Particle spectrograph

Wave operator and propagator

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

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

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}\,\dagger$	$-t_1$	$i\sqrt{2}\,kt_1$	0	0
$f_{0^+}^{\#1}\,\dagger$	$-i\sqrt{2}\,kt_1$	$-2k^2t_1$	0	0
$f_{0^+}^{\#2}\,\dagger$	0	0	0	0
$\omega_{0^-}^{\#1}\,\dagger$	0	0	0	t_2

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

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

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

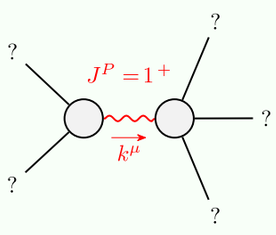
Quadratic (free) action

$$S_F = \int\int\int\int\left(\frac{1}{6}(-6t_1\,\omega_{\iota}^{\alpha\prime}\,\omega_{\kappa\alpha}^{\ \ \kappa} - 2(t_1-2t_2)\,\omega_{\iota}^{\kappa\lambda}\,\omega_{\kappa\lambda}^{\ \ \prime} + 2t_1\,\omega_{\kappa\lambda}^{\ \ \prime}\,\omega^{\kappa\lambda}{}_{\iota} + 2t_2\,\omega_{\kappa\lambda}^{\ \ \prime}\,\omega^{\kappa\lambda}{}_{\iota} + 6f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} - 6r_5\,\partial_{\iota}\omega^{\kappa\lambda}{}_{\kappa}\,\partial^{\prime}\omega_{\lambda}^{\ \ \alpha} - 6r_5\,\partial_{\alpha}\omega_{\lambda}^{\ \ \alpha}\,\partial_{\theta}\omega^{\theta\kappa\lambda} + 6r_5\,\partial_{\theta}\omega_{\lambda}^{\ \ \alpha}\,\partial_{\kappa}\omega^{\kappa\lambda\theta} + 6r_5\,\partial_{\theta}\omega_{\lambda}^{\ \ \alpha}\,\partial_{\kappa}\omega^{\kappa\lambda\theta} - 2t_1\,\partial^{\alpha}f_{\theta\kappa}\,\partial^{\kappa}f_{\alpha}^{\ \ \theta} + t_2\,\partial^{\alpha}f_{\theta\kappa}\,\partial^{\kappa}f_{\alpha}^{\ \ \theta} - 4t_1\,\partial^{\alpha}f_{\kappa\theta}\,\partial^{\kappa}f_{\alpha}^{\ \ \theta} - 2t_1\,\partial^{\alpha}f^{\lambda}{}_{\kappa}\,\partial^{\kappa}f_{\alpha\lambda} + t_2\,\partial^{\alpha}f^{\lambda}{}_{\kappa}\,\partial^{\kappa}f_{\alpha\lambda} + 6t_1\,\omega_{\kappa\alpha}^{\ \ \alpha}\,\partial^{\kappa}f^{\prime}{}_{\iota} + 6t_1\,\omega_{\kappa\lambda}^{\ \ \prime}\,\partial^{\kappa}f^{\prime}{}_{\iota} + 12t_1\,\partial^{\alpha}f_{\kappa\alpha}\,\partial^{\kappa}f^{\prime}{}_{\iota} - 6t_1\,\partial_{\kappa}f^{\lambda}{}_{\lambda}\,\partial^{\kappa}f^{\prime}{}_{\iota} + 2t_1\,\omega_{\iota\theta\kappa}\,\partial^{\kappa}f^{\prime\theta} + 2t_2\,\omega_{\iota\theta\kappa}\,\partial^{\kappa}f^{\prime\theta} + 8t_1\,\omega_{\iota\kappa\theta}\,\partial^{\kappa}f^{\prime\theta} - 4t_2\,\omega_{\iota\kappa\theta}\,\partial^{\kappa}f^{\prime\theta} - 2t_1\,\omega_{\theta\iota\kappa}\,\partial^{\kappa}f^{\prime\theta} + 4t_1\,\omega_{\theta\iota\kappa}\,\partial^{\kappa}f^{\prime\theta} + 4t_2\,\omega_{\theta\kappa\iota}\,\partial^{\kappa}f^{\prime\theta} - 6t_1\,\omega_{\iota\alpha}^{\ \ \alpha}\,\partial^{\kappa}f^{\prime}{}_{\kappa} + 2t_1\,\omega_{\iota\lambda}^{\ \ \lambda}\,\partial^{\kappa}f^{\prime}{}_{\kappa} + 2t_1\,\partial^{\alpha}f^{\lambda}{}_{\kappa}\,\partial^{\kappa}f_{\lambda\alpha} - t_2\,\partial^{\alpha}f^{\lambda}{}_{\kappa}\,\partial^{\kappa}f_{\lambda\alpha} + 2t_1\,\partial_{\kappa}f_{\theta}^{\ \ \lambda}\,\partial^{\kappa}f_{\lambda}^{\ \ \theta} - 4t_1\,\partial_{\kappa}f_{\theta}^{\ \ \lambda}\,\partial^{\kappa}f_{\lambda}^{\ \ \theta} + t_2\,\partial_{\kappa}f_{\theta}^{\ \ \lambda}\,\partial^{\kappa}f_{\lambda}^{\ \ \theta} - 6t_1\,\partial^{\alpha}f^{\lambda}{}_{\alpha}\,\partial^{\kappa}f_{\lambda\kappa} + 6r_5\,\partial_{\alpha}\omega_{\lambda}^{\ \ \alpha}\,\partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa} - 6r_5\,\partial_{\theta}\omega_{\lambda}^{\ \ \alpha}\,\partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa})\right)[t,x,y,z]\,dz\,dy\,dx\,dt$$

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

Massive and massless spectra



Massive particle	
Pole residue:	$\frac{-3t_1t_2(t_1+t_2)+3r_5(t_1^2+2t_2^2)}{r_5(t_1+t_2)(-3t_1t_2+2r_5(t_1+t_2))} > 0$
Polarisations:	3
Square mass:	$-\frac{3t_1t_2}{2r_5t_1+2r_5t_2} > 0$
Spin:	1
Parity:	Even

(No massless particles)

Unitarity conditions

$r_5 > 0 \;\&\&\; (t_1 < 0 \;\&\&\; (t_2 < 0 \,||\, t_2 > -t_1)) \,||\, (t_1 > 0 \;\&\&\; -t_1 < t_2 < 0)$