Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$S_F == \iiiint \left(-\tfrac{1}{2}\,\alpha_0\,\omega_{\alpha\zeta\beta}\,\omega^{\alpha\beta\zeta} - \tfrac{1}{2}\,\alpha_0\,\omega^{\alpha\beta}{}_\alpha\,\omega_\beta{}^\zeta{}_\zeta + f^{\alpha\beta}\,\tau_{\alpha\beta} + \omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} - \alpha_0\,f^{\alpha\beta}\,\partial_\beta\omega_\alpha{}^\zeta{}_\zeta + \alpha_0\,\partial_\beta\omega^{\alpha\beta}{}_\alpha + \alpha_0\,f^{\alpha\beta}\,\partial_\zeta\omega_\alpha{}^\zeta{}_\beta - \alpha_0\,f^\alpha{}_\alpha\,\partial_\zeta\omega^{\beta\zeta}{}_\beta\right)[t,x,y,z]\,dz\,dy\,dx\,dt$$

Matrix (spin-1 sector, σ/τ):

	$\sigma_{1+}^{\#1\,\alpha\beta}\dagger$	$\sigma_{1+}^{\#2\,\alpha\beta}\dagger$	$\tau_{1+}^{\#1\,\alpha\beta}\dagger$	$\sigma_{1-}^{\#1\,\alpha}\dagger$	$\sigma_{1-}^{\#2\,\alpha}\dagger$	$\tau_{1-}^{\#1\,\alpha}\dagger$	$\tau_{1-}^{\#2\,\alpha}\dagger$
$\tau_{1-}^{\#2\,\alpha}$	0	0	0	$-\frac{4ik}{\alpha_0+2\alpha_0 k^2}$	$-\frac{2i\sqrt2\,k}{\alpha_0(1+2k^2)}$	0	$-\frac{4k^2}{\alpha_0(1+2k^2)^2}$
$\tau_{1-}^{\#1\,\alpha}$	0	0	0	0	0	0	0
$\sigma_{1-}^{\#2\,\alpha}$	0	0	0	$-\frac{2\sqrt2}{\alpha_0+2\alpha_0 k^2}$	$-\frac{2}{\alpha_0(1+2k^2)}$	0	$\frac{2i\sqrt2\,k}{\alpha_0(1+2k^2)^2}$
$\sigma_{1-}^{\#1\,\alpha}$	0	0	0	0	$\frac{2\sqrt2}{\alpha_0+2\alpha_0 k^2}$	0	$\frac{4ik}{\alpha_0+2\alpha_0 k^2}$
$\tau_{1+}^{\#1\,\alpha\beta}$	$\frac{2i\sqrt2\,k}{\alpha_0+\alpha_0 k^2}$	$\frac{2ik}{\alpha_0(1+k^2)^2}$	$\frac{2k^2}{\alpha_0(1+k^2)^2}$	0	0	0	0
$\sigma_{1+}^{\#2\,\alpha\beta}$	$\frac{2\sqrt2}{\alpha_0+\alpha_0 k^2}$	$-\frac{2}{\alpha_0(1+k^2)^2}$	$\frac{2ik}{\alpha_0(1+k^2)^2}$	0	0	0	0
$\sigma_{1+}^{\#1\,\alpha\beta}$	0	$\frac{2\sqrt2}{\alpha_0+\alpha_0 k^2}$	$\frac{2i\sqrt2\,k}{\alpha_0+\alpha_0 k^2}$	0	0	0	0

Matrix (spin-1 sector, ω/f):

	$\omega_{1+}^{\#1\,\alpha\beta}\dagger$	$\omega_{1+}^{\#2\,\alpha\beta}\dagger$	$f_{1+}^{\#1\,\alpha\beta}\dagger$	$\omega_{1-}^{\#1\,\alpha}\dagger$	$\omega_{1-}^{\#2\,\alpha}\dagger$	$f_{1-}^{\#1\,\alpha}\dagger$	$f_{1-}^{\#2\,\alpha}\dagger$
$f_{1-}^{\#2\,\alpha}$	0	0	0	$-\tfrac{1}{2}i\alpha_0 k$	0	0	0
$f_{1-}^{\#1\,\alpha}$	0	0	0	0	0	0	0
$\omega_{1-}^{\#2\,\alpha}$	0	0	0	$-\frac{\alpha_0}{2\sqrt2}$	0	0	0
$\omega_{1-}^{\#1\,\alpha}$	0	0	0	$\frac{\alpha_0}{4}$	$\frac{\alpha_0}{2\sqrt2}$	$-\frac{\alpha_0}{2\sqrt2}$	$\frac{i\alpha_0 k}{2}$
$f_{1+}^{\#1\,\alpha\beta}$	$\frac{i\alpha_0 k}{2\sqrt2}$	0	0	0	0	0	0
$\omega_{1+}^{\#2\,\alpha\beta}$	$\frac{\alpha_0}{2\sqrt2}$	0	0	0	0	0	0
$\omega_{1+}^{\#1\,\alpha\beta}$	$\frac{\alpha_0}{4}$	$\frac{\alpha_0}{2\sqrt2}$	$-\frac{i\alpha_0 k}{2\sqrt2}$	0	0	0	0

Matrix (spin-0, ω/f):

	$\omega_{0+}^{\#1}\dagger$	$f_{0+}^{\#1}\dagger$	$f_{0+}^{\#2}\dagger$	$\omega_{0-}^{\#1}\dagger$
$\omega_{0-}^{\#1}$	0	0	0	$\frac{\alpha_0}{2}$
$f_{0+}^{\#2}$	0	0	0	0
$f_{0+}^{\#1}$	$-\frac{i\alpha_0 k}{\sqrt2}$	0	0	0
$\omega_{0+}^{\#1}$	$\frac{\alpha_0}{2}$	$\frac{i\alpha_0 k}{\sqrt2}$	0	0

Matrix (spin-2, σ/τ):

	$\sigma_{2+}^{\#1\,\alpha\beta}$	$\tau_{2+}^{\#1\,\alpha\beta}$	$\sigma_{2-}^{\#1\,\alpha\beta\chi}$
$\sigma_{2+}^{\#1\,\alpha\beta}\dagger$	0	$\frac{2i\sqrt2}{\alpha_0 k}$	0
$\tau_{2+}^{\#1\,\alpha\beta}\dagger$	$-\frac{2i\sqrt2}{\alpha_0 k}$	$\frac{2}{\alpha_0 k^2}$	0
$\sigma_{2-}^{\#1\,\alpha\beta\chi}\dagger$	0	0	$-\frac{4}{\alpha_0}$

Matrix (spin-2, ω/f):

	$\omega_{2+}^{\#1\,\alpha\beta}\dagger$	$f_{2+}^{\#1\,\alpha\beta}\dagger$	$\omega_{2-}^{\#1\,\alpha\beta\chi}\dagger$
$\omega_{2-}^{\#1\,\alpha\beta\chi}$	0	0	$-\frac{\alpha_0}{4}$
$f_{2+}^{\#1\,\alpha\beta}$	$\frac{i\alpha_0 k}{2\sqrt2}$	0	0
$\omega_{2+}^{\#1\,\alpha\beta}$	$-\frac{\alpha_0}{4}$	$\frac{i\alpha_0 k}{2\sqrt2}$	0

Matrix (spin-0, σ/τ):

	$\sigma_{0+}^{\#1}$	$\tau_{0+}^{\#1}$	$\tau_{0+}^{\#2}$	$\sigma_{0-}^{\#1}$
$\sigma_{0+}^{\#1}\dagger$	0	$-\frac{i\sqrt2}{\alpha_0 k}$	0	0
$\tau_{0+}^{\#1}\dagger$	$\frac{i\sqrt2}{\alpha_0 k}$	$-\frac{1}{\alpha_0 k^2}$	0	0
$\tau_{0+}^{\#2}\dagger$	0	0	0	0
$\sigma_{0-}^{\#1}\dagger$	0	0	0	$\frac{2}{\alpha_0}$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau_{0+}^{\#2} == 0$	1
$\tau_{1-}^{\#2\,\alpha} + 2ik\,\sigma_{1-}^{\#2\,\alpha} == 0$	3
$\tau_{1-}^{\#1\,\alpha} == 0$	3
$\tau_{1+}^{\#1\,\alpha\beta} + ik\,\sigma_{1+}^{\#2\,\alpha\beta} == 0$	3
Total constraints:	10

Massive and massless spectra
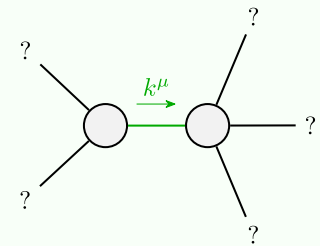
Quadratic pole

Pole residue:	$\frac{1}{\alpha_0} > 0$
Polarisations:	2

(No massive particles)

Unitarity conditions

$\alpha_0 > 0$