

Particle spectrograph

Wave operator and propagator

Quadratic (free) action

$$S = \iiint [(\frac{1}{6}(6t_1\omega_{\alpha}^{\alpha i}\omega_{,\theta}^{\theta}+6f^{\alpha\beta}\tau_{\alpha\beta}+6\omega^{\alpha\beta\chi}\sigma_{\alpha\beta\chi}-12t_1\omega_{\alpha}^{\theta}\partial_{,f}f^{\alpha i}+12t_1\omega_{,\theta}^{\theta}\partial_{,f}f^{\alpha}{}_{\alpha}-6t_1\partial_{,f}f^{\theta}{}_{\alpha}\partial_{,f}f^{\alpha}{}_{\alpha}-12r_1\partial_{\beta}\omega_{,\theta}^{\theta}\partial_{,f}\omega^{\alpha\beta}{}_{\alpha}+12r_1\partial_{,f}\omega_{\beta}^{\theta}\partial_{,f}\omega^{\alpha\beta}{}_{\alpha}-6t_1\partial_{,f}f^{\alpha i}\partial_{\theta}f^{\theta}{}_{\alpha}+12t_1\partial_{,f}f^{\alpha}{}_{\alpha}\partial_{\theta}f^{\theta}{}_{,i}+12r_1\partial_{\alpha}\omega^{\alpha\beta i}\partial_{\theta}\omega_{\beta}^{\theta}-24r_1\partial_{,f}\omega_{\alpha}^{\alpha\beta}\partial_{\theta}\omega_{\beta}^{\theta}-12r_1\partial_{\alpha}\omega^{\alpha\beta i}\partial_{\theta}\omega_{,\beta}^{\theta}+24r_1\partial_{,f}\omega_{,\beta}^{\alpha\beta}\partial_{\theta}\omega_{,\beta}^{\theta}+4t_1\omega_{,\theta\alpha}^{\theta}\partial^{\theta}f^{\alpha i}+4t_2\omega_{,\theta\alpha}\partial^{\theta}f^{\alpha i}-t_2\partial_{\alpha}f_{,\theta}^{\theta}f^{\alpha i}-4t_1\partial_{\alpha}f_{,\theta}^{\theta}f^{\alpha i}-t_2\partial_{\alpha}f_{\theta i}^{\theta}\partial^{\theta}f^{\alpha i}+2t_1\partial_{,f}{}_{\alpha\theta}\partial^{\theta}f^{\alpha i}-t_2\partial_{,f}{}_{\alpha\theta}\partial^{\theta}f^{\alpha i}+4t_1\partial_{\theta}f_{,\alpha i}\partial^{\theta}f^{\alpha i}+t_2\partial_{\theta}f_{,\alpha i}\partial^{\theta}f^{\alpha i}+2t_1\partial_{\theta}f_{,\alpha i}\partial^{\theta}f^{\alpha i}-t_2\partial_{\theta}f_{,\alpha i}\partial^{\theta}f^{\alpha i}+2(t_1+t_2)\omega_{\alpha i\theta}(\omega^{\alpha i\theta}+2\partial^{\theta}f^{\alpha i})+2\omega_{\alpha\theta i}((t_1-2t_2)\omega^{\alpha i\theta}+2(2t_1-t_2)\partial^{\theta}f^{\alpha i})-8r_1\partial_{\beta}\omega_{\alpha i\theta}\partial^{\theta}\omega^{\alpha\beta i}+4r_1\partial_{\beta}\omega_{\alpha\theta i}\partial^{\theta}\omega^{\alpha\beta i}-16r_1\partial_{\beta}\omega_{,\theta\alpha}\partial^{\theta}\omega^{\alpha\beta i}-4r_1\partial_{,f}\omega_{\alpha\beta\theta}\partial^{\theta}\omega^{\alpha\beta i}+4r_1\partial_{\theta}\omega_{\alpha\beta i}\partial^{\theta}\omega^{\alpha\beta i}+4r_1\partial_{\theta}\omega_{\alpha i\beta}\partial^{\theta}\omega^{\alpha\beta i}))[t,x,y,z]dzdydxdt$$

$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$\sigma_{1-}^{\#1} \dagger^{\alpha}$	$\sigma_{1-}^{\#2} \dagger^{\alpha}$	$\tau_{1-}^{\#1} \dagger^{\alpha}$	$\tau_{1-}^{\#2} \dagger^{\alpha}$
$\frac{2(t_1+t_2)}{3t_1t_2}$	$\frac{\sqrt{2}(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$\frac{i\sqrt{2}k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	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	$\frac{2k^2(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$

$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\omega_{1-}^{\#1} \dagger^{\alpha}$	$\omega_{1-}^{\#2} \dagger^{\alpha}$	$f_{1-}^{\#1} \dagger^{\alpha}$	$f_{1-}^{\#2} \dagger^{\alpha}$
$\frac{1}{6}(t_1+4t_2)$	$-\frac{t_1-2t_2}{3\sqrt{2}}$	$-\frac{ik(t_1-2t_2)}{3\sqrt{2}}$	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

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

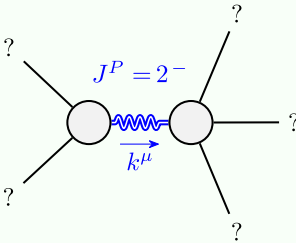
$\omega_{0+}^{\#1} \dagger$	$\omega_{0+}^{\#1}$	$f_{0+}^{\#1}$	$f_{0+}^{\#2}$	$\omega_{0-}^{\#1}$
-t ₁	$i\sqrt{2}kt_1$	0	0	0
$-i\sqrt{2}kt_1$	-2k ² t ₁	0	0	0
0	0	0	0	0
0	0	0	t ₂	

Source constraints/gauge generators	
SO(3) irreps	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

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

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

Massive and massless spectra



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

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