Particle spectrograph

Wave operator and propagator

	$\sigma_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^+}^{\#2}{}_{\alpha\beta}$	$\tau_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^-}^{\#1}{}_{\alpha}$	$\tau_{1^-}^{\#1}{}_{\alpha}$	$\sigma_{1^-}^{\#2}{}_{\alpha}$	$\tau_{1^-}^{\#2}{}_{\alpha}$
$\sigma_{1^+}^{\#1}{}_{\alpha\beta}\,\dagger$	0	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$-\frac{i\sqrt{2}\,k}{t_1+k^2 t_1}$	0	$-\frac{\sqrt{2}\,(t_1-2t_3)}{(1+2k^2)(3t_1t_3+2k^2r_5(t_1+t_3))}$	$\frac{6k^2r_5+t_1+4t_3}{(1+2k^2)^2(3t_1t_3+2k^2r_5(t_1+t_3))}$	$\frac{i\sqrt{2}\,k(6k^2r_5+t_1+4t_3)}{(1+2k^2)^2(3t_1t_3+2k^2r_5(t_1+t_3))}$
$\sigma_{1^+}^{\#2}{}_{\alpha\beta}\,\dagger$	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$\frac{-2k^2r_5+t_1}{(1+k^2)^2t_1^2}$	$\frac{i(2k^3r_5-kt_1)}{(1+k^2)^2t_1^2}$	0	$\frac{\sqrt{2}\,(t_1-2t_3)}{(1+2k^2)(3t_1t_3+2k^2r_5(t_1+t_3))}$	0	$\frac{2k^2(6k^2r_5+t_1+4t_3)}{(1+2k^2)^2(3t_1t_3+2k^2r_5(t_1+t_3))}$
$\tau_{1^+}^{\#1}{}_{\alpha\beta}\,\dagger$	$\frac{i\sqrt{2}\,k}{t_1+k^2 t_1}$	$\frac{i(2k^3r_5-kt_1)}{(1+k^2)^2t_1^2}$	$\frac{-2k^4r_5+k^2t_1}{(1+k^2)^2t_1^2}$	0	$\frac{2(t_1+t_3)}{3t_1t_3+2k^2r_5(t_1+t_3)}$	$\frac{\sqrt{2}\,(t_1-2t_3)}{(1+2k^2)(3t_1t_3+2k^2r_5(t_1+t_3))}$	$\frac{2ik(t_1-2t_3)}{(1+2k^2)(3t_1t_3+2k^2r_5(t_1+t_3))}$
$\sigma_{1^-}^{\#1}{}_{\alpha}\,\dagger$	0	0	0	0	0	0	0
$\sigma_{1^-}^{\#2}{}_{\alpha}\,\dagger$	0	0	0	0	0	0	0
$\tau_{1^-}^{\#1}{}_{\alpha}\,\dagger$	0	0	0	0	$-\frac{2ik(t_1-2t_3)}{(1+2k^2)(3t_1t_3+2k^2r_5(t_1+t_3))}$	$\frac{6k^2r_5+t_1+4t_3}{(1+2k^2)^2(3t_1t_3+2k^2r_5(t_1+t_3))}$	$\frac{2k^2(6k^2r_5+t_1+4t_3)}{(1+2k^2)^2(3t_1t_3+2k^2r_5(t_1+t_3))}$
$\tau_{1^-}^{\#2}{}_{\alpha}\,\dagger$	0	0	0	0	$\frac{2(t_1+t_3)}{3t_1t_3+2k^2r_5(t_1+t_3)}$	$-\frac{\sqrt{2}\,(t_1-2t_3)}{(1+2k^2)(3t_1t_3+2k^2r_5(t_1+t_3))}$	$-\frac{2ik(t_1-2t_3)}{(1+2k^2)(3t_1t_3+2k^2r_5(t_1+t_3))}$

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1}\,\dagger$	$\frac{1}{(1+2k^2)^2t_3}$	$-\frac{i\sqrt{2}\,k}{(1+2k^2)^2t_3}$	0	0
$\tau_{0^+}^{\#1}\,\dagger$	$\frac{i\sqrt{2}\,k}{(1+2k^2)^2t_3}$	$\frac{2k^2}{(1+2k^2)^2t_3}$	0	0
$\tau_{0^+}^{\#2}\,\dagger$	0	0	0	0
$\sigma_{0^-}^{\#1}\,\dagger$	0	0	0	$-\frac{1}{t_1}$

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

	$\omega_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^+}^{\#2}{}_{\alpha\beta}$	$f_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^-}^{\#1}{}_{\alpha}$	$\omega_{1^-}^{\#2}{}_{\alpha}$	$f_{1^-}^{\#1}{}_{\alpha}$	$f_{1^-}^{\#2}{}_{\alpha}$
$\omega_{1^+}^{\#1}{}_{\alpha\beta}\,\dagger$	$k^2r_5-\frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{ikt_1}{\sqrt{2}}$	0	0	0	0
$\omega_{1^+}^{\#2}{}_{\alpha\beta}\,\dagger$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$f_{1^+}^{\#1}{}_{\alpha\beta}\,\dagger$	$\frac{ikt_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega_{1^-}^{\#1}{}_{\alpha}\,\dagger$	0	0	0	$\frac{1}{6}(6k^2r_5+t_1+4t_3)$	$\frac{t_1-2t_3}{3\sqrt{2}}$	$-\frac{1}{3}ik(t_1-2t_3)$	$\frac{2}{3}k^2(t_1+t_3)$
$\omega_{1^-}^{\#2}{}_{\alpha}\,\dagger$	0	0	0	$\frac{t_1-2t_3}{3\sqrt{2}}$	$\frac{t_1+t_3}{3}$	0	$\frac{i\sqrt{2}}{3}k(t_1+t_3)$
$f_{1^-}^{\#1}{}_{\alpha}\,\dagger$	0	0	0	$-\frac{1}{3}ik(t_1-2t_3)$	0	$-\frac{1}{3}t_3$	0
$f_{1^-}^{\#2}{}_{\alpha}\,\dagger$	0	0	0	$\frac{2}{3}k^2(t_1+t_3)$	$\frac{i\sqrt{2}}{3}k(t_1+t_3)$	0	$-\frac{1}{3}t_3$

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}\,\dagger$	t_3	$-i\sqrt{2}\,kt_3$	0	0
$f_{0^+}^{\#1}\,\dagger$	$i\sqrt{2}\,kt_3$	$2k^2t_3$	0	0
$f_{0^+}^{\#2}\,\dagger$	0	0	0	0
$\omega_{0^-}^{\#1}\,\dagger$	0	0	0	$-t_1$

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

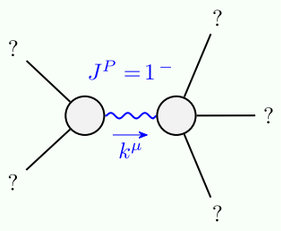
Source constraints/gauge generators

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

Quadratic (free) Lagrangian density

$$
\begin{aligned}
&-\tfrac{1}{3}t_1\,\omega_{I}^{\alpha\prime}\,\omega_{\kappa\alpha}^{\kappa}+\tfrac{2}{3}t_3\,\omega_{I}^{\alpha\prime}\,\omega_{\kappa\alpha}^{\kappa}-t_1\,\omega_{I}^{\kappa\lambda}\,\omega_{\kappa\lambda}{}'+f^{\alpha\beta}\,\tau_{\alpha\beta}+\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi}-\\
&r_5\,\partial_I\omega^{\kappa\lambda}{}_{\kappa}\,\partial'\omega_{\lambda}{}^{\alpha}{}_{\alpha}-r_5\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\,\partial_\kappa\omega^{\theta\kappa\lambda}+r_5\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\,\partial_\kappa\omega^{\theta\kappa\lambda}-r_5\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\,\partial_\kappa\omega^{\kappa\lambda\theta}+\\
&2\,r_5\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\,\partial_\kappa\omega^{\kappa\lambda\theta}-\tfrac{1}{2}t_1\,\partial^\alpha f_{\theta\kappa}\,\partial^\kappa f_{\alpha}{}^{\theta}-\tfrac{1}{2}t_1\,\partial^\alpha f_{\kappa\theta}\,\partial^\kappa f_{\alpha}{}^{\theta}-\tfrac{1}{2}t_1\,\partial^\alpha f_{\kappa}{}^{\lambda}\,\partial^\kappa f_{\alpha\lambda}+\\
&\tfrac{1}{3}t_1\,\omega_{\kappa\alpha}{}^{\alpha}\,\partial^\kappa f'_{I}+\tfrac{1}{3}t_1\,\omega_{\kappa\lambda}{}^{\lambda}\,\partial^\kappa f'_{I}-\tfrac{2}{3}t_3\,\omega_{\kappa\lambda}{}^{\lambda}\,\partial^\kappa f'_{I}+\\
&\tfrac{2}{3}t_1\,\partial^\alpha f_{\kappa\alpha}\,\partial^\kappa f'_{I}-\tfrac{4}{3}t_3\,\partial^\alpha f_{\kappa\alpha}\,\partial^\kappa f'_{I}-\tfrac{1}{3}t_1\,\partial_\kappa f^{\lambda}{}_{\lambda}\,\partial^\kappa f'_{I}+\tfrac{2}{3}t_3\,\partial_\kappa f^{\lambda}{}_{\lambda}\,\partial^\kappa f'_{I}+\\
&\omega_{I\kappa\theta}\,\partial^\kappa f'^{\theta}-\tfrac{1}{3}t_1\,\omega_{I\alpha}{}^{\alpha}\,\partial^\kappa f'_{\kappa}+\tfrac{2}{3}t_3\,\omega_{I\alpha}{}^{\alpha}\,\partial^\kappa f'_{\kappa}-\tfrac{1}{3}t_1\,\omega_{I\lambda}{}^{\lambda}\,\partial^\kappa f'_{\kappa}+\\
&\omega_{I\lambda}{}^{\lambda}\,\partial^\kappa f'_{\kappa}+\tfrac{1}{2}t_1\,\partial^\alpha f^{\lambda}{}_{\kappa}\,\partial^\kappa f_{\lambda\alpha}+\tfrac{1}{2}t_1\,\partial_\kappa f^{\lambda}{}_{\theta}\,\partial^\kappa f_{\lambda}{}^{\theta}+\tfrac{1}{2}t_1\,\partial_\kappa f^{\lambda}{}_{\theta}\,\partial^\kappa f_{\lambda}{}^{\theta}-\\
&\partial^\alpha f^{\lambda}{}_{\alpha}\,\partial^\kappa f_{\lambda\kappa}+\tfrac{2}{3}t_3\,\partial^\alpha f^{\lambda}{}_{\alpha}\,\partial^\kappa f_{\lambda\kappa}+r_5\,\partial_\alpha\omega_{\lambda}{}^{\alpha}{}_{\theta}\,\partial^\lambda\omega^{\theta\kappa}{}_{\kappa}-r_5\,\partial_\theta\omega_{\lambda}{}^{\alpha}{}_{\alpha}\,\partial^\lambda\omega^{\theta\kappa}{}_{\kappa}
\end{aligned}
$$

Massive and massless spectra



Massive particle	
Pole residue:	$\frac{6t_1t_3(t_1+t_3)-3r_5(t_1{}^2+2t_3{}^2)}{2r_5(t_1+t_3)(-3t_1t_3+r_5(t_1+t_3))}>0$
Polarisations:	3
Square mass:	$-\frac{3t_1t_3}{2r_5t_1+2r_5t_3}>0$
Spin:	1
Parity:	Odd

(No massless particles)

Unitarity conditions

$r_5<0\;\&\&\;(t_1<0\,\&\&\,0<t_3<-t_1)\,||\,(t_1>0\,\&\&\,(t_3<-t_1\,||\,t_3>0))$