Particle spectrograph

Wave operator and propagator

Source constraints

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

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

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

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

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

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

0	0	0
0	0	0
0	0	0

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

0	0	0
0	0	0
0	0	0

$\tau_{1^-}^{\#2\,\alpha}$

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

$\sigma_{1^-}^{\#1\,\alpha}$

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

$\tau_{1^-}^{\#1\,\alpha}$

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

$\sigma_{1^-}^{\#2\,\alpha}$

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

$\tau_{1^-}^{\#2\,\alpha}$

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

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

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

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

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

Quadratic (free) action

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

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

$\frac{t_1}{2}$	$-\frac{i\,k\,t_1}{\sqrt{2}}$	0
$\frac{i\,k\,t_1}{\sqrt{2}}$	$k^2\,t_1$	0
0	0	$k^2\,r_1+\frac{t_1}{2}$

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

$-\frac{i\,k\,t_1}{3\,\sqrt{2}}$	$\frac{i\,k\,t_1}{3}$	$\frac{k^2\,t_1}{3}$
$-\frac{t_1}{3\,\sqrt{2}}$	$\frac{t_1}{3}$	$-\frac{1}{3}\,i\,k\,t_1$
$\frac{i\,k\,t_1}{3\,\sqrt{2}}$	$-\frac{t_1}{3}$	$\frac{k^2\,t_1}{3}$

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

0	0	0
0	0	0
0	0	0

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

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

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

0	0	0
0	0	0
0	0	0

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

$-\frac{i\,k\,t_1}{3\,\sqrt{2}}$	$\frac{i\,k\,t_1}{3}$	$\frac{k^2\,t_1}{3}$
$-\frac{t_1}{3\,\sqrt{2}}$	$\frac{t_1}{3}$	$-\frac{1}{3}\,i\,k\,t_1$
0	0	$\frac{t_1}{\sqrt{2}}$

$\omega_{1^-}^{\#1\,\alpha}$

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

$\omega_{1^-}^{\#2\,\alpha}$

0	0	0
0	0	0
0	0	0

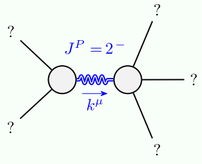
$f_{1^-}^{\#1\,\alpha}$

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

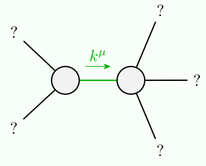
$f_{1^-}^{\#2\,\alpha}$

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

Unitarity conditions

$r_1 < 0$ && $r_5 > -2\,r_1$ && $t_1 > 0$