Particle spectrograph

Wave operator and propagator

	$\sigma_{1^+}^{\#1}{}^{\alpha\beta}\dagger$	$\sigma_{1^+}^{\#2}{}^{\alpha\beta}\dagger$	$\tau_{1^+}^{\#1}{}^{\alpha\beta}\dagger$	$\sigma_{1^-}^{\#1}\dagger^{\alpha}$	$\sigma_{1^-}^{\#2}\dagger^{\alpha}$	$\tau_{1^-}^{\#1}\dagger^{\alpha}$	$\tau_{1^-}^{\#2}\dagger^{\alpha}$
$\tau_{1^-\ \alpha}^{\#2}$	0	0	0	$-\dfrac{i}{k r_5 + 2 k^3 r_5}$	$\dfrac{i(6 k^2 r_5 + t_1)}{\sqrt{2}\,k(1+2k^2)^2 r_5 t_1}$	0	$\dfrac{6 k^2 r_5 + t_1}{(1+2k^2)^2 r_5 t_1}$
$\tau_{1^-\ \alpha}^{\#1}$	0	0	0	0	0	0	0
$\sigma_{1^-\ \alpha}^{\#2}$	0	0	0	$-\dfrac{1}{\sqrt{2}(k^2 r_5 + 2k^4 r_5)}$	$\dfrac{6 k^2 r_5 + t_1}{2(k+2k^3)^2 r_5 t_1}$	0	$-\dfrac{i(6 k^2 r_5 + t_1)}{\sqrt{2}\,k(1+2k^2)^2 r_5 t_1}$
$\sigma_{1^-\ \alpha}^{\#1}$	0	0	0	$\dfrac{1}{k^2 r_5}$	$-\dfrac{1}{\sqrt{2}(k^2 r_5 + 2k^4 r_5)}$	0	$\dfrac{i}{k r_5 + 2 k^3 r_5}$
$\tau_{1^+\ \alpha\beta}^{\#1}$	$\dfrac{i\sqrt{2}\,k}{t_1 + k^2 t_1}$	$-\dfrac{i(2k^3 r_5 - k t_1)}{(1+k^2)^2 t_1^2}$	$-\dfrac{2k^4 r_5 + t_1}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\sigma_{1^+\ \alpha\beta}^{\#2}$	$-\dfrac{\sqrt{2}}{t_1 + k^2 t_1}$	$-\dfrac{2k^2 r_5 + t_1}{(1+k^2)^2 t_1^2}$	$\dfrac{i(2k^3 r_5 - k t_1)}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\sigma_{1^+\ \alpha\beta}^{\#1}$	0	$-\dfrac{\sqrt{2}}{t_1 + k^2 t_1}$	$\dfrac{i\sqrt{2}\,k}{t_1 + k^2 t_1}$	0	0	0	0

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

	$\omega_{2^+\ \alpha\beta}^{\#1}$	$f_{2^+\ \alpha\beta}^{\#1}$	$\omega_{2^-\ \alpha\beta\chi}^{\#1}$
$\omega_{2^+}^{\#1}\dagger^{\alpha\beta}$	$\dfrac{t_1}{2}$	$-\dfrac{ikt_1}{\sqrt{2}}$	0
$f_{2^+}^{\#1}\dagger^{\alpha\beta}$	$\dfrac{ikt_1}{\sqrt{2}}$	$k^2 t_1$	0
$\omega_{2^-}^{\#1}\dagger^{\alpha\beta\chi}$	0	0	$\dfrac{t_1}{2}$

	$\sigma_{0^+}^{\#1}\dagger$	$\tau_{0^+}^{\#1}\dagger$	$\tau_{0^+}^{\#2}\dagger$	$\sigma_{0^-}^{\#1}\dagger$
$\sigma_{0^-}^{\#1}$	0	0	0	$\dfrac{1}{k^2 r_2 - t_1}$
$\tau_{0^+}^{\#2}$	0	0	0	0
$\tau_{0^+}^{\#1}$	0	0	0	0
$\sigma_{0^+}^{\#1}$	0	0	0	0

	$\omega_{1^+\alpha\beta}^{\#1}\dagger$	$\omega_{1^+\alpha\beta}^{\#2}\dagger$	$f_{1^+\alpha\beta}^{\#1}\dagger$	$\omega_{1^-}^{\#1}\dagger^{\alpha}$	$\omega_{1^-}^{\#2}\dagger^{\alpha}$	$f_{1^-}^{\#1}\dagger^{\alpha}$	$f_{1^-}^{\#2}\dagger^{\alpha}$
$f_{1^-\ \alpha}^{\#2}$	0	0	0	$\dfrac{ikt_1}{3}$	$\dfrac{1}{3}i\sqrt{2}\,kt_1$	0	$\dfrac{2k^2 t_1}{3}$
$f_{1^-\ \alpha}^{\#1}$	0	0	0	0	0	0	0
$\omega_{1^-\ \alpha}^{\#2}$	0	0	0	$\dfrac{t_1}{3\sqrt{2}}$	$\dfrac{t_1}{3}$	0	$-\dfrac{1}{3}i\sqrt{2}\,kt_1$
$\omega_{1^-\ \alpha}^{\#1}$	0	0	0	$k^2 r_5 + \dfrac{t_1}{6}$	$\dfrac{t_1}{3\sqrt{2}}$	0	$-\dfrac{1}{3}ikt_1$
$f_{1^+\ \alpha\beta}^{\#1}$	$-\dfrac{ikt_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega_{1^+\ \alpha\beta}^{\#2}$	$-\dfrac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega_{1^+\ \alpha\beta}^{\#1}$	$k^2 r_5 - \dfrac{t_1}{2}$	$-\dfrac{t_1}{\sqrt{2}}$	$\dfrac{ikt_1}{\sqrt{2}}$	0	0	0	0

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}\dagger$	0	0	0	0
$f_{0^+}^{\#1}\dagger$	0	0	0	0
$f_{0^+}^{\#2}\dagger$	0	0	0	0
$\omega_{0^-}^{\#1}\dagger$	0	0	0	$k^2 r_2 - t_1$

Quadratic (free) action

$$S_F ==$$
$$\iiint \Big(\tfrac{1}{6}\big(-2 t_1\, \omega_\iota{}^{\alpha\iota}\omega_\iota{}^\kappa{}_{\kappa\alpha} - 6 t_1\, \omega_\iota{}^{\kappa\lambda}\omega_{\kappa\lambda}{}^\iota + 6 f^{\alpha\beta}\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi}\sigma_{\alpha\beta\chi} - 6 r_5 \partial_\iota \omega^{\kappa\lambda}{}_\kappa$$
$$\partial^\iota \omega_\lambda{}^\alpha{}_\alpha + 4 r_2 \partial^\beta \omega^{\theta\alpha}{}_\theta \partial_\theta \omega_{\alpha\beta}{}^\kappa - 2 r_2 \partial_\theta \omega_{\alpha\beta}{}^\kappa \partial_\kappa \omega^{\theta\alpha\beta} -$$
$$6 r_5 \partial_\alpha \omega_\lambda{}^\alpha{}_\theta \partial_\kappa \omega^{\theta\kappa\lambda} + 6 r_5 \partial_\theta \omega_\lambda{}^\alpha{}_\kappa \partial_\kappa \omega^{\theta\kappa\lambda\theta} - 6 r_5 \partial_\alpha \omega_\lambda{}^\alpha{}_\theta \partial_\kappa \omega^{\kappa\lambda\theta} +$$
$$12 r_5 \partial_\theta \omega_\lambda{}^\alpha{}_\theta \partial_\kappa \omega^{\kappa\lambda\theta} - 3 t_1 \partial_\theta f_{\kappa\theta}{}^\theta \partial^\kappa f_\alpha{}^\theta - 3 t_1 \partial^\alpha f_\kappa{}^\lambda \partial^\kappa f_{\alpha\lambda} +$$
$$2 t_1\, \omega_{\kappa\alpha}{}^\alpha \partial^\kappa f^\iota{}_\iota + 2 t_1\, \omega_{\kappa\lambda}{}^\lambda \partial^\kappa f^\iota{}_\iota + 4 t_1 \partial^\alpha f_{\kappa\alpha} \partial^\kappa f^\iota{}_\iota - 2 t_1 \partial_\kappa f_\lambda{}^\lambda \partial^\kappa f^\iota{}_\iota +$$
$$12 t_1\, \omega_{\iota\kappa\theta} \partial^{\kappa} f^{\iota\theta} - 2 t_1\, \omega_{\iota\alpha}{}^\alpha \partial^\kappa f^\iota{}_\kappa - 2 t_1\, \omega_{\iota\alpha}{}^\alpha \partial^\kappa f^\iota{}_\kappa + 3 t_1 \partial^\alpha f^\lambda{}_\kappa \partial^\kappa f_{\lambda\alpha} +$$
$$3 t_1 \partial_\kappa f_\lambda{}^\lambda \partial^\kappa f_\theta{}^\theta + 3 t_1 \partial_\kappa f_\lambda{}^\theta \partial^\kappa f^\lambda{}_\theta - 2 t_1 \partial_\alpha f^\lambda{}_\theta \partial^\kappa f_{\lambda\kappa} + 2 r_2 \partial_\kappa \omega_\iota{}^{\lambda\alpha} \partial_\lambda \omega_{\alpha\beta}{}^\iota +$$
$$4 r_2 \partial_\kappa \omega^{\theta\alpha\beta} \partial^\kappa \omega_{\alpha\beta\theta} - 4 r_2 \partial^\beta \omega^{\alpha\lambda} \partial_\lambda \omega_{\alpha\beta}{}^\iota + 4 r_2 \partial^\beta \omega_\iota{}^{\lambda\alpha} \partial_\lambda \omega_{\alpha\beta}{}^\iota +$$
$$6 r_5 \partial_\alpha \omega_\lambda{}^\alpha{}_\theta \partial^\lambda \omega^{\theta\kappa}{}_\kappa - 6 r_5 \partial_\theta \omega_\lambda{}^\alpha{}_\alpha \partial^\lambda \omega^{\theta\kappa}{}_\kappa \big)\Big)[t,x,y,z]\,dz\,dy\,dx\,dt$$

Source constraints/gauge generators	Multiplicities
SO(3) irreps	
$\tau_{0^+}^{\#2} == 0$	1
$\tau_{0^+}^{\#1} == 0$	1
$\sigma_{0^+}^{\#1} == 0$	1
$\tau_1^{\#2\alpha} + 2ik\,\sigma_{1^-}^{\#2\alpha} == 0$	3
$\tau_1^{\#1\alpha} == 0$	3
$\tau_{1^+}^{\#1\alpha\beta} + ik\,\sigma_{1^+}^{\#2\alpha\beta} == 0$	3
$\sigma_{2^+}^{\#1\alpha\beta} - 2ik\,\sigma_{2^+}^{\#1\alpha\beta} == 0$	5
Total constraints:	17

Massive and massless spectra
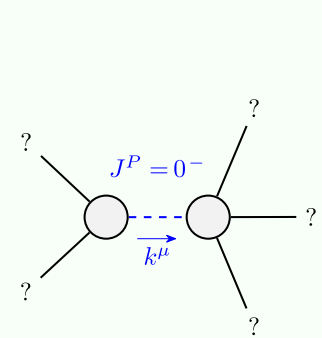
Massive particle ($J^P = 0^-$)

Pole residue:	$-\dfrac{1}{r_2} > 0$
Polarisations:	1
Square mass:	$\dfrac{t_1}{r_2} > 0$
Spin:	0
Parity:	Odd
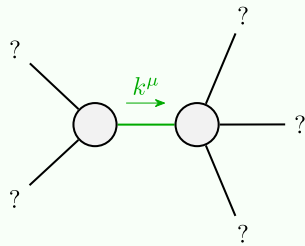
Quadratic pole

Pole residue:	$-\dfrac{1}{r_5 t_1^2} > 0$
Polarisations:	2

Unitarity conditions

$r_2 < 0\ \&\&\ r_5 < 0\ \&\&\ t_1 < 0$