

Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$\begin{aligned} S_F = & \iiint (\frac{1}{6} (-2t_1 \omega_{\kappa}^{\alpha'} \omega_{\kappa\alpha}^{\kappa} - 6t_1 \omega_{\kappa\lambda}^{\kappa\lambda} \omega_{\kappa\lambda}^{\lambda} + 6f^{\alpha\beta} \tau_{\alpha\beta} + 6\omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} + \\ & 6r_1 \partial_{\lambda} \omega_{\kappa}^{\kappa\lambda} \partial' \omega_{\lambda}^{\alpha} - 4r_1 \partial^{\beta} \omega_{\kappa}^{\beta\alpha} \partial_{\theta} \omega_{\alpha\beta}^{\kappa} - 4r_1 \partial_{\theta} \omega_{\alpha\beta}^{\kappa} \partial_{\kappa} \omega^{\alpha\beta\theta} + \\ & 4r_1 \partial_{\theta} \omega_{\alpha\beta}^{\kappa} \partial_{\kappa} \omega^{\theta\alpha\beta} - 18r_1 \partial_{\alpha} \omega_{\lambda}^{\alpha} \partial_{\kappa} \omega^{\theta\kappa\lambda} + 24r_3 \partial_{\alpha} \omega_{\lambda}^{\alpha} \partial_{\kappa} \omega^{\theta\kappa\lambda} + \\ & 18r_1 \partial_{\theta} \omega_{\lambda}^{\alpha} \partial_{\kappa} \omega^{\theta\kappa\lambda} - 24r_3 \partial_{\theta} \omega_{\lambda}^{\alpha} \partial_{\kappa} \omega^{\theta\kappa\lambda} + 6r_1 \partial_{\alpha} \omega_{\lambda}^{\alpha} \partial_{\kappa} \omega^{\kappa\lambda\theta} - \\ & 12r_1 \partial_{\theta} \omega_{\lambda}^{\alpha} \partial_{\kappa} \omega^{\kappa\lambda\theta} - 3t_1 \partial^{\alpha} f_{\kappa} \partial^{\kappa} f_{\alpha}^{\theta} - 3t_1 \partial^{\alpha} f_{\kappa\theta} \partial^{\kappa} f_{\alpha}^{\theta} - 3t_1 \partial^{\alpha} f_{\lambda}^{\theta} \partial^{\kappa} f_{\alpha}^{\lambda} \partial^{\kappa} f_{\alpha\lambda} + \\ & 2t_1 \omega_{\kappa\alpha}^{\alpha} \partial^{\kappa} f_{\lambda}^{\lambda} + 2t_1 \omega_{\kappa\lambda}^{\lambda} \partial^{\kappa} f_{\lambda}^{\lambda} + 4t_1 \partial^{\alpha} f_{\kappa\alpha} \partial^{\kappa} f_{\lambda}^{\lambda} - 2t_1 \partial_{\kappa} f_{\lambda}^{\lambda} \partial^{\kappa} f_{\lambda}^{\lambda} + \\ & 12t_1 \omega_{\kappa\theta}^{\theta} \partial^{\kappa} f_{\lambda}^{\lambda} - 2t_1 \omega_{\lambda\alpha}^{\alpha} \partial^{\kappa} f_{\kappa}^{\lambda} - 2t_1 \omega_{\lambda\lambda}^{\lambda} \partial^{\kappa} f_{\kappa}^{\lambda} + 3t_1 \partial^{\alpha} f_{\kappa}^{\lambda} \partial^{\kappa} f_{\lambda\alpha} + \\ & 3t_1 \partial_{\kappa} f_{\theta}^{\lambda} \partial^{\kappa} f_{\lambda}^{\theta} + 3t_1 \partial_{\kappa} f_{\theta}^{\lambda} \partial^{\kappa} f_{\lambda}^{\theta} - 2t_1 \partial^{\alpha} f_{\lambda}^{\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^{\beta} \omega_{\lambda}^{\alpha\lambda} \partial_{\lambda} \omega_{\alpha\beta}^{\lambda} + 8r_1 \partial^{\beta} \omega_{\lambda}^{\lambda\alpha} \partial_{\lambda} \omega_{\alpha\beta}^{\lambda} - \\ & 24r_3 \partial^{\beta} \omega_{\lambda}^{\lambda\alpha} \partial_{\lambda} \omega_{\alpha\beta}^{\lambda} + 18r_1 \partial_{\alpha} \omega_{\lambda}^{\alpha} \partial^{\lambda} \omega_{\kappa}^{\theta\kappa} - 24r_3 \partial_{\alpha} \omega_{\lambda}^{\alpha} \partial^{\lambda} \omega_{\kappa}^{\theta\kappa} - \\ & 18r_1 \partial_{\theta} \omega_{\lambda}^{\alpha} \partial^{\lambda} \omega_{\kappa}^{\theta\kappa} + 24r_3 \partial_{\theta} \omega_{\lambda}^{\alpha} \partial^{\lambda} \omega_{\kappa}^{\theta\kappa})) [t, x, y, z] dz dy dx dt \end{aligned}$$

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

$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1+}^{\#2} \omega_{1+}^{\alpha\beta}$	$f_{1+}^{\#1} \omega_{1+}^{\alpha\beta}$	$\omega_{1-}^{\#1} \omega_{1-}^{\alpha}$	$\omega_{1-}^{\#2} \omega_{1-}^{\alpha}$	$f_{1-}^{\#1} \omega_{1-}^{\alpha}$	$f_{1-}^{\#2} \omega_{1-}^{\alpha}$
$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$k^2 r_1 - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0
$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0
$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{ikt_1}{\sqrt{2}}$	0	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	$\frac{1}{3} i \sqrt{2} k t_1$
$f_{1-}^{\#1} \dagger^{\alpha}$	0	0	0	0	0	0
$f_{1-}^{\#2} \dagger^{\alpha}$	0	0	$-\frac{1}{3} i k t_1$	$-\frac{1}{3} i \sqrt{2} k t_1$	0	$\frac{2k^2 t_1}{3}$

Source constraints/gauge generators

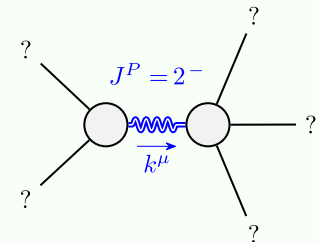
SO(3) irreps	Multiplicities
$\tau_{0+}^{\#2} == 0$	1
$\tau_{0+}^{\#1} == 0$	1
$\tau_{1-}^{\#2\alpha} + 2ik \sigma_{1-}^{\#1\alpha} == 0$	3
$\tau_{1-}^{\#1\alpha} == 0$	3
$\sigma_{1-}^{\#1\alpha} == \sigma_{1-}^{\#2\alpha}$	3
$\tau_{1+}^{\#1\alpha\beta} + ik \sigma_{1+}^{\#2\alpha\beta} == 0$	3
$\tau_{2+}^{\#1\alpha\beta}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

$\sigma_0^{\#1} \dagger$	$\frac{1}{6k^2(-r_1+r_3)}$	$\tau_0^{\#1} \sigma_0^{\alpha}$	$\tau_0^{\#2} \sigma_0^{\alpha}$	$\sigma_0^{\#1}$
$\sigma_0^{\#1} \dagger$	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	$-\frac{1}{t_1}$

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

$\omega_0^{\#1} \dagger$	$6k^2(-r_1+r_3)$	$f_0^{\#1} \omega_0^{\alpha}$	$f_0^{\#2} \omega_0^{\alpha}$	$\omega_0^{\#1}$
$\omega_0^{\#1} \dagger$	$6k^2(-r_1+r_3)$	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	$-t_1$

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

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