

Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$S_F = \iiint \Big((\frac{1}{6} (-2 t_1 \omega_{\kappa\lambda}^{\alpha'} \omega_{\kappa\alpha}^{\kappa} - 2 (t_1 - 2 t_2) \omega_{\kappa\lambda}^{\kappa\lambda} \omega_{\kappa\lambda}^{\lambda'} + 2 t_1 \omega_{\kappa\lambda}^{\lambda'} \omega_{\kappa\lambda}^{\kappa\lambda} + 2 t_2 \omega_{\kappa\lambda}^{\lambda'} \omega_{\kappa\lambda}^{\kappa\lambda} + 6 f^{\alpha\beta} \tau_{\alpha\beta} + 6 \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} + 4 r_2 \partial^\beta \omega_{\kappa}^{\alpha} \partial_\theta \omega_{\alpha\beta}^{\kappa} - 2 r_2 \partial_\theta \omega_{\alpha\beta}^{\kappa} \partial_\kappa \omega^{\alpha\beta\theta} - 4 r_2 \partial_\theta \omega_{\alpha\beta}^{\kappa} \partial_\kappa \omega^{\theta\alpha\beta} + 24 r_3 \partial_\alpha \omega_{\lambda}^{\alpha} \partial_\theta \omega_{\lambda}^{\alpha} \partial_\kappa \omega^{\theta\kappa\lambda} - 24 r_3 \partial_\theta \omega_{\lambda}^{\alpha} \partial_\kappa \omega^{\theta\kappa\lambda} - 2 t_1 \partial^\alpha f_{\kappa\theta} \partial^\kappa f_{\alpha}^{\theta} - t_2 \partial^\alpha f_{\kappa\theta} \partial^\kappa f_{\alpha}^{\theta} - 2 t_1 \partial^\alpha f_{\kappa}^{\lambda} \partial^\kappa f_{\alpha}^{\lambda} - 2 t_2 \partial^\alpha f_{\kappa}^{\lambda} \partial^\kappa f_{\alpha}^{\lambda} + 4 t_1 \partial^\alpha f_{\kappa\theta} \partial^\kappa f_{\lambda}^{\theta} + 4 t_2 \partial^\alpha f_{\kappa\theta} \partial^\kappa f_{\lambda}^{\theta} - 2 t_1 \omega_{\kappa\alpha}^{\alpha} \partial^\kappa f_{\lambda}^{\theta} + 2 t_2 \omega_{\kappa\lambda}^{\lambda} \partial^\kappa f_{\lambda}^{\theta} + 4 t_1 \partial^\alpha f_{\kappa\alpha} \partial^\kappa f_{\lambda}^{\theta} - 2 t_1 \partial_\kappa f_{\lambda}^{\lambda} \partial^\kappa f_{\theta}^{\theta} - 4 t_2 \omega_{\theta\kappa} \partial^\kappa f_{\theta}^{\theta} + 8 t_1 \omega_{\theta\kappa} \partial^\kappa f_{\theta}^{\theta} + 4 t_2 \omega_{\theta\kappa} \partial^\kappa f_{\theta}^{\theta} - 2 t_1 \omega_{\theta\kappa} \partial^\kappa f_{\theta}^{\theta} - 2 t_2 \omega_{\theta\kappa} \partial^\kappa f_{\theta}^{\theta} + 4 t_1 \omega_{\theta\kappa} \partial^\kappa f_{\theta}^{\theta} + 4 t_2 \omega_{\theta\kappa} \partial^\kappa f_{\theta}^{\theta} - 2 t_1 \omega_{\theta\kappa} \partial^\kappa f_{\theta}^{\theta} - 2 t_2 \omega_{\theta\kappa} \partial^\kappa f_{\theta}^{\theta} + 2 t_1 \partial^\alpha f_{\lambda}^{\lambda} \partial^\kappa f_{\alpha}^{\theta} + 2 t_2 \partial^\alpha f_{\lambda}^{\lambda} \partial^\kappa f_{\alpha}^{\theta} - t_2 \partial_\kappa f_{\lambda}^{\lambda} \partial^\kappa f_{\theta}^{\theta} + 4 t_1 \partial_\kappa f_{\lambda}^{\lambda} \partial^\kappa f_{\theta}^{\theta} + t_2 \partial_\kappa f_{\lambda}^{\lambda} \partial^\kappa f_{\theta}^{\theta} - 2 t_1 \partial^\alpha f_{\lambda}^{\lambda} \partial^\kappa f_{\alpha}^{\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_{\lambda}^{\alpha\lambda} \partial_\lambda \omega_{\alpha\beta}^{\lambda'} + 4 r_2 \partial^\beta \omega_{\lambda}^{\lambda\alpha} \partial_\lambda \omega_{\alpha\beta}^{\lambda'} - 24 r_3 \partial^\beta \omega_{\lambda}^{\lambda\alpha} \partial_\lambda \omega_{\alpha\beta}^{\lambda'} - 24 r_3 \partial_\alpha \omega_{\lambda}^{\alpha} \partial_\theta \omega_{\lambda}^{\alpha} \partial^\alpha \omega_{\lambda}^{\theta\kappa}) [t, x, y, z] dz dy dx dt$$

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

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

Source constraints/gauge generators

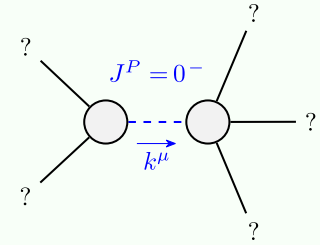
SO(3) irreps	Multiplicities
$\tau_{0^+}^{\#2} == 0$	1
$\tau_{0^+}^{\#1} == 0$	1
$\tau_{1^+}^{\#2\alpha} + 2ik\sigma_{1^+}^{\#1\alpha} == 0$	3
$\tau_{1^+}^{\#1\alpha} == 0$	3
$\sigma_{1^+}^{\#1\alpha} == \sigma_{1^+}^{\#2\alpha}$	3
$\tau_{1^+}^{\#1\alpha\beta} + ik\sigma_{1^+}^{\#2\alpha\beta} == 0$	3
$\tau_{2^+}^{\#1\alpha\beta} - 2ik\sigma_{2^+}^{\#1\alpha\beta} == 0$	5
Total constraints:	19

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

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

$\omega_{0^+}^{\#1} \dagger$	$f_{0^+}^{\#1} \dagger$	$f_{0^+}^{\#2} \dagger$	$\omega_{0^+}^{\#1}$
$\omega_{0^+}^{\#1} \dagger$	$6k^2r_3$	0	0
$f_{0^+}^{\#1} \dagger$	0	0	0
$f_{0^+}^{\#2} \dagger$	0	0	0
$\omega_{0^+}^{\#1} \dagger$	0	0	$k^2r_2+t_2$

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

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