

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_{,i}^{\theta}+4t_1\omega_{,\theta\alpha}^{\theta}\partial^{\theta}\omega^{\alpha\beta i}-4t_1\partial_{\alpha}f_{,\theta}^{\theta}f^{\alpha i}-4t_1\partial_{\alpha}f_{\theta i}^{\theta}f^{\alpha i}-t_2\partial_{\alpha}f_{\theta i}^{\theta}f^{\alpha i}+4t_1\partial_{\alpha}f_{\theta}^{\theta}f^{\alpha i}-t_2\partial_{,f}f_{\alpha\theta}^{\theta}f^{\alpha i}+4t_1\partial_{\theta}f_{\alpha i}^{\theta}f^{\alpha i}+t_2\partial_{\theta}f_{\alpha i}^{\theta}f^{\alpha i}+2t_1\partial_{\theta}f_{\alpha}^{\theta}f^{\alpha i}-t_2\partial_{\theta}f_{,\alpha}^{\theta}f^{\alpha i}+2(t_1+t_2)\omega_{\alpha i\theta}^{\alpha}(\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}^{\alpha}\partial^{\theta}\omega^{\alpha\beta i}+4r_1\partial_{\beta}\omega_{\alpha\theta i}^{\alpha}\partial^{\theta}\omega^{\alpha\beta i}-16r_1\partial_{\beta}\omega_{,\theta\alpha}^{\alpha}\partial^{\theta}\omega^{\alpha\beta i}-4r_1\partial_{,f}\omega_{\alpha\beta\theta}^{\alpha}\partial^{\theta}\omega^{\alpha\beta i}+4r_1\partial_{\theta}\omega_{\alpha\beta i}^{\alpha}\partial^{\theta}\omega^{\alpha\beta i}+4r_1\partial_{\theta}\omega_{\alpha i\beta}^{\alpha}\partial^{\theta}\omega^{\alpha\beta i})][t,x,y,z]dzdydxdt$$

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

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

$\omega_{0+}^{\#1}+$	$f_{0+}^{\#1}+$	$f_{0+}^{\#2}+$	$\omega_{0-}^{\#1}$
$\omega_{0+}^{\#1}+$	$-t_1$	$i\sqrt{2}kt_1$	0
$f_{0+}^{\#1}+$	$-i\sqrt{2}kt_1$	$-2k^2t_1$	0
$f_{0+}^{\#2}+$	0	0	0
$\omega_{0-}^{\#1}$	0	0	t_2

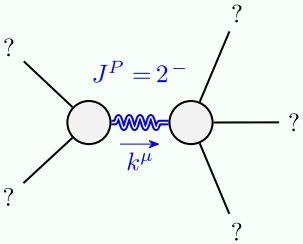
$\omega_{2+}^{\#1}+\alpha\beta$	$f_{2+}^{\#1}+\alpha\beta$	$\omega_{2-}^{\#1}+\alpha\beta\chi$
$\omega_{2+}^{\#1}+\alpha\beta$	$-\frac{ikt_1}{\sqrt{2}}$	0
$f_{2+}^{\#1}+\alpha\beta$	k^2t_1	0
$\omega_{2-}^{\#1}+\alpha\beta\chi$	0	$k^2r_1+\frac{t_1}{2}$

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

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

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

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