Particle spectrograph

Wave operator and propagator

Quadratic (free) Lagrangian density

$$
\begin{aligned}
&-\tfrac{1}{3} t_1\, \omega_\iota{}^{\alpha\iota}\, \omega_{\kappa\alpha}{}^{\kappa} - \tfrac{1}{3} t_1\, \omega_\iota{}^{\kappa\lambda}\, \omega_{\kappa\lambda}{}^{\iota} + \tfrac{2}{3} t_2\, \omega_\iota{}^{\kappa\lambda}\, \omega_{\kappa\lambda}{}^{\iota} + \tfrac{1}{3} t_1\, \omega_{\kappa\lambda}{}^{\iota}\, \omega^{\kappa\lambda}{}_{\iota} + \\
&\tfrac{1}{3} t_2\, \omega_{\kappa\lambda}{}^{\iota}\, \omega^{\kappa\lambda}{}_{\iota} + f^{\alpha\beta}\, \tau_{\alpha\beta} + \omega^{\alpha\beta\chi}\, \sigma_{\alpha\beta\chi} + \tfrac{2}{3} r_2\, \partial^\beta \omega^{\theta\alpha}{}_{\kappa}\, \partial_\theta \omega_{\alpha\beta}{}^{\kappa} - \\
&\tfrac{1}{3} r_2\, \partial_\theta \omega_{\alpha\beta}{}^{\kappa}\, \partial_\kappa \omega^{\alpha\beta\theta} - \tfrac{2}{3} r_2\, \partial_\theta \omega_{\alpha\beta}{}^{\kappa}\, \partial_\kappa \omega^{\theta\alpha\beta} - \tfrac{1}{3} t_1\, \partial^\alpha f_{\theta\kappa}\, \partial^\kappa f_\alpha{}^{\theta} + \\
&\tfrac{1}{6} t_2\, \partial^\alpha f_{\theta\kappa}\, \partial^\kappa f_\alpha{}^{\theta} - \tfrac{2}{3} t_1\, \partial^\alpha f_{\kappa\theta}\, \partial^\kappa f_\alpha{}^{\theta} - \tfrac{1}{6} t_2\, \partial^\alpha f_{\kappa\theta}\, \partial^\kappa f_\alpha{}^{\theta} - \tfrac{1}{3} t_1\, \partial^\alpha f^\lambda{}_\kappa\, \partial^\kappa f_{\alpha\lambda} + \\
&\tfrac{1}{6} t_2\, \partial^\alpha f^\lambda{}_\kappa\, \partial^\kappa f_{\alpha\lambda} + \tfrac{1}{3} t_1\, \omega_{\kappa\alpha}{}^{\alpha}\, \partial^\kappa f^\iota{}_\iota + \tfrac{1}{3} t_1\, \omega_{\kappa\lambda}{}^{\lambda}\, \partial^\kappa f^\iota{}_\iota + \tfrac{2}{3} t_1\, \partial^\alpha f_{\kappa\alpha}\, \partial^\kappa f^\iota{}_\iota - \\
&\tfrac{1}{3} t_1\, \partial_\kappa f^\lambda{}_\lambda\, \partial^\kappa f^\iota{}_\iota + \tfrac{1}{3} t_1\, \omega_{\iota\theta\kappa}\, \partial^\kappa f^{\iota\theta} + \tfrac{1}{3} t_2\, \omega_{\iota\theta\kappa}\, \partial^\kappa f^{\iota\theta} + \tfrac{4}{3} t_1\, \omega_{\iota\kappa\theta}\, \partial^\kappa f^{\iota\theta} - \\
&\tfrac{2}{3} t_2\, \omega_{\iota\kappa\theta}\, \partial^\kappa f^{\iota\theta} - \tfrac{1}{3} t_1\, \omega_{\theta\iota\kappa}\, \partial^\kappa f^{\iota\theta} - \tfrac{1}{3} t_2\, \omega_{\theta\iota\kappa}\, \partial^\kappa f^{\iota\theta} + \tfrac{2}{3} t_1\, \omega_{\theta\kappa\iota}\, \partial^\kappa f^{\iota\theta} + \\
&\tfrac{2}{3} t_2\, \omega_{\theta\kappa\iota}\, \partial^\kappa f^{\iota\theta} - \tfrac{1}{3} t_1\, \omega_{\iota\alpha}{}^{\alpha}\, \partial^\kappa f^\iota{}_\kappa - \tfrac{1}{3} t_1\, \omega_{\iota\lambda}{}^{\lambda}\, \partial^\kappa f^\iota{}_\kappa + \tfrac{1}{3} t_1\, \partial^\alpha f^\lambda{}_\kappa\, \partial^\kappa f_{\lambda\alpha} - \\
&\tfrac{1}{6} t_2\, \partial^\alpha f^\lambda{}_\kappa\, \partial^\kappa f_{\lambda\alpha} + \tfrac{1}{3} t_1\, \partial_\kappa f_\theta{}^{\lambda}\, \partial^\kappa f_\lambda{}^{\theta} - \tfrac{1}{6} t_2\, \partial_\kappa f_\theta{}^{\lambda}\, \partial^\kappa f_\lambda{}^{\theta} + \tfrac{2}{3} t_1\, \partial_\kappa f^\lambda{}_\theta\, \partial^\kappa f_\lambda{}^{\theta} + \\
&\tfrac{1}{6} t_2\, \partial_\kappa f^\lambda{}_\theta\, \partial^\kappa f_\lambda{}^{\theta} - \tfrac{1}{3} t_1\, \partial^\alpha f^\lambda{}_\alpha\, \partial^\kappa f_{\lambda\kappa} + \tfrac{1}{3} r_2\, \partial_\kappa \omega^{\alpha\beta\theta}\, \partial^\kappa \omega_{\alpha\beta\theta} + \\
&\tfrac{2}{3} r_2\, \partial_\kappa \omega^{\theta\alpha\beta}\, \partial^\kappa \omega_{\alpha\beta\theta} - \tfrac{2}{3} r_2\, \partial^\beta \omega_\iota{}^{\alpha\lambda}\, \partial_\lambda \omega_{\alpha\beta}{}^{\iota} + \tfrac{2}{3} r_2\, \partial^\beta \omega_\iota{}^{\lambda\alpha}\, \partial_\lambda \omega_{\alpha\beta}{}^{\iota}
\end{aligned}
$$

	$\sigma^{\#1}_{1^+\,\alpha\beta}$	$\sigma^{\#2}_{1^+\,\alpha\beta}$	$\tau^{\#1}_{1^+\,\alpha\beta}$	$\sigma^{\#1}_{1^-\,\alpha}$	$\sigma^{\#2}_{1^-\,\alpha}$	$\tau^{\#1}_{1^-\,\alpha}$	$\tau^{\#2}_{1^-\,\alpha}$
$\sigma^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{2(t_1+t_2)}{3t_1t_2}$	$\frac{\sqrt{2}(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$\frac{i\sqrt{2}k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	0	0	0	0
$\sigma^{\#2}_{1^+}\dagger^{\alpha\beta}$	$\frac{\sqrt{2}(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$\frac{t_1+4t_2}{3(1+k^2)^2t_1t_2}$	$\frac{ik(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	0	0	0	0
$\tau^{\#1}_{1^+}\dagger^{\alpha\beta}$	$-\frac{i\sqrt{2}k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$-\frac{ik(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	$\frac{k^2(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	0	0	0	0
$\sigma^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{6}{(3+4k^2)^2t_1}$	$\frac{6\sqrt{2}}{(3+4k^2)^2t_1}$	0	$\frac{12ik}{(3+4k^2)^2t_1}$
$\sigma^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{6\sqrt{2}}{(3+4k^2)^2t_1}$	$\frac{12}{(3+4k^2)^2t_1}$	0	$\frac{12i\sqrt{2}k}{(3+4k^2)^2t_1}$
$\tau^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	0	0	0	0
$\tau^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$-\frac{12ik}{(3+4k^2)^2t_1}$	$-\frac{12i\sqrt{2}k}{(3+4k^2)^2t_1}$	0	$\frac{24k^2}{(3+4k^2)^2t_1}$

	$\omega^{\#1}_{1^+\,\alpha\beta}$	$\omega^{\#2}_{1^+\,\alpha\beta}$	$f^{\#1}_{1^+\,\alpha\beta}$	$\omega^{\#1}_{1^-\,\alpha}$	$\omega^{\#2}_{1^-\,\alpha}$	$f^{\#1}_{1^-\,\alpha}$	$f^{\#2}_{1^-\,\alpha}$
$\omega^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{1}{6}(t_1+4t_2)$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$-\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	0	0	0	0
$\omega^{\#2}_{1^+}\dagger^{\alpha\beta}$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{t_1+t_2}{3}$	$\frac{1}{3}ik(t_1+t_2)$	0	0	0	0
$f^{\#1}_{1^+}\dagger^{\alpha\beta}$	$\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	$-\frac{1}{3}ik(t_1+t_2)$	$\frac{1}{3}k^2(t_1+t_2)$	0	0	0	0
$\omega^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{t_1}{6}$	$\frac{t_1}{3\sqrt{2}}$	0	$\frac{ikt_1}{3}$
$\omega^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	0	$\frac{1}{3}i\sqrt{2}kt_1$
$f^{\#1}_{1^-}\dagger^{\alpha}$	0	0	0	0	0	0	0
$f^{\#2}_{1^-}\dagger^{\alpha}$	0	0	0	$-\frac{1}{3}ikt_1$	$-\frac{1}{3}i\sqrt{2}kt_1$	0	$\frac{2k^2t_1}{3}$

	$\omega^{\#1}_{2^+\,\alpha\beta}$	$f^{\#1}_{2^+\,\alpha\beta}$	$\omega^{\#1}_{2^-\,\alpha\beta\chi}$
$\omega^{\#1}_{2^+}\dagger^{\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	0
$f^{\#1}_{2^+}\dagger^{\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	k^2t_1	0
$\omega^{\#1}_{2^-}\dagger^{\alpha\beta\chi}$	0	0	$\frac{t_1}{2}$

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

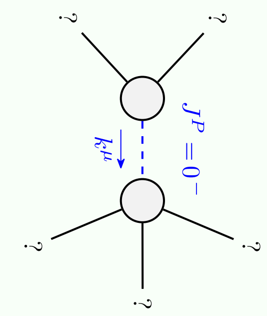
	$\sigma^{\#1}_{0^+}$	$\tau^{\#1}_{0^+}$	$\tau^{\#2}_{0^+}$	$\sigma^{\#1}_{0^-}$
$\sigma^{\#1}_{0^+}\dagger$	0	0	0	0
$\tau^{\#1}_{0^+}\dagger$	0	0	0	0
$\tau^{\#2}_{0^+}\dagger$	0	0	0	0
$\sigma^{\#1}_{0^-}\dagger$	0	0	0	$\frac{1}{k^2r_2+t_2}$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau^{\#2}_{0^+} == 0$	1
$\tau^{\#1}_{0^+} == 0$	1
$\sigma^{\#1}_{0^+} == 0$	1
$\tau^{\#2}_{1^-}{}^{\alpha} + 2ik\,\sigma^{\#1}_{1^-}{}^{\alpha} == 0$	3
$\tau^{\#1}_{1^-}{}^{\alpha} == 0$	3
$\sigma^{\#1}_{1^-}{}^{\alpha} == \sigma^{\#2}_{1^-}{}^{\alpha}$	3
$\tau^{\#1}_{1^+}{}^{\alpha\beta} + ik\,\sigma^{\#2}_{1^+}{}^{\alpha\beta} == 0$	3
$\tau^{\#1}_{2^+}{}^{\alpha\beta} - 2ik\,\sigma^{\#1}_{2^+}{}^{\alpha\beta} == 0$	5
Total constraints:	20

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

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

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