

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	$\frac{1}{k^2r_2+t_2}$

	$\sigma_{2+}^{\#1\alpha\beta}$	$\tau_{2+}^{\#1\alpha\beta}$	$\sigma_{2-}^{\#1\alpha\beta\chi}$
$\sigma_{2+}^{\#1\alpha\beta} \uparrow$	$\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	0
$\tau_{2+}^{\#1\alpha\beta} \uparrow$	$\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	$\frac{4k^2}{(1+2k^2)^2t_1}$	0
$\sigma_{2-}^{\#1\alpha\beta\chi} \uparrow$	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
$\tau_{2+}^{\#1\alpha\beta} - 2i k \sigma_{2+}^{\#1\alpha\beta} == 0$	$-i (4 \partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2 \partial_\delta \partial^\delta \partial^\beta \partial^\alpha \tau^\chi_\chi -$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi} - 3 \partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} -$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi} - 3 \partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha} +$ $3 \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3 \partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\beta\alpha} +$ $4i k^\chi \partial_\epsilon \partial_\chi \partial^\beta \partial^\alpha \sigma^{\delta\epsilon}_\delta -$ $6i k^\chi \partial_\epsilon \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon} -$ $6i k^\chi \partial_\epsilon \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon} +$ $2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} +$ $6i k^\chi \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\alpha\delta\beta} +$ $6i k^\chi \partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\beta\delta\alpha} -$ $2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \tau^\chi_\chi -$ $4i \eta^{\alpha\beta} k^\chi \partial_\phi \partial^\phi \partial_\epsilon \partial_\chi \sigma^{\delta\epsilon}_\delta) == 0$	5
Total constraints/gauge generators:		16

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

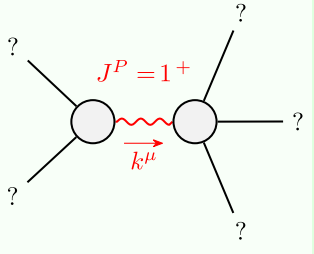
Quadratic (free) action

$$S == \int \int \int \int \bigg(\frac{1}{6} (6 t_1 \omega_{\alpha}^{\alpha \iota} \omega_{\iota}^{\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 \iota}_{\alpha} - 6 t_1 \partial_{\iota} f^{\alpha \iota}_{\alpha} \partial_{\theta} f^{\theta}_{\alpha} + 12 t_1 \partial_{\iota} f^{\alpha}_{\alpha} \partial_{\theta} f^{\theta}_{\iota} + 4 t_1 \omega_{\iota \alpha} \partial^{\theta} f^{\alpha \iota} + 4 t_2 \omega_{\iota \alpha} \partial^{\theta} f^{\alpha \iota} - 4 t_1 \partial_{\alpha} f_{\iota \theta} \partial^{\theta} f^{\alpha \iota} + 2 t_2 \partial_{\alpha} f_{\iota \theta} \partial^{\theta} f^{\alpha \iota} - 4 t_1 \partial_{\alpha} f_{\theta \iota} \partial^{\theta} f^{\alpha \iota} - t_2 \partial_{\alpha} f_{\theta \iota} \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^{\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$$

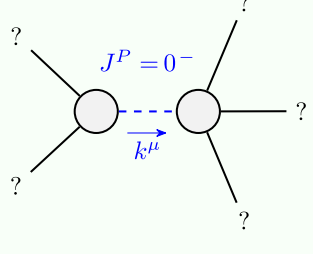
$\omega_{1+}^{\#1\alpha\beta} \uparrow$	$\frac{1}{6} (6 k^2 r_5 + t_1 + 4 t_2)$	$\omega_{1+}^{\#2\alpha\beta} \uparrow$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$f_{1+}^{\#1\alpha\beta} \uparrow$	$-\frac{i k (t_1-2t_2)}{3\sqrt{2}}$	$\omega_{1-}^{\#1\alpha} \uparrow$	0	$\omega_{1-}^{\#2\alpha} \uparrow$	0	$f_{1-}^{\#1\alpha}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

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

Massive and massless spectra



Massive particle	
Pole residue:	$\frac{-3 t_1 t_2 (t_1+t_2)+3 r_5 (t_1^2+2 t_2^2)}{r_5 (t_1+t_2) (-3 t_1 t_2+2 r_5 (t_1+t_2))} > 0$
Polarisations:	3
Square mass:	$-\frac{3 t_1 t_2}{2 r_5 t_1+2 r_5 t_2} > 0$
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

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