

Particle spectrograph

Wave operator and propagator

Source constraints		Fundamental fields	Multiplicities
SO(3) irreps			
$\tau_{0+}^{\#2} == 0$		$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$	1
$\tau_{0+}^{\#1} - 2 i k \sigma_0^{\#1} == 0$		$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial_\beta \tau^\alpha_\alpha + 2 \partial_\chi \partial^\chi \partial_\beta \sigma^{\alpha\beta}_\alpha$	1
$\tau_1^{\#2\alpha} + 2 i k \sigma_1^{\#2\alpha} == 0$		$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta} + 2 \partial_\theta \partial^\theta \partial_\chi \partial_\beta \sigma^{\alpha\beta\chi}$	3
$\tau_1^{\#1\alpha} == 0$		$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\beta\alpha}$	3
$\tau_1^{\#1\alpha\beta} + i k \sigma_1^{\#2\alpha\beta} == 0$		$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\beta \tau^{\chi\alpha} + \partial_\chi \partial^\chi \tau^{\alpha\beta} + 2 \partial_\theta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2 \partial_\theta \partial^\theta \partial_\chi \sigma^{\alpha\beta\chi} == \partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha\chi} + \partial_\chi \partial^\chi \tau^{\beta\alpha} + 2 \partial_\theta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}$	3
$\tau_2^{\#1\alpha\beta} - 2 i k \sigma_2^{\#1\alpha\beta} == 0$		$-i (4 \partial_\theta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2 \partial_\theta \partial^\theta \partial^\beta \partial^\alpha \tau^\chi_\chi - 3 \partial_\theta \partial^\theta \partial_\chi \partial^\alpha \tau^{\beta\chi} - 3 \partial_\theta \partial^\theta \partial_\chi \partial^\alpha \tau^{\chi\beta} - 3 \partial_\theta \partial^\theta \partial_\chi \partial^\beta \tau^{\alpha\chi} - 3 \partial_\theta \partial^\theta \partial_\chi \partial^\beta \tau^{\chi\alpha} + 3 \partial_\theta \partial^\theta \partial_\chi \partial^\alpha \tau^{\chi\beta} + 3 \partial_\theta \partial^\theta \partial_\chi \partial^\beta \tau^{\alpha\chi} + 4 i k^\chi \partial_\epsilon \partial_\chi \partial^\beta \partial^\alpha \sigma^{\delta\epsilon}_\delta - 6 i k^\chi \partial_\epsilon \partial_\theta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon} - 6 i k^\chi \partial_\epsilon \partial_\theta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon} + 2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\theta \partial_\chi \tau^{\chi\delta} + 6 i k^\chi \partial_\epsilon \partial^\epsilon \partial_\theta \partial_\chi \sigma^{\alpha\delta\beta} + 6 i k^\chi \partial_\epsilon \partial^\epsilon \partial_\theta \partial_\chi \sigma^{\beta\delta\alpha} - 2 \eta^{\alpha\beta} \partial_\epsilon \partial^\epsilon \partial_\theta \partial^\chi \tau^\chi_\chi - 4 i \eta^{\alpha\beta} k^\chi \partial_\theta \partial^\theta \partial_\epsilon \partial_\chi \sigma^{\delta\epsilon}_\delta) == 0$	5
Total constraints/gauge generators:			16

Quadratic (free) action

$S ==$

$$\iiint\iiint\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_{,f}\omega^\alpha_{\theta}+12t_1\omega^\theta_{\theta}\partial'f^\alpha_\alpha-6t_1\partial_{,f}\omega^\theta_{\theta}\partial'f^\alpha_\alpha-12r_1\partial_\beta\omega^\theta_{\theta}\partial'\omega^{\alpha\beta}_\alpha+12r_1\partial_{,}\omega_{\beta\theta}\partial'\omega^{\alpha\beta}_\alpha-6t_1\partial_{,f}\omega^\alpha_{\theta}\partial_\theta f^\theta_\alpha+12t_1\partial'f^\alpha_\alpha\partial_\theta f^\theta_{\theta}+12r_1\partial_\alpha\omega^{\alpha\beta_{\theta}}\partial_\theta\omega_{\beta\theta}-24r_1\partial'\omega^{\alpha\beta}_\alpha\partial_\theta\omega_{\beta\theta}-12r_1\partial_\alpha\omega^{\alpha\beta_{\theta}}\partial_\theta\omega_{\beta\theta}+24r_1\partial'\omega^{\alpha\beta}_\alpha\partial_\theta\omega_{\beta\theta}+4t_1\omega_{\theta\alpha}\partial^\theta f^{\alpha_{\theta}}+4t_2\omega_{\theta\alpha}\partial^\theta f^{\alpha_{\theta}}-4t_1\partial_\alpha f_{\theta\theta}\partial^\theta f^{\alpha_{\theta}}+2t_2\partial_\alpha f_{\theta\theta}\partial^\theta f^{\alpha_{\theta}}-4t_1\partial_\alpha f_{\theta\theta}\partial^\theta f^{\alpha_{\theta}}-t_2\partial_\alpha f_{\theta\theta}\partial^\theta f^{\alpha_{\theta}}+2t_1\partial_{,f}\alpha_\theta\partial^\theta f^{\alpha_{\theta}}-t_2\partial_{,f}\alpha_\theta\partial^\theta f^{\alpha_{\theta}}+4t_1\partial_\theta f_{\alpha\theta}\partial^\theta f^{\alpha_{\theta}}+t_2\partial_\theta f_{\alpha\theta}\partial^\theta f^{\alpha_{\theta}}+2t_1\partial_\theta f_{\alpha\theta}\partial^\theta f^{\alpha_{\theta}}-t_2\partial_\theta f_{\alpha\theta}\partial^\theta f^{\alpha_{\theta}}+2(t_1+t_2)\omega_{\alpha\theta}(\omega^{\alpha_{\theta}}+2\partial^\theta f^{\alpha_{\theta}})+2\omega_{\alpha\theta}((t_1-2t_2)\omega^{\alpha_{\theta}}+2(2t_1-t_2)\partial^\theta f^{\alpha_{\theta}})-8r_1\partial_\beta\omega_{\alpha\theta}\partial^\theta\omega^{\alpha\beta_{\theta}}+8r_2\partial_\beta\omega_{\alpha\theta}\partial^\theta\omega^{\alpha\beta_{\theta}}+4r_1\partial_\beta\omega_{\alpha\theta}\partial^\theta\omega^{\alpha\beta_{\theta}}-4r_2\partial_\beta\omega_{\alpha\theta}\partial^\theta\omega^{\alpha\beta_{\theta}}-16r_1\partial_\beta\omega_{\theta\alpha}\partial^\theta\omega^{\alpha\beta_{\theta}}+4r_2\partial_\beta\omega_{\theta\alpha}\partial^\theta\omega^{\alpha\beta_{\theta}}-4r_1\partial_{,}\omega_{\alpha\beta\theta}\partial^\theta\omega^{\alpha\beta_{\theta}}-2r_2\partial_{,}\omega_{\alpha\beta\theta}\partial^\theta\omega^{\alpha\beta_{\theta}}+4r_1\partial_\theta\omega_{\alpha\beta\theta}\partial^\theta\omega^{\alpha\beta_{\theta}}-2r_2\partial_\theta\omega_{\alpha\beta\theta}\partial^\theta\omega^{\alpha\beta_{\theta}}+4r_1\partial_\theta\omega_{\alpha\beta\theta}\partial^\theta\omega^{\alpha\beta_{\theta}}-4r_2\partial_\theta\omega_{\alpha\beta\theta}\partial^\theta\omega^{\alpha\beta_{\theta}})) [t, \chi, y, z] dz dy dx dt$$

$\sigma_1^{#1} + \alpha\beta$	$\sigma_1^{#2} + \alpha\beta$	$\tau_1^{#1} + \alpha\beta$	$\sigma_1^{#1} \alpha$	$\sigma_1^{#2} \alpha$	$\tau_1^{#1} \alpha$	$\tau_1^{#2} \alpha$
$\frac{2(t_1+t_2)}{3t_1t_2}$	$\frac{\sqrt{2}(t_1-2t_2)}{3(1+k^2)t_1t_2}$	$\frac{i\sqrt{2}k(t_1-2t_2)}{3(1+k^2)t_1t_2}$	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	$\frac{2k^2(2k^2r_1+t_1)}{(t_1+2k^2t_1)^2}$

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

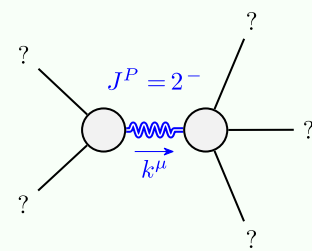
$\sigma_0^{#1} + \alpha\beta$	$\tau_0^{#1} + \alpha\beta$	$\tau_0^{#2} + \alpha\beta$	$\sigma_0^{#1}$
0	0	0	$\frac{1}{k^2r_2+t_2}$
$-\frac{1}{(1+2k^2)^2t_1}$	$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_1}$	0	0
$-\frac{i\sqrt{2}k}{(1+2k^2)^2t_1}$	$-\frac{2k^2}{(1+2k^2)^2t_1}$	0	0
0	0	0	0
0	0	0	0

$\omega_0^{#1} + \alpha\beta$	$f_0^{#1} + \alpha\beta$	$f_0^{#2} + \alpha\beta$	$\omega_0^{#1}$
0	0	0	$k^2r_2+t_2$
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

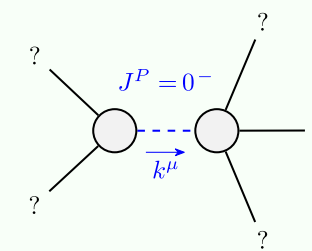
$\sigma_2^{#1} + \alpha\beta$	$\tau_2^{#1} + \alpha\beta$	$\tau_2^{#2} + \alpha\beta$	$\sigma_2^{#1} \alpha\beta\chi$
0	0	0	$\frac{2}{2k^2r_1+t_1}$
$-\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	0	0
$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	$-\frac{4k^2}{(1+2k^2)^2t_1}$	0	0
0	0	0	0
0	0	0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

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

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



Massive particle	
Pole residue:	$-\frac{1}{r_2} > 0$
Polarisations:	1
Square mass:	$-\frac{t_2}{r_2} > 0$
Spin:	0
Parity:	Odd

(No massless particles)

Unitarity conditions

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