Particle spectrograph

Lagrangian density

$$-\frac{1}{3} t_1\ \omega_{\iota}{}^{\alpha\iota}\ \omega_{\kappa\alpha}{}^{\kappa} - t_1\ \omega_{\iota}{}^{\kappa\lambda}\ \omega_{\kappa\lambda}{}^{\iota} - 2\, r_3\, \partial_{\iota}\omega^{\kappa\lambda}{}_{\kappa}\partial^{\iota}\omega_{\lambda}{}^{\alpha}{}_{\alpha} - r_5\, \partial_{\iota}\omega^{\kappa\lambda}{}_{\kappa}\partial^{\iota}\omega_{\lambda}{}^{\alpha}{}_{\alpha} + 2\, r_3\, \partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial_{\kappa}\omega^{\theta\kappa\lambda} - r_5\, \partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial_{\kappa}\omega^{\theta\kappa\lambda} -$$
$$2\, r_3\, \partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial_{\kappa}\omega^{\theta\kappa\lambda} + r_5\, \partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial_{\kappa}\omega^{\theta\kappa\lambda} - 2\, r_3\, \partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial_{\kappa}\omega^{\kappa\lambda\theta} - r_5\, \partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial_{\kappa}\omega^{\kappa\lambda\theta} + 4\, r_3\, \partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial_{\kappa}\omega^{\kappa\lambda\theta} + 2\, r_5\, \partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial_{\kappa}\omega^{\kappa\lambda\theta} -$$
$$\frac{1}{2} t_1\, \partial^{\alpha}f_{\theta\kappa}\partial^{\kappa}f_{\alpha}{}^{\theta} - \frac{1}{2} t_1\, \partial^{\alpha}f_{\kappa\theta}\partial^{\kappa}f_{\alpha}{}^{\theta} - \frac{1}{2} t_1\, \partial^{\alpha}f^{\lambda}{}_{\kappa}\partial^{\kappa}f_{\alpha\lambda} + \frac{1}{3} t_1\ \omega_{\kappa\alpha}{}^{\alpha}\,\partial^{\kappa}f^{\prime}{}_{\iota} + \frac{1}{3} t_1\ \omega_{\kappa\lambda}{}^{\lambda}\,\partial^{\kappa}f^{\prime}{}_{\iota} + \frac{2}{3} t_1\, \partial^{\alpha}f_{\kappa\alpha}\partial^{\kappa}f^{\prime}{}_{\iota} -$$
$$\frac{1}{3} t_1\, \partial_{\kappa}f^{\lambda}{}_{\lambda}\partial^{\kappa}f^{\prime}{}_{\iota} + 2\, t_1\ \omega_{\iota\kappa\theta}\,\partial^{\kappa}f^{\iota\theta} - \frac{1}{3} t_1\ \omega_{\iota\alpha}{}^{\alpha}\,\partial^{\kappa}f^{\prime}{}_{\kappa} - \frac{1}{3} t_1\ \omega_{\iota\lambda}{}^{\lambda}\,\partial^{\kappa}f^{\prime}{}_{\kappa} + \frac{1}{2} t_1\, \partial^{\alpha}f^{\lambda}{}_{\kappa}\partial^{\kappa}f_{\lambda\alpha} + \frac{1}{2} t_1\, \partial_{\kappa}f_{\theta}{}^{\lambda}\partial^{\kappa}f_{\lambda}{}^{\theta} + \frac{1}{2} t_1\, \partial_{\kappa}f^{\lambda}{}_{\theta}\partial^{\kappa}f_{\lambda}{}^{\theta} -$$
$$\frac{1}{3} t_1\, \partial^{\alpha}f^{\lambda}{}_{\alpha}\partial^{\kappa}f_{\lambda\kappa} - 4\, r_3\, \partial^{\beta}\omega_{\iota}{}^{\lambda\alpha}\partial_{\lambda}\omega_{\alpha\beta}{}^{\iota} - 2\, r_3\, \partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa} + r_5\, \partial_{\alpha}\omega_{\lambda}{}^{\alpha}{}_{\theta}\partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa} + 2\, r_3\, \partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa} - r_5\, \partial_{\theta}\omega_{\lambda}{}^{\alpha}{}_{\alpha}\partial^{\lambda}\omega^{\theta\kappa}{}_{\kappa}$$

Added source term: $f^{\alpha\beta}\ \tau_{\alpha\beta} + \omega^{\alpha\beta\chi}\ \sigma_{\alpha\beta\chi}$

Wave operator

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}\,\dagger$	$6\,k^2\,r_3$	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	$-t_1$

	$\omega_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^+}^{\#2}{}_{\alpha\beta}$	$f_{1^+}^{\#1}{}_{\alpha\beta}$	$\omega_{1^-}^{\#1}{}_{\alpha}$	$\omega_{1^-}^{\#2}{}_{\alpha}$	$f_{1^-}^{\#1}{}_{\alpha}$	$f_{1^-}^{\#2}{}_{\alpha}$
$\omega_{1^+}^{\#1}\,\dagger^{\alpha\beta}$	$k^2\,(2\,r_3 + r_5) - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{i\,k\,t_1}{\sqrt{2}}$	0	0	0	0
$\omega_{1^+}^{\#2}\,\dagger^{\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$f_{1^+}^{\#1}\,\dagger^{\alpha\beta}$	$\frac{i\,k\,t_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega_{1^-}^{\#1}\,\dagger^{\alpha}$	0	0	0	$k^2\,(2\,r_3 + r_5) + \frac{t_1}{6}$	$\frac{t_1}{3\,\sqrt{2}}$	0	$\frac{i\,k\,t_1}{3}$
$\omega_{1^-}^{\#2}\,\dagger^{\alpha}$	0	0	0	$\frac{t_1}{3\,\sqrt{2}}$	$\frac{t_1}{3}$	0	$\frac{1}{3}\,i\,\sqrt{2}\,k\,t_1$
$f_{1^-}^{\#1}\,\dagger^{\alpha}$	0	0	0	0	0	0	0
$f_{1^-}^{\#2}\,\dagger^{\alpha}$	0	0	0	$-\frac{1}{3}\,i\,k\,t_1$	$-\frac{1}{3}\,i\,\sqrt{2}\,k\,t_1$	0	$\frac{2\,k^2\,t_1}{3}$

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

Saturated propagator

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1}\,\dagger$	$\frac{1}{6\,k^2\,r_3}$	0	0	0
$\tau_{0^+}^{\#1}\,\dagger$	0	0	0	0
$\tau_{0^+}^{\#2}\,\dagger$	0	0	0	0
$\sigma_{0^-}^{\#1}\,\dagger$	0	0	0	$-\frac{1}{t_1}$

	$\sigma_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^+}^{\#2}{}_{\alpha\beta}$	$\tau_{1^+}^{\#1}{}_{\alpha\beta}$	$\sigma_{1^-}^{\#1}{}_{\alpha}$	$\sigma_{1^-}^{\#2}{}_{\alpha}$	$\tau_{1^-}^{\#1}{}_{\alpha}$	$\tau_{1^-}^{\#2}{}_{\alpha}$
$\sigma_{1^+}^{\#1}\,\dagger^{\alpha\beta}$	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
$\sigma_{1^+}^{\#2}\,\dagger^{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1 + k^2\,t_1}$	$\frac{-2\,k^2\,(2\,r_3 + r_5) + t_1}{(1 + k^2)^2\,t_1{}^2}$	$\frac{-2\,i\,k^3\,(2\,r_3 + r_5) + i\,k\,t_1}{(1 + k^2)^2\,t_1{}^2}$	0	0	0	0
$\tau_{1^+}^{\#1}\,\dagger^{\alpha\beta}$	$\frac{i\,\sqrt{2}\,k}{t_1 + k^2\,t_1}$	$\frac{i\,(2\,k^3\,(2\,r_3 + r_5) - k\,t_1)}{(1 + k^2)^2\,t_1{}^2}$	$\frac{-2\,k^4\,(2\,r_3 + r_5) + k^2\,t_1}{(1 + k^2)^2\,t_1{}^2}$	0	0	0	0
$\sigma_{1^-}^{\#1}\,\dagger^{\alpha}$	0	0	0	$\frac{1}{k^2\,(2\,r_3 + r_5)}$	$-\frac{1}{\sqrt{2}\,(k^2 + 2\,k^4)\,(2\,r_3 + r_5)}$	0	$-\frac{i}{k\,(1 + 2\,k^2)\,(2\,r_3 + r_5)}$
$\sigma_{1^-}^{\#2}\,\dagger^{\alpha}$	0	0	0	$-\frac{1}{\sqrt{2}\,(k^2 + 2\,k^4)\,(2\,r_3 + r_5)}$	$\frac{6\,k^2\,(2\,r_3 + r_5) + t_1}{2\,(k + 2\,k^3)^2\,(2\,r_3 + r_5)\,t_1}$	0	$\frac{i\,(6\,k^2\,(2\,r_3 + r_5) + t_1)}{\sqrt{2}\,k\,(1 + 2\,k^2)^2\,(2\,r_3 + r_5)\,t_1}$
$\tau_{1^-}^{\#1}\,\dagger^{\alpha}$	0	0	0	0	0	0	0
$\tau_{1^-}^{\#2}\,\dagger^{\alpha}$	0	0	0	$\frac{i}{k\,(1 + 2\,k^2)\,(2\,r_3 + r_5)}$	$-\frac{i\,(6\,k^2\,(2\,r_3 + r_5) + t_1)}{\sqrt{2}\,k\,(1 + 2\,k^2)^2\,(2\,r_3 + r_5)\,t_1}$	0	$\frac{6\,k^2\,(2\,r_3 + r_5) + t_1}{(1 + 2\,k^2)^2\,(2\,r_3 + r_5)\,t_1}$

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

Source constraints

Source constraints

SO(3) irreps	#
$\tau_{0^+}^{\#2} == 0$	1
$\tau_{0^+}^{\#1} == 0$	1
$\tau_{1^-}^{\#2\,\alpha} + 2\,i\,k\ \sigma_{1^-}^{\#2\,\alpha} == 0$	3
$\tau_{1^-}^{\#1\,\alpha} == 0$	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 #:	16

Massive spectrum

(No massive particles)

Massless spectrum

PDFTools`Private`PDFReader[558]

Quadratic pole

Pole residue:	$-\frac{1}{(2\,r_3 + r_5)\,t_1{}^2} > 0$
Polarisations:	2

Unitarity conditions

Unitarity conditions

$$r_5 < -2\,r_3\ \&\&\ t_1 < 0\ ||\ t_1 > 0$$