Particle spectrograph

Wave operator and propagator

	$\sigma_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^+}^{\#2}{}_{\alpha\beta}$	$\tau_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^-}^{\#1}{}_{\alpha}$	$\sigma_{1^-}^{\#2}{}_{\alpha}$	$\tau_{1^-}^{\#1}{}_{\alpha}$	$\tau_{1^-}^{\#2}{}_{\alpha}$
$\sigma_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{2(t_1+t_2)}{3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2)}$	$\frac{\sqrt{2}(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	$\frac{i\sqrt{2}k(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	0	0	0	0
$\sigma_{1^+}^{\#2}{}^{\dagger\alpha\beta}$	$\frac{\sqrt{2}(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	$\frac{6k^2(2r_1+r_5)+t_1+4t_2}{(1+k^2)^2(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	$\frac{ik(6k^2(2r_1+r_5)+t_1+4t_2)}{(1+k^2)^2(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	0	0	0	0
$\tau_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$-\frac{i\sqrt{2}k(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	$-\frac{ik(6k^2(2r_1+r_5)+t_1+4t_2)}{(1+k^2)^2(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	$\frac{k^2(6k^2(2r_1+r_5)+t_1+4t_2)}{(1+k^2)^2(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	0	0	0	0
$\sigma_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	0	$\frac{2ik}{t_1+2k^2t_1}$
$\sigma_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{-2k^2(r_1+r_5)+t_1}{(t_1+2k^2t_1)^2}$	0	$-\frac{i\sqrt{2}k(2k^2(r_1+r_5)-t_1)}{(t_1+2k^2t_1)^2}$
$\tau_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	0	0	0	0
$\tau_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$-\frac{2ik}{t_1+2k^2t_1}$	$\frac{i\sqrt{2}k(2k^2(r_1+r_5)-t_1)}{(t_1+2k^2t_1)^2}$	0	$\frac{-4k^4(r_1+r_5)+2k^2t_1}{(t_1+2k^2t_1)^2}$

	$\mathcal{A}_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$f_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$\mathcal{A}_{2^-}^{\#1}{}^{\dagger\alpha\beta\chi}$
$\mathcal{A}_{2^+}^{\#1}{}_{\alpha\beta}$	$\frac{t_1}{2}$	$\frac{ikt_1}{\sqrt{2}}$	0
$f_{2^+}^{\#1}{}_{\alpha\beta}$	$-\frac{ikt_1}{\sqrt{2}}$	k^2t_1	0
$\mathcal{A}_{2^-}^{\#1}{}_{\alpha\beta\chi}$	0	0	$k^2r_1+\frac{t_1}{2}$

Source constraints

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

	$\mathcal{A}_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\mathcal{A}_{1^+}^{\#2}{}^{\dagger\alpha\beta}$	$f_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\mathcal{A}_{1^-}^{\#1}{}^{\dagger\alpha}$	$\mathcal{A}_{1^-}^{\#2}{}^{\dagger\alpha}$	$f_{1^-}^{\#1}{}^{\dagger\alpha}$	$f_{1^-}^{\#2}{}^{\dagger\alpha}$
$\mathcal{A}_{1^+}^{\#1}{}_{\alpha\beta}$	$\frac{1}{6}(6k^2(2r_1+r_5)+t_1+4t_2)$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	0	0	0	0
$\mathcal{A}_{1^+}^{\#2}{}_{\alpha\beta}$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{t_1+t_2}{3}$	$-\frac{1}{3}ik(t_1+t_2)$	0	0	0	0
$f_{1^+}^{\#1}{}_{\alpha\beta}$	$\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	$\frac{1}{3}ik(t_1+t_2)$	$\frac{1}{3}k^2(t_1+t_2)$	0	0	0	0
$\mathcal{A}_{1^-}^{\#1}{}_{\alpha}$	0	0	0	$k^2(r_1+r_5)-\frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0	$-ikt_1$
$\mathcal{A}_{1^-}^{\#2}{}_{\alpha}$	0	0	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
$f_{1^-}^{\#1}{}_{\alpha}$	0	0	0	0	0	0	0
$f_{1^-}^{\#2}{}_{\alpha}$	0	0	0	ikt_1	0	0	0

	$\mathcal{A}_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\mathcal{A}_{0^-}^{\#1}$
$\mathcal{A}_{0^+}^{\#1}{}^\dagger$	$-t_1$	$i\sqrt{2}kt_1$	0	0
$f_{0^+}^{\#1}{}^\dagger$	$-i\sqrt{2}kt_1$	$-2k^2t_1$	0	0
$f_{0^+}^{\#2}{}^\dagger$	0	0	0	0
$\mathcal{A}_{0^-}^{\#1}{}^\dagger$	0	0	0	t_2

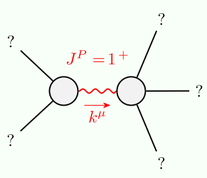
	$\sigma_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$\tau_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$\sigma_{2^-}^{\#1}{}^{\dagger\alpha\beta\chi}$
$\sigma_{2^+}^{\#1}{}_{\alpha\beta}$	$\frac{2}{(1+2k^2)^2t_1}$	$\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	0
$\tau_{2^+}^{\#1}{}_{\alpha\beta}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$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

	$\sigma_{0^+}^{\#1}{}^\dagger$	$\tau_{0^+}^{\#2}{}^\dagger$	$\tau_{0^+}^{\#1}{}^\dagger$	$\sigma_{0^-}^{\#1}{}^\dagger$
$\sigma_{0^+}^{\#1}$	$-\frac{1}{(1+2k^2)^2t_1}$	$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_1}$	0	0
$\tau_{0^+}^{\#2}$	$\frac{i\sqrt{2}k}{(1+2k^2)^2t_1}$	$-\frac{2k^2}{(1+2k^2)^2t_1}$	0	0
$\tau_{0^+}^{\#1}$	0	0	0	0
$\sigma_{0^-}^{\#1}$	0	0	0	$\frac{1}{t_2}$

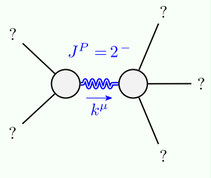
Quadratic (free) action

$$
\begin{aligned}
S == \iiiint \Big(&\tfrac{1}{6}(6t_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} - 12t_1\,\mathcal{A}_\alpha{}^\theta{}_\theta\,\partial_\prime f^{\alpha\prime} + 12\\
&t_1\,\mathcal{A}_\prime{}^\theta{}_\theta\,\partial^\prime f^\alpha{}_\alpha - 6t_1\,\partial_\prime f^\theta{}_\theta\partial^\prime f^\alpha{}_\alpha - 6t_1\,\partial_\prime f^{\alpha\prime}\partial_\theta f_\alpha{}^\theta +\\
&12t_1\,\partial^\prime f^\alpha{}_\alpha\partial_\theta f_\prime{}^\theta + 4t_1\,\mathcal{A}_{\prime\theta\alpha}\,\partial^\theta f^{\alpha\prime} + 4t_2\,\mathcal{A}_{\prime\theta\alpha}\,\partial^\theta f^{\alpha\prime} -\\
&4t_1\,\partial_\alpha f_{\prime\theta}\partial^\theta f^{\alpha\prime} + 2t_2\,\partial_\alpha f_{\prime\theta}\partial^\theta f^{\alpha\prime} - 4t_1\,\partial_\alpha f_{\theta\prime}\partial^\theta f^{\alpha\prime} -\\
&t_2\,\partial_\alpha f_{\theta\prime}\partial^\theta f^{\alpha\prime} + 2t_1\,\partial_\prime f_{\alpha\theta}\partial^\theta f^{\alpha\prime} - t_2\,\partial_\prime f_{\alpha\theta}\partial^\theta f^{\alpha\prime} +\\
&4t_1\,\partial_\theta f_{\alpha\prime}\partial^\theta f^{\alpha\prime} + t_2\,\partial_\theta f_{\alpha\prime}\partial^\theta f^{\alpha\prime} + 2t_1\,\partial_\theta f_{\prime\alpha}\partial^\theta f^{\alpha\prime} -\\
&t_2\,\partial_\theta f_{\prime\alpha}\partial^\theta f^{\alpha\prime} + 2(t_1+t_2)\,\mathcal{A}_{\alpha\prime\theta}\,(\mathcal{A}^{\alpha\prime\theta} + 2\,\partial^\theta f^{\alpha\prime}) +\\
&2\,\mathcal{A}_{\alpha\theta\prime}\,((t_1-2t_2)\,\mathcal{A}^{\alpha\prime\theta} + 2(2t_1-t_2)\,\partial^\theta f^{\alpha\prime}) -\\
&8r_1\,\partial_\beta\mathcal{A}_{\alpha\prime\theta}\partial^\theta\mathcal{A}^{\alpha\beta\prime} + 4r_1\,\partial_\beta\mathcal{A}_{\alpha\theta\prime}\partial^\theta\mathcal{A}^{\alpha\beta\prime} -\\
&16r_1\,\partial_\beta\mathcal{A}_{\prime\theta\alpha}\partial^\theta\mathcal{A}^{\alpha\beta\prime} - 4r_1\,\partial_\prime\mathcal{A}_{\alpha\beta\theta}\partial^\theta\mathcal{A}^{\alpha\beta\prime} +\\
&4r_1\,\partial_\theta\mathcal{A}_{\alpha\beta\prime}\partial^\theta\mathcal{A}^{\alpha\beta\prime} + 4r_1\,\partial_\theta\mathcal{A}_{\alpha\prime\beta}\partial^\theta\mathcal{A}^{\alpha\beta\prime} + 6r_5\,\partial_\prime\mathcal{A}_\theta{}^\kappa{}_\kappa\\
&\partial^\theta\mathcal{A}^{\alpha\prime}{}_\alpha - 6r_5\,\partial_\theta\mathcal{A}_\prime{}^\kappa{}_\kappa\partial^\theta\mathcal{A}^{\alpha\prime}{}_\alpha - 6r_5\,\partial_\alpha\mathcal{A}^{\alpha\prime\theta}\partial_\kappa\mathcal{A}_\prime{}^\kappa{}_\theta +\\
&12r_5\,\partial^\theta\mathcal{A}^{\alpha\prime}{}_\alpha\partial_\kappa\mathcal{A}_\prime{}^\kappa{}_\theta + 6r_5\,\partial_\alpha\mathcal{A}^{\alpha\prime\theta}\partial_\kappa\mathcal{A}_\theta{}^\kappa{}_\prime -\\
&12r_5\,\partial^\theta\mathcal{A}^{\alpha\prime}{}_\alpha\partial_\kappa\mathcal{A}_\theta{}^\kappa{}_\prime)\Big)[t, x, y, z]\,dz\,dy\,dx\,dt
\end{aligned}
$$

Massive and massless spectra



Massive particle	
Pole residue:	$\frac{-3t_1t_2(t_1+t_2)+6r_1(t_1^2+2t_2^2)+3r_5(t_1^2+2t_2^2)}{(2r_1+r_5)(t_1+t_2)(-3t_1t_2+4r_1(t_1+t_2)+2r_5(t_1+t_2))} > 0$
Polarisations:	3
Square mass:	$-\frac{3t_1t_2}{2(2r_1+r_5)(t_1+t_2)} > 0$
Spin:	1
Parity:	Even



Massive particle	
Pole residue:	$-\frac{1}{r_1} > 0$
Polarisations:	5
Square mass:	$-\frac{t_1}{2r_1} > 0$
Spin:	2
Parity:	Odd

(No massless particles)

Unitarity conditions

$r_1 < 0$ && $r_5 > -2r_1$ && $t_1 > 0$ && $-t_1 < t_2 < 0$