Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$S_F = \iiiint \Big[\tfrac{1}{6}\big(4\,t_2\,\omega_i{}^{\kappa\lambda}\,\omega_{\kappa\lambda}{}^i + 2\,t_2\,\omega_{\kappa\lambda}{}^i\,\omega^{\kappa\lambda}{}_i +$$
$$6\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} - 2\,r_2\,\partial_\theta\omega_{\alpha\beta}{}^\kappa\,\partial_\kappa\omega^{\alpha\beta\theta} -$$
$$6\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 4\,r_2\,\partial_\beta\omega^{\theta\alpha}{}_\kappa\,\partial_\theta\omega_{\alpha\beta}{}^\kappa - 2\,r_2\,\partial_\theta\omega_{\alpha\beta}{}^\kappa\,\partial_\kappa\omega^{\theta\alpha\beta} +$$
$$4\,r_2\,\partial_\theta\omega_{\alpha\beta}{}^\kappa\,\partial_\kappa\omega^{\theta\alpha\beta} + 6\,r_3\,\partial_\theta\omega_\lambda{}^\alpha{}_\alpha\,\partial_\kappa\omega^{\theta\kappa\lambda} - 6\,r_3\,\partial_\theta\omega_\lambda{}^\alpha{}_\alpha\,\partial_\kappa\omega^{\theta\kappa\lambda} +$$
$$t_2\,\partial^\theta f_{\theta\kappa}\partial^\kappa f_\alpha{}^\theta - t_2\,\partial^\theta f_{\kappa\theta}\partial^\kappa f_\alpha{}^\theta + t_2\,\partial^\theta f_{\alpha\lambda}\partial^\kappa f_\kappa{}^\theta + 2\,t_2\,\omega_{\theta\kappa}\partial^\kappa f^{l\theta} -$$
$$4\,t_2\,\omega_{l\kappa\theta}\,\partial^\kappa f^{l\theta} - 2\,t_2\,\omega_{\theta\kappa l}\,\partial^\kappa f^{l\theta} - t_2\,\partial^\alpha f_\kappa{}^\lambda\,\partial^\kappa f_{\lambda\alpha} -$$
$$t_2\,\partial_\kappa f_\theta{}^\lambda\,\partial^\kappa f_\lambda{}^\theta + t_2\,\partial_\kappa f^\lambda{}_\theta\,\partial^\kappa f_\lambda{}^\theta + 2\,r_2\,\partial_\kappa\omega^{\alpha\beta\theta}\partial^\kappa\omega_{\alpha\beta\theta} + 4\,r_2\,\partial_\kappa\omega^{\theta\alpha\beta}\partial^\kappa\omega_{\alpha\beta\theta} -$$
$$4\,r_2\,\partial^\beta\omega_i{}^{\alpha\lambda}\,\partial_\lambda\omega_{\alpha\beta}{}^i + 4\,r_2\,\partial^\beta\omega_\lambda{}^{\lambda\alpha}\,\partial_\lambda\omega_{\alpha\beta}{}^i -$$
$$6\,r_3\,\partial_\theta\omega_\lambda{}^\alpha{}_\alpha\,\partial^\lambda\omega^{\theta\kappa}{}_\kappa + 6\,r_3\,\partial_\theta\omega_\lambda{}^\alpha{}_\alpha\,\partial^\lambda\omega^{\theta\kappa}{}_\kappa \big)\Big]\,[t,x,y,z]\,dz\,dy\,dx\,dt$$

|	$\sigma_{1^+}^{\#1}\dagger^{\alpha\beta}$	$\sigma_{1^+}^{\#2}\dagger^{\alpha\beta}$	$\tau_{1^+}^{\#1}\dagger^{\alpha\beta}$	$\sigma_{1^-}^{\#1}\dagger^{\alpha}$	$\sigma_{1^-}^{\#2}\dagger^{\alpha}$	$\tau_{1^-}^{\#1}\dagger^{\alpha}$	$\tau_{1^-}^{\#2}\dagger^{\alpha}$
$\tau_{1^-}^{\#2}{}_\alpha$	0	0	0	0	0	0	0
$\tau_{1^-}^{\#1}{}_\alpha$	0	0	0	0	0	0	0
$\sigma_{1^-}^{\#2}{}_\alpha$	0	0	0	0	0	0	0
$\sigma_{1^-}^{\#1}{}_\alpha$	0	0	0	0	0	0	0
$\tau_{1^+}^{\#1}{}_{\alpha\beta}$	$-\dfrac{2i\sqrt{2}}{3k r_3+3k^3 r_3}$	$\dfrac{i(9k^2 r_3+4t_2)}{3k(1+k^3)^2 r_3 t_2}$	$\dfrac{9k^2 r_3+4t_2}{3(1+k^2)^2 r_3 t_2}$	0	0	0	0
$\sigma_{1^+}^{\#2}{}_{\alpha\beta}$	$-\dfrac{2\sqrt{2}}{3k^2 r_3+3k^4 r_3}$	$\dfrac{9k^2 r_3+4t_2}{3(k+k^3)^2 r_3 t_2}$	$-\dfrac{i(9k^2 r_3+4t_2)}{3k(1+k^3)^2 r_3 t_2}$	0	0	0	0
$\sigma_{1^+}^{\#1}{}_{\alpha\beta}$	$\dfrac{2}{3k^2 r_3}$	$-\dfrac{2\sqrt{2}}{3k r_3+3k^3 r_3}$	$\dfrac{2i\sqrt{2}}{3k r_3+3k^3 r_3}$	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	0	0	0	0
$f_{1^-}^{\#1}{}_\alpha$	0	0	0	0	0	0	0
$\omega_{1^-}^{\#2}{}_\alpha$	0	0	0	0	0	0	0
$\omega_{1^-}^{\#1}{}_\alpha$	0	0	0	0	0	0	0
$f_{1^+}^{\#1}{}_{\alpha\beta}$	$\tfrac{1}{3}i\sqrt{2}\,k t_2$	$\dfrac{ik t_2}{3}$	$\dfrac{k^2 t_2}{3}$	0	0	0	0
$\omega_{1^+}^{\#2}{}_{\alpha\beta}$	$\dfrac{\sqrt{2}\,t_2}{3}$	$\dfrac{t_2}{3}$	$-\tfrac{1}{3}i\,k t_2$	0	0	0	0
$\omega_{1^+}^{\#1}{}_{\alpha\beta}$	$\tfrac{1}{6}(9k^2 r_3+4t_2)$	$\dfrac{\sqrt{2}\,t_2}{3}$	$-\tfrac{1}{3}i\sqrt{2}\,k t_2$	0	0	0	0

	$\omega_{2^+ \alpha\beta}^{\#1}$	$f_{2^+ \alpha\beta}^{\#1}$	$\omega_{2^- \alpha\beta\chi}^{\#1}$
$\omega_{2^+}^{\#1}\dagger^{\alpha\beta}$	$-\dfrac{3k^2 r_3}{2}$	0	0
$f_{2^+}^{\#1}\dagger^{\alpha\beta}$	0	0	0
$\omega_{2^-}^{\#1}\dagger^{\alpha\beta\chi}$	0	0	0

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}\dagger$	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	$k^2 r_2 + t_2$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau_{0^+}^{\#2} == 0$	1
$\tau_{0^+}^{\#1} == 0$	1
$\sigma_{0^+}^{\#1} == 0$	1
$\tau_{1^-}^{\#2\,\alpha} == 0$	3
$\tau_{1^-}^{\#1\,\alpha} == 0$	3
$\sigma_{1^-}^{\#2\,\alpha} == 0$	3
$\sigma_{1^-}^{\#1\,\alpha} == 0$	3
$\tau_{1^+}^{\#1\,\alpha\beta} + i\,k\,\sigma_{1^+}^{\#2\,\alpha\beta} == 0$	3
$\sigma_{2^-}^{\#1\,\alpha\beta\chi} == 0$	5
$\tau_{2^+}^{\#1\,\alpha\beta} == 0$	5
Total constraints:	28

	$\sigma_{2^+ \alpha\beta}^{\#1}$	$\tau_{2^+ \alpha\beta}^{\#1}$	$\sigma_{2^- \alpha\beta\chi}^{\#1}$
$\sigma_{2^+}^{\#1}\dagger^{\alpha\beta}$	$-\dfrac{2}{3k^2 r_3}$	0	0
$\tau_{2^+}^{\#1}\dagger^{\alpha\beta}$	0	0	0
$\sigma_{2^-}^{\#1}\dagger^{\alpha\beta\chi}$	0	0	0

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1}\dagger$	0	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	$\dfrac{1}{k^2 r_2 + t_2}$

Massive and massless spectra
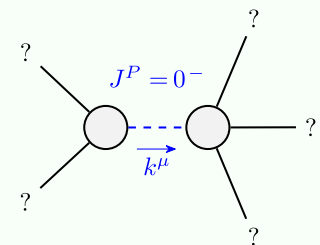
Massive particle	
Pole residue:	$-\dfrac{1}{r_2} > 0$
Polarisations:	1
Square mass:	$-\dfrac{t_2}{r_2} > 0$
Spin:	0
Parity:	Odd

(No massless particles)

Unitarity conditions

$r_2 < 0$ && $t_2 > 0$