Particle spectrograph

Wave operator and propagator

	$\sigma^{\#1}_{1^+\,\alpha\beta}$	$\sigma^{\#2}_{1^+\,\alpha\beta}$	$\tau^{\#1}_{1^+\,\alpha\beta}$	$\sigma^{\#1}_{1^-\,\alpha}$	$\sigma^{\#2}_{1^-\,\alpha}$	$\tau^{\#1}_{1^-\,\alpha}$	$\tau^{\#2}_{1^-\,\alpha}$
$\sigma^{\#1}_{1^+}{}^{\dagger\alpha\beta}$	$\frac{6}{(3+k^2)^2 t_2}$	$\frac{3\sqrt{2}}{(3+k^2)^2 t_2}$	$\frac{3i\sqrt{2}\,k}{(3+k^2)^2 t_2}$	0	0	0	0
$\sigma^{\#2}_{1^+}{}^{\dagger\alpha\beta}$	$\frac{3\sqrt{2}}{(3+k^2)^2 t_2}$	$\frac{3}{(3+k^2)^2 t_2}$	$\frac{3ik}{(3+k^2)^2 t_2}$	0	0	0	0
$\tau^{\#1}_{1^+}{}^{\dagger\alpha\beta}$	$-\frac{3i\sqrt{2}\,k}{(3+k^2)^2 t_2}$	$-\frac{3ik}{(3+k^2)^2 t_2}$	$\frac{3k^2}{(3+k^2)^2 t_2}$	0	0	0	0
$\sigma^{\#1}_{1^-}{}^{\dagger\alpha}$	0	0	0	$-\frac{2}{3k^2 r_3}$	$-\frac{2\sqrt{2}}{3k^2 r_3+6k^4 r_3}$	0	$-\frac{4i}{3k r_3+6k^3 r_3}$
$\sigma^{\#2}_{1^-}{}^{\dagger\alpha}$	0	0	0	$-\frac{2\sqrt{2}}{3k^2 r_3+6k^4 r_3}$	$\frac{9k^2 r_3-4t_3}{3(k+2k^3)^2 r_3 t_3}$	0	$\frac{i\sqrt{2}\,(9k^2 r_3-4t_3)}{3k(1+2k^2)^2 r_3 t_3}$
$\tau^{\#1}_{1^-}{}^{\dagger\alpha}$	0	0	0	0	0	0	0
$\tau^{\#2}_{1^-}{}^{\dagger\alpha}$	0	0	0	$\frac{4i}{3k r_3+6k^3 r_3}$	$-\frac{i\sqrt{2}\,(9k^2 r_3-4t_3)}{3k(1+2k^2)^2 r_3 t_3}$	0	$\frac{2(9k^2 r_3-4t_3)}{3(1+2k^2)^2 r_3 t_3}$

Quadratic (free) action

$$
\begin{aligned}
S == \iiint\Big(&\tfrac{1}{6}\,(-4t_3\,\omega^{\alpha\prime}{}_{\alpha}\,\omega_{\prime}{}^{\kappa}{}_{\kappa} + 6\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} + 8t_3\,\omega_{\alpha}{}^{\kappa}{}_{\kappa}\,\partial_{\prime}f^{\alpha\prime} - 8t_3\,\omega_{\prime}{}^{\kappa}{}_{\kappa}\\
&\partial^{\prime}f^{\alpha}{}_{\alpha} + 4t_3\,\partial_{\prime}f^{\kappa}{}_{\kappa}\partial^{\prime}f^{\alpha}{}_{\alpha} - 15r_3\,\partial_{\beta}\omega_{\prime}{}^{\theta}{}_{\theta}\partial^{\prime}\omega^{\alpha\beta}{}_{\alpha} + 9r_3\,\partial_{\prime}\omega_{\beta}{}^{\theta}{}_{\theta}\partial^{\prime}\omega^{\alpha\beta}{}_{\alpha} +\\
&9r_3\,\partial_{\alpha}\omega^{\alpha\beta\prime}\partial_{\theta}\omega_{\beta}{}^{\theta}{}_{\prime} - 18r_3\,\partial^{\prime}\omega^{\alpha\beta}{}_{\alpha}\partial_{\theta}\omega_{\beta}{}^{\theta}{}_{\prime} - 15r_3\,\partial_{\alpha}\omega^{\alpha\beta\prime}\partial_{\theta}\omega_{\prime}{}^{\theta}{}_{\beta} +\\
&30r_3\,\partial^{\prime}\omega^{\alpha\beta}{}_{\alpha}\partial_{\theta}\omega_{\prime}{}^{\theta}{}_{\beta} + 4t_2\,\omega_{\prime\theta\alpha}\,\partial^{\theta}f^{\alpha\prime} + 2t_2\,\partial_{\alpha}f_{\prime\theta}\partial^{\theta}f^{\alpha\prime} - t_2\,\partial_{\alpha}f_{\theta\prime}\partial^{\theta}f^{\alpha\prime} -\\
&t_2\,\partial_{\prime}f_{\alpha\theta}\partial^{\theta}f^{\alpha\prime} + t_2\,\partial_{\theta}f_{\alpha\prime}\partial^{\theta}f^{\alpha\prime} - t_2\,\partial_{\theta}f_{\prime\alpha}\partial^{\theta}f^{\alpha\prime} - 4t_2\,\omega_{\alpha\theta\prime}\,(\omega^{\alpha\prime\theta} + \partial^{\theta}f^{\alpha\prime}) +\\
&2t_2\,\omega_{\alpha\prime\theta}\,(\omega^{\alpha\prime\theta} + 2\,\partial^{\theta}f^{\alpha\prime}) + 8r_2\,\partial_{\beta}\omega_{\alpha\prime\theta}\partial^{\theta}\omega^{\alpha\beta\prime} - 4r_2\,\partial_{\beta}\omega_{\alpha\theta\prime}\partial^{\theta}\omega^{\alpha\beta\prime} + 4r_2\\
&\partial_{\beta}\omega_{\prime\theta\alpha}\partial^{\theta}\omega^{\alpha\beta\prime} - 24r_3\,\partial_{\beta}\omega_{\prime\theta\alpha}\partial^{\theta}\omega^{\alpha\beta\prime} - 2r_2\,\partial_{\prime}\omega_{\alpha\beta\theta}\partial^{\theta}\omega^{\alpha\beta\prime} + 2r_2\,\partial_{\theta}\omega_{\alpha\beta\prime}\partial^{\theta}\omega^{\alpha\beta\prime} -\\
&4r_2\,\partial_{\theta}\omega_{\alpha\prime\beta}\partial^{\theta}\omega^{\alpha\beta\prime} + 4t_3\,\partial_{\prime}f^{\alpha\prime}\,\partial_{\kappa}f_{\alpha}{}^{\kappa} - 8t_3\,\partial^{\prime}f^{\alpha}{}_{\alpha}\partial_{\kappa}f_{\prime}{}^{\kappa})\Big)[t, x, y, z]\,dz\,dy\,dx\,dt
\end{aligned}
$$

	$\omega^{\#1}_{1^+\,\alpha\beta}$	$\omega^{\#2}_{1^+\,\alpha\beta}$	$f^{\#1}_{1^+\,\alpha\beta}$	$\omega^{\#1}_{1^-\,\alpha}$	$\omega^{\#2}_{1^-\,\alpha}$	$f^{\#1}_{1^-\,\alpha}$	$f^{\#2}_{1^-\,\alpha}$
$\omega^{\#1}_{1^+}{}^{\dagger\alpha\beta}$	$\frac{2t_2}{3}$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{1}{3}i\sqrt{2}\,k t_2$	0	0	0	0
$\omega^{\#2}_{1^+}{}^{\dagger\alpha\beta}$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{t_2}{3}$	$\frac{ik t_2}{3}$	0	0	0	0
$f^{\#1}_{1^+}{}^{\dagger\alpha\beta}$	$-\frac{1}{3}i\sqrt{2}\,k t_2$	$-\frac{1}{3}ik t_2$	$\frac{k^2 t_2}{3}$	0	0	0	0
$\omega^{\#1}_{1^-}{}^{\dagger\alpha}$	0	0	0	$\frac{1}{6}(-9k^2 r_3 + 4t_3)$	$-\frac{\sqrt{2}\,t_3}{3}$	0	$-\frac{2}{3}ik t_3$
$\omega^{\#2}_{1^-}{}^{\dagger\alpha}$	0	0	0	$-\frac{\sqrt{2}\,t_3}{3}$	$\frac{t_3}{3}$	0	$\frac{1}{3}i\sqrt{2}\,k t_3$
$f^{\#1}_{1^-}{}^{\dagger\alpha}$	0	0	0	0	0	0	0
$f^{\#2}_{1^-}{}^{\dagger\alpha}$	0	0	0	$\frac{2ik t_3}{3}$	$-\frac{1}{3}i\sqrt{2}\,k t_3$	0	$\frac{2k^2 t_3}{3}$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau^{\#2}_{0^+} == 0$	1
$\tau^{\#1}_{0^+} - 2ik\,\sigma^{\#1}_{0^+} == 0$	1
$\tau^{\#2\,\alpha}_{1^-} + 2ik\,\sigma^{\#2\,\alpha}_{1^-} == 0$	3
$\tau^{\#1\,\alpha}_{1^-} == 0$	3
$\tau^{\#1\,\alpha\beta}_{1^+} + ik\,\sigma^{\#1\,\alpha\beta}_{1^+} == 0$	3
$\sigma^{\#1\,\alpha\beta}_{1^+} == \sigma^{\#2\,\alpha\beta}_{1^+}$	3
$\sigma^{\#1\,\alpha\beta\chi}_{2^-} == 0$	5
$\tau^{\#1\,\alpha\beta}_{2^+} == 0$	5
Total constraints:	24

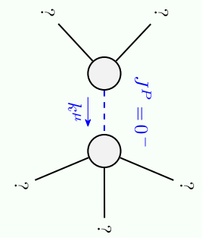
	$\sigma^{\#1}_{0^+}$	$\tau^{\#1}_{0^+}$	$\tau^{\#2}_{0^+}$	$\sigma^{\#1}_{0^-}$
$\sigma^{\#1}_{0^+}{}^{\dagger}$	$\frac{1}{(1+2k^2)^2 t_3}$	$-\frac{i\sqrt{2}\,k}{(1+2k^2)^2 t_3}$	0	0
$\tau^{\#1}_{0^+}{}^{\dagger}$	$\frac{i\sqrt{2}\,k}{(1+2k^2)^2 t_3}$	$\frac{2k^2}{(1+2k^2)^2 t_3}$	0	0
$\tau^{\#2}_{0^+}{}^{\dagger}$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

	$\sigma^{\#1}_{2^+\,\alpha\beta}$	$\tau^{\#1}_{2^+\,\alpha\beta}$	$\sigma^{\#1}_{2^-\,\alpha\beta\chi}$
$\sigma^{\#1}_{2^+}{}^{\dagger\alpha\beta}$	$-\frac{2}{3k^2 r_3}$	0	0
$\tau^{\#1}_{2^+}{}^{\dagger\alpha\beta}$	0	0	0
$\sigma^{\#1}_{2^-}{}^{\dagger\alpha\beta\chi}$	0	0	0

	$\omega^{\#1}_{0^+}$	$f^{\#1}_{0^+}$	$f^{\#2}_{0^+}$	$\omega^{\#1}_{0^-}$
$\omega^{\#1}_{0^+}{}^{\dagger}$	t_3	$-i\sqrt{2}\,k t_3$	0	0
$f^{\#1}_{0^+}{}^{\dagger}$	$i\sqrt{2}\,k t_3$	$2k^2 t_3$	0	0
$f^{\#2}_{0^+}{}^{\dagger}$	0	0	0	0
$\omega^{\#1}_{0^-}{}^{\dagger}$	0	0	0	$k^2 r_2 + t_2$

	$\omega^{\#1}_{2^+\,\alpha\beta}$	$f^{\#1}_{2^+\,\alpha\beta}$	$\omega^{\#1}_{2^-\,\alpha\beta\chi}$
$\omega^{\#1}_{2^+}{}^{\dagger\alpha\beta}$	$-\frac{3k^2 r_3}{2}$	0	0
$f^{\#1}_{2^+}{}^{\dagger\alpha\beta}$	0	0	0
$\omega^{\#1}_{2^-}{}^{\dagger\alpha\beta\chi}$	0	0	0

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

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