,r_2\,\partial_\beta\omega_{\prime\theta\alpha}\,\partial^\theta\omega^{\alpha\beta\prime} - \\ &24\,r_3\,\partial_\beta\omega_{\prime\theta\alpha}\,\partial^\theta\omega^{\alpha\beta\prime} - 2\,r_2\,\partial_\prime\omega_{\alpha\beta\theta}\,\partial^\theta\omega^{\alpha\beta\prime} + \\ &2\,r_2\,\partial_\theta\omega_{\alpha\beta\prime}\,\partial^\theta\omega^{\alpha\beta\prime} - 4\,r_2\,\partial_\theta\omega_{\alpha\prime\beta}\,\partial^\theta\omega^{\alpha\beta\prime} + \\ &6\,r_5\,\partial_\prime\omega_\theta{}^\kappa{}_\kappa\,\partial^\theta\omega^{\alpha\prime}{}_\alpha - 6\,r_5\,\partial_\theta\omega_\prime{}^\kappa{}_\kappa\,\partial^\theta\omega^{\alpha\prime}{}_\alpha + \\ &4\,t_3\,\partial_\prime f^{\alpha\prime}\,\partial_\kappa f_\alpha{}^\kappa - 8\,t_3\,\partial^\prime f^\alpha{}_\alpha\,\partial_\kappa f_\prime{}^\kappa - 6\,r_5\,\partial_\alpha\omega^{\alpha\prime\theta}\,\partial_\kappa\omega_\prime{}^\kappa{}_\theta + \\ &12\,r_5\,\partial^\theta\omega^{\alpha\prime}{}_\alpha\,\partial_\kappa\omega_\prime{}^\kappa{}_\theta + 6\,r_5\,\partial_\alpha\omega^{\alpha\prime\theta}\,\partial_\kappa\omega_\theta{}^\kappa{}_\prime - \\ &12\,r_5\,\partial^\theta\omega^{\alpha\prime}{}_\alpha\,\partial_\kappa\omega_\theta{}^\kappa{}_\prime\Big))[t,\,x,\,y,\,z]\,dt\,dz\,dy\,dx\,dt\end{aligned}$$

	$\sigma_{1^+}^{\#1\,\alpha\beta}$	$\sigma_{1^+}^{\#2\,\alpha\beta}$	$\tau_{1^+}^{\#1\,\alpha\beta}$	$\sigma_{1^-}^{\#1\,\alpha}$	$\sigma_{1^-}^{\#2\,\alpha}$	$\tau_{1^-}^{\#1\,\alpha}$	$\tau_{1^-}^{\#2\,\alpha}$
$\sigma_{1^+}^{\#1\,\dagger\,\alpha\beta}$	$\frac{1}{k^2\,(2r_3+r_5)}$	0	0	0	0	0	0
$\sigma_{1^+}^{\#2\,\dagger\,\alpha\beta}$	0	0	0	0	0	0	0
$\tau_{1^+}^{\#1\,\dagger\,\alpha\beta}$	0	0	0	0	0	0	0
$\sigma_{1^-}^{\#1\,\dagger\,\alpha}$	0	0	0	$\frac{2}{k^2\,(r_3+2r_5)}$	$\frac{2\sqrt{2}}{k^2\,(1+2k^2)\,(r_3+2r_5)}$	0	$\frac{4i}{k\,(1+2k^2)\,(r_3+2r_5)}$
$\sigma_{1^-}^{\#2\,\dagger\,\alpha}$	0	0	0	$\frac{2\sqrt{2}}{k^2\,(1+2k^2)\,(r_3+2r_5)}$	$\frac{3k^2\,(r_3+2r_5)+4t_3}{(k+2k^3)^2\,(r_3+2r_5)\,t_3}$	0	$\frac{i\sqrt{2}\,(3k^2\,(r_3+2r_5)+4t_3)}{k\,(1+2k^2)^2\,(r_3+2r_5)\,t_3}$
$\tau_{1^-}^{\#1\,\dagger\,\alpha}$	0	0	0	0	0	0	0
$\tau_{1^-}^{\#2\,\dagger\,\alpha}$	0	0	0	$-\frac{4i}{k\,(1+2k^2)\,(r_3+2r_5)}$	$-\frac{i\sqrt{2}\,(3k^2\,(r_3+2r_5)+4t_3)}{k\,(1+2k^2)^2\,(r_3+2r_5)\,t_3}$	0	$\frac{6k^2\,(r_3+2r_5)+8t_3}{(1+2k^2)^2\,(r_3+2r_5)\,t_3}$

	$\omega_{1^+}^{\#1\,\alpha\beta}$	$\omega_{1^+}^{\#2\,\alpha\beta}$	$f_{1^+}^{\#1\,\alpha\beta}$	$\omega_{1^-}^{\#1\,\alpha}$	$\omega_{1^-}^{\#2\,\alpha}$	$f_{1^-}^{\#1\,\alpha}$	$f_{1^-}^{\#2\,\alpha}$
$\omega_{1^+}^{\#1\,\dagger\,\alpha\beta}$	$k^2\,(2\,r_3+r_5)$	0	0	0	0	0	0
$\omega_{1^+}^{\#2\,\dagger\,\alpha\beta}$	0	0	0	0	0	0	0
$f_{1^+}^{\#1\,\dagger\,\alpha\beta}$	0	0	0	0	0	0	0
$\omega_{1^-}^{\#1\,\dagger\,\alpha}$	0	0	0	$k^2\,(\frac{r_3}{2}+r_5) + \frac{2t_3}{3}$	$-\frac{\sqrt{2}\,t_3}{3}$	0	$-\frac{2}{3}\,i\,k\,t_3$
$\omega_{1^-}^{\#2\,\dagger\,\alpha}$	0	0	0	$-\frac{\sqrt{2}\,t_3}{3}$	$\frac{t_3}{3}$	0	$\frac{1}{3}\,i\,\sqrt{2}\;k\,t_3$
$f_{1^-}^{\#1\,\dagger\,\alpha}$	0	0	0	0	0	0	0
$f_{1^-}^{\#2\,\dagger\,\alpha}$	0	0	0	$\frac{2\,i\,k\,t_3}{3}$	$-\frac{1}{3}\,i\,\sqrt{2}\;k\,t_3$	0	$\frac{2\,k^2\,t_3}{3}$

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\tau_{0^+}^{\#1}$	$\sigma_{0^+}^{\#1}$
$\sigma_{0^+}^{\#1\,\dagger}$	0	0	$\frac{1}{(1+2k^2)^2\,r_3}$	$\frac{1}{(1+2k^2)^2\,r_3}$
$\tau_{0^+}^{\#2\,\dagger}$	0	0	$\frac{i\sqrt{2}\,k}{(1+2k^2)^2\,r_3}$	$-\frac{i\sqrt{2}\,k}{(1+2k^2)^2\,r_3}$
$\tau_{0^+}^{\#1\,\dagger}$	0	0	$\frac{2k^2}{(1+2k^2)^2\,t_3}$	$-\frac{i\sqrt{2}\,k}{(1+2k^2)^2\,r_3}$
$\sigma_{0^+}^{\#1\,\dagger}$	0	0	0	0

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

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1\,\dagger}$	t_3	$-i\,\sqrt{2}\;k\,t_3$	0	0
$f_{0^+}^{\#1\,\dagger}$	$i\,\sqrt{2}\;k\,t_3$	$2\,k^2\,t_3$	0	0
$f_{0^+}^{\#2\,\dagger}$	0	0	0	0
$\omega_{0^-}^{\#1\,\dagger}$	0	0	0	$k^2\,r_2$

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