

Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$\begin{aligned}
 S = & \iiint (\frac{1}{6} (6 t_1 \omega^{\alpha'}_{\alpha} \omega^{\theta}_{\prime\theta} + 6 f^{\alpha\beta} \tau_{\alpha\beta} + 6 \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - 12 t_1 \omega^{\theta}_{\alpha} \partial_{\prime} f^{\alpha\prime} + 12 t_1 \omega^{\theta}_{\prime\theta} \partial_{\prime} f^{\alpha}_{\prime} - 6 t_1 \partial_{\prime} f^{\alpha}_{\prime} - 6 t_1 \partial_{\prime} f^{\theta}_{\prime} \partial_{\prime} f^{\alpha}_{\prime} - 12 r_1 \partial_{\beta} \omega^{\theta}_{\prime\theta} \partial_{\prime} \omega^{\alpha\beta}_{\prime} + 12 r_1 \partial_{\prime} \omega^{\theta}_{\prime} \partial_{\prime} \omega^{\alpha\beta}_{\prime} - 6 t_1 \partial_{\prime} f^{\alpha\prime} \partial_{\theta} f^{\theta}_{\prime} + 12 t_1 \partial_{\prime} f^{\alpha}_{\prime} \partial_{\theta} f^{\theta}_{\prime} + 12 r_1 \partial_{\alpha} \omega^{\alpha\beta\prime} \partial_{\theta} \omega^{\theta}_{\prime\theta} + 24 r_1 \partial_{\prime} \omega^{\alpha\beta}_{\prime} \partial_{\theta} \omega^{\theta}_{\prime\theta} - 24 r_1 \partial_{\prime} \omega^{\alpha\beta}_{\prime} \partial_{\theta} \omega^{\theta}_{\prime\theta} - 12 r_1 \partial_{\alpha} \omega^{\alpha\beta\prime} \partial_{\theta} \omega^{\theta}_{\prime\theta} + 24 r_1 \partial_{\prime} \omega^{\alpha\beta}_{\prime} \partial_{\theta} \omega^{\theta}_{\prime\theta} + 4 t_1 \omega_{\prime\theta\theta} \partial^{\theta} f^{\alpha\prime} - t_2 \partial_{\alpha} f_{\prime\theta} \partial^{\theta} f^{\alpha\prime} - t_2 \partial_{\alpha} f_{\prime\theta} \partial^{\theta} f^{\alpha\prime} + 4 t_1 \partial_{\alpha} f_{\prime\theta} \partial^{\theta} f^{\alpha\prime} - t_2 \partial_{\alpha} f_{\prime\theta} \partial^{\theta} f^{\alpha\prime} + 4 t_1 \partial_{\alpha} f_{\prime\theta} \partial^{\theta} f^{\alpha\prime} + 2 t_1 \partial_{\alpha} f_{\prime\theta} \partial^{\theta} f^{\alpha\prime} - t_2 \partial_{\alpha} f_{\prime\theta} \partial^{\theta} f^{\alpha\prime} + 4 t_1 \partial_{\alpha} f_{\prime\theta} \partial^{\theta} f^{\alpha\prime} + 2 t_1 \partial_{\alpha} f_{\prime\theta} \partial^{\theta} f^{\alpha\prime} - t_2 \partial_{\alpha} f_{\prime\theta} \partial^{\theta} f^{\alpha\prime} + 2 (t_1 + t_2) \omega^{\alpha\theta} (\omega^{\alpha\theta} + 2 \partial^{\theta} f^{\alpha\prime}) + 2 \omega_{\alpha\theta} ((t_1 - 2 t_2) \omega^{\alpha\theta} + 2 (2 t_1 - t_2) \partial^{\theta} f^{\alpha\prime}) - 8 r_1 \partial_{\beta} \omega_{\alpha\theta} \partial^{\theta} \omega^{\alpha\beta\prime} - 8 r_2 \partial_{\beta} \omega_{\alpha\theta} \partial^{\theta} \omega^{\alpha\beta\prime} - 4 r_1 \partial_{\beta} \omega_{\alpha\theta} \partial^{\theta} \omega^{\alpha\beta\prime} - 4 r_2 \partial_{\beta} \omega_{\alpha\theta} \partial^{\theta} \omega^{\alpha\beta\prime} - 16 r_1 \partial_{\beta} \omega_{\prime\theta\theta} \partial^{\theta} \omega^{\alpha\beta\prime} + 4 r_2 \partial_{\beta} \omega_{\prime\theta\theta} \partial^{\theta} \omega^{\alpha\beta\prime} - 4 r_1 \partial_{\prime} \omega_{\alpha\beta\theta} \partial^{\theta} \omega^{\alpha\beta\prime} - 4 r_2 \partial_{\prime} \omega_{\alpha\beta\theta} \partial^{\theta} \omega^{\alpha\beta\prime} - 2 r_2 \partial_{\prime} \omega_{\alpha\beta\theta} \partial^{\theta} \omega^{\alpha\beta\prime} + 4 r_1 \partial_{\theta} \omega_{\alpha\beta\prime} \partial^{\theta} \omega^{\alpha\beta\prime} + 2 r_2 \partial_{\theta} \omega_{\alpha\beta\prime} \partial^{\theta} \omega^{\alpha\beta\prime} + 4 r_1 \partial_{\theta} \omega_{\alpha\beta\prime} \partial^{\theta} \omega^{\alpha\beta\prime} - 4 r_2 \partial_{\theta} \omega_{\alpha\beta\prime} \partial^{\theta} \omega^{\alpha\beta\prime})) [t, x, y, z] d x d y d z d t
 \end{aligned}$$

$\sigma^{\#1}_{1+} \dagger^{\alpha\beta}$	$\sigma^{\#2}_{1+} \dagger^{\alpha\beta}$	$\tau^{\#1}_{1+} \dagger^{\alpha\beta}$	$\sigma^{\#1}_{1-} \dagger^{\alpha}$	$\sigma^{\#2}_{1-} \dagger^{\alpha}$	$\tau^{\#1}_{1-} \dagger^{\alpha}$	$\tau^{\#2}_{1-} \dagger^{\alpha}$
$\frac{2(t_1+t_2)}{3t_1t_2}$	$\frac{\sqrt{2}(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$\frac{i\sqrt{2}k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	0	0	0	0
$\frac{\sqrt{2}(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$\frac{t_1+4t_2}{3(1+k^2)^2t_1t_2}$	$\frac{ik(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	0	0	0	0
$-\frac{i\sqrt{2}k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$-\frac{ik(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	$-\frac{k^2(t_1+4t_2)}{3(1+k^2)^2t_1t_2}$	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	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{2k^2r_1+t_1}{(t_1+2k^2t_1)^2}$	0	$\frac{i\sqrt{2}k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$
0	0	0	0	0	0	0
0	0	0	$-\frac{2ik}{t_1+2k^2t_1}$	$-\frac{i\sqrt{2}k(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$	0	$\frac{2k^2(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$

$\omega^{\#1}_{1+} \dagger^{\alpha\beta}$	$\omega^{\#2}_{1+} \dagger^{\alpha\beta}$	$f^{\#1}_{1+} \dagger^{\alpha\beta}$	$\omega^{\#1}_{1-} \dagger^{\alpha}$	$\omega^{\#2}_{1-} \dagger^{\alpha}$	$f^{\#1}_{1-} \dagger^{\alpha}$	$f^{\#2}_{1-} \dagger^{\alpha}$
$\frac{1}{6}(t_1+4t_2)$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$-\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	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	$-k^2r_1-\frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	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

$\omega^{\#1}_{2+} \dagger^{\alpha\beta}$	$f^{\#1}_{2+} \dagger^{\alpha\beta}$	$\omega^{\#1}_{2-} \dagger^{\alpha\beta\chi}$
$\frac{t_1}{2}$	$-\frac{ik t_1}{\sqrt{2}}$	0
$\frac{ik t_1}{\sqrt{2}}$	$k^2 t_1$	0
0	0	$k^2 r_1 + \frac{t_1}{2}$

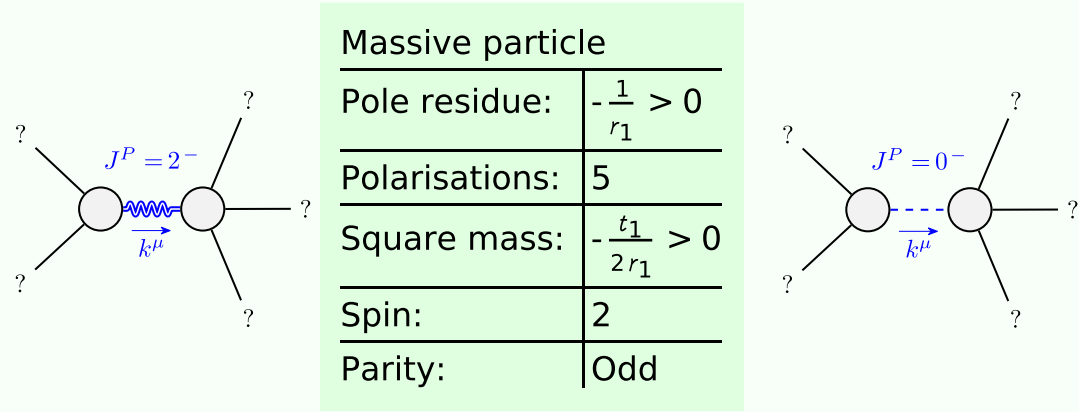
$\sigma^{\#1}_{2+} \dagger^{\alpha\beta}$	$\tau^{\#1}_{2+} \dagger^{\alpha\beta}$	$\sigma^{\#1}_{2-} \dagger^{\alpha\beta\chi}$
$\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	0
$\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	$\frac{4k^2}{(1+2k^2)^2t_1}$	0
0	0	$\frac{2}{2k^2r_1+t_1}$

Source constraints/gauge generators	
SO(3) irreps	Multiplicities
$\tau^{\#2}_{0+} == 0$	1
$\tau^{\#1}_{0+} - 2ik\sigma^{\#1}_{0+} == 0$	1
$\tau^{\#2\alpha}_{1-} + 2ik\sigma^{\#2\alpha}_{1-} == 0$	3
$\tau^{\#1\alpha}_{1-} == 0$	3
$\tau^{\#1\alpha\beta}_{1+} + ik\sigma^{\#2\alpha\beta}_{1+} == 0$	3
$\tau^{\#1\alpha\beta}_{2+} - 2ik\sigma^{\#1\alpha\beta}_{2+} == 0$	5
Total constraints:	16

$f^{\#1}_{0+} \dagger^{\alpha}$	$f^{\#2}_{0+} \dagger^{\alpha}$	$\omega^{\#1}_{0-} \dagger^{\alpha}$
$i\sqrt{2}k t_1$	0	0
$-i\sqrt{2}k t_1$	0	0
0	0	0
0	0	$k^2 r_2 + t_2$

$\sigma^{\#1}_{0+} \dagger^{\alpha}$	$\tau^{\#1}_{0+} \dagger^{\alpha}$	$\tau^{\#2}_{0+} \dagger^{\alpha}$	$\sigma^{\#1}_{0-} \dagger^{\alpha}$
$-\frac{1}{(1+2k^2)^2t_1}$	$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_1}$	0	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
0	0	0	$\frac{1}{k^2r_2+t_2}$

Massive and massless spectra



(No massless particles)

Unitarity conditions

$r_1 < 0 \ \&\& \ r_2 < 0 \ \&\& \ t_1 > 0 \ \&\& \ t_2 > 0$