Particle spectrograph

Wave operator and propagator

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

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}{}^{\dagger}$	t_3	$-i\sqrt{2}\,k t_3$	0	0
$f_{0^+}^{\#1}{}^{\dagger}$	$i\sqrt{2}\,k t_3$	$2k^2 t_3$	0	0
$f_{0^+}^{\#2}{}^{\dagger}$	0	0	0	0
$\omega_{0^-}^{\#1}{}^{\dagger}$	0	0	0	$k^2 r_2 + t_2$

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

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1}{}^{\dagger}$	$\frac{1}{(1+2k^2)^2 t_3}$	$-\frac{i\sqrt{2}\,k}{(1+2k^2)^2 t_3}$	0	0
$\tau_{0^+}^{\#1}{}^{\dagger}$	$\frac{i\sqrt{2}\,k}{(1+2k^2)^2 t_3}$	$\frac{2k^2}{(1+2k^2)^2 t_3}$	0	0
$\tau_{0^+}^{\#2}{}^{\dagger}$	0	0	0	0
$\sigma_{0^-}^{\#1}{}^{\dagger}$	0	0	0	$\frac{1}{k^2 r_2 + t_2}$

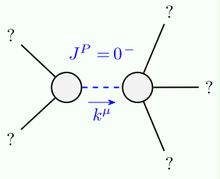
	$\omega_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^+}^{\#2}{}_{\alpha\beta}$	$f_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^-}^{\#1}{}_{\alpha}$	$\omega_{1^-}^{\#2}{}_{\alpha}$	$f_{1^-}^{\#1}{}_{\alpha}$	$f_{1^-}^{\#2}{}_{\alpha}$
$\omega_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{1}{6}(t_1+4t_2)$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$-\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	0	0	0	0
$\omega_{1^+}^{\#2}{}^{\dagger\alpha\beta}$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{t_1+t_2}{3}$	$\frac{1}{3}ik(t_1+t_2)$	0	0	0	0
$f_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	$-\frac{1}{3}ik(t_1+t_2)$	$\frac{1}{3}k^2(t_1+t_2)$	0	0	0	0
$\omega_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	$\frac{1}{6}(t_1+4t_3)$	$\frac{t_1-2t_3}{3\sqrt{2}}$	0	$\frac{1}{3}ik(t_1-2t_3)$
$\omega_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$\frac{t_1-2t_3}{3\sqrt{2}}$	$\frac{t_1+t_3}{3}$	0	$\frac{1}{3}i\sqrt{2}\,k(t_1+t_3)$
$f_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	0	0	0	0
$f_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$-\frac{1}{3}ik(t_1-2t_3)$	$-\frac{1}{3}i\sqrt{2}\,k(t_1+t_3)$	0	$\frac{2}{3}k^2(t_1+t_3)$

	$\tau_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^+}^{\#2}{}_{\alpha\beta}$	$\sigma_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^-}^{\#1}{}_{\alpha}$	$\tau_{1^-}^{\#1}{}_{\alpha}$	$\sigma_{1^-}^{\#2}{}_{\alpha}$	$\tau_{1^-}^{\#2}{}_{\alpha}$
$\sigma_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{i\sqrt{2}\,k(t_1-2t_2)}{3(1+k^2)t_1 t_2}$	$\frac{\sqrt{2}\,(t_1-2t_2)}{3(1+k^2)t_1 t_2}$	$\frac{2(t_1+t_2)}{3t_1 t_2}$	$\frac{2(t_1+t_3)}{3t_1 t_3}$	0	0	$-\frac{2ikt_1-4ikt_3}{3t_1 t_3+6k^2 t_1 t_3}$
$\sigma_{1^+}^{\#2}{}^{\dagger\alpha\beta}$	$\frac{ik(t_1+4t_2)}{3(1+k^2)^2 t_1 t_2}$	$\frac{t_1+4t_2}{3(1+k^2)^2 t_1 t_2}$	$\frac{\sqrt{2}\,(t_1-2t_2)}{3(1+k^2)t_1 t_2}$	$-\frac{\sqrt{2}\,(t_1-2t_3)}{3(1+2k^2)t_1 t_3}$	0	0	$\frac{i\sqrt{2}\,k(t_1+4t_3)}{3(1+2k^2)^2 t_1 t_3}$
$\tau_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{k^2(t_1+4t_2)}{3(1+k^2)^2 t_1 t_2}$	$-\frac{ik(t_1+4t_2)}{3(1+k^2)^2 t_1 t_2}$	$\frac{2k^2(t_1+t_2)}{3(1+k^2)^2 t_1 t_2}$	$\frac{t_1+4t_3}{3(1+2k^2)^2 t_1 t_3}$	$-\frac{\sqrt{2}\,(t_1-2t_3)}{3(1+2k^2)t_1 t_3}$	$\frac{\sqrt{2}\,k(t_1+4t_3)}{3(1+2k^2)^2 t_1 t_3}$	$\frac{2k^2(t_1+4t_3)}{3(1+2k^2)^2 t_1 t_3}$
$\sigma_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	$\frac{2(t_1+t_3)}{3t_1 t_3}$	$-\frac{\sqrt{2}\,(t_1-2t_3)}{3(1+2k^2)t_1 t_3}$	$\frac{t_1+4t_3}{3(1+2k^2)^2 t_1 t_3}$	$-\frac{2ikt_1-4ikt_3}{3t_1 t_3+6k^2 t_1 t_3}$
$\sigma_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	$-\frac{\sqrt{2}\,(t_1-2t_3)}{3(1+2k^2)t_1 t_3}$	$\frac{2k^2}{3(1+2k^2)t_1 t_3}$	$-\frac{i\sqrt{2}\,k(t_1+4t_3)}{3(1+2k^2)^2 t_1 t_3}$	$\frac{2k^2(t_1+4t_3)}{3(1+2k^2)^2 t_1 t_3}$
$\tau_{1^-}^{\#1}{}^{\dagger\alpha}$	0	0	0	$\frac{2ikt_1-4ikt_3}{3t_1 t_3+6k^2 t_1 t_3}$	0	$\frac{i\sqrt{2}\,k(t_1+4t_3)}{3(1+2k^2)^2 t_1 t_3}$	$\frac{2k^2(t_1+4t_3)}{3(1+2k^2)^2 t_1 t_3}$
$\tau_{1^-}^{\#2}{}^{\dagger\alpha}$	0	0	0	0	0	0	0

Quadratic (free) action

$$
\begin{aligned}
S_F == \iiint\Big(&\tfrac{1}{6}(-2(t_1-2t_3)\,\omega_{\iota}^{\alpha\iota}\,\omega_{\kappa\alpha}{}^{\kappa} - 2(t_1-2t_2)\,\omega_{\iota}^{\kappa\lambda}\,\omega_{\kappa\lambda}{}' + 2t_1\,\omega_{\kappa\lambda}{}'\,\omega^{\kappa\lambda}{}_{\iota}' + 2t_2\\
&\omega_{\kappa\lambda}{}'\,\omega^{\kappa\lambda}{}_{\iota}' + 6f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} + 4r_2\,\partial^{\beta}\omega^{\theta\alpha}{}_{\kappa}\,\partial_{\theta}\omega_{\alpha\beta}{}^{\kappa} -\\
&2r_2\,\partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\,\partial_{\kappa}\omega^{\alpha\beta\theta} - 4r_2\,\partial_{\theta}\omega_{\alpha\beta}{}^{\kappa}\,\partial_{\kappa}\omega^{\theta\alpha\beta} - 2t_1\,\partial^{\alpha}f_{\kappa\theta}\,\partial^{\kappa}f_{\alpha}{}^{\theta} + 2t_1\,\partial^{\alpha}f_{\kappa\theta}\,\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_2\,\partial^{\alpha}f_{\kappa\theta}\,\partial^{\kappa}f_{\alpha}{}^{\theta} +\\
&t_2\,\partial^{\alpha}f^{\kappa\lambda}\,\partial_{\kappa}f_{\alpha\lambda} + 2t_1\,\omega_{\kappa\alpha}{}^{\alpha}\,\partial^{\kappa}f'_{\iota}{}^{\iota} + 2t_1\,\omega_{\kappa\lambda}{}^{\lambda}\,\partial^{\kappa}f'_{\iota}{}^{\iota} -\\
&4t_3\,\omega_{\kappa\lambda}{}^{\lambda}\,\partial^{\kappa}f'_{\iota}{}^{\iota} - 4t_1\,\partial^{\alpha}f_{\kappa\alpha}\,\partial^{\kappa}f'_{\iota}{}^{\iota} - 2t_1\,\partial_{\kappa}f^{\lambda}{}_{\lambda}\,\partial^{\kappa}f'_{\iota}{}^{\iota} + 8t_1\,\omega_{\iota\kappa\theta}\,\partial^{\kappa}f'^{\iota\theta} -\\
&4t_3\,\partial_{\kappa}f^{\kappa\lambda}\,\partial_{\lambda}f'_{\iota}{}^{\iota} + 2t_1\,\omega_{\iota\theta\kappa}\,\partial^{\kappa}f'^{\iota\theta} + 8t_1\,\omega_{\iota\kappa\theta}\,\partial^{\kappa}f'^{\iota\theta} - 2t_2\,\omega_{\theta\iota\kappa}\,\partial^{\kappa}f'^{\iota\theta} +\\
&4t_2\,\omega_{\iota\kappa\theta}\,\partial^{\kappa}f'^{\iota\theta} - 2t_1\,\omega_{\theta\iota\kappa}\,\partial^{\kappa}f'^{\iota\theta} + 4t_2\,\omega_{\theta\kappa\iota}\,\partial^{\kappa}f'^{\iota\theta} - 2t_1\,\omega_{\iota\alpha}{}^{\alpha}\,\partial^{\kappa}f'_{\kappa}{}^{\iota} + 4t_3\,\omega_{\iota\alpha}{}^{\alpha}\,\partial^{\kappa}f'_{\kappa}{}^{\iota} +\\
&4t_3\,\omega_{\iota\lambda}{}^{\lambda}\,\partial^{\kappa}f'_{\kappa}{}^{\iota} + 2t_1\,\partial^{\alpha}f^{\kappa\lambda}{}_{\kappa}\,\partial^{\kappa}f_{\lambda\alpha} - 2t_2\,\partial^{\alpha}f^{\lambda}{}_{\kappa}\,\partial^{\kappa}f_{\lambda\alpha} + 2t_1\,\partial_{\kappa}f_{\theta}{}^{\lambda}\,\partial^{\kappa}f_{\lambda}{}^{\theta} -\\
&t_2\,\partial_{\kappa}f_{\theta}{}^{\lambda}\,\partial^{\kappa}f_{\lambda}{}^{\theta} + 4t_1\,\partial_{\kappa}f^{\lambda}{}_{\theta}\,\partial^{\kappa}f_{\lambda}{}^{\theta} - 2t_1\,\partial^{\alpha}f_{\lambda}{}^{\theta}\,\partial^{\kappa}f_{\alpha}{}^{\lambda} + 2t_1\,\partial^{\alpha}f_{\lambda\kappa}\,\partial^{\kappa}f_{\alpha}{}^{\lambda} +\\
&4t_3\,\partial^{\alpha}f^{\kappa\lambda}\,\partial_{\alpha}f_{\lambda\kappa} + 2r_2\,\partial_{\kappa}\omega^{\alpha\beta\theta}\,\partial^{\kappa}\omega_{\alpha\beta\theta} - 4r_2\,\partial_{\kappa}\omega^{\theta\alpha\beta}\,\partial^{\kappa}\omega_{\alpha\beta\theta} -\\
&4r_2\,\partial^{\beta}\omega_{\iota}^{\alpha\lambda}\,\partial_{\lambda}\omega_{\alpha\beta}{}' + 4r_2\,\partial^{\beta}\omega_{\iota}^{\lambda\alpha}\,\partial_{\lambda}\omega_{\alpha\beta}{}')\Big)(t,x,y,z]\,dz\,dy\,dx\,dt
\end{aligned}
$$

Massive and massless spectra



Massive particle	
Pole residue:	$-\frac{1}{r_2} > 0$
Polarisations:	1
Square mass:	$-\frac{t_2}{r_2} > 0$
Spin:	0
Parity:	Odd

(No massless particles)

Unitarity conditions

$r_2 < 0 \;\&\&\; t_2 > 0$