

Particle spectrograph

Wave operator and propagator

$\sigma_1^{#1} \uparrow \alpha\beta$	$\sigma_1^{#2} \uparrow \alpha\beta$	$\tau_1^{#1} \uparrow \alpha\beta$	$\sigma_1^{#1} \downarrow \alpha$	$\sigma_1^{#2} \downarrow \alpha$	$\tau_1^{#1} \downarrow \alpha$	$\tau_1^{#2} \downarrow \alpha$
$\frac{2(t_1+t_2)}{3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2)}$	$\frac{\sqrt{2}(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	$\frac{i\sqrt{2}k(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	0	0	0	0
$\frac{\sqrt{2}(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	$\frac{6k^2(2r_1+r_5)+t_1+4t_2}{(1+k^2)^2(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	$\frac{ik(6k^2(2r_1+r_5)+t_1+4t_2)}{(1+k^2)^2(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	0	0	0	0
$-\frac{i\sqrt{2}k(t_1-2t_2)}{(1+k^2)(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	$-\frac{ik(6k^2(2r_1+r_5)+t_1+4t_2)}{(1+k^2)^2(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	$\frac{k^2(6k^2(2r_1+r_5)+t_1+4t_2)}{(1+k^2)^2(3t_1t_2+2k^2(2r_1+r_5)(t_1+t_2))}$	0	0	0	0
0	0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	0	$\frac{2ik}{t_1+2k^2t_1}$
0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{-2k^2(r_1+r_5)+t_1}{(t_1+2k^2t_1)^2}$	0	$-\frac{i\sqrt{2}k(2k^2(r_1+r_5)-t_1)}{(t_1+2k^2t_1)^2}$
0	0	0	0	0	0	0
0	0	0	$-\frac{2ik}{t_1+2k^2t_1}$	$\frac{i\sqrt{2}k(2k^2(r_1+r_5)+2k^2t_1)}{(t_1+2k^2t_1)^2}$	0	$\frac{-4k^4(r_1+r_5)+2k^2t_1}{(t_1+2k^2t_1)^2}$

$\omega_1^{#1} \uparrow \alpha\beta$	$\omega_1^{#2} \uparrow \alpha\beta$	$f_1^{#1} \uparrow \alpha\beta$	$\omega_1^{#1} \downarrow \alpha$	$\omega_1^{#2} \downarrow \alpha$	$f_1^{#1} \downarrow \alpha$	$f_1^{#2} \downarrow \alpha$
$\frac{1}{6}(6k^2(2r_1+r_5)+t_1+4t_2)$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$-\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	0	0	0	0
$-\frac{t_1-2t_2}{3\sqrt{2}}$	$\frac{t_1+t_2}{3}$	$\frac{1}{3}ik(t_1+t_2)$	0	0	0	0
$\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	$-\frac{1}{3}ik(t_1+t_2)$	$\frac{1}{3}k^2(t_1+t_2)$	0	0	0	0
0	0	0	$k^2(r_1+r_5)-\frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0	$ik t_1$
0	0	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
0	0	0	0	0	0	0
0	0	0	$-ik t_1$	0	0	0

$\omega_2^{#1} \uparrow \alpha\beta$	$f_2^{#1} \uparrow \alpha\beta$	$\omega_2^{#1} \downarrow \alpha\beta\chi$
$\frac{t_1}{2}$	$-\frac{ik t_1}{\sqrt{2}}$	0
$\frac{ik t_1}{\sqrt{2}}$	$k^2 t_1$	0
0	0	$k^2 r_1 + \frac{t_1}{2}$

Source constraints/gauge generators	Multiplicities
$\tau_0^{#2} == 0$	1
$\tau_0^{#1} - 2ik\sigma_0^{#1} == 0$	1
$\tau_1^{#2\alpha} + 2ik\sigma_1^{#2\alpha} == 0$	3
$\tau_1^{#1\alpha} == 0$	3
$\tau_1^{#1\alpha\beta} + ik\sigma_1^{#2\alpha\beta} == 0$	3
$\tau_2^{#1\alpha\beta} - 2ik\sigma_2^{#1\alpha\beta} == 0$	5
Total constraints:	16

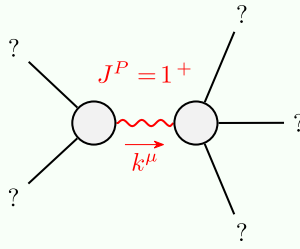
$\omega_0^{#1} \uparrow$	$f_0^{#2} \uparrow$	$\omega_0^{#1} \downarrow$
-t ₁	$i\sqrt{2}kt_1$	0
$-i\sqrt{2}kt_1$	$-2k^2t_1$	0
0	0	0
0	0	t ₂

$\sigma_2^{#1} \uparrow \alpha\beta$	$\tau_2^{#1} \uparrow \alpha\beta$	$\sigma_2^{#1} \downarrow \alpha\beta\chi$
$\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	0
$\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	$\frac{4k^2}{(1+2k^2)^2t_1}$	0
0	0	$\frac{2}{2k^2r_1+t_1}$

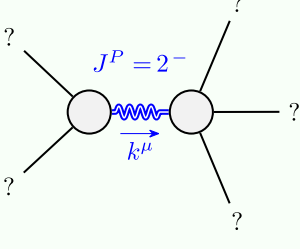
$\sigma_0^{#1} \uparrow$	$\tau_0^{#2} \uparrow$	$\sigma_0^{#1} \downarrow$
$-\frac{1}{(1+2k^2)^2t_1}$	$\frac{i\sqrt{2}k}{(1+2k^2)^2t_1}$	0
$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_1}$	$-\frac{2k^2}{(1+2k^2)^2t_1}$	0
0	0	0
0	0	$\frac{1}{t_2}$

Quadratic (free) action
$\begin{aligned} S = & \iiint \left(\frac{1}{6} (6t_1 \omega^{\alpha'}_{\alpha} \omega^{\theta}_{\theta} + 6f^{\alpha\beta} \tau_{\alpha\beta} + 6\omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - 12t_1 \omega^{\theta}_{\alpha} \partial_{\theta} f^{\alpha'} + 12t_1 \omega^{\theta}_{\theta} \partial' f^{\alpha}_{\alpha} - 6t_1 \partial_{\theta} f^{\theta}_{\theta} \partial' f^{\alpha}_{\alpha} - 6t_1 \partial_{\theta} f^{\alpha'} \partial_{\theta} f^{\theta}_{\alpha} + 12t_1 \partial' f^{\alpha}_{\alpha} \partial_{\theta} f^{\theta}_{\theta} + \right. \\ & 4t_1 \omega_{\theta\alpha} \partial^{\theta} f^{\alpha'} + 4t_2 \omega_{\theta\alpha} \partial^{\theta} f^{\alpha'} - 4t_1 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha'} + 2t_2 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha'} - \\ & 4t_1 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha'} - t_2 \partial_{\alpha} f_{\theta} \partial^{\theta} f^{\alpha'} + 2t_1 \partial_{\theta} f_{\alpha\theta} \partial^{\theta} f^{\alpha'} - t_2 \partial_{\theta} f_{\alpha\theta} \partial^{\theta} f^{\alpha'} + \\ & 4t_1 \partial_{\theta} f_{\alpha'} \partial^{\theta} f^{\alpha'} + t_2 \partial_{\theta} f_{\alpha'} \partial^{\theta} f^{\alpha'} + 2t_1 \partial_{\theta} f_{\alpha'} \partial^{\theta} f^{\alpha'} - 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_1-2t_2) \omega^{\alpha\theta} + 2(2t_1-t_2) \partial^{\theta} f^{\alpha'}) - \\ & 8r_1 \partial_{\beta} \omega_{\alpha\theta} \partial^{\theta} \omega^{\alpha\beta} + 4r_1 \partial_{\beta} \omega_{\alpha\theta} \partial^{\theta} \omega^{\alpha\beta} - 16r_1 \partial_{\beta} \omega_{\theta\alpha} \partial^{\theta} \omega^{\alpha\beta} - \\ & 4r_1 \partial_{\theta} \omega_{\alpha\beta\theta} \partial^{\theta} \omega^{\alpha\beta} + 4r_1 \partial_{\theta} \omega_{\alpha\beta} \partial^{\theta} \omega^{\alpha\beta} + 4r_1 \partial_{\theta} \omega_{\alpha\beta} \partial^{\theta} \omega^{\alpha\beta} + 6r_5 \partial_{\theta} \omega_{\theta}^{\kappa} \\ & \left. \partial^{\theta} \omega^{\alpha'}_{\alpha} - 6r_5 \partial_{\theta} \omega_{\theta}^{\kappa} \partial^{\theta} \omega^{\alpha'}_{\alpha} - 6r_5 \partial_{\alpha} \omega^{\alpha\theta} \partial_{\kappa} \omega_{\theta}^{\kappa} + 12r_5 \partial^{\theta} \omega^{\alpha'}_{\alpha} \partial_{\kappa} \omega_{\theta}^{\kappa} + \right. \\ & \left. 6r_5 \partial_{\alpha} \omega^{\alpha\theta} \partial_{\kappa} \omega_{\theta}^{\kappa} - 12r_5 \partial^{\theta} \omega^{\alpha'}_{\alpha} \partial_{\kappa} \omega_{\theta}^{\kappa} \right) [t, x, y, z] dz dy dx dt \end{aligned}$

Massive and massless spectra



Massive particle	
Pole residue:	$\frac{-3t_1t_2(t_1+t_2)+6r_1(t_1^2+2t_2^2)+3r_5(t_1^2+2t_2^2)}{(2r_1+r_5)(t_1+t_2)(-3t_1t_2+4r_1(t_1+t_2)+2r_5(t_1+t_2))} > 0$
Polarisations:	3
Square mass:	$-\frac{3t_1t_2}{2(2r_1+r_5)(t_1+t_2)} > 0$
Spin:	1
Parity:	Even



Massive particle	
Pole residue:	$-\frac{1}{r_1} > 0$
Polarisations:	5
Square mass:	$-\frac{t_1}{2r_1} > 0$
Spin:	2
Parity:	Odd

(No massless particles)

Unitarity conditions

$r_1 < 0 \ \&\& \ r_5 > -2r_1 \ \&\& \ t_1 > 0 \ \&\& \ -t_1 < t_2 < 0$