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

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

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

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

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

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

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	0
$-\frac{\sqrt{2}}{t_1+k^2 t_1}$	$\frac{-2k^2(2r_1+r_5)+t_1}{(1+k^2)^2 t_1^2}$	$\frac{i(2k^3(2r_1+r_5)+k t_1)}{(1+k^2)^2 t_1^2}$	0	0	0	0	0
$\frac{i\sqrt{2}\,k}{t_1+k^2 t_1}$	$\frac{i(2k^3(2r_1+r_5)+k t_1)}{(1+k^2)^2 t_1^2}$	$\frac{-2k^4(2r_1+r_5)+k^2 t_1}{(1+k^2)^2 t_1^2}$	0	0	0	0	0
0	0	0	0	0	0	0	0

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

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

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

$\mathcal{A}_{2^+}^{\#1\,\dagger\,\alpha\beta}$ $\quad f_{2^+}^{\#1\,\dagger\,\alpha\beta}$ $\quad \mathcal{A}_{2^-}^{\#1\,\dagger\,\alpha\beta\chi}$

$\mathcal{A}_{2^+}^{\#1\,\alpha\beta}$	$\frac{t_1}{2}$	$-\frac{i k t_1}{\sqrt{2}}$	0
$f_{2^+}^{\#1\,\alpha\beta}$	$\frac{i k t_1}{\sqrt{2}}$	$k^2 t_1$	0
$\mathcal{A}_{2^-}^{\#1\,\alpha\beta\chi}$	0	0	$k^2 r_1 + \frac{t_1}{2}$

$\mathcal{A}_{0^+}^{\#1\,\dagger}$ $\quad f_{0^+}^{\#1\,\dagger}$ $\quad f_{0^+}^{\#2\,\dagger}$ $\quad \mathcal{A}_{0^-}^{\#1\,\dagger}$

$\mathcal{A}_{0^+}^{\#1}$	0	0	0	0
$f_{0^+}^{\#1}$	0	0	0	0
$f_{0^+}^{\#2}$	0	0	0	$-t_1$
$\mathcal{A}_{0^-}^{\#1}$	0	0	$-t_1$	0

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

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

Quadratic (free) action

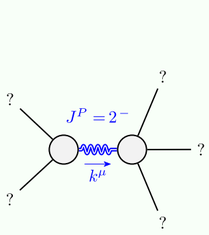
$$S == \int\int\int\int \tfrac{1}{6} (2\,t_1\,\mathcal{A}^{\alpha\prime}{}_\alpha\,\mathcal{A}_{,\theta}{}^\theta + 6\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 6\,\mathcal{A}^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} - 4\,t_1\,\mathcal{A}_\alpha{}^\theta{}_\theta\,\partial_\prime f^{\alpha\prime} + 4\,t_1\,\mathcal{A}_{,\theta}{}^\theta\,\partial^\prime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

$\mathcal{A}_{1^+}^{\#1\,\dagger\,\alpha\beta}$ $\quad \mathcal{A}_{1^+}^{\#2\,\dagger\,\alpha\beta}$ $\quad f_{1^+}^{\#1\,\dagger\,\alpha\beta}$ $\quad \mathcal{A}_{1^-}^{\#1\,\dagger\,\alpha}$ $\quad \mathcal{A}_{1^-}^{\#2\,\dagger\,\alpha}$ $\quad f_{1^-}^{\#1\,\dagger\,\alpha}$ $\quad f_{1^-}^{\#2\,\dagger\,\alpha}$

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

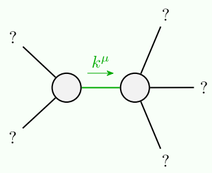
$\mathcal{A}_{1^+}^{\#1\,\alpha\beta}$ $\quad \mathcal{A}_{1^+}^{\#2\,\alpha\beta}$ $\quad f_{1^+}^{\#1\,\alpha\beta}$

$\mathcal{A}_{1^+}^{\#1\,\dagger\,\alpha\beta}$	$k^2 (2 r_1 + r_5) - \frac{t_1}{2}$	$-\frac{t_1}{\sqrt{2}}$	$\frac{i k t_1}{\sqrt{2}}$
$\mathcal{A}_{1^+}^{\#2\,\dagger\,\alpha\beta}$	$-\frac{t_1}{\sqrt{2}}$	0	0
$f_{1^+}^{\#1\,\dagger\,\alpha\beta}$	$\frac{i k t_1}{\sqrt{2}}$	0	0



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

Massive and massless spectra

Unitarity conditions

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