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

$\tau_{1^+}^{\#1\,\alpha\beta}$

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

$\sigma_{1^+}^{\#1\,\alpha\beta}$ / $\sigma_{1^+}^{\#2\,\alpha\beta}$

0	$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$\frac{i\sqrt{2}\,k}{t_1+k^2 t_1}$
$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$\frac{-2k^2(2r_1+r_5)+t_1}{(1+k^2)^2 t_1^2}$	$\frac{i(2k^3(2r_1+r_5)-k t_1)}{(1+k^2)^2 t_1^2}$
$\frac{i\sqrt{2}\,k}{t_1+k^2 t_1}$	$\frac{i(2k^3(2r_1+r_5)-k t_1)}{(1+k^2)^2 t_1^2}$	0

$\sigma_{1^+}^{\#1\,\alpha\beta}\,\dagger^{\alpha\beta}$ / $\sigma_{1^+}^{\#2\,\alpha\beta}\,\dagger^{\alpha\beta}$ / $\tau_{1^+}^{\#1\,\alpha\beta}\,\dagger^{\alpha\beta}$ / $\sigma_{1^-}^{\#1}\,\dagger^{\alpha}$ / $\sigma_{1^-}^{\#2}\,\dagger^{\alpha}$ / $\tau_{1^-}^{\#1}\,\dagger^{\alpha}$ / $\tau_{1^-}^{\#2}\,\dagger^{\alpha}$

$\sigma_{2^+}^{\#1\,\alpha\beta}$ / $\tau_{2^+}^{\#1\,\alpha\beta}$ / $\sigma_{2^-}^{\#1\,\alpha\beta\chi}$

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

$\sigma_{0^+}^{\#1}\,\dagger$ / $\tau_{0^+}^{\#1}\,\dagger$ / $\tau_{0^+}^{\#2}\,\dagger$ / $\sigma_{0^-}^{\#1}\,\dagger$

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

$\omega_{0^+}^{\#1}\,\dagger$ / $f_{0^+}^{\#1}\,\dagger$ / $f_{0^+}^{\#2}\,\dagger$ / $\omega_{0^-}^{\#1}\,\dagger$

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

$\omega_{1^+}^{\#1}\,\dagger$ / $f_{1^+}^{\#1}\,\dagger$ / $f_{1^+}^{\#2}\,\dagger$ / $\omega_{1^-}^{\#1}\,\dagger$

$\omega_{1^+}^{\#1}$	0	$-\frac{i k t_1}{\sqrt{2}}$	$\frac{t_1}{2}$	0
$f_{1^+}^{\#1}$	$\frac{i k t_1}{\sqrt{2}}$	$k^2 t_1$	$-\frac{i k t_1}{\sqrt{2}}$	0
$f_{1^+}^{\#2}$	0	0	0	$k^2 r_1 + \frac{t_1}{2}$
$\omega_{1^-}^{\#1}$	0	0	0	0

Quadratic (free) action

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

$\omega_{1^+}^{\#1\,\alpha\beta}$

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

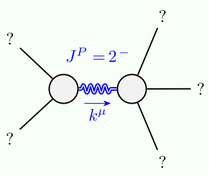
$\omega_{1^+}^{\#2\,\alpha\beta}$

$-\frac{i k t_1}{\sqrt{2}}$	0	0	0
$-\frac{t_1}{\sqrt{2}}$	0	0	0
$\frac{i k t_1}{\sqrt{2}}$	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

$f_{1^+}^{\#1\,\alpha\beta}$

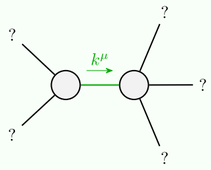
$k^2(2r_1+r_5)-\frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$\frac{i k t_1}{\sqrt{2}}$	0
$-\frac{t_1}{\sqrt{2}}$	0	0	0
$\frac{i k t_1}{\sqrt{2}}$	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Massive and massless spectra



Massive particle

Pole residue:	$-\frac{1}{r_1} > 0$
Polarisations:	5
Square mass:	$-\frac{t_1}{2 r_1} > 0$
Spin:	2
Parity:	Odd



Quadratic pole

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

Unitarity conditions

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