

Particle spectrograph

Wave operator and propagator

$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1+}^{\#2} \alpha\beta$	$\tau_{1+}^{\#1} \alpha\beta$	$\sigma_{1-}^{\#1} \alpha$	$\sigma_{1-}^{\#2} \alpha$	$\tau_{1-}^{\#1} \alpha$	$\tau_{1-}^{\#2} \alpha$
$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{2}{3k^2r_3}$	$-\frac{2i\sqrt{2}}{3kr_3+3k^3r_3}$	0	0	0	0
$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$-\frac{2\sqrt{2}}{3k^2r_3+3k^4r_3}$	$\frac{i(9k^2r_3+4t_2)}{3k(1+k^2)^2r_3t_2}$	0	0	0	0
$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{2i\sqrt{2}}{3kr_3+3k^3r_3}$	$-\frac{i(9k^2r_3+4t_2)}{3k(1+k^2)^2r_3t_2}$	0	0	0	0
$\sigma_{1-}^{\#1} \dagger^{\alpha}$	0	0	$\frac{6}{(3+2k^2)^2t_3}$	$-\frac{3\sqrt{2}}{(3+2k^2)^2t_3}$	0	$-\frac{6ik}{(3+2k^2)^2t_3}$
$\sigma_{1-}^{\#2} \dagger^{\alpha}$	0	0	$-\frac{3\sqrt{2}}{(3+2k^2)^2t_3}$	$\frac{3}{(3+2k^2)^2t_3}$	0	$\frac{3i\sqrt{2}k}{(3+2k^2)^2t_3}$
$\tau_{1-}^{\#1} \dagger^{\alpha}$	0	0	0	0	0	0
$\tau_{1-}^{\#2} \dagger^{\alpha}$	0	0	$\frac{6ik}{(3+2k^2)^2t_3}$	$-\frac{3i\sqrt{2}k}{(3+2k^2)^2t_3}$	0	$\frac{6k^2}{(3+2k^2)^2t_3}$

Quadratic (free) action

$S_F =$

$$\iiint \left[\frac{1}{6} (4t_3 \omega_{\lambda'}^{\alpha\lambda} \omega_{\kappa\alpha}^{\kappa} + 4t_2 \omega_{\lambda'}^{\kappa\lambda} \omega_{\kappa\lambda'}^{\lambda} + 2t_2 \omega_{\kappa\lambda'}^{\lambda} \omega_{\lambda\kappa}^{\kappa} + 6f^{\alpha\beta} \tau_{\alpha\beta} + 6\omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} + 4r_2 \partial^\beta \omega_{\alpha\beta}^{\theta\alpha} \partial_\theta \omega_{\alpha\beta}^{\kappa} - 2r_2 \partial_\theta \omega_{\alpha\beta}^{\kappa} \partial_\kappa \omega^{\alpha\beta\theta} - 4r_2 \partial_\theta \omega_{\alpha\beta}^{\kappa} \partial_\kappa \omega^{\theta\alpha\beta} + 6r_3 \partial_\alpha \omega_{\lambda}^{\alpha} \partial_\theta \omega_{\lambda}^{\theta\kappa\lambda} - 6r_3 \partial_\theta \omega_{\lambda}^{\alpha} \partial_\alpha \omega_{\theta\kappa\lambda}^{\kappa} + t_2 \partial^\alpha f_{\theta\kappa}^{\theta} \partial_\theta \partial^\alpha f_{\alpha}^{\theta} - t_2 \partial^\alpha f_{\kappa\theta}^{\theta} \partial^\kappa f_{\alpha}^{\theta} + t_2 \partial^\alpha f_{\kappa}^{\lambda} \partial_{\alpha\lambda}^{\kappa} \partial^\kappa f_{\alpha\lambda}^{\lambda} - 4t_3 \omega_{\kappa\alpha}^{\alpha} \partial^\kappa f_{\lambda'}^{\lambda} - 4t_3 \omega_{\kappa\lambda}^{\lambda} \partial^\kappa f_{\lambda'}^{\lambda} - 8t_3 \partial^\alpha f_{\kappa\alpha}^{\theta} \partial^\kappa f_{\lambda'}^{\theta} + 4t_3 \partial_\kappa f_{\lambda}^{\lambda} \partial^\kappa f_{\lambda'}^{\lambda} + 2t_2 \omega_{\theta\kappa} \partial^\kappa f_{\lambda'}^{\theta} - 4t_2 \omega_{\lambda\theta\kappa} \partial^\kappa f_{\lambda'}^{\theta} - 2t_2 \omega_{\theta\lambda\kappa} \partial^\kappa f_{\lambda'}^{\theta} + 4t_2 \omega_{\theta\kappa\lambda} \partial^\kappa f_{\lambda'}^{\theta} + 4t_3 \omega_{\lambda\alpha}^{\alpha} \partial^\kappa f_{\lambda'}^{\lambda} + 4t_3 \omega_{\lambda\lambda'}^{\lambda} \partial^\kappa f_{\lambda'}^{\lambda} - t_2 \partial^\alpha f_{\lambda}^{\lambda} \partial^\kappa f_{\lambda\alpha}^{\lambda} - t_2 \partial_\kappa f_{\theta}^{\lambda} \partial^\kappa f_{\lambda}^{\theta} + t_2 \partial_\kappa f_{\theta}^{\lambda} \partial^\kappa f_{\lambda}^{\theta} + 4t_3 \partial^\alpha f_{\lambda}^{\lambda} \partial_\alpha \omega_{\alpha\beta}^{\theta\alpha} - 4r_2 \partial^\beta \omega_{\alpha\beta}^{\theta\alpha} \partial_\lambda \omega_{\alpha\beta}^{\lambda} + 4r_2 \partial^\beta \omega_{\alpha\beta}^{\theta\alpha} \partial_\lambda \omega_{\alpha\beta}^{\lambda} - 24r_3 \partial^\beta \omega_{\lambda'}^{\lambda\alpha} \partial_\lambda \omega_{\alpha\beta}^{\lambda} + \partial_\lambda \omega_{\alpha\beta}^{\lambda} - 6r_3 \partial_\alpha \omega_{\lambda}^{\alpha} \partial^\lambda \omega_{\theta}^{\theta\kappa} + 6r_3 \partial_\theta \omega_{\lambda}^{\alpha} \partial^\lambda \omega_{\alpha}^{\theta\kappa})] [t, x, y, z] dz dy dx dt$$

$\omega_{1+}^{\#1} \alpha\beta$	$\omega_{1+}^{\#2} \alpha\beta$	$f_{1+}^{\#1} \alpha\beta$	$\omega_{1-}^{\#1} \alpha$	$\omega_{1-}^{\#2} \alpha$	$f_{1-}^{\#1} \alpha$	$f_{1-}^{\#2} \alpha$
$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{1}{6} (9k^2r_3 + 4t_2)$	$\frac{1}{3} i \sqrt{2} k t_2$	0	0	0	0
$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$\frac{\sqrt{2} t_2}{3}$	$\frac{i k t_2}{3}$	0	0	0	0
$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{1}{3} i \sqrt{2} k t_2$	$-\frac{1}{3} i k t_2$	0	0	0	0
$\omega_{1-}^{\#1} \dagger^{\alpha}$	0	0	$\frac{2t_3}{3}$	$-\frac{\sqrt{2} t_3}{3}$	0	$-\frac{2}{3} i k t_3$
$\omega_{1-}^{\#2} \dagger^{\alpha}$	0	0	$-\frac{\sqrt{2} t_3}{3}$	$\frac{t_3}{3}$	0	$\frac{1}{3} i \sqrt{2} k t_3$
$f_{1-}^{\#1} \dagger^{\alpha}$	0	0	0	0	0	0
$f_{1-}^{\#2} \dagger^{\alpha}$	0	0	$\frac{2i k t_3}{3}$	$-\frac{1}{3} i \sqrt{2} k t_3$	0	$\frac{2k^2 t_3}{3}$

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau_{0+}^{\#2} = 0$	1
$\tau_{0+}^{\#1} - 2ik\sigma_{0+}^{\#1} = 0$	1
$\tau_{1-}^{\#2\alpha} - ik\sigma_{1-}^{\#1\alpha} = 0$	3
$\tau_{1-}^{\#1\alpha} = 0$	3
$\sigma_{1-}^{\#1\alpha} + 2\sigma_{1-}^{\#2\alpha} = 0$	3
$\tau_{1+}^{\#1\alpha\beta} + ik\sigma_{1+}^{\#2\alpha\beta} = 0$	3
$\sigma_{2-}^{\#1\alpha\beta\chi} = 0$	5
$\tau_{2+}^{\#1\alpha\beta} = 0$	5
Total constraints:	24

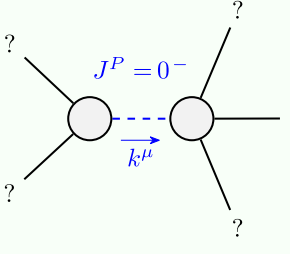
	$\sigma_{2+}^{\#1} \alpha\beta$	$\tau_{2+}^{\#1} \alpha\beta$	$\sigma_{2-}^{\#1} \alpha\beta\chi$
$\sigma_{2+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{2}{3k^2r_3}$	0	0
$\tau_{2+}^{\#1} \dagger^{\alpha\beta}$	0	0	0
$\sigma_{2-}^{\#1} \dagger^{\alpha\beta\chi}$	0	0	0

	$\sigma_{0+}^{\#1}$	$\tau_{0+}^{\#1}$	$\tau_{0+}^{\#2}$	$\sigma_{0-}^{\#1}$
$\sigma_{0+}^{\#1} \dagger$	$\frac{1}{(1+2k^2)^2t_3}$	$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_3}$	0	0
$\tau_{0+}^{\#1} \dagger$	$\frac{i\sqrt{2}k}{(1+2k^2)^2t_3}$	$\frac{2k^2}{(1+2k^2)^2t_3}$	0	0
$\tau_{0+}^{\#2} \dagger$	0	0	0	0
$\sigma_{0-}^{\#1} \dagger$	0	0	0	$\frac{1}{k^2r_2+t_2}$

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

	$\omega_{0+}^{\#1}$	$f_{0+}^{\#1}$	$f_{0+}^{\#2}$	$\omega_{0-}^{\#1}$
$\omega_{0+}^{\#1} \dagger$	t_3	$-i\sqrt{2}kt_3$	0	0
$f_{0+}^{\#1} \dagger$	$i\sqrt{2}kt_3$	$2k^2t_3$	0	0
$f_{0+}^{\#2} \dagger$	0	0	0	0
$\omega_{0-}^{\#1} \dagger$	0	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 (see massless particles)

Unitarity conditions

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