Particle spectrograph

Wave operator and propagator

Quadratic (free) Lagrangian density

$$-\frac{1}{3} t_1 \omega_{\prime}^{\alpha\prime} \omega_{\kappa\alpha}^{\kappa} - t_1 \omega_{\prime}^{\kappa\lambda} \omega_{\kappa\lambda}^{\prime} + f^{\alpha\beta} \tau_{\alpha\beta} + \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} +$$
$$r_1 \partial_{\prime} \omega^{\kappa\lambda}{}_{\kappa}{}^{\prime} \partial \omega_{\lambda}{}^{\alpha}{}_{\alpha} - \frac{2}{3} r_1 \partial^{\beta} \omega^{\theta\alpha}{}_{\kappa}{}^{\kappa} \partial_{\theta} \omega_{\alpha\beta}{}^{\kappa} - \frac{2}{3} r_1 \partial_{\theta} \omega_{\alpha\beta}{}^{\kappa} \partial_{\kappa} \omega^{\alpha\beta\theta} +$$
$$\frac{2}{3} r_1 \partial_{\theta} \omega_{\alpha\beta}{}^{\kappa} \partial_{\kappa} \omega^{\theta\alpha\beta} - 3 r_1 \partial_{\alpha} \omega_{\lambda}{}^{\alpha}{}_{\theta} \partial_{\kappa} \omega^{\theta\kappa\lambda} + 4 r_3 \partial_{\alpha} \omega_{\lambda}{}^{\alpha}{}_{\theta} \partial_{\kappa} \omega^{\theta\kappa\lambda} +$$
$$3 r_1 \partial_{\theta} \omega_{\lambda}{}^{\alpha}{}_{\alpha} \partial_{\kappa} \omega^{\theta\kappa\lambda} - 4 r_3 \partial_{\theta} \omega_{\lambda}{}^{\alpha}{}_{\alpha} \partial_{\kappa} \omega^{\theta\kappa\lambda} + r_1 \partial_{\alpha} \omega_{\lambda}{}^{\alpha}{}_{\theta} \partial_{\kappa} \omega^{\kappa\lambda\theta} -$$
$$2 r_1 \partial_{\theta} \omega_{\lambda}{}^{\alpha}{}_{\alpha} \partial_{\kappa} \omega^{\kappa\lambda\theta} - \frac{1}{2} t_1 \partial^{\alpha} f_{\theta\kappa} \partial^{\kappa} f_{\alpha}{}^{\theta} - \frac{1}{2} t_1 \partial^{\alpha} f_{\kappa\theta} \partial^{\kappa} f_{\alpha}{}^{\theta} -$$
$$\frac{1}{2} t_1 \partial^{\alpha} f^{\kappa\lambda} \partial^{\kappa} f_{\alpha\lambda} + \frac{1}{3} t_1 \omega_{\kappa\alpha}{}^{\alpha} \partial^{\kappa} f_{\prime}^{\prime} + \frac{1}{3} t_1 \omega_{\kappa\lambda}{}^{\lambda} \partial^{\kappa} f_{\prime}^{\prime} + \frac{2}{3} t_1 \partial^{\alpha} f_{\kappa\alpha} \partial^{\kappa} f_{\prime}^{\prime} -$$
$$\frac{1}{3} t_1 \partial_{\kappa} f_{\lambda}{}^{\lambda} \partial^{\kappa} f_{\prime}^{\prime} + 2 t_1 \omega_{\prime\kappa\theta} \partial^{\kappa} f^{\prime\theta} - \frac{1}{3} t_1 \omega_{\prime\alpha}{}^{\alpha} \partial^{\kappa} f_{\kappa}^{\prime} - \frac{1}{3} t_1 \omega_{\prime\lambda}{}^{\lambda} \partial^{\kappa} f_{\kappa}^{\prime} +$$
$$\frac{1}{2} t_1 \partial_{\kappa} f_{\theta}{}^{\lambda} \partial^{\kappa} f_{\lambda}{}^{\theta} + \frac{1}{2} t_1 \partial_{\kappa} f^{\prime\lambda} \partial^{\kappa} f_{\lambda}{}^{\theta} - \frac{1}{3} t_1 \partial^{\alpha} f_{\lambda}{}^{\lambda} \partial^{\kappa} f_{\kappa\alpha} +$$
$$\frac{1}{2} t_1 \partial^{\alpha} f_{\kappa}{}^{\lambda} \partial^{\kappa} f_{\lambda\alpha} + \frac{1}{2} t_1 \partial^{\alpha} f_{\lambda}{}^{\lambda} \partial^{\kappa} f_{\kappa\alpha} + \frac{1}{3} t_1 \partial^{\alpha} f_{\kappa}{}^{\kappa} \partial^{\lambda} f_{\lambda\alpha} +$$
$$\frac{2}{3} r_1 \partial_{\kappa} \omega^{\alpha\beta\theta} \partial^{\kappa} \omega_{\alpha\beta\theta} + \frac{2}{3} r_1 \partial^{\beta} \omega_{\prime}^{\alpha\lambda} \partial_{\lambda} \omega_{\alpha\beta}{}^{\prime} +$$
$$\frac{4}{3} r_1 \partial^{\beta} \omega_{\prime}^{\lambda\alpha} \partial_{\lambda} \omega_{\alpha\beta}{}^{\prime} - 4 r_3 \partial^{\beta} \omega_{\prime}^{\lambda\alpha} \partial_{\lambda} \omega_{\alpha\beta}{}^{\prime} + 3 r_1 \partial_{\alpha} \omega_{\lambda}{}^{\alpha}{}_{\theta} \partial^{\lambda} \omega^{\theta\kappa}{}_{\kappa} -$$
$$4 r_3 \partial_{\alpha} \omega_{\lambda}{}^{\alpha}{}_{\theta} \partial^{\lambda} \omega^{\theta\kappa}{}_{\kappa} - 3 r_1 \partial_{\theta} \omega_{\lambda}{}^{\alpha}{}_{\alpha} \partial^{\lambda} \omega^{\theta\kappa}{}_{\kappa} + 4 r_3 \partial_{\theta} \omega_{\lambda}{}^{\alpha}{}_{\alpha} \partial^{\lambda} \omega^{\theta\kappa}{}_{\kappa}$$

$\sigma_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\sigma_{1^+}^{\#2}{}^{\alpha\beta}$	$\tau_{1^+}^{\#1}{}^{\alpha\beta}$	$\sigma_{1^-}^{\#1}{}^{\alpha}$	$\sigma_{1^-}^{\#2}{}^{\alpha}$	$\tau_{1^-}^{\#1}{}^{\alpha}$	$\tau_{1^-}^{\#2}{}^{\alpha}$
0	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$-\frac{i\sqrt{2}\,k}{t_1+k^2 t_1}$	0	0	0	0
$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$\frac{-2k^2 r_1+t_1}{(1+k^2)^2 t_1^2}$	$-\frac{i(2k^3 r_1-k t_1)}{(1+k^2)^2 t_1^2}$	0	0	0	0
$-\frac{i\sqrt{2}\,k}{t_1+k^2 t_1}$	$-\frac{i(2k^3 r_1-k t_1)}{(1+k^2)^2 t_1^2}$	$\frac{-2k^4 r_1+k^2 t_1}{(1+k^2)^2 t_1^2}$	0	0	0	0
0	0	0	$\frac{6}{(3+4k^2)^2 t_1}$	$\frac{6\sqrt{2}}{(3+4k^2)^2 t_1}$	0	$\frac{12 i k}{(3+4k^2)^2 t_1}$
0	0	0	$\frac{6\sqrt{2}}{(3+4k^2)^2 t_1}$	$\frac{12}{(3+4k^2)^2 t_1}$	0	$\frac{12 i\sqrt{2}\,k}{(3+4k^2)^2 t_1}$
0	0	0	0	0	0	0
0	0	0	$-\frac{12 i k}{(3+4k^2)^2 t_1}$	$-\frac{12 i\sqrt{2}\,k}{(3+4k^2)^2 t_1}$	0	$\frac{24k^2}{(3+4k^2)^2 t_1}$

$\omega_{1^+}^{\#1}{}^{\dagger\alpha\beta}$	$\omega_{1^+}^{\#2}{}^{\alpha\beta}$	$f_{1^+}^{\#1}{}^{\alpha\beta}$	$\omega_{1^-}^{\#1}{}^{\alpha}$	$\omega_{1^-}^{\#2}{}^{\alpha}$	$f_{1^-}^{\#1}{}^{\alpha}$	$f_{1^-}^{\#2}{}^{\alpha}$
$k^2 r_1 - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$\frac{i k t_1}{\sqrt{2}}$	0	0	0	0
$-\frac{t_1}{\sqrt{2}}$	0	0	$\frac{t_1}{6}$	$\frac{t_1}{3\sqrt{2}}$	0	$\frac{i k t_1}{3}$
$\frac{i k t_1}{\sqrt{2}}$	0	0	$\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	0	$\frac{1}{3} i\sqrt{2}\, k t_1$
0	0	0	0	0	0	0
0	0	0	$-\frac{1}{3} i k t_1$	$-\frac{1}{3} i\sqrt{2}\, k t_1$	0	$\frac{2k^2 t_1}{3}$

	$\sigma_{2^+}^{\#1}{}_{\alpha\beta}$	$\tau_{2^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{2^-}^{\#1}{}_{\alpha\beta\chi}$
$\sigma_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{2}{(1+2k^2)^2 t_1}$	$-\frac{2 i\sqrt{2}\,k}{(1+2k^2)^2 t_1}$	0
$\tau_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{2 i\sqrt{2}\,k}{(1+2k^2)^2 t_1}$	$\frac{4k^2}{(1+2k^2)^2 t_1}$	0
$\sigma_{2^-}^{\#1}{}^{\dagger\alpha\beta\chi}$	0	0	$\frac{2}{2k^2 r_1+t_1}$

	$\omega_{2^+}^{\#1}{}_{\alpha\beta}$	$f_{2^+}^{\#1}{}_{\alpha\beta}$	$\omega_{2^-}^{\#1}{}_{\alpha\beta\chi}$
$\omega_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{i k t_1}{\sqrt{2}}$	0
$f_{2^+}^{\#1}{}^{\dagger\alpha\beta}$	$\frac{i k t_1}{\sqrt{2}}$	$k^2 t_1$	0
$\omega_{2^-}^{\#1}{}^{\dagger\alpha\beta\chi}$	0	0	$k^2 r_1 + \frac{t_1}{2}$

Source constraints/gauge generators

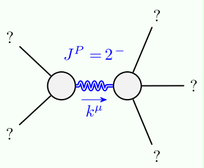
SO(3) irreps	Multiplicities
$\tau_{0^+}^{\#2} == 0$	1
$\tau_{0^+}^{\#1} == 0$	1
$\tau_{1^-}^{\#2\alpha} + 2 i k\ \sigma_{1^-}^{\#1\alpha} == 0$	3
$\tau_{1^-}^{\#1\alpha} == 0$	3
$\sigma_{1^-}^{\#1\alpha} == \sigma_{1^-}^{\#2\alpha}$	3
$\tau_{1^+}^{\#1\alpha\beta} + i k\ \sigma_{1^+}^{\#2\alpha\beta} == 0$	3
$\tau_{2^+}^{\#1\alpha\beta} - 2 i k\ \sigma_{2^+}^{\#1\alpha\beta} == 0$	5
Total constraints:	19

	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}{}^{\dagger}$	0	0	$-t_1$
$f_{0^+}^{\#1}{}^{\dagger}$	0	0	0
$f_{0^+}^{\#2}{}^{\dagger}$	0	0	0
$\omega_{0^-}^{\#1}{}^{\dagger}$	$-t_1$	0	0

	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1}{}^{\dagger}$	0	0	$-\frac{1}{t_1}$
$\tau_{0^+}^{\#1}{}^{\dagger}$	0	0	0
$\tau_{0^+}^{\#2}{}^{\dagger}$	0	0	0
$\sigma_{0^-}^{\#1}{}^{\dagger}$	$-\frac{1}{t_1}$	0	0

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}{}^{\dagger}$	$6k^2(-r_1+r_3)$	0	0	0
$f_{0^+}^{\#1}{}^{\dagger}$	0	0	0	0
$f_{0^+}^{\#2}{}^{\dagger}$	0	0	0	0
$\omega_{0^-}^{\#1}{}^{\dagger}$	0	0	0	0

Massive and massless spectra



Massive particle	
Pole residue:	$-\frac{1}{r_1} > 0$
Polarisations:	5
Square mass:	$-\frac{t_1}{2 r_1} > 0$
Spin:	2
Parity:	Odd

(No massless particles)

Unitarity conditions

$r_1 < 0 \,\&\&\, t_1 > 0$