

Particle spectrograph

Wave operator and propagator

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

Quadratic (free) action

$$S = \iiint (\frac{1}{6} (2t_1 \omega_{\alpha}^{\alpha'} \omega_{\theta}^{\theta} + 6 f^{\alpha\beta} \tau_{\alpha\beta} + 6 \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - 4 t_1 \omega_{\alpha}^{\theta} \partial_{\theta} f^{\alpha'} + 4 t_1 \omega_{\theta}^{\alpha} \partial_{\alpha'} f^{\alpha} - 2 t_1 \partial_{\theta} f^{\alpha} \partial_{\alpha'} f^{\alpha} - 2 t_1 \partial_{\alpha'} f^{\alpha} \partial_{\theta} f^{\alpha} - 4 t_1 \omega_{\theta\alpha} \partial^{\theta} f^{\alpha'} + 4 t_2 \omega_{\theta\alpha} \partial^{\theta} f^{\alpha'} - 4 t_2 \omega_{\theta\alpha} \partial^{\theta} f^{\alpha'} - 4 t_1 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha'} + 2 t_1 \partial_{\theta} f_{\alpha} \partial^{\theta} f^{\alpha'} - 2 t_2 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha'} + 4 t_1 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha'} + t_2 \partial_{\theta} f_{\alpha'} \partial^{\theta} f^{\alpha'} + 2 t_1 \partial_{\theta} f_{\alpha} \partial^{\theta} f^{\alpha'} - 2 t_2 \partial_{\theta} f_{\alpha} \partial^{\theta} f^{\alpha'} + 2 (t_1 + t_2) \omega_{\alpha\theta} (\omega^{\alpha'\theta} + 2 \partial^{\theta} f^{\alpha'}) + 2 \omega_{\alpha\theta} ((t_1 - 2 t_2) \omega^{\alpha'\theta} + 2 (2 t_1 - t_2) \partial^{\theta} f^{\alpha'}) + 8 r_2 \partial_{\beta} \omega_{\alpha\theta} \partial^{\theta} \omega^{\alpha\beta'} - 4 r_2 \partial_{\beta} \omega_{\alpha\theta} \partial^{\theta} \omega^{\alpha\beta'} + 4 r_2 \partial_{\beta} \omega_{\theta\alpha} \partial^{\theta} \omega^{\alpha\beta'} - 2 r_2 \partial_{\theta} \omega_{\alpha\beta\theta} \partial^{\theta} \omega^{\alpha\beta'} + 2 r_2 \partial_{\theta} \omega_{\alpha\beta\theta} \partial^{\theta} \omega^{\alpha\beta'} - 4 r_2 \partial_{\theta} \omega_{\alpha\beta\theta} \partial^{\theta} \omega^{\alpha\beta'}) [t, x, y, z] dz dy dx dt$$

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

Source constraints/gauge generators

SO(3) irreps	Multiplicities
$\tau_{0+}^{\#2} == 0$	1
$\tau_{0+}^{\#1} == 0$	1
$\sigma_{0+}^{\#1} == 0$	1
$\tau_{1-}^{\#2\alpha} + 2 ik \sigma_{1-}^{\#1\alpha} == 0$	3
$\tau_{1-}^{\#1\alpha} == 0$	3
$\sigma_{1-}^{\#1\alpha} == \sigma_{1-}^{\#2\alpha}$	3
$\tau_{1+}^{\#1\alpha\beta} + ik \sigma_{1+}^{\#2\alpha\beta} == 0$	3
$\tau_{2+}^{\#1\alpha\beta} - 2 ik \sigma_{2+}^{\#1\alpha\beta} == 0$	5
Total constraints:	20

$\omega_{0+}^{\#1} \uparrow, f_{0+}^{\#1} \uparrow, f_{0+}^{\#2} \uparrow, \omega_{0-}^{\#1} \uparrow$

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

$\sigma_{0+}^{\#1} \uparrow, \tau_{0+}^{\#1} \uparrow, \tau_{0+}^{\#2} \uparrow, \sigma_{0-}^{\#1} \uparrow$

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

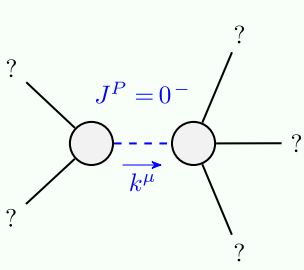
$\omega_{2+}^{\#1} \uparrow^{\alpha\beta}, f_{2+}^{\#1} \uparrow^{\alpha\beta}, \omega_{2-}^{\#1} \uparrow^{\alpha\beta\chi}$

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

$\sigma_{2+}^{\#1} \uparrow^{\alpha\beta}, \tau_{2+}^{\#1} \uparrow^{\alpha\beta}, \sigma_{2-}^{\#1} \uparrow^{\alpha\beta\chi}$

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

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 spurious particles)

Unitarity conditions

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