Particle spectrograph

Wave operator and propagator

	$\omega^{\#1}_{1^+\alpha\beta}$	$\omega^{\#2}_{1^+\alpha\beta}$	$f^{\#1}_{1^+\alpha\beta}$	$\omega^{\#1}_{1^-\alpha}$	$\omega^{\#2}_{1^-\alpha}$	$f^{\#1}_{1^-\alpha}$	$f^{\#2}_{1^-\alpha}$
$\omega^{\#1}_{1^+}\dagger^{\alpha\beta}$	$k^2(2r_3+r_5)+\frac{2t_2}{3}$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{1}{3}i\sqrt{2}\,kt_2$	0	0	0	0
$\omega^{\#2}_{1^+}\dagger^{\alpha\beta}$	$\frac{\sqrt{2}\,t_2}{3}$	$\frac{t_2}{3}$	$\frac{ikt_2}{3}$	0	0	0	0
$f^{\#1}_{1^+}\dagger^{\alpha\beta}$	$-\frac{1}{3}i\sqrt{2}\,kt_2$	$-\frac{1}{3}ikt_2$	$\frac{k^2 t_2}{3}$	0	0	0	0
$\omega^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	$k^2(\frac{r_3}{2}+r_5)+\frac{2t_3}{3}$	$-\frac{\sqrt{2}\,t_3}{3}$	0	$-\frac{2}{3}ikt_3$
$\omega^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$-\frac{\sqrt{2}\,t_3}{3}$	$\frac{t_3}{3}$	0	$\frac{1}{3}i\sqrt{2}\,kt_3$
$f^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	0	0	0	0
$f^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{2ikt_3}{3}$	$-\frac{1}{3}i\sqrt{2}\,kt_3$	0	$\frac{2k^2t_3}{3}$

Propagator table:

	$\sigma^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\sigma^{\#2}_{1^+}\dagger^{\alpha\beta}$	$\tau^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\sigma^{\#1}_{1^-}\dagger^{\alpha}$	$\sigma^{\#2}_{1^-}\dagger^{\alpha}$	$\tau^{\#1}_{1^-}\dagger^{\alpha}$	$\tau^{\#2}_{1^-}\dagger^{\alpha}$
$\tau^{\#2}_{1^-\alpha}$	0	0	0	$\frac{4i}{k(1+2k^2)(r_3+2r_5)}$	$\frac{i\sqrt{2}(3k^2(r_3+2r_5)+4t_3)}{k(1+2k^2)^2(r_3+2r_5)t_3}$	0	$\frac{6k^2(r_3+2r_5)+8t_3}{(1+2k^2)^2(r_3+2r_5)t_3}$
$\tau^{\#1}_{1^-\alpha}$	0	0	0	0	0	0	0
$\sigma^{\#2}_{1^-\alpha}$	0	0	0	$\frac{2\sqrt{2}}{k^2(1+2k^2)^2(r_3+2r_5)}$	$\frac{3k^2(r_3+2r_5)+4t_3}{3k^2(1+2k^2)^2(r_3+2r_5)t_3}$	0	$-\frac{i\sqrt{2}(3k^2(r_3+2r_5)+4t_3)}{k(1+2k^2)^2(r_3+2r_5)t_3}$
$\sigma^{\#1}_{1^-\alpha}$	0	0	0	$\frac{2}{k^2(r_3+2r_5)}$	$\frac{2\sqrt{2}}{k^2(1+2k^2)^2(r_3+2r_5)}$	0	$-\frac{4i}{k(1+2k^2)(r_3+2r_5)}$
$\tau^{\#1}_{1^+\alpha\beta}$	$-\frac{i\sqrt{2}}{k(1+k^2)(2r_3+r_5)}$	$-\frac{i(3k^2(2r_3+r_5)+2t_2)}{k(1+k^2)^2(2r_3+r_5)t_2}$	$\frac{3k^2(2r_3+r_5)+2t_2}{(1+k^2)^2(2r_3+r_5)t_2}$	0	0	0	0
$\sigma^{\#2}_{1^+\alpha\beta}$	$-\frac{\sqrt{2}}{k^2(1+k^2)^2(2r_3+r_5)}$	$\frac{3k^2(2r_3+r_5)+2t_2}{(k+k^2)^2(2r_3+r_5)t_2}$	$\frac{i(3k^2(2r_3+r_5)+2t_2)}{k(1+k^2)^2(2r_3+r_5)t_2}$	0	0	0	0
$\sigma^{\#1}_{1^+\alpha\beta}$	$\frac{1}{k^2(2r_3+r_5)}$	$\frac{\sqrt{2}}{k^2(1+k^2)^2(2r_3+r_5)}$	$\frac{i\sqrt{2}}{k(1+k^2)(2r_3+r_5)}$	0	0	0	0

σ_{2} block:

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

ω_{2} block:

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

ω_0 block:

	$\omega^{\#1}_{0^+}\dagger$	$f^{\#1}_{0^+}\dagger$	$f^{\#2}_{0^+}\dagger$	$\omega^{\#1}_{0^-}\dagger$
$\omega^{\#1}_{0^-}$	0	0	0	$k^2 r_2+t_2$
$f^{\#2}_{0^+}$	0	0	0	0
$f^{\#1}_{0^+}$	0	$-i\sqrt{2}\,kt_3$	$2k^2 t_3$	0
$\omega^{\#1}_{0^+}$	t_3	$i\sqrt{2}\,kt_3$	0	0

σ_0 block:

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

Quadratic (free) action

$\mathcal{S} ==$

$$\iiint [\tfrac{1}{6}(-4t_3\,\omega^{\alpha}{}_{\alpha}{}^{\kappa}\,\omega_{\iota\kappa}{}^{\iota} + 6\,f^{\alpha}{}_{\alpha}\,f^{\kappa}{}_{\kappa} + 6\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} + 8t_3\,\omega_{\alpha}{}^{\kappa}{}_{\kappa}\,\partial_{\iota}f^{\alpha\iota} - 8t_3\,\omega_{\iota}{}^{\kappa}{}_{\kappa}$$
$$\partial^{\iota}f^{\alpha}{}_{\alpha} + 4t_3\,\partial_{\iota}f^{\kappa}{}_{\kappa}\,\partial^{\iota}f^{\alpha}{}_{\alpha} - 3r_3\,\partial_{\beta}\omega^{\theta}_{\iota\theta}\,\partial^{\iota}\omega^{\alpha\beta}{}_{\alpha} - 3r_3\,\partial_{\iota}\omega^{\alpha\beta}{}_{\beta}{}^{\theta}\,\partial^{\iota}\omega^{\theta}_{\alpha} -$$
$$3r_3\,\partial_{\alpha}\omega^{\alpha\beta\iota}\,\partial_{\theta}\omega^{\theta}_{\beta\iota} + 6r_3\,\partial^{\iota}\omega^{\alpha\beta}{}_{\beta\iota}\,\partial_{\theta}\omega^{\theta}{}_{\alpha} + 4t_2\,\omega_{\iota\theta\alpha}\,\partial_{\theta}\omega^{\theta}{}_{\iota\beta} +$$
$$6r_3\,\partial^{\iota}\omega^{\alpha\beta}{}_{\alpha}\,\partial_{\theta}\omega^{\theta}{}_{\iota\beta} + 2t_2\,\partial_{\alpha}f_{\iota\theta}\,\partial^{\theta}f^{\alpha\iota} - t_2\,\partial_{\alpha}f_{\theta\iota}\,\partial^{\theta}f^{\alpha\iota} -$$
$$t_2\,\partial_{\iota}f_{\alpha\theta}\,\partial^{\theta}f^{\alpha\iota} + t_2\,\partial_{\theta}f_{\alpha\iota}\,\partial^{\theta}f^{\alpha\iota} - 4t_2\,\omega_{\alpha\theta\iota}\,(\omega^{\alpha\iota\theta}+\partial^{\theta}f^{\alpha\iota}) +$$
$$2t_2\,\omega_{\alpha\iota\theta}\,(\omega^{\alpha\iota\theta}+2\partial^{\theta}f^{\alpha\iota}) + 8r_2\,\partial_{\theta}\omega_{\iota\theta\alpha}\,\partial^{\theta}\omega^{\alpha\beta\iota} - 4r_2\,\partial_{\beta}\omega_{\alpha\theta\iota}\,\partial^{\theta}\omega^{\alpha\beta\iota} +$$
$$\partial^{\theta}\omega^{\alpha\beta\iota} - 4r_2\,\partial_{\theta}\omega_{\alpha\iota\beta}\,\partial^{\theta}\omega^{\alpha\beta\iota} + 6r_5\,\partial_{\theta}\omega_{\iota}{}^{\kappa}{}_{\alpha}\,\partial^{\theta}\omega^{\alpha\iota}{}_{\kappa} - 6r_5\,\partial_{\theta}\omega_{\iota}{}^{\kappa}{}_{\alpha}\,\partial^{\theta}\omega^{\alpha\iota}{}_{\kappa} +$$
$$4t_3\,\partial_{\iota}f^{\alpha\iota}\,\partial_{\kappa}f^{\alpha}{}_{\alpha} - 8t_3\,\partial f^{\alpha}{}_{\alpha}\,\partial_{\kappa}f_{\iota}{}^{\kappa} - 6r_5\,\partial_{\alpha}\omega^{\alpha\iota\theta}\,\partial_{\kappa}\omega_{\iota}{}^{\kappa}{}_{\theta} +$$
$$6r_5\,\partial_{\alpha}\omega^{\alpha\iota\theta}\,\partial_{\kappa}\omega_{\theta\iota}{}^{\kappa} - 12r_5\,\partial^{\theta}\omega^{\alpha\iota}{}_{\alpha}\,\partial_{\kappa}\omega_{\theta\iota}{}^{\kappa})][t,\,x,\,y,\,z]\,dz\,dy\,dx\,dt$$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$t^{\#2}_{0^+}==0$	1
$t^{\#1}_{0^+}-2ik\sigma^{\#1}_{0^+}==0$	1
$\tau^{\#2\alpha}_{1^-}+2ik\sigma^{\#2\alpha}_{1^-}==0$	3
$\tau^{\#1\alpha}_{1^-}==0$	3
$\tau^{\#1\alpha\beta}_{1^+}+ik\sigma^{\#2\alpha\beta}_{1^+}==0$	3
$\sigma^{\#1\alpha\beta\chi}_{2^-}==0$	5
$\tau^{\#1\alpha\beta}_{2^+}==0$	5
Total constraints:	21

Massive and massless spectra

Massive particle ($J^P=0^-$, momentum k^μ)

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

Quadratic pole (momentum k^μ)

Pole residue:	$-\frac{1}{r_3(2r_3+r_5)(r_3+2r_5)p^2}>0$
Polarisations:	2

Unitarity conditions

$r_2<0\,\&\&\,r_3<0\,\&\&\,r_5<-\frac{r_3}{2}\,\&\&\,t_2>0\ \|\ r_2<0\,\&\&\,r_3<0\,\&\&\,r_5>-2r_3\,\&\&\,t_2>0\ \|\ r_2<0\,\&\&\,r_3>0\,\&\&\,-2r_3<r_5<-\frac{r_3}{2}\,\&\&\,t_2>0$