Particle spectrograph

Wave operator and propagator

	$\sigma_{1^-}^{\#1}{}_{\alpha}$	$\sigma_{1^-}^{\#2}{}_{\alpha}$	$\tau_{1^-}^{\#1}{}_{\alpha}$	$\tau_{1^-}^{\#2}{}_{\alpha}$
$\sigma_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	0	0	0	0
$\sigma_{1^+}^{\#2}{}^{\dagger\alpha\beta}$	0	0	0	0
$\tau_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	0	0	0	0
$\sigma_{1^-}^{\#1}{}^{\dagger\alpha}$	$\frac{1}{k^2 (2 r_3+r_5)}$	$-\frac{1}{\sqrt{2}\ (k^2+2 k^4)(2 r_3+r_5)}$	0	$-\frac{i}{k (1+2 k^2)(2 r_3+r_5)}$
$\sigma_{1^-}^{\#2}{}^{\dagger\alpha}$	$-\frac{1}{\sqrt{2}\ (k^2+2 k^4)(2 r_3+r_5)}$	$\frac{6 k^2 (2 r_3+r_5)+t_1}{2 (k+2 k^3)^2 (2 r_3+r_5) t_1}$	0	$\frac{i (6 k^2 (2 r_3+r_5)+t_1)}{\sqrt{2}\ k (1+2 k^2)^2 (2 r_3+r_5) t_1}$
$\tau_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	0
$\tau_{1^-}^{\#2}{}^{\dagger\alpha}$	$-\frac{i}{k (1+2 k^2)(2 r_3+r_5)}$	$-\frac{i (6 k^2 (2 r_3+r_5)+t_1)}{\sqrt{2}\ k (1+2 k^2)^2 (2 r_3+r_5) t_1}$	0	$\frac{6 k^2 (2 r_3+r_5)+t_1}{(1+2 k^2)^2 (2 r_3+r_5) t_1}$

	$\sigma_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^+}^{\#2}{}_{\alpha\beta}$	$\tau_{1^+}^{\#1}{}_{\alpha\beta}$
$\sigma_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	0	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$-\frac{i\sqrt{2}\ k}{t_1+k^2 t_1}$
$\sigma_{1^+}^{\#2}{}^{\dagger\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$\frac{-2 k^2 (2 r_3+r_5)+t_1}{(1+k^2)^2 t_1{}^2}$	$\frac{-2 i k^3 (2 r_3+r_5)+i k t_1}{(1+k^2)^2 t_1{}^2}$
$\tau_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{i\sqrt{2}\ k}{t_1+k^2 t_1}$	$\frac{i (2 k^3 (2 r_3+r_5)-k t_1)}{(1+k^2)^2 t_1{}^2}$	$\frac{-2 k^4 (2 r_3+r_5)+k^2 t_1}{(1+k^2)^2 t_1{}^2}$
$\sigma_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0
$\sigma_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0
$\tau_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0
$\tau_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0

	$\omega_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^+}^{\#2}{}_{\alpha\beta}$	$f_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^-}^{\#1}{}_{\alpha}$	$\omega_{1^-}^{\#2}{}_{\alpha}$	$f_{1^-}^{\#1}{}_{\alpha}$	$f_{1^-}^{\#2}{}_{\alpha}$
$\omega_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$k^2 (2 r_3+r_5)-\frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{i k t_1}{\sqrt{2}}$	0	$k^2 (2 r_3+r_5)+\frac{t_1}{6}$	0	$\frac{i k t_1}{3}$
$\omega_{1^+}^{\#2}{}^{\dagger\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	$\frac{t_1}{3\sqrt{2}}$	0	$\frac{1}{3} i \sqrt{2}\ k t_1$
$f_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{i k t_1}{\sqrt{2}}$	0	0	0	$\frac{t_1}{3}$	0	0
$\omega_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	0	0	0	$-\frac{1}{3} i \sqrt{2}\ k t_1$
$\omega_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$\frac{t_1}{3\sqrt{2}}$	0	$\frac{1}{3} i \sqrt{2}\ k t_1$	0
$f_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	0	0	0	$\frac{2 k^2 t_1}{3}$
$f_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$-\frac{1}{3} i k t_1$	0	$\frac{2 k^2 t_1}{3}$	0

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

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

	$\sigma_{0^+}^{\#1}{}$	$\tau_{0^+}^{\#1}{}$	$\tau_{0^+}^{\#2}{}$	$\sigma_{0^-}^{\#1}{}$
$\sigma_{0^+}^{\#1}{}^{\dagger}$	$\frac{1}{6 k^2 r_3}$	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	$-\frac{1}{t_1}$

	$\omega_{0^+}^{\#1}{}$	$f_{0^+}^{\#1}{}$	$f_{0^+}^{\#2}{}$	$\omega_{0^-}^{\#1}{}$
$\omega_{0^+}^{\#1}{}^{\dagger}$	$6 k^2 r_3$	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	$-t_1$

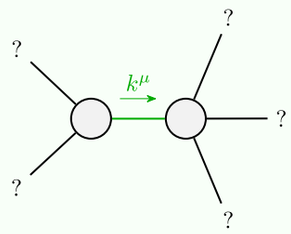
Quadratic (free) action

$$
\begin{aligned}
S == \int\int\int\int (& f^{\alpha\beta}\ \tau_{\alpha\beta} + \omega^{\alpha\beta\chi}\ \sigma_{\alpha\beta\chi} + \frac{1}{6} t_1 (2\ \omega^{\alpha\prime}{}_{\alpha}\ \omega_{\prime}{}_{\theta} - 4\ \omega_{\alpha}{}^{\theta}\ \omega_{\prime}{}_{\theta}\ \partial^{\prime} f^{\alpha}{}_{\alpha} - \\
& 2 \partial_{\prime} f^{\theta}{}_{\theta} \partial^{\prime} f^{\alpha}{}_{\alpha} - 2 \partial_{\prime} f^{\alpha\prime} \partial_{\theta} f^{\theta}{}_{\alpha} + 4 \partial^{\prime} f^{\alpha}{}_{\alpha} \partial_{\theta} f^{\theta}{}_{\prime} - 6 \partial_{\alpha} f_{\prime\theta} \partial^{\theta} f^{\alpha\prime} + \\
& 3 \partial_{\prime} f_{\alpha\theta} \partial^{\theta} f^{\alpha\prime} + 3 \partial_{\theta} f_{\alpha\prime} \partial^{\theta} f^{\alpha\prime} + 3 \partial_{\theta} f_{\prime\alpha} \partial^{\theta} f^{\alpha\prime} + 6\ \omega_{\alpha\theta\prime}\ (\omega^{\alpha\prime\theta} + 2 \partial^{\theta} f^{\alpha\prime}) - \\
& 2 r_3 (\partial_{\beta} \omega_{\prime}{}^{\theta} \partial^{\prime} \omega^{\alpha\beta}{}_{\alpha} + \partial_{\prime} \omega_{\beta}{}^{\theta} \partial^{\prime} \omega^{\alpha\beta}{}_{\alpha} + \partial_{\alpha} \omega^{\alpha\beta\prime} \partial_{\theta} \omega_{\beta}{}^{\theta}{}_{\prime} - 2 \partial^{\prime} \omega^{\alpha\beta}{}_{\alpha} \partial_{\theta} \omega_{\beta}{}^{\theta}{}_{\prime} + \\
& \partial_{\alpha} \omega^{\alpha\beta\prime} \partial_{\theta} \omega_{\prime}{}^{\theta}{}_{\beta} - 2 \partial^{\prime} \omega^{\alpha\beta}{}_{\alpha} \partial_{\theta} \omega_{\prime}{}^{\theta}{}_{\beta} + 2 \partial_{\beta} \omega_{\prime\theta\alpha} \partial^{\theta} \omega^{\alpha\beta\prime}) + r_5 (\partial_{\prime} \omega_{\theta}{}^{\kappa} \partial^{\theta} \omega^{\alpha\prime}{}_{\alpha} - \\
& \partial_{\theta} \omega_{\prime}{}^{\kappa} \partial^{\theta} \omega^{\alpha\prime}{}_{\alpha} - (\partial_{\alpha} \omega^{\alpha\prime\theta} - 2 \partial^{\theta} \omega^{\alpha\prime}{}_{\alpha}) (\partial_{\kappa} \omega_{\prime}{}^{\kappa}{}_{\theta} - \partial_{\kappa} \omega_{\theta}{}^{\kappa}{}_{\prime}))) [t, x, y, z]\, dz\, dy\, dx\, dt
\end{aligned}
$$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau_{0^+}^{\#2} == 0$	1
$\tau_{0^+}^{\#1} == 0$	1
$\tau_{1^-}^{\#2\alpha} + 2 i k\ \sigma_{1^-}^{\#2\alpha} == 0$	3
$\tau_{1^-}^{\#1\alpha} == 0$	3
$\tau_{1^+}^{\#1\alpha\beta} + i k\ \sigma_{1^+}^{\#2\alpha\beta} == 0$	3
$\tau_{2^+}^{\#1\alpha\beta} - 2 i k\ \sigma_{2^+}^{\#1\alpha\beta} == 0$	5
Total constraints:	16

Massive and massless spectra



Quadratic pole

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

(No massive particles)

Unitarity conditions

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