Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$\mathcal{S}_F == \iiint\int \tfrac{1}{6}(-6\,t_1\,\omega_{\prime}^{\alpha\prime}{}_{\kappa\alpha}^{\kappa}\,\omega_{\kappa\lambda}^{\prime\kappa\lambda} + 6\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} + 12\,r_1\,\partial_\iota\omega^{\kappa\lambda}{}_{\lambda\alpha}^{\alpha}\,\partial^\prime\omega_{\kappa}{}_{\alpha}^{\alpha} - 4\,r_1\,\partial^\beta\omega^{\theta\alpha}{}_{\kappa}^{\kappa} + 4\,r_1\,\partial_\theta\omega_{\alpha\beta}{}^{\kappa}\,\partial_\kappa\omega^{\alpha\beta\theta} + 4\,r_1\,\partial_\theta\omega_{\alpha\beta}{}^{\kappa}\,\partial_\kappa\omega^{\theta\alpha\beta} + 12\,r_1\,\partial_\alpha\omega_{\lambda}{}_{\theta}^{\alpha}\,\partial_\kappa\omega^{\theta\kappa\lambda} + 12\,r_1\,\partial_\theta\omega_{\lambda}{}_{\alpha}^{\alpha}\,\partial_\kappa\omega^{\kappa\lambda\theta} - 3\,t_1\,\partial^\alpha f_{\theta\kappa}\,\partial^\kappa f_{\alpha}{}^{\theta} - 3\,t_1\,\partial^\alpha f_{\kappa\theta}\,\partial^\kappa f_{\alpha}{}^{\theta} - 3\,t_1\,\partial^\alpha f_{\kappa}{}^{\theta}\,\partial^\kappa f_{\alpha\lambda} + 6\,t_1\,\omega_{\kappa\lambda}{}^{\lambda}\,\partial^\kappa f^{\prime}{}_{\iota}^{\iota} + 12\,t_1\,\partial^\alpha f_{\kappa\alpha}\,\partial^\kappa f^{\prime}{}_{\lambda}^{\lambda} - 6\,t_1\,\partial_\kappa f^{\lambda}{}_{\lambda}\,\partial^\kappa f^{\prime}{}_{\iota}^{\iota} + 12\,t_1\,\omega_{\iota\kappa\theta}\,\partial^\kappa f^{\prime\theta} - 6\,t_1\,\omega_{\iota\alpha}{}^{\alpha}\,\partial^\kappa f^{\prime}{}_{\kappa}^{\iota} - 6\,t_1\,\omega_{\iota\lambda}{}^{\lambda}\,\partial^\kappa f^{\prime}{}_{\kappa}^{\iota} + 3\,t_1\,\partial^\alpha f_{\kappa}{}^{\lambda}\,\partial^\kappa f_{\lambda}{}^{\theta} + 3\,t_1\,\partial_\kappa f^{\lambda}{}_{\theta}\,\partial^\kappa f_{\lambda}{}^{\theta} - 6\,t_1\,\partial^\alpha f^{\lambda}{}_{\alpha}\,\partial^\kappa f_{\lambda\kappa} + 4\,r_1\,\partial_\kappa\omega^{\alpha\beta\theta}\,\partial^\kappa\omega_{\alpha\beta\theta} - 4\,r_1\,\partial_\kappa\omega^{\theta\alpha\beta}\,\partial^\kappa\omega_{\alpha\beta\theta} + 4\,r_1\,\partial^\beta\omega_{\iota}^{\alpha\lambda}\,\partial_\lambda\omega_{\alpha\beta}^{\prime} - 16\,r_1\,\partial^\beta\omega_{\iota}^{\lambda\alpha}\,\partial_\lambda\omega_{\alpha\beta}^{\prime} - 12\,r_1\,\partial_\alpha\omega_{\lambda}{}_{\theta}^{\alpha}\,\partial^\lambda\omega^{\theta\kappa}{}_{\kappa} + 12\,r_1\,\partial_\theta\omega_{\lambda}{}_{\alpha}^{\alpha}\,\partial^\lambda\omega^{\theta\kappa}{}_{\kappa})[t,\,x,\,y,\,z]\,dz\,dy\,dx\,dt$$

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

	$\omega_{1^+}^{\#1}{}^{\alpha\beta}\dagger$	$\omega_{1^+}^{\#2}{}^{\alpha\beta}\dagger$	$f_{1^+}^{\#1}{}^{\alpha\beta}\dagger$	$\omega_{1^-}^{\#1}{}^{\alpha}\dagger$	$\omega_{1^-}^{\#2}{}^{\alpha}\dagger$	$f_{1^-}^{\#1}{}^{\alpha}\dagger$	$f_{1^-}^{\#2}{}^{\alpha}\dagger$
$\omega_{1^+}^{\#1}{}^{\alpha\beta}$	$-\frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$\frac{ikt_1}{\sqrt{2}}$	0	0	0	0
$\omega_{1^+}^{\#2}{}^{\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$f_{1^+}^{\#1}{}^{\alpha\beta}$	$-\frac{ikt_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega_{1^-}^{\#1}{}^{\alpha}$	0	0	0	$-k^2 r_1 - \frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0	$-ik\,t_1$
$\omega_{1^-}^{\#2}{}^{\alpha}$	0	0	0	$\frac{t_1}{\sqrt{2}}$	0	$ik\,t_1$	0
$f_{1^-}^{\#1}{}^{\alpha}$	0	0	0	0	$-ik\,t_1$	0	0
$f_{1^-}^{\#2}{}^{\alpha}$	0	0	0	$-ik\,t_1$	0	0	0

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

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

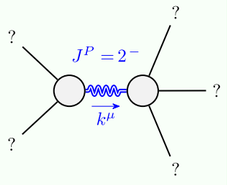
	$\omega_{0^+}^{\#1}\dagger$	$f_{0^+}^{\#1}\dagger$	$f_{0^+}^{\#2}\dagger$	$\omega_{0^-}^{\#1}\dagger$
$\omega_{0^+}^{\#1}$	$-t_1$	$i\sqrt{2}\,k\,t_1$	0	0
$f_{0^+}^{\#1}$	$-i\sqrt{2}\,k\,t_1$	$-2k^2 t_1$	0	0
$f_{0^+}^{\#2}$	0	0	0	0
$\omega_{0^-}^{\#1}$	0	0	0	$-t_1$

	$\omega_{2^+}^{\#1}{}^{\alpha\beta}\dagger$	$f_{2^+}^{\#1}{}^{\alpha\beta}\dagger$	$\omega_{2^-}^{\#1}{}^{\alpha\beta\chi}\dagger$
$\omega_{2^+}^{\#1}{}^{\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	0
$f_{2^+}^{\#1}{}^{\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	$k^2 t_1$	0
$\omega_{2^-}^{\#1}{}^{\alpha\beta\chi}$	0	0	$k^2 r_1 + \frac{t_1}{2}$

Source constraints/gauge generators

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

Massive and massless spectra



Massive particle

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

(No massless particles)

Unitarity conditions

$r_1 < 0$ && $t_1 > 0$