

Particle spectrograph

Wave operator and propagator

Source constraints		
SO(3) irreps	Fundamental fields	Multiplicities
$\tau_{0+}^{\#2} == 0$	$\partial_\beta \partial_\alpha \tau^{\alpha\beta} == 0$	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
$\tau_1^{\#2\alpha} + 2\,i\,k\,\sigma_1^{\#2\alpha} == 0$	$\partial_\chi \partial_\beta \partial^\alpha \tau^{\beta\chi} == \partial_\chi \partial^\chi \partial_\beta \tau^{\alpha\beta} + 2\,\partial_\delta \partial^\delta \partial_\chi \partial_\beta \sigma^{\alpha\beta\chi}$	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:		16

$\sigma_1^{\#1+}\alpha\beta$	$\sigma_1^{\#2+}\alpha\beta$	$\tau_1^{\#1+}\alpha\beta$	$\sigma_1^{\#1-}\alpha$	$\sigma_1^{\#2-}\alpha$	$\tau_1^{\#1-}\alpha$	$\tau_1^{\#2-}\alpha$
0	$-\frac{\sqrt{2}}{t_1+k^2t_1}$	$-\frac{i\sqrt{2}k}{t_1+k^2t_1}$	0	0	0	0
$-\frac{\sqrt{2}}{t_1+k^2t_1}$	$\frac{-2k^2(2r_1+r_5)+t_1}{(1+k^2)^2t_1^2}$	$\frac{-2ik^3(2r_1+r_5)+ikt_1}{(1+k^2)^2t_1^2}$	0	0	0	0
$\frac{i\sqrt{2}k}{t_1+k^2t_1}$	$\frac{i(2k^3(2r_1+r_5)-kt_1)}{(1+k^2)^2t_1^2}$	$\frac{-2k^4(2r_1+r_5)+k^2t_1}{(1+k^2)^2t_1^2}$	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{2ik}{t_1+2k^2t_1}$
0	0	0	0	0	0	0
0	0	0	$\frac{\sqrt{2}}{t_1+2k^2t_1}$	$\frac{-2k^2(r_1+r_5)+t_1}{(t_1+2k^2t_1)^2}$	0	$-\frac{i\sqrt{2}k(2k^2(r_1+r_5)-t_1)}{(t_1+2k^2t_1)^2}$
0	0	0	0	0	0	0
0	0	0	$-\frac{2ik}{t_1+2k^2t_1}$	$\frac{i\sqrt{2}k(2k^2(r_1+r_5)-t_1)}{(t_1+2k^2t_1)^2}$	0	$\frac{-4k^4(r_1+r_5)+2k^2t_1}{(t_1+2k^2t_1)^2}$

Quadratic (free) action

$$S == \int \int \int \int (f^{\alpha\beta} \tau_{\alpha\beta} + \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} +$$
$$\frac{1}{2} t_1 (2 \omega^{\alpha\iota}_{\alpha} \omega^{\theta}_{\iota\theta} - 4 \omega^{\theta}_{\alpha} \omega_{\theta} \partial_{\iota} f^{\alpha\iota} + 4 \omega^{\theta}_{\iota\theta} \partial_{\iota} f^{\alpha\theta} -$$
$$2 \partial_{\iota} f^{\theta}_{\theta} \partial_{\iota} f^{\alpha\theta} - 2 \partial_{\iota} f^{\alpha\iota} \partial_{\theta} f^{\theta}_{\alpha} + 4 \partial_{\iota} f^{\alpha}_{\alpha} \partial_{\theta} f^{\theta}_{\iota} - 2 \partial_{\alpha} f^{\theta}_{\theta} - 2 \partial_{\alpha} f^{\alpha}_{\iota} \partial^{\theta} f^{\iota\theta} +$$
$$\partial^{\theta} f^{\alpha\iota} - \partial_{\alpha} f^{\theta}_{\theta} \partial^{\theta} f^{\alpha\iota} + \partial_{\iota} f^{\alpha\theta} \partial^{\theta} f^{\alpha\iota} + \partial_{\theta} f^{\alpha\iota} \partial^{\theta} f^{\alpha\iota} +$$
$$\partial_{\theta} f^{\alpha\iota} \partial^{\theta} f^{\alpha\iota} + 2 \omega_{\alpha\theta\iota} (\omega^{\alpha\iota\theta} + 2 \partial^{\theta} f^{\alpha\iota})) -$$
$$\frac{2}{3} r_1 (2 \partial_{\beta} \omega_{\alpha\iota\theta} - \partial_{\beta} \omega_{\alpha\theta\iota} + 4 \partial_{\beta} \omega_{\iota\theta\alpha} + \partial_{\iota} \omega_{\alpha\beta\theta} -$$
$$\partial_{\theta} \omega_{\alpha\beta\iota} - \partial_{\theta} \omega_{\alpha\iota\beta}) \partial^{\theta} \omega^{\alpha\beta\iota} +$$
$$r_5 (\partial_{\iota} \omega^{\kappa}_{\theta\kappa} \partial^{\theta} \omega^{\alpha\iota}_{\alpha} - \partial_{\theta} \omega^{\kappa}_{\alpha} \partial^{\theta} \omega^{\alpha\iota}_{\iota\kappa} \partial^{\theta} \omega^{\alpha\iota}_{\alpha} - (\partial_{\alpha} \omega^{\alpha\iota\theta} - 2 \partial^{\theta} \omega^{\alpha\iota}_{\alpha})$$
$$(\partial_{\kappa} \omega^{\kappa}_{\iota\theta} - \partial_{\kappa} \omega^{\kappa}_{\theta\iota}))) [t, x, y, z] dz dy dx dt$$

$\omega_2^{\#1+}\alpha\beta$	$f_2^{\#1+}\alpha\beta$	$\omega_2^{\#1-}\alpha\beta\chi$
$\frac{t_1}{2}$	$-\frac{ikt_1}{\sqrt{2}}$	0
$\frac{ikt_1}{\sqrt{2}}$	k^2t_1	0
0	0	$k^2r_1+\frac{t_1}{2}$

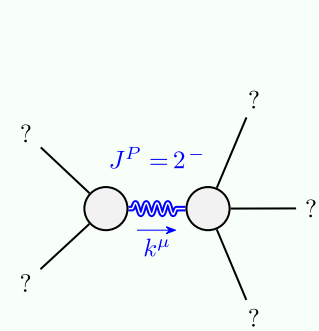
	$\sigma_2^{\#1+}\alpha\beta$	$\tau_2^{\#1+}\alpha\beta$	$\sigma_2^{\#1-}\alpha\beta\chi$
$\sigma_2^{\#1+}\alpha\beta$	$\frac{2}{(1+2k^2)^2t_1}$	$-\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	0
$\tau_2^{\#1+}\alpha\beta$	$\frac{2i\sqrt{2}k}{(1+2k^2)^2t_1}$	$\frac{4k^2}{(1+2k^2)^2t_1}$	0
$\sigma_2^{\#1-}\alpha\beta\chi$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

	$\omega_0^{\#1+}$	$f_0^{\#1+}$	$f_0^{\#2+}$	$\omega_0^{\#1-}$
$\omega_0^{\#1+}$	$-t_1$	$i\sqrt{2}kt_1$	0	0
$f_0^{\#1+}$	$-i\sqrt{2}kt_1$	$-2k^2t_1$	0	0
$f_0^{\#2+}$	0	0	0	0
$\omega_0^{\#1-}$	0	0	0	$-t_1$

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

$\omega_1^{\#1+}\alpha\beta$	$\omega_1^{\#2+}\alpha\beta$	$f_1^{\#1+}\alpha\beta$	$\omega_1^{\#1-}\alpha$	$\omega_1^{\#2-}\alpha$	$f_1^{\#1-}\alpha$	$f_1^{\#2-}\alpha$
$k^2(2r_1+r_5)-\frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$-\frac{ikt_1}{\sqrt{2}}$	0	0	0	0
$-\frac{t_1}{\sqrt{2}}$	0	0	0	0	0	0
$\frac{ikt_1}{\sqrt{2}}$	0	0	0	0	0	0
0	0	0	$k^2(r_1+r_5)-\frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	ikt_1	0
0	0	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
0	0	0	0	0	0	0
0	0	0	$-ikt_1$	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

(No massless particles)

Unitarity conditions

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