

Particle spectrograph

Wave operator and propagator

Source constraints		
SO(3) irreps	Fundamental fields	Multiplicities
$\sigma_{0+}^{\#1} == 0$	$\partial_\beta \sigma^{\alpha\beta}_\alpha == 0$	1
$\tau_{0+}^{\#1} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == \partial_\beta \partial^\beta \tau^\alpha_\alpha$	1
$\tau_{0+}^{\#2} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$	1
$\tau_{1-}^{\#2\alpha} + 2\,i\,k\,\sigma_{1+}^{\#2\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta} + 2\,\partial_\delta \partial^\delta \partial_\chi \partial_\beta \sigma^{\alpha\beta\chi}$	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
$\tau_{1+}^{\#1\alpha\beta} + i\,k\,\sigma_{1+}^{\#2\alpha\beta} == 0$	$\partial_\chi \partial^\alpha \tau^{\beta\chi} + \partial_\chi \partial^\beta \tau^{\chi\alpha} + \partial_\chi \partial^\chi \tau^{\alpha\beta} +$ $2\,\partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\chi\delta} + 2\,\partial_\delta \partial^\delta \partial_\chi \sigma^{\alpha\beta\chi} ==$ $\partial_\chi \partial^\alpha \tau^{\chi\beta} + \partial_\chi \partial^\beta \tau^{\alpha\chi} +$ $\partial_\chi \partial^\chi \tau^{\beta\alpha} + 2\,\partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\chi\delta}$	3
$\tau_{2+}^{\#1\alpha\beta} - 2\,i\,k\,\sigma_{2+}^{\#1\alpha\beta} == 0$	$-i\,(4\,\partial_\delta \partial_\chi \partial^\beta \partial^\alpha \tau^{\chi\delta} + 2\,\partial_\delta \partial^\delta \partial^\beta \partial^\alpha \tau^\chi_\chi -$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\beta\chi} - 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\alpha \tau^{\chi\beta} -$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\alpha\chi} - 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\beta \tau^{\chi\alpha} +$ $3\,\partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\alpha\beta} + 3\,\partial_\delta \partial^\delta \partial_\chi \partial^\chi \tau^{\beta\alpha} +$ $4\,i\,k^\chi\,\partial_\epsilon \partial_\chi \partial^\beta \partial^\alpha \sigma^{\delta\epsilon}_\delta -$ $6\,i\,k^\chi\,\partial_\epsilon \partial_\delta \partial_\chi \partial^\alpha \sigma^{\beta\delta\epsilon} -$ $6\,i\,k^\chi\,\partial_\epsilon \partial_\delta \partial_\chi \partial^\beta \sigma^{\alpha\delta\epsilon} +$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \tau^{\chi\delta} +$ $6\,i\,k^\chi\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\alpha\delta\beta} +$ $6\,i\,k^\chi\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial_\chi \sigma^{\beta\delta\alpha} -$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon \partial^\epsilon \partial_\delta \partial^\delta \tau^\chi_\chi -$ $4\,i\,\eta^{\alpha\beta}\,k^\chi\,\partial_\phi \partial^\phi \partial_\epsilon \partial_\chi \sigma^{\delta\epsilon}_\delta) == 0$	5
Total constraints/gauge generators:		17

$\sigma_{1+}^{\#1} + \alpha\beta$	$\sigma_{1+}^{\#2} + \alpha\beta$	$\tau_{1+}^{\#1} + \alpha\beta$	$\sigma_{1-}^{\#1} - \alpha$	$\sigma_{1-}^{\#2} - \alpha$	$\tau_{1-}^{\#1} - \alpha$	$\tau_{1-}^{\#2} - \alpha$
0	$-\frac{\sqrt{2}}{t_1+k^2}t_1$	$-\frac{i\sqrt{2}k}{t_1+k^2}t_1$	0	0	0	0
$-\frac{\sqrt{2}}{t_1+k^2}t_1$	$\frac{-2k^2(2r_1+r_5)+t_1}{(1+k^2)^2}t_1^2$	$\frac{-2ik^3(2r_1+r_5)+ikt_1}{(1+k^2)^2}t_1^2$	0	0	0	0
$\frac{i\sqrt{2}k}{t_1+k^2}t_1$	$\frac{i(2k^3(2r_1+r_5)+kt_1)}{(1+k^2)^2}t_1^2$	$\frac{-2k^4(2r_1+r_5)+k^2t_1}{(1+k^2)^2}t_1^2$	0	0	0	0
0	0	0	$\frac{1}{k^2(r_1+r_5)}$	$-\frac{1}{\sqrt{2}(k^2+2k^4)(r_1+r_5)}$	0	$-\frac{i}{k(1+2k^2)(r_1+r_5)}$
0	0	0	0	$-\frac{1}{\sqrt{2}(k^2+2k^4)(r_1+r_5)}$	0	$\frac{i(6k^2(r_1+r_5)+t_1)}{\sqrt{2}k(1+2k^2)^2(r_1+r_5)t_1}$
0	0	0	0	0	0	0
0	0	0	$\frac{i}{k(1+2k^2)(r_1+r_5)}$	$-\frac{i(6k^2(r_1+r_5)+t_1)}{\sqrt{2}k(1+2k^2)^2(r_1+r_5)t_1}$	0	$\frac{6k^2(r_1+r_5)+t_1}{(1+2k^2)^2(r_1+r_5)t_1}$

Quadratic (free) action

$$S = \iiint\int (\frac{1}{6}(2t_1\omega^{\alpha\iota}_\alpha\omega^{\theta}_{\iota\theta} + 6f^{\alpha\beta}\tau_{\alpha\beta} + 6\omega^{\alpha\beta\chi}\sigma_{\alpha\beta\chi} - 4t_1\omega^{\theta}_\alpha\partial_\iota f^{\alpha\iota}_\theta + 4t_1\omega^{\theta}_{\iota\theta}\partial_\iota f^{\alpha\iota}_\alpha - 2t_1\partial_\iota f^{\theta}_{\theta}\partial^\theta f^{\alpha\iota}_\alpha - 2t_1\partial_\iota f^{\alpha\iota}_\theta\partial^\theta f^{\theta}_{\alpha} + 4t_1\partial_\iota f^{\alpha\iota}_\alpha\partial_\theta f^{\theta}_{\theta} - 6t_1\partial_\alpha f_{\iota\theta}\partial^\theta f^{\alpha\iota}_\theta - 3t_1\partial_\alpha f_{\theta\iota}\partial^\theta f^{\alpha\iota}_\theta + 3t_1\partial_\iota f_{\alpha\theta}\partial^\theta f^{\alpha\iota}_\theta + 3t_1\partial_\theta f_{\alpha\iota}\partial^\theta f^{\alpha\iota}_\theta + 3t_1\partial_\theta f_{\iota\alpha}\partial^\theta f^{\alpha\iota}_\theta + 6t_1\omega_{\alpha\theta\iota}(\omega^{\alpha\iota\theta} + 2\partial^\theta f^{\alpha\iota}_\theta) - 8r_1\partial_\beta\omega_{\alpha\iota\theta}\partial^\theta\omega^{\alpha\beta\iota} + 4r_1\partial_\beta\omega_{\alpha\theta\iota}\partial^\theta\omega^{\alpha\beta\iota} - 16r_1\partial_\beta\omega_{\iota\theta\alpha}\partial^\theta\omega^{\alpha\beta\iota} - 4r_1\partial_\iota\omega_{\alpha\beta\theta}\partial^\theta\omega^{\alpha\beta\iota} + 4r_1\partial_\theta\omega_{\alpha\beta\iota}\partial^\theta\omega^{\alpha\beta\iota} + 4r_1\partial_\theta\omega_{\alpha\iota\beta}\partial^\theta\omega^{\alpha\beta\iota} + 6r_5\partial_\beta\omega_{\iota\kappa}\partial^\theta\omega^{\alpha\iota}_\kappa - 6r_5\partial_\alpha\omega^{\alpha\iota\theta}\partial_\kappa\omega^{\kappa}_{\theta} + 12r_5\partial^\theta\omega^{\alpha\iota}_\alpha\partial_\kappa\omega^{\kappa}_{\iota\theta} + 6r_5\partial_\alpha\omega^{\alpha\iota\theta}\partial_\kappa\omega^{\kappa}_{\theta} + 12r_5\partial^\theta\omega^{\alpha\iota}_\alpha\partial_\kappa\omega^{\kappa}_{\theta})[t,x,y,z]dzdydxdt$$

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

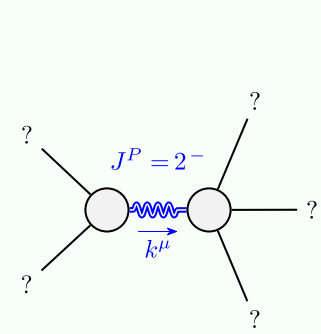
$\omega_{2+}^{\#1} + \alpha\beta$	$f_{2+}^{\#1} + \alpha\beta$	$\omega_{2-}^{\#1} - \alpha\beta\chi$
$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	0
$\frac{ikt_1}{\sqrt{2}}$	k^2t_1	0
0	0	$k^2r_1 + \frac{t_1}{2}$

$\sigma_{0+}^{\#1} +$	$\tau_{0+}^{\#1} +$	$\sigma_{0+}^{\#1} -$	$\tau_{0+}^{\#2} +$	$\sigma_{0-}^{\#1} -$
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	$-\frac{1}{t_1}$

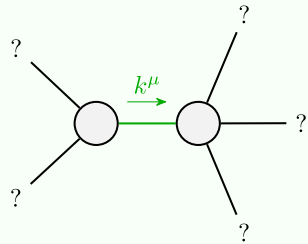
$\omega_{0+}^{\#1} +$	$f_{0+}^{\#1} +$	$\omega_{0+}^{\#2} +$	$f_{0+}^{\#2} +$	$\omega_{0-}^{\#1} -$
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	0
0	0	0	0	$-t_1$

$\omega_{1+}^{\#1} + \alpha\beta$	$\omega_{1+}^{\#2} + \alpha\beta$	$f_{1+}^{\#1} + \alpha\beta$	$\omega_{1-}^{\#1} - \alpha$	$\omega_{1-}^{\#2} - \alpha$	$f_{1-}^{\#2} - \alpha$
$k^2(2r_1+r_5) - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{ikt_1}{\sqrt{2}}$	0	0	0
$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0
$\frac{ikt_1}{\sqrt{2}}$	0	0	0	0	0
0	0	0	$k^2(r_1+r_5) + \frac{t_1}{6}$	$\frac{t_1}{3\sqrt{2}}$	$\frac{ikt_1}{3}$
0	0	0	$\frac{t_1}{3\sqrt{2}}$	$\frac{t_1}{3}$	$\frac{1}{3}i\sqrt{2}kt_1$
0	0	0	0	0	0
0	0	0	$-\frac{1}{3}ikt_1$	$-\frac{1}{3}i\sqrt{2}kt_1$	$\frac{2k^2t_1}{3}$

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



Quadratic pole	
Pole residue:	$-\frac{1}{(r_1+r_5)t_1^2} > 0$
Polarisations:	2

Unitarity conditions

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