

Particle spectrograph

Wave operator and propagator

$\sigma_{1+}^{\#1} \uparrow \alpha\beta$	$\sigma_{1+}^{\#2} \alpha\beta$	$\tau_{1+}^{\#1} \uparrow \alpha\beta$	$\sigma_{1-}^{\#1} \alpha$	$\sigma_{1-}^{\#2} \alpha$	$\tau_{1-}^{\#1} \alpha$	$\tau_{1-}^{\#2} \alpha$
$\sigma_{1+}^{\#1} \uparrow \alpha\beta$	0	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	0	0	0	0
$\sigma_{1+}^{\#2} \uparrow \alpha\beta$	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$\frac{-2 k^2 (2 r_3+r_5)+t_1}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\tau_{1+}^{\#1} \uparrow \alpha\beta$	$\frac{i \sqrt{2} k}{t_1+k^2 t_1}$	$\frac{i (2 k^3 (2 r_3+r_5)-k t_1)}{(1+k^2)^2 t_1^2}$	0	0	0	0
$\sigma_{1-}^{\#1} \uparrow \alpha$	0	0	$\frac{1}{k^2 (2 r_3+r_5)}$	$-\frac{1}{\sqrt{2} (k^2+2 k^4) (2 r_3+r_5)}$	0	$-\frac{i}{k (1+2 k^2) (2 r_3+r_5)}$
$\sigma_{1-}^{\#2} \uparrow \alpha$	0	0	$-\frac{1}{\sqrt{2} (k^2+2 k^4) (2 r_3+r_5)}$	$\frac{6 k^2 (2 r_3+r_5)+t_1}{2 (k+2 k^3)^2 (2 r_3+r_5) t_1}$	0	$\frac{i (6 k^2 (2 r_3+r_5)+t_1)}{\sqrt{2} k (1+2 k^2)^2 (2 r_3+r_5) t_1}$
$\tau_{1-}^{\#1} \uparrow \alpha$	0	0	0	0	0	0
$\tau_{1-}^{\#2} \uparrow \alpha$	0	0	$\frac{i}{k (1+2 k^2) (2 r_3+r_5)}$	$-\frac{i (6 k^2 (2 r_3+r_5)+t_1)}{\sqrt{2} k (1+2 k^2)^2 (2 r_3+r_5) t_1}$	0	$\frac{6 k^2 (2 r_3+r_5)+t_1}{(1+2 k^2)^2 (2 r_3+r_5) t_1}$

Source constraints/gauge generators	SO(3) irreps	Multiplicities
	$\tau_{0+}^{\#2} == 0$	1
	$\tau_{0+}^{\#1} == 0$	1
	$\tau_{1-}^{\#2 \alpha} + 2 i k \sigma_{1-}^{\#2 \alpha} == 0$	3
	$\tau_{1-}^{\#1 \alpha} == 0$	3
	$\tau_{1+}^{\#1 \alpha \beta} + i k \sigma_{1+}^{\#2 \alpha \beta} == 0$	3
	$\tau_{2+}^{\#1 \alpha \beta} - 2 i k \sigma_{2+}^{\#1 \alpha \beta} == 0$	5
	Total constraints:	16

Quadratic (free) action
$S_F == \iiint (\frac{1}{6} (-2 t_1 \omega_{\mu}^{\alpha \nu} \omega_{\kappa \alpha}^{\mu} \omega_{\kappa}^{\nu} - 6 t_1 \omega_{\mu}^{\kappa \lambda} \omega_{\lambda}^{\mu} \omega_{\nu}^{\kappa} + 6 f^{\alpha \beta} \tau_{\alpha \beta} + 6 \omega^{\alpha \beta \chi} \sigma_{\alpha \beta \chi} -$ $12 r_3 \partial_{\mu} \omega_{\kappa}^{\kappa \lambda} \partial' \omega_{\lambda}^{\alpha} \omega_{\alpha}^{\mu} - 6 r_5 \partial_{\mu} \omega_{\kappa}^{\kappa \lambda} \partial' \omega_{\lambda}^{\alpha} + 12 r_3 \partial_{\alpha} \omega_{\lambda}^{\alpha} \partial_{\theta} \omega_{\lambda}^{\alpha} \omega_{\theta}^{\kappa \lambda} -$ $6 r_5 \partial_{\alpha} \omega_{\lambda}^{\alpha} \partial_{\theta} \omega_{\theta}^{\kappa \lambda} - 12 r_3 \partial_{\theta} \omega_{\lambda}^{\alpha} \partial_{\alpha} \omega_{\theta}^{\kappa \lambda} + 6 r_5 \partial_{\theta} \omega_{\lambda}^{\alpha} \partial_{\alpha} \omega_{\theta}^{\kappa \lambda} -$ $12 r_3 \partial_{\alpha} \omega_{\lambda}^{\alpha} \partial_{\theta} \omega_{\theta}^{\kappa \lambda \theta} - 6 r_5 \partial_{\alpha} \omega_{\lambda}^{\alpha} \partial_{\theta} \omega_{\theta}^{\kappa \lambda \theta} + 24 r_3 \partial_{\theta} \omega_{\lambda}^{\alpha} \partial_{\alpha} \omega_{\theta}^{\kappa \lambda \theta} +$ $12 r_5 \partial_{\theta} \omega_{\lambda}^{\alpha} \partial_{\alpha} \omega_{\theta}^{\kappa \lambda \theta} - 3 t_1 \partial^{\alpha} f_{\theta \kappa} \partial^{\kappa} f_{\alpha}^{\theta} - 3 t_1 \partial^{\alpha} f_{\kappa \theta} \partial^{\kappa} f_{\alpha}^{\theta} -$ $3 t_1 \partial^{\alpha} f_{\kappa}^{\lambda} \partial^{\kappa} f_{\alpha \lambda} + 2 t_1 \omega_{\kappa \alpha}^{\alpha} \partial^{\kappa} f_{\mu}^{\mu} + 2 t_1 \omega_{\kappa \lambda}^{\lambda} \partial^{\kappa} f_{\mu}^{\mu} + 4 t_1 \partial^{\alpha} f_{\kappa \alpha} \partial^{\kappa} f_{\mu}^{\mu} -$ $2 t_1 \partial_{\kappa} f_{\lambda}^{\lambda} \partial^{\kappa} f_{\mu}^{\mu} + 12 t_1 \omega_{\mu \kappa \theta} \partial^{\kappa} f_{\mu}^{\theta} - 2 t_1 \omega_{\mu \alpha}^{\alpha} \partial^{\kappa} f_{\mu}^{\mu} - 2 t_1 \omega_{\mu \lambda}^{\lambda} \partial^{\kappa} f_{\mu}^{\mu} +$ $3 t_1 \partial^{\alpha} f_{\kappa}^{\lambda} \partial^{\kappa} f_{\lambda \alpha} + 3 t_1 \partial_{\kappa} f_{\theta}^{\lambda} \partial^{\kappa} f_{\lambda}^{\theta} + 3 t_1 \partial_{\kappa} f_{\theta}^{\lambda} \partial^{\kappa} f_{\lambda}^{\theta} - 2 t_1 \partial^{\alpha} f_{\lambda}^{\alpha} \partial^{\kappa} f_{\lambda \kappa} -$ $24 r_3 \partial^{\beta} \omega_{\mu}^{\lambda \alpha} \partial_{\lambda} \omega_{\alpha \beta}^{\mu} - 12 r_3 \partial_{\alpha} \omega_{\lambda}^{\alpha} \partial^{\lambda} \omega_{\theta}^{\theta \kappa} + 6 r_5 \partial_{\alpha} \omega_{\lambda}^{\alpha} \partial^{\lambda} \omega_{\theta}^{\theta \kappa} +$ $12 r_3 \partial_{\theta} \omega_{\lambda}^{\alpha} \partial^{\lambda} \omega_{\alpha}^{\theta \kappa} - 6 r_5 \partial_{\theta} \omega_{\lambda}^{\alpha} \partial^{\lambda} \omega_{\alpha}^{\theta \kappa})) [t, x, y, z] d z d y d x d t$

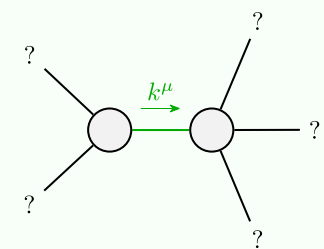
$\sigma_{2+}^{\#1} \uparrow \alpha\beta$	$\sigma_{2+}^{\#1} \alpha\beta$	$\tau_{2+}^{\#1} \alpha\beta$	$\sigma_{2-}^{\#1} \alpha\beta\chi$
$\sigma_{2+}^{\#1} \uparrow \alpha\beta$	$\frac{2}{(1+2k^2)^2 t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2 t_1}$	0
$\tau_{2+}^{\#1} \uparrow \alpha\beta$	$\frac{2i\sqrt{2}k}{(1+2k^2)^2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

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

$\omega_{0+}^{\#1} \uparrow$	$\omega_{0+}^{\#1} f_{0+}^{\#1}$	$\omega_{0+}^{\#2} f_{0+}^{\#2}$	$\omega_{0-}^{\#1}$
$\omega_{0+}^{\#1} \uparrow$	$6 k^2 r_3$	0	0
$f_{0+}^{\#1} \uparrow$	0	0	0
$f_{0+}^{\#2} \uparrow$	0	0	0
$\omega_{0-}^{\#1} \uparrow$	0	0	$-t_1$

	$\omega_{1+}^{\#1} \alpha\beta$	$\omega_{1+}^{\#2} \alpha\beta$	$f_{1+}^{\#1} \alpha\beta$	$\omega_{1-}^{\#1} \alpha$	$\omega_{1-}^{\#2} \alpha$	$f_{1-}^{\#1} \alpha$	$f_{1-}^{\#2} \alpha$
$\omega_{1+}^{\#1} \uparrow \alpha\beta$	$k^2 (2 r_3+r_5) - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{i k t_1}{\sqrt{2}}$	0	0	0	0
$\omega_{1+}^{\#2} \uparrow \alpha\beta$	$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$f_{1+}^{\#1} \uparrow \alpha\beta$	$\frac{i k t_1}{\sqrt{2}}$	0	0	0	0	0	0
$\omega_{1-}^{\#1} \uparrow \alpha$	0	0	0	$k^2 (2 r_3+r_5) + \frac{t_1}{6}$	$\frac{t_1}{3 \sqrt{2}}$	0	$\frac{i k t_1}{3}$
$\omega_{1-}^{\#2} \uparrow \alpha$	0	0	0	$\frac{t_1}{3 \sqrt{2}}$	$\frac{t_1}{3}$	0	$\frac{1}{3} i \sqrt{2} k t_1$
$f_{1-}^{\#1} \uparrow \alpha$	0	0	0	0	0	0	0
$f_{1-}^{\#2} \uparrow \alpha$	0	0	0	$-\frac{1}{3} i k t_1$	$-\frac{1}{3} i \sqrt{2} k t_1$	0	$\frac{2 k^2 t_1}{3}$

Massive and massless spectra



Quadratic pole	
Pole residue:	$-\frac{1}{(2 r_3+r_5) t_1^2} > 0$
Polarisations:	2

(No massive particles)

Unitarity conditions

$r_5 < -2 r_3 \ \&\& \ t_1 < 0 \ || \ t_1 > 0$