

Particle spectrograph

Wave operator and propagator

	$\sigma_{0+}^{\#1}$	$\tau_{0+}^{\#1}$	$\tau_{0+}^{\#2}$	$\sigma_0^{\#1}$
$\sigma_{0+}^{\#1} \uparrow$	$-\frac{1}{(1+2k^2)^2t_1}$	$\frac{i\sqrt{2}k}{(1+2k^2)^2t_1}$	0	0
$\tau_{0+}^{\#1} \uparrow$	$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_1}$	$-\frac{2k^2}{(1+2k^2)^2t_1}$	0	0
$\tau_{0+}^{\#2} \uparrow$	0	0	0	0
$\sigma_0^{\#1} \uparrow$	0	0	0	$\frac{1}{k^2r_2+t_2}$

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

	$\omega_{0+}^{\#1}$	$f_{0+}^{\#1}$	$f_{0+}^{\#2}$	$\omega_0^{\#1}$
$\omega_{0+}^{\#1} \uparrow$	$-t_1$	$i\sqrt{2}kt_1$	0	0
$f_{0+}^{\#1} \uparrow$	$-i\sqrt{2}kt_1$	$-2k^2t_1$	0	0
$f_{0+}^{\#2} \uparrow$	0	0	0	0
$\omega_0^{\#1} \uparrow$	0	0	0	$k^2r_2+t_2$

Source constraints		
SO(3) irreps	Fundamental fields	Multiplicities
$\tau_{0+}^{\#2} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$	1
$\tau_{0+}^{\#1} - 2i k \sigma_{0+}^{\#1} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau^\alpha_\alpha + 2 \partial_\chi \partial^\chi \partial_\beta \sigma^{\alpha\beta}_\alpha$	1
$\tau_1^{\#2\alpha} + 2i k \sigma_1^{\#2\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta} + 2 \partial_\delta \partial^\delta \partial_\chi \partial_\beta \sigma^{\alpha\beta\chi}$	3
$\tau_1^{\#1\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\beta\alpha}$	3
$\tau_{1+}^{\#1\alpha\beta} + i k \sigma_{1+}^{\#2\alpha\beta} == 0$	$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\beta \tau^{\chi\alpha} + \partial_\chi \partial^\chi \tau^{\alpha\beta} +$ $2 \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2 \partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi} ==$ $\partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha\chi} +$ $\partial_\chi \partial^\chi \tau^{\beta\alpha} + 2 \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}$	3
$\tau_{2+}^{\#1\alpha\beta} - 2i k \sigma_{2+}^{\#1\alpha\beta} == 0$	$-i (4 \partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2 \partial_\delta \partial^\delta \partial^\beta \partial^\alpha \tau^\chi_\chi -$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi} - 3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} -$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi} - 3 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha} +$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3 \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\beta\alpha} +$ $4i k^\chi \partial_\epsilon \partial_\chi \partial^\beta \partial^\alpha \sigma^{\delta\epsilon}_\delta -$ $6i i k^\chi \partial_\epsilon \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon} -$ $6i i k^\chi \partial_\epsilon \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon} +$ $2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} +$ $6i i k^\chi \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\alpha\delta\beta} +$ $6i i k^\chi \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\beta\delta\alpha} -$ $2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \tau^\chi_\chi -$ $4i i \eta^{\alpha\beta} k^\chi \partial_\phi \partial^\phi \partial_\epsilon \partial_\chi \sigma^{\delta\epsilon}_\delta) == 0$	5
Total constraints/gauge generators:		16

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

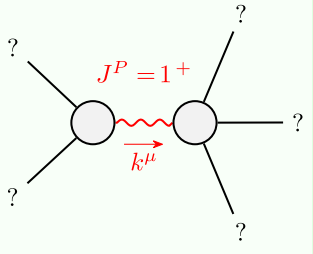
Quadratic (free) action

$$S == \int \int \int \int \Big( \frac{1}{6} (6 t_1 \omega_{\alpha}^{\alpha\iota} \omega_{\iota}^{\theta} + 6 f_{\theta}^{\alpha\beta} \tau_{\alpha\beta} + 6 \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - 12 t_1 \omega_{\alpha}^{\theta} \partial_{\iota} f^{\alpha\iota} + 12 t_1 \omega_{\iota}^{\theta} \partial f^{\alpha}_{\alpha} - 6 t_1 \partial_{\iota} f^{\alpha}_{\theta} \partial_{\iota} f^{\alpha\iota} - 6 t_1 \partial_{\iota} f^{\alpha}_{\alpha} \partial^{\theta} f^{\alpha\iota} + 12 t_1 \partial_{\iota} f^{\alpha}_{\alpha} \partial^{\theta} f^{\theta}_{\iota} + 4 t_1 \omega_{\theta\alpha} \partial^{\theta} f^{\alpha\iota} + 4 t_2 \omega_{\theta\alpha} \partial^{\theta} f^{\alpha\iota} - 4 t_1 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha\iota} + 2 t_2 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha\iota} - 4 t_1 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha\iota} - 4 t_1 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha\iota} + 2 t_1 \partial_{\iota} f_{\alpha\theta} \partial^{\theta} f^{\alpha\iota} - t_2 \partial_{\iota} f_{\alpha\theta} \partial^{\theta} f^{\alpha\iota} + 4 t_1 \partial_{\theta} f_{\alpha\iota} \partial^{\theta} f^{\alpha\iota} + t_2 \partial_{\theta} f_{\alpha\iota} \partial^{\theta} f^{\alpha\iota} + 2 t_1 \partial_{\theta} f_{\iota\alpha} \partial^{\theta} f^{\alpha\iota} - t_2 \partial_{\theta} f_{\iota\alpha} \partial^{\theta} f^{\alpha\iota}) + 2 \omega_{\alpha\theta\iota} ((t_1 - 2 t_2) \omega^{\alpha\iota\theta} + 2 (2 t_1 - t_2) \partial^{\theta} f^{\alpha\iota}) + 8 r_2 \partial_{\beta} \omega_{\alpha\iota\theta} \partial^{\theta} \omega^{\alpha\beta\iota} - 4 r_2 \partial_{\beta} \omega_{\alpha\theta\iota} \partial^{\theta} \omega^{\alpha\beta\iota} + 4 r_2 \partial_{\beta} \omega_{\iota\theta\alpha} \partial^{\theta} \omega^{\alpha\beta\iota} - 2 r_2 \partial_{\iota} \omega_{\alpha\beta\theta} \partial^{\theta} \omega^{\alpha\beta\iota} + 2 r_2 \partial_{\theta} \omega_{\alpha\beta\iota} \partial^{\theta} \omega^{\alpha\beta\iota} - 4 r_2 \partial_{\theta} \omega_{\alpha\iota\beta} \partial^{\theta} \omega^{\alpha\beta\iota} + 6 r_5 \partial_{\iota} \omega_{\theta}^{\kappa} \partial^{\theta} \omega^{\alpha\iota}_{\alpha} - 6 r_5 \partial_{\alpha} \omega_{\iota}^{\kappa} \partial^{\theta} \omega^{\alpha\iota}_{\alpha} - 6 r_5 \partial_{\alpha} \omega^{\alpha\iota\theta} \partial_{\kappa} \omega_{\iota}^{\kappa} + 12 r_5 \partial^{\theta} \omega^{\alpha\iota}_{\alpha} \partial_{\kappa} \omega_{\iota}^{\kappa} + 6 r_5 \partial_{\alpha} \omega^{\alpha\iota\theta} \partial_{\kappa} \omega_{\theta}^{\kappa} - 12 r_5 \partial^{\theta} \omega^{\alpha\iota}_{\alpha} \partial_{\kappa} \omega_{\theta}^{\kappa}) [t, x, y, z] d z d y d x d t$$

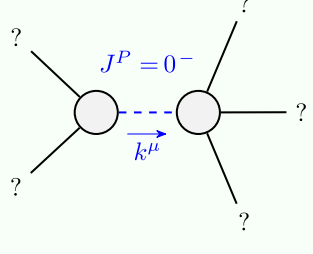
$\omega_{1+}^{\#1} \uparrow^{\alpha\beta}$	$\frac{1}{6} (6 k^2 r_5 + t_1 + 4 t_2)$	$\omega_{1+}^{\#2} \uparrow^{\alpha\beta}$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\omega_{1-}^{\#1} \uparrow^{\alpha\beta}$	$-\frac{i k (t_1-2t_2)}{3\sqrt{2}}$	$f_{1+}^{\#1} \uparrow^{\alpha\beta}$	$-\frac{1}{3} i k (t_1+t_2)$	$\omega_{1-}^{\#2} \uparrow^{\alpha\beta}$	$0$	$\omega_{1-}^{\#1} \uparrow^{\alpha\beta}$	$0$	$f_{1-}^{\#1} \uparrow^{\alpha\beta}$	$0$	$\omega_{1-}^{\#2} \uparrow^{\alpha\beta}$	$0$
$\omega_{1+}^{\#2} \uparrow^{\alpha\beta}$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\omega_{1+}^{\#1} \uparrow^{\alpha\beta}$	$\frac{t_1+t_2}{3}$	$\omega_{1-}^{\#1} \uparrow^{\alpha\beta}$	$\frac{1}{3} i k (t_1+t_2)$	$f_{1+}^{\#2} \uparrow^{\alpha\beta}$	$\frac{1}{3} k^2 (t_1+t_2)$	$\omega_{1-}^{\#1} \uparrow^{\alpha\beta}$	$0$	$\omega_{1-}^{\#2} \uparrow^{\alpha\beta}$	$0$	$f_{1-}^{\#2} \uparrow^{\alpha\beta}$	$0$	$\omega_{1-}^{\#1} \uparrow^{\alpha\beta}$	$0$
$\omega_{1-}^{\#1} \uparrow^{\alpha\beta}$	$\frac{i k (t_1-2t_2)}{3\sqrt{2}}$	$\omega_{1-}^{\#2} \uparrow^{\alpha\beta}$	$-\frac{1}{3} i k (t_1+t_2)$	$\omega_{1+}^{\#1} \uparrow^{\alpha\beta}$	$0$	$\omega_{1+}^{\#2} \uparrow^{\alpha\beta}$	$0$	$\omega_{1-}^{\#1} \uparrow^{\alpha\beta}$	$0$	$\omega_{1-}^{\#2} \uparrow^{\alpha\beta}$	$0$	$f_{1-}^{\#1} \uparrow^{\alpha\beta}$	$0$	$\omega_{1-}^{\#1} \uparrow^{\alpha\beta}$	$0$
$\omega_{1+}^{\#1} \uparrow^{\alpha}$	0	$\omega_{1+}^{\#2} \uparrow^{\alpha}$	0	$\omega_{1-}^{\#1} \uparrow^{\alpha}$	0	$\omega_{1-}^{\#2} \uparrow^{\alpha}$	0	$\omega_{1+}^{\#1} \uparrow^{\alpha}$	$k^2 r_5 - \frac{t_1}{2}$	$\omega_{1+}^{\#2} \uparrow^{\alpha}$	$\frac{t_1}{\sqrt{2}}$	$f_{1+}^{\#1} \uparrow^{\alpha}$	0	$\omega_{1+}^{\#1} \uparrow^{\alpha}$	0
$\omega_{1-}^{\#1} \uparrow^{\alpha}$	0	$\omega_{1-}^{\#2} \uparrow^{\alpha}$	0	$\omega_{1+}^{\#1} \uparrow^{\alpha}$	0	$\omega_{1+}^{\#2} \uparrow^{\alpha}$	0	$\omega_{1-}^{\#1} \uparrow^{\alpha}$	0	$\omega_{1-}^{\#2} \uparrow^{\alpha}$	0	$f_{1-}^{\#1} \uparrow^{\alpha}$	0	$\omega_{1-}^{\#1} \uparrow^{\alpha}$	0
$f_{1+}^{\#1} \uparrow^{\alpha}$	0	$f_{1+}^{\#2} \uparrow^{\alpha}$	0	$f_{1-}^{\#1} \uparrow^{\alpha}$	0	$f_{1-}^{\#2} \uparrow^{\alpha}$	0	$f_{1+}^{\#1} \uparrow^{\alpha}$	0	$f_{1+}^{\#2} \uparrow^{\alpha}$	0	$f_{1-}^{\#1} \uparrow^{\alpha}$	0	$f_{1-}^{\#2} \uparrow^{\alpha}$	0
$f_{1+}^{\#2} \uparrow^{\alpha}$	0	$f_{1+}^{\#1} \uparrow^{\alpha}$	0	$f_{1-}^{\#2} \uparrow^{\alpha}$	0	$f_{1-}^{\#1} \uparrow^{\alpha}$	0	$f_{1+}^{\#2} \uparrow^{\alpha}$	0	$f_{1+}^{\#1} \uparrow^{\alpha}$	0	$f_{1-}^{\#2} \uparrow^{\alpha}$	0	$f_{1-}^{\#1} \uparrow^{\alpha}$	0

	$\sigma_{1+}^{\#1} \uparrow^{\alpha\beta}$	$\sigma_{1+}^{\#2} \uparrow^{\alpha\beta}$	$\tau_{1+}^{\#1} \uparrow^{\alpha\beta}$	$\sigma_{1-}^{\#1} \uparrow^{\alpha}$	$\sigma_{1-}^{\#2} \uparrow^{\alpha}$	$\tau_{1-}^{\#1} \uparrow^{\alpha}$	$\tau_{1-}^{\#2} \uparrow^{\alpha}$
$\sigma_{1+}^{\#1} \uparrow^{\alpha\beta}$	$\frac{2(t_1+t_2)}{3t_1t_2+2k^2r_5(t_1+t_2)}$	$\frac{\sqrt{2}(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2r_5(t_1+t_2))}$	$\frac{i\sqrt{2}k(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2r_5(t_1+t_2))}$	0	0	0	0
$\sigma_{1+}^{\#2} \uparrow^{\alpha\beta}$	$\frac{\sqrt{2}(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2r_5(t_1+t_2))}$	$\frac{6k^2r_5+t_1+4t_2}{(1+k^2)^2(3t_1t_2+2k^2r_5(t_1+t_2))}$	$\frac{ik(6k^2r_5+t_1+4t_2)}{(1+k^2)^2(3t_1t_2+2k^2r_5(t_1+t_2))}$	0	0	0	0
$\tau_{1+}^{\#1} \uparrow^{\alpha\beta}$	$-\frac{i\sqrt{2}k(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2r_5(t_1+t_2))}$	$-\frac{ik(6k^2r_5+t_1+4t_2)}{(1+k^2)^2(3t_1t_2+2k^2r_5(t_1+t_2))}$	$-\frac{k^2(6k^2r_5+t_1+4t_2)}{(1+k^2)^2(3t_1t_2+2k^2r_5(t_1+t_2))}$	0	0	0	0
$\sigma_{1-}^{\#1} \uparrow^{\alpha}$	0	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	0	$\frac{2ik}{t_1+2k^2t_1}$
$\sigma_{1-}^{\#2} \uparrow^{\alpha}$	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{-2k^2r_5+t_1}{(t_1+2k^2t_1)^2}$	0	$-\frac{i\sqrt{2}k(2k^2r_5+t_1)}{(t_1+2k^2t_1)^2}$
$\tau_{1-}^{\#1} \uparrow^{\alpha}$	0	0	0	0	0	0	0
$\tau_{1-}^{\#2} \uparrow^{\alpha}$	0	0	0	$-\frac{2ik}{t_1+2k^2t_1}$	$\frac{i\sqrt{2}k(2k^2r_5+t_1)}{(t_1+2k^2t_1)^2}$	0	$\frac{-4k^4r_5+2k^2t_1}{(t_1+2k^2t_1)^2}$

Massive and massless spectra



Massive particle	
Pole residue:	$\frac{-3t_1t_2(t_1+t_2)+3r_5(t_1^2+2t_2^2)}{r_5(t_1+t_2)(-3t_1t_2+2r_5(t_1+t_2))} > 0$
Polarisations:	3
Square mass:	$-\frac{3t_1t_2}{2r_5t_1+2r_5t_2} > 0$
Spin:	1
Parity:	Even



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

$r_2 < 0 \ \&\& \ r_5 > 0 \ \&\& \ t_1 < 0 \ \&\& \ t_2 > -t_1$