Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$S_F = = \iiint \Big(\tfrac{1}{6}\big(-2t_1\,\omega_i{}^{\alpha I}\,\omega_{\kappa\alpha}{}^{\kappa} - 6t_1\,\omega_i{}^{\kappa\lambda}\,\omega_{\kappa\lambda}{}^{I} + 6f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta X}\,\sigma_{\alpha\beta X} +$$

$$6r_1\partial_\iota\omega_\kappa{}^{\kappa\lambda}\,\partial^\iota\omega_\lambda{}_\alpha{}^{\alpha} - 4r_1\partial^\beta\omega^{\theta\alpha}{}_\kappa\,\partial_\theta\omega_{\alpha\beta}{}^{\kappa} + 4r_1\partial_\theta\omega_{\alpha\beta}{}^{\kappa} -$$

$$\partial_\kappa\omega^{\theta\alpha\beta} + 6r_1\partial_\alpha\omega_\lambda{}^\alpha{}_\theta\,\partial_\kappa\omega^{\theta\kappa\lambda} - 6r_1\partial_\theta\omega_\lambda{}^\alpha{}_\alpha\,\partial_\kappa\omega^{\theta\kappa\lambda} -$$

$$12r_1\partial_\theta\omega_\lambda{}^\alpha{}_\alpha\,\partial_\kappa\omega^{\kappa\lambda\theta} - 3t_1\partial^\alpha f^{\kappa\theta}{}_\theta\,\partial^\kappa f_\alpha{}^\theta - 3t_1\partial^\alpha f^{\kappa\lambda}{}_\kappa\,\partial^\kappa f_{\alpha\lambda} +$$

$$2t_1\,\omega_{\kappa\alpha}{}^\alpha\,\partial^\kappa f^\iota{}_\iota + 2t_1\,\omega_{\kappa\lambda}{}^\lambda\,\partial^\kappa f^\iota{}_\iota + 4t_1\partial^\alpha f_{\kappa\alpha}{}^\theta\,\partial^\kappa f^\iota{}_\iota -$$

$$12t_1\,\omega_{\iota\kappa\theta}\,\partial^\kappa f^{\iota\theta} - 2t_1\,\omega_{\iota\alpha}{}^\alpha\,\partial^\kappa f^\iota{}_\kappa - 2t_1\,\omega_{\iota\lambda}{}^\lambda\,\partial^\kappa f^\iota{}_\kappa + 3t_1\partial^\alpha f^\kappa{}_\lambda\,\partial^\kappa f_{\lambda\alpha} +$$

$$3t_1\partial_\kappa f^\lambda{}_\theta\,\partial^\kappa f_\lambda{}^\theta - 2t_1\partial^\alpha f^\kappa{}_\alpha\,\partial^\kappa f_{\lambda\kappa} + 4r_1\partial_\kappa\omega^{\alpha\beta\theta}\,\partial^\kappa\omega_{\alpha\beta\theta} -$$

$$4r_1\partial_\kappa\omega^{\theta\alpha\beta}\,\partial^\kappa\omega_{\alpha\beta\theta} + 4r_1\partial^\lambda\omega^{\theta\kappa}{}_\kappa\,\partial_\lambda\omega_{\alpha\beta}{}^{I} - 16r_1\partial_\lambda\omega_{\alpha\beta}{}^{I} -$$

$$6r_1\partial_\alpha\omega_\lambda{}^\alpha{}_\theta\,\partial^\lambda\omega^{\theta\kappa}{}_\kappa + 6r_1\partial_\theta\omega_\lambda{}^\alpha{}_\alpha\,\partial^\lambda\omega^{\theta\kappa}{}_\kappa\big)\Big)[t,x,y,z]\,dz\,dy\,dx\,dt$$

	$\sigma_1^{\#1+}\dagger^{\alpha\beta}$	$\sigma_1^{\#2+}\dagger^{\alpha\beta}$	$\tau_1^{\#1+}\dagger^{\alpha\beta}$	$\sigma_1^{\#1-}\dagger^{\alpha}$	$\sigma_1^{\#2-}\dagger^{\alpha}$	$\tau_1^{\#1-}\dagger^{\alpha}$	$\tau_1^{\#2-}\dagger^{\alpha}$
$\tau_1^{\#2-}{}_{\alpha}$	0	0	0	$\frac{12ik}{(3+4k^2)^2 t_1}$	$\frac{12i\sqrt{2}k}{(3+4k^2)^2 t_1}$	0	$\frac{24k^2}{(3+4k^2)^2 t_1}$
$\tau_1^{\#1-}{}_{\alpha}$	0	0	0	0	0	0	0
$\sigma_1^{\#2-}{}_{\alpha}$	0	0	0	$\frac{6\sqrt{2}k}{(3+4k^2)^2 t_1}$	$\frac{12}{(3+4k^2)^2 t_1}$	0	$-\frac{12i\sqrt{2}k}{(3+4k^2)^2 t_1}$
$\sigma_1^{\#1-}{}_{\alpha}$	0	0	0	$\frac{6}{(3+4k^2)^2 t_1}$	$\frac{6\sqrt{2}}{(3+4k^2)^2 t_1}$	0	$-\frac{12ik}{(3+4k^2)^2 t_1}$
$\tau_1^{\#1+}{}_{\alpha\beta}$	$-\frac{i\sqrt{2}k}{t_1+k^2 t_1}$	$-\frac{i(2k^3-kt_1)}{(1+k^2)^2 t_1^2}$	$-\frac{2k^4 r_1+k^2 t_1}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\sigma_1^{\#2+}{}_{\alpha\beta}$	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$-\frac{2k^2 r_1+t_1}{(1+k^2)^2 t_1^2}$	$\frac{i(2k^3 r_1-kt_1)}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\sigma_1^{\#1+}{}_{\alpha\beta}$	0	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$\frac{i\sqrt{2}k}{t_1+k^2 t_1}$	0	0	0	0

	$\omega_1^{\#1+}\dagger^{\alpha\beta}$	$\omega_1^{\#2+}\dagger^{\alpha\beta}$	$f_1^{\#1+}\dagger^{\alpha\beta}$	$\omega_1^{\#1-}\dagger^{\alpha}$	$\omega_1^{\#2-}\dagger^{\alpha}$	$f_1^{\#1-}\dagger^{\alpha}$	$f_1^{\#2-}\dagger^{\alpha}$
$f_1^{\#2-}{}_{\alpha}$	0	0	0	$\frac{ikt_1}{3}$	$\frac{1}{3}i\sqrt{2}kt_1$	0	$\frac{2k^2 t_1}{3}$
$f_1^{\#1-}{}_{\alpha}$	0	0	0	0	0	0	0
$\omega_1^{\#2-}{}_{\alpha}$	0	0	0	$\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	0	$-\frac{1}{3}i\sqrt{2}kt_1$
$\omega_1^{\#1-}{}_{\alpha}$	0	0	0	$\frac{t_1}{6}$	$\frac{t_1}{3\sqrt{2}}$	0	$-\frac{1}{3}ikt_1$
$f_1^{\#1+}{}_{\alpha\beta}$	$-\frac{ikt_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega_1^{\#2+}{}_{\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega_1^{\#1+}{}_{\alpha\beta}$	$k^2 r_1 - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$\frac{ikt_1}{\sqrt{2}}$	0	0	0	0

	$\sigma_0^{\#1}\dagger$	$\tau_0^{\#1}\dagger$	$\tau_0^{\#2}\dagger$	$\sigma_0^{\#1}\dagger$
$\sigma_0^{\#1+}{}$	0	0	0	$-\frac{1}{t_1}$
$\tau_0^{\#1+}{}$	0	0	0	0
$\tau_0^{\#2+}{}$	0	0	0	0
$\sigma_0^{\#1-}{}$	0	0	0	$-t_1$

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

	$\omega_{2+}^{\#1}\dagger^{\alpha\beta}$	$f_{2+}^{\#1}\dagger^{\alpha\beta}$	$\omega_{2-}^{\#1}\dagger^{\alpha\beta X}$
$\omega_2^{\#1-}{}_{\alpha\beta X}$	0	0	$k^2 r_1 + \frac{t_1}{2}$
$f_2^{\#1+}{}_{\alpha\beta}$	$-\frac{ikt_1}{\sqrt{2}}$	$k^2 t_1$	0
$\omega_2^{\#1+}{}_{\alpha\beta}$	$\frac{t_1}{2}$	$\frac{ikt_1}{\sqrt{2}}$	0

	$\sigma_{2+}^{\#1}\dagger^{\alpha\beta}$	$\tau_{2+}^{\#1}\dagger^{\alpha\beta}$	$\sigma_{2-}^{\#1}\dagger^{\alpha\beta X}$
$\sigma_2^{\#1-}{}_{\alpha\beta X}$	0	0	$\frac{2}{2k^2 r_1 + t_1}$
$\tau_2^{\#1+}{}_{\alpha\beta}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2 t_1}$	$\frac{4k^2}{(1+2k^2)^2 t_1}$	0
$\sigma_2^{\#1+}{}_{\alpha\beta}$	$\frac{2}{(1+2k^2)^2 t_1}$	$\frac{2i\sqrt{2}k}{(1+2k^2)^2 t_1}$	0

Source constraints/gauge generators

SO(3) Irreps	Multiplicities
$\sigma_0^{\#1} == 0$	1
$\tau_0^{\#1} == 0$	1
$\tau_0^{\#2} == 0$	1
$\tau_1^{\#2\alpha} + 2ik\,\sigma_1^{\#1\alpha} == 0$	3
$\tau_1^{\#1\alpha} == 0$	3
$\sigma_1^{\#1\alpha} == \sigma_1^{\#2\alpha}$	3
$\tau_1^{\#1\alpha\beta} + ik\,\sigma_1^{\#2\alpha\beta} == 0$	3
$\tau_2^{\#1\alpha\beta} - 2ik\,\sigma_2^{\#1\alpha\beta} == 0$	5
Total constraints:	20

Massive and massless spectra

$J^P = 2^-$, $\vec{k}^\mu$
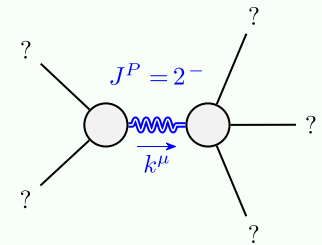
Massive particle	
Pole residue:	$-\frac{1}{r_1} > 0$
Polarisations:	5
Square mass:	$-\frac{t_1}{2r_1} > 0$
Spin:	2
Parity:	Odd

(No massless particles)

Unitarity conditions

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