Particle spectrograph

Wave operator and propagator

	$\sigma^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\sigma^{\#2}_{1^+}\dagger^{\alpha\beta}$	$\tau^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\sigma^{\#1}_{1^-}\dagger^{\alpha}$	$\sigma^{\#2}_{1^-}\dagger^{\alpha}$	$\tau^{\#1}_{1^-}\dagger^{\alpha}$	$\tau^{\#2}_{1^-}\dagger^{\alpha}$
$\tau^{\#2}_{1^-\alpha}$	0	0	0	$-\frac{i}{k(1+2k^2)(2r_3+r_5)}$	$\frac{i(6k^2(2r_3+r_5)+t_1)}{\sqrt2\,k(1+2k^2)^2(2r_3+r_5)t_1}$	0	$\frac{6k^2(2r_3+r_5)+t_1}{(1+2k^2)^2(2r_3+r_5)t_1}$
$\tau^{\#1}_{1^-\alpha}$	0	0	0	0	0	0	0
$\sigma^{\#2}_{1^-\alpha}$	0	0	0	$-\frac{1}{\sqrt2(k^2+2k^4)(2r_3+r_5)}$	$\frac{6k^2(2r_3+r_5)+t_1}{2(k+2k^3)^2(2r_3+r_5)t_1}$	0	$-\frac{i(6k^2(2r_3+r_5)+t_1)}{\sqrt2\,k(1+2k^2)^2(2r_3+r_5)t_1}$
$\sigma^{\#1}_{1^-\alpha}$	0	0	0	$\frac{1}{k^2(2r_3+r_5)}$	$\frac{1}{\sqrt2(k^2+2k^4)(2r_3+r_5)}$	0	$\frac{i}{k(1+2k^2)(2r_3+r_5)}$
$\tau^{\#1}_{1^+\alpha\beta}$	$-\frac{i\sqrt2\,k}{t_1+k^2 t_1}$	$-\frac{2ik^3(2r_3+r_5)+ikt_1}{(1+k^2)^2 t_1^2}$	$-\frac{2k^4(2r_3+r_5)+k^2 t_1}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\sigma^{\#2}_{1^+\alpha\beta}$	$-\frac{\sqrt2}{t_1+k^2 t_1}$	$-\frac{2k^2(2r_3+r_5)+t_1}{(1+k^2)^2 t_1^2}$	$\frac{i(2k^3(2r_3+r_5)+kt_1)}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\sigma^{\#1}_{1^+\alpha\beta}$	0	$-\frac{\sqrt2}{t_1+k^2 t_1}$	$\frac{i\sqrt2\,k}{t_1+k^2 t_1}$	0	0	0	0

	$\sigma^{\#1}_{2^+\alpha\beta}$	$\tau^{\#1}_{2^+\alpha\beta}$	$\sigma^{\#1}_{2^-\alpha\beta\chi}$
$\sigma^{\#1}_{2^+}\dagger^{\alpha\beta}$	$\frac{2}{(1+2k^2)^2 t_1}$	$-\frac{2i\sqrt2\,k}{(1+2k^2)^2 t_1}$	0
$\tau^{\#1}_{2^+}\dagger^{\alpha\beta}$	$\frac{2i\sqrt2\,k}{(1+2k^2)^2 t_1}$	$\frac{4k^2}{(1+2k^2)^2 t_1}$	0
$\sigma^{\#1}_{2^-}\dagger^{\alpha\beta\chi}$	0	0	$\frac{2}{t_1}$

	$\omega^{\#1}_{2^+\alpha\beta}$	$f^{\#1}_{2^+\alpha\beta}$	$\omega^{\#1}_{2^-\alpha\beta\chi}$
$\omega^{\#1}_{2^+}\dagger^{\alpha\beta}$	0	0	$\frac{t_1}{2}$
$f^{\#1}_{2^+}\dagger^{\alpha\beta}$	$-\frac{ikt_1}{\sqrt2}$	$k^2 t_1$	0
$\omega^{\#1}_{2^-}\dagger^{\alpha\beta\chi}$	$\frac{t_1}{2}$	$\frac{ikt_1}{\sqrt2}$	0

	$\omega^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\omega^{\#2}_{1^+}\dagger^{\alpha\beta}$	$f^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\omega^{\#1}_{1^-}\dagger^{\alpha}$	$\omega^{\#2}_{1^-}\dagger^{\alpha}$	$f^{\#1}_{1^-}\dagger^{\alpha}$	$f^{\#2}_{1^-}\dagger^{\alpha}$
$f^{\#2}_{1^-\alpha}$	0	0	0	$\frac{ikt_1}{3}$	$\frac{1}{3}i$	0	$\frac{2k^2 t_1}{3}$
$f^{\#1}_{1^-\alpha}$	0	0	0	0	0	0	0
$\omega^{\#2}_{1^-\alpha}$	0	0	0	$\frac{t_1}{3\sqrt2}$	$\frac{t_1}{3}$	0	$-\frac13 i\sqrt2\,kt_1$
$\omega^{\#1}_{1^-\alpha}$	0	0	0	$k^2(2r_3+r_5)+\frac{t_1}{6}$	$\frac{t_1}{3\sqrt2}$	0	$-\frac13 ikt_1$
$f^{\#1}_{1^+\alpha\beta}$	$-\frac{ikt_1}{\sqrt2}$	$-\frac{t_1}{\sqrt2}$	0	0	0	0	0
$\omega^{\#2}_{1^+\alpha\beta}$	$-\frac{t_1}{\sqrt2}$	0	0	0	0	0	0
$\omega^{\#1}_{1^+\alpha\beta}$	$k^2(2r_3+r_5)-\frac{t_1}{2}$	$-\frac{t_1}{\sqrt2}$	$\frac{ikt_1}{\sqrt2}$	0	0	0	0

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau^{\#2}_{0^+} == 0$	1
$\tau^{\#1}_{0^+} == 0$	1
$\tau^{\#2\alpha}_{1^-} + 2ik\,\sigma^{\#2\alpha}_{1^-} == 0$	3
$\tau^{\#1\alpha}_{1^-} == 0$	3
$\tau^{\#1\alpha\beta}_{1^+} + ik\,\sigma^{\#2\alpha\beta}_{1^+} == 0$	3
$\tau^{\#1\alpha\beta}_{2^+} - 2ik\,\sigma^{\#1\alpha\beta}_{2^+} == 0$	5
Total constraints:	16

	$\omega^{\#1}_{0^+}$	$f^{\#1}_{0^+}$	$f^{\#2}_{0^+}$	$\omega^{\#1}_{0^-}$
$\omega^{\#1}_{0^+}\dagger$	$6k^2 r_3$	0	0	0
$f^{\#1}_{0^+}\dagger$	0	0	0	0
$f^{\#2}_{0^+}\dagger$	0	0	0	0
$\omega^{\#1}_{0^-}\dagger$	0	0	0	$-t_1$

	$\sigma^{\#1}_{0^+}$	$\tau^{\#1}_{0^+}$	$\tau^{\#2}_{0^+}$	$\sigma^{\#1}_{0^-}$
$\sigma^{\#1}_{0^+}\dagger$	$\frac{1}{6k^2 r_3}$	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	$-\frac{1}{t_1}$

Quadratic (free) Lagrangian density

$$-\tfrac13 t_1\,\omega_i{}^{\alpha l}\omega_{\kappa\alpha}{}^{\kappa} - t_1\,\omega_i{}^{\kappa\lambda}\omega_{\kappa\lambda}{}^{l} + f^{\alpha\beta}\tau_{\alpha\beta} + \omega^{\alpha\beta\chi}\sigma_{\alpha\beta\chi} - 2r_3\,\partial_i\omega_{\kappa}{}^{\kappa\lambda}\partial^l\omega_{\lambda}{}^{\alpha}{}_{\alpha} -$$
$$r_5\,\partial_i\omega^{\kappa\lambda}{}_{\kappa}\partial^l\omega_{\lambda}{}^{\alpha}{}_{\alpha} + 2r_3\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial_\kappa\omega^{\theta\kappa\lambda} - r_5\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial_\kappa\omega^{\theta\kappa\lambda} - 2r_3\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial_\kappa\omega^{\kappa\lambda\theta} + 4r_3\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial_\kappa\omega^{\kappa\lambda\theta} +$$
$$r_5\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial_\kappa\omega^{\kappa\lambda\theta} - 2r_3\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial_\kappa\omega^{\kappa\lambda\theta} - r_5\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial_\kappa\omega^{\kappa\lambda\theta} +$$
$$2r_5\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial_\kappa\omega^{\kappa\lambda\theta} - \tfrac12 t_1\,\partial_\theta f_{\theta\kappa}\partial^\kappa f_\alpha{}^{\theta} - \tfrac12 t_1\,\partial^{\alpha}f_{\kappa\theta}\partial^\kappa f_{\alpha}{}^{\theta} - \tfrac12 t_1\,\partial^{\alpha}f^{\lambda}{}_{\kappa}\partial^\kappa f_{\alpha l} +$$
$$\tfrac13 t_1\,\omega_{\kappa\alpha}\partial^\kappa f^{l}{}_{l} + \tfrac13 t_1\,\omega_{\kappa\lambda}{}^{\lambda}\partial^\kappa f^{l}{}_{l} + \tfrac23 t_1\,\partial^{\alpha}f_{\kappa\alpha}\partial^\kappa f^{l}{}_{l} - \tfrac13 t_1\,\partial_\kappa f^{\lambda}{}_{\lambda}\partial^\kappa f_l +$$
$$2t_1\,\omega_{l\kappa\theta}\partial^\kappa f^{l\theta} - \tfrac13 t_1\,\omega_{l\alpha}{}^{\alpha}\partial^\kappa f^{l}{}_{\kappa} - t_1\,\omega_{l\lambda}{}^{\lambda}\partial^\kappa f^{l}{}_{\kappa} + \tfrac12 t_1\,\partial^{\alpha}f^{\lambda}{}_{\alpha}\partial^\kappa f_{\lambda\kappa} - 4r_3\,\partial^{\beta}\omega_i{}^{\lambda\alpha}\partial_\lambda\omega_{i\alpha}{}^{l} -$$
$$\tfrac12 t_1\,\partial_\kappa f_{\theta}{}^{\lambda}\partial^\kappa f_{\lambda}{}^{\theta} + \tfrac12 t_1\,\partial_\kappa f^{\lambda}{}_{\theta}\partial^\kappa f_{\lambda}{}^{\theta} - \tfrac13 t_1\,\partial^{\alpha}f^{\lambda}{}_{\alpha}\partial^\kappa f_{\lambda\kappa} - 4r_3\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial^\lambda\omega^{\theta\kappa}{}_{\kappa} - r_5\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial^\lambda\omega^{\theta\kappa}{}_{\kappa} +$$
$$2r_3\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial^\lambda\omega^{\theta\kappa}{}_{\kappa} + r_5\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial^\lambda\omega^{\theta\kappa}{}_{\kappa}$$

Massive and massless spectra
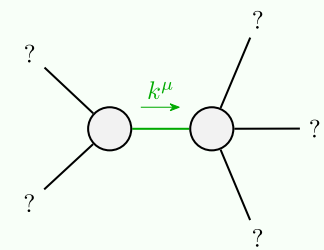
Quadratic pole

Pole residue:	$-\frac{1}{(2r_3+r_5)t_1^2} > 0$
Polarisations:	2

(No massive particles)

Unitarity conditions

$r_5 < -2r_3 \,\&\&\, t_1 < 0 \,||\, t_1 > 0$