

Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$S = \int \int \int \int \left(\frac{1}{6} (2 t_1 \omega_{\alpha}^{\alpha i} \omega_{\beta}^{\theta} \omega_{\theta}^{\theta} + 6 f^{\alpha \beta} \tau_{\alpha \beta} + 6 \omega^{\alpha \beta \chi} \sigma_{\alpha \beta \chi} - 4 t_1 \omega_{\alpha}^{\theta} \omega_{\theta}^{\theta} \partial_i f^{\alpha i} + 4 t_1 \omega_{\theta}^{\theta} \partial_i f^{\alpha} - 2 t_1 \partial_i f_{\theta}^{\theta} \partial f_{\alpha}^{\alpha} - 24 r_3 \partial_{\beta} \omega_{\beta}^{\theta} \partial_i \omega_{\theta}^{\alpha \beta} - 2 t_1 \partial_i f^{\alpha i} \partial_{\theta} f_{\alpha}^{\theta} + 4 t_1 \partial_i f_{\alpha}^{\alpha} \partial_{\theta} f_{\beta}^{\theta} - 24 r_3 \partial_{\alpha} \omega_{\alpha}^{\alpha \beta i} \partial_{\theta} \omega_{\beta}^{\theta} + 48 r_3 \partial_i \omega_{\alpha}^{\alpha \beta} \partial_{\theta} \omega_{\beta}^{\theta} + 4 t_1 \omega_{\theta \alpha} \partial^{\theta} f^{\alpha i} + 4 t_2 \omega_{\theta \alpha} \partial^{\theta} f^{\alpha i} - 4 t_1 \partial_{\alpha} f_{\theta}^{\theta} \partial^{\theta} f^{\alpha i} + 2 t_2 \partial_{\alpha} f_{\theta}^{\theta} \partial^{\theta} f^{\alpha i} - 4 t_1 \partial_{\alpha} f_{\theta}^{\theta} \partial^{\theta} f^{\alpha i} - t_2 \partial_{\alpha} f_{\theta}^{\theta} \partial^{\theta} f^{\alpha i} + 4 t_1 \partial_{\theta} f_{\alpha}^{\alpha} \partial^{\theta} f^{\alpha i} + t_2 \partial_{\theta} f_{\alpha}^{\alpha} \partial^{\theta} f^{\alpha i} + 2 t_1 \partial_{\theta} f_{\alpha}^{\alpha} \partial^{\theta} f^{\alpha i} - t_2 \partial_{\theta} f_{\alpha}^{\alpha} \partial^{\theta} f^{\alpha i} + 2 (t_1 + t_2) \omega_{\alpha i \theta} (\omega^{\alpha i \theta} + 2 \partial^{\theta} f^{\alpha i}) + 2 \omega_{\alpha \theta i} ((t_1 - 2 t_2) \omega^{\alpha i \theta} + 2 (2 t_1 - t_2) \partial^{\theta} f^{\alpha i}) + 8 r_2 \partial_{\beta} \omega_{\alpha i \theta} \partial^{\theta} \omega_{\beta}^{\alpha \beta i} - 24 r_3 \partial_{\beta} \omega_{\theta \alpha} \partial^{\theta} \omega_{\beta}^{\alpha \beta i} - 2 r_2 \partial_i \omega_{\alpha \beta \theta} \partial^{\theta} \omega^{\alpha \beta i} + 2 r_2 \partial_{\theta} \omega_{\alpha \beta i} \partial^{\theta} \omega^{\alpha \beta i} - 4 r_2 \partial_{\theta} \omega_{\alpha i \beta} \partial^{\theta} \omega^{\alpha \beta i}) [t, x, y, z] d^3 x d y d z d t \right)$$

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

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

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

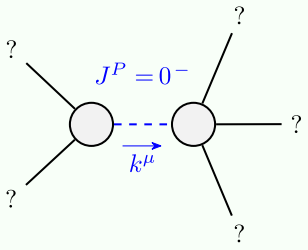
	$\omega_{0+}^{\#1} \dagger$	$f_{0+}^{\#1} \dagger$	$f_{0+}^{\#2} \dagger$	$\omega_{0-}^{\#1} \dagger$
$\omega_{0+}^{\#1} \dagger$	$6k^2r_3$	0	0	0
$f_{0+}^{\#1} \dagger$	0	0	0	0
$f_{0+}^{\#2} \dagger$	0	0	0	0
$\omega_{0-}^{\#1} \dagger$	0	0	0	$k^2r_2+t_2$

Source constraints/gauge generators	Multiplicities
$\tau_{0+}^{\#2} == 0$	1
$\tau_{0+}^{\#1} == 0$	1
$\tau_{1-}^{\#2 \alpha} + 2\bar{ik}\sigma_{1-}^{\#1 \alpha} == 0$	3
$\tau_{1-}^{\#1 \alpha} == 0$	3
$\sigma_{1-}^{\#1 \alpha} == \sigma_{1-}^{\#2 \alpha}$	3
$\tau_{1+}^{\#1 \alpha \beta} + \bar{ik}\sigma_{1+}^{\#2 \alpha \beta} == 0$	3
$\tau_{2+}^{\#1 \alpha \beta} - 2\bar{ik}\sigma_{2+}^{\#1 \alpha \beta} == 0$	5
Total constraints:	19

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

	$\sigma_{0+}^{\#1} \dagger$	$\tau_{0+}^{\#1} \dagger$	$\tau_{0+}^{\#2} \dagger$	$\sigma_{0-}^{\#1} \dagger$
$\sigma_{0+}^{\#1} \dagger$	$\frac{1}{6k^2r_3}$	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	$\frac{1}{k^2r_2+t_2}$

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

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