Particle spectrograph

Wave operator and propagator

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

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

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

Quadratic (free) action

$$S == \iiint\!\!\int \Big(\tfrac{1}{6}\big(2 t_1\, \omega^{\alpha\iota}{}_{\alpha}\, \omega_{\iota}{}^{\theta}{}_{\theta} - 4 t_3\, \omega^{\alpha\iota}{}_{\alpha}\, \omega_{\iota}{}^{\kappa}{}_{\kappa} + 6 f^{\alpha\beta}\, \tau_{\alpha\beta} + 6\, \omega^{\alpha\beta\chi}\, \sigma_{\alpha\beta\chi} - 4 t_1\, \omega_{\alpha}{}^{\theta}{}_{\theta}\, \partial_{\iota} f^{\alpha\iota} + 8 t_3\, \omega_{\alpha}{}^{\kappa}{}_{\kappa}\, \partial_{\iota} f^{\alpha\iota} + 4 t_1\, \omega_{\iota}{}^{\theta}{}_{\theta}\, \partial^{\iota} f^{\alpha}{}_{\alpha} - 8 t_3\, \omega_{\iota}{}^{\kappa}{}_{\kappa}\, \partial^{\iota} f^{\alpha}{}_{\alpha} -$$
$$2 t_1\, \partial_{\iota} f^{\theta}{}_{\theta}\, \partial^{\iota} f^{\alpha}{}_{\alpha} + 4 t_3\, \partial_{\iota} f^{\kappa}{}_{\kappa}\, \partial^{\iota} f^{\alpha}{}_{\alpha} - 2 t_1\, \partial_{\iota} f^{\alpha\iota}\, \partial_{\theta} f_{\alpha}{}^{\theta} + 4 t_1\, \partial^{\iota} f^{\alpha}{}_{\alpha}\, \partial_{\theta} f_{\iota}{}^{\theta} +$$
$$4 t_1\, \omega_{\iota\theta\alpha}\, \partial^{\theta} f^{\alpha\iota} + 4 t_2\, \omega_{\iota\theta\alpha}\, \partial^{\theta} f^{\alpha\iota} - 4 t_1\, \partial_{\alpha} f_{\iota\theta}\, \partial^{\theta} f^{\alpha\iota} + 2 t_2\, \partial_{\alpha} f_{\iota\theta}\, \partial^{\theta} f^{\alpha\iota} -$$
$$4 t_1\, \partial_{\alpha} f_{\theta\iota}\, \partial^{\theta} f^{\alpha\iota} - 2 t_2\, \partial_{\alpha} f_{\theta\iota}\, \partial^{\theta} f^{\alpha\iota} + 2 t_1\, \partial_{\iota} f_{\alpha\theta}\, \partial^{\theta} f^{\alpha\iota} - t_2\, \partial_{\iota} f_{\alpha\theta}\, \partial^{\theta} f^{\alpha\iota} +$$
$$4 t_1\, \partial_{\theta} f_{\alpha\iota}\, \partial^{\theta} f^{\alpha\iota} + t_2\, \partial_{\theta} f_{\alpha\iota}\, \partial^{\theta} f^{\alpha\iota} + 2 t_1\, \partial_{\theta} f_{\iota\alpha}\, \partial^{\theta} f^{\alpha\iota} - t_2\, \partial_{\theta} f_{\iota\alpha}\, \partial^{\theta} f^{\alpha\iota} +$$
$$2 (t_1 + t_2)\, \omega_{\alpha\iota\theta}\, (\omega^{\alpha\iota\theta} + 2\, \partial^{\theta} f^{\alpha\iota}) + 2\, \omega_{\alpha\theta\iota}\, ((t_1 - 2 t_2)\, \omega^{\alpha\iota\theta} + 2 (2 t_1 - t_2)\, \partial^{\theta} f^{\alpha\iota}) +$$
$$8 r_2\, \partial_{\beta}\omega_{\alpha\iota\theta}\, \partial^{\theta}\omega^{\alpha\beta\iota} - 4 r_2\, \partial_{\beta}\omega_{\alpha\theta\iota}\, \partial^{\theta}\omega^{\alpha\beta\iota} + 4 r_2\, \partial_{\beta}\omega_{\iota\theta\alpha}\, \partial^{\theta}\omega^{\alpha\beta\iota} -$$
$$2 r_2\, \partial_{\iota}\omega_{\alpha\beta\theta}\, \partial^{\theta}\omega^{\alpha\beta\iota} + 2 r_2\, \partial_{\theta}\omega_{\alpha\beta\iota}\, \partial^{\theta}\omega^{\alpha\beta\iota} - 4 r_2\, \partial_{\theta}\omega_{\alpha\iota\beta}\, \partial^{\theta}\omega^{\alpha\beta\iota} +$$
$$4 t_3\, \partial_{\iota} f^{\alpha\iota}\, \partial_{\kappa} f_{\alpha}{}^{\kappa} - 8 t_3\, \partial^{\iota} f^{\alpha}{}_{\alpha}\, \partial_{\kappa} f_{\iota}{}^{\kappa}\big)\Big)[t, x, y, z]\, dz\, dy\, dx\, dt$$

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

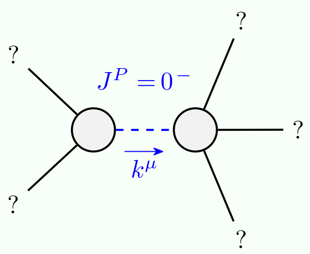
Source constraints/gauge generators

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

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

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

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

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