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
$\tau_{1^+}^{\#1\,\alpha\beta} == 0$	$\partial_{\chi}\partial^{\alpha}\tau^{\beta\chi} + \partial_{\chi}\partial^{\beta}\tau^{\chi\alpha} + \partial_{\chi}\partial^{\chi}\tau^{\alpha\beta} == \partial_{\chi}\partial^{\alpha}\tau^{\chi\beta} + \partial_{\chi}\partial^{\beta}\tau^{\alpha\chi} + \partial_{\chi}\partial^{\chi}\tau^{\beta\alpha}$	3
$\sigma_{1^+}^{\#2\,\alpha\beta} == 0$	$\partial_{\delta}\partial_{\chi}\partial^{\alpha}\sigma^{\beta\chi\delta} + \partial_{\delta}\partial^{\delta}\partial_{\chi}\sigma^{\alpha\beta\chi} == \partial_{\delta}\partial_{\chi}\partial^{\beta}\sigma^{\alpha\chi\delta}$	3
$\tau_{2^+}^{\#1\,\alpha\beta} == 0$	$4\,\partial_{\delta}\partial_{\chi}\partial^{\beta}\partial^{\alpha}\tau^{\chi\delta} + 2\,\partial_{\delta}\partial^{\delta}\partial^{\beta}\partial^{\alpha}\tau^{\chi}{}_{\chi} + 3\,\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\chi}\tau^{\alpha\beta} + 3\,\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\chi}\tau^{\beta\alpha} + 2\,\eta^{\alpha\beta}\,\partial_{\epsilon}\partial^{\epsilon}\partial_{\delta}\partial_{\chi}\tau^{\chi\delta} == 3\,\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\alpha}\tau^{\beta\chi} + 3\,\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\chi}\tau^{\alpha\beta} + 3\,\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\beta}\tau^{\alpha\chi} + 3\,\partial_{\delta}\partial^{\delta}\partial_{\chi}\partial^{\beta}\tau^{\chi\alpha} + 2\,\eta^{\alpha\beta}\,\partial_{\epsilon}\partial^{\epsilon}\partial_{\delta}\partial^{\delta}\tau^{\chi}{}_{\chi}$	5
$\sigma_{2^+}^{\#1\,\alpha\beta} == 0$	$3\,\partial_{\delta}\partial_{\chi}\partial^{\alpha}\sigma^{\beta\chi\delta} + 3\,\partial_{\delta}\partial_{\chi}\partial^{\beta}\sigma^{\alpha\chi\delta} + 2\,\eta^{\alpha\beta}\,\partial_{\epsilon}\partial^{\epsilon}\partial_{\delta}\sigma^{\chi\delta}{}_{\chi} == 2\,\partial_{\delta}\partial^{\beta}\partial^{\alpha}\sigma^{\chi\delta}{}_{\chi} + 3\,(\partial_{\delta}\partial^{\delta}\partial_{\chi}\sigma^{\alpha\chi\beta} + \partial_{\delta}\partial^{\delta}\partial_{\chi}\sigma^{\beta\chi\alpha})$	5
Total constraints/gauge generators:		25

	$\sigma_{1^+}^{\#1\,\alpha\beta}$	$\sigma_{1^+}^{\#2\,\alpha\beta}$	$\tau_{1^+}^{\#1\,\alpha\beta}$	$\sigma_{1^-}^{\#1\,\alpha}$	$\sigma_{1^-}^{\#2\,\alpha}$	$\tau_{1^-}^{\#1\,\alpha}$	$\tau_{1^-}^{\#2\,\alpha}$
$\sigma_{1^+}^{\#1\,\dagger\,\alpha\beta}$	$\frac{1}{k^2\,(2\,r_1+r_5)}$	0	0	0	0	0	0
$\sigma_{1^+}^{\#2\,\dagger\,\alpha\beta}$	0	0	0	0	0	0	0
$\tau_{1^+}^{\#1\,\dagger\,\alpha\beta}$	0	0	0	0	0	0	0
$\sigma_{1^-}^{\#1\,\dagger\,\alpha}$	0	0	0	$\frac{1}{k^2\,(r_1+r_5)}$	$\frac{\sqrt{2}}{k^2\,(1+2\,k^2)\,(r_1+r_5)}$	0	$-\frac{2\,i}{k\,(1+2\,k^2)\,(r_1+r_5)}$
$\sigma_{1^-}^{\#2\,\dagger\,\alpha}$	0	0	0	$\frac{\sqrt{2}}{k^2\,(1+2\,k^2)\,(r_1+r_5)}$	$\frac{3\,k^2\,(r_1+r_5)+2\,t_3}{(k+2\,k^3)^2\,(r_1+r_5)\,t_3}$	0	$\frac{i\,\sqrt{2}\,(3\,k^2\,(r_1+r_5)+2\,t_3)}{k\,(1+2\,k^2)^2\,(r_1+r_5)\,t_3}$
$\tau_{1^-}^{\#1\,\dagger\,\alpha}$	0	0	0	0	0	0	0
$\tau_{1^-}^{\#2\,\dagger\,\alpha}$	0	0	0	$-\frac{2\,i}{k\,(1+2\,k^2)\,(r_1+r_5)}$	$-\frac{i\,\sqrt{2}\,(3\,k^2\,(r_1+r_5)+2\,t_3)}{k\,(1+2\,k^2)^2\,(r_1+r_5)\,t_3}$	0	$\frac{6\,k^2\,(r_1+r_5)+4\,t_3}{(1+2\,k^2)^2\,(r_1+r_5)\,t_3}$

Quadratic (free) action

$$S == \int\int\int\int \tfrac{1}{3}\,(-2\,t_3\,\omega^{\alpha\prime}{}_{\alpha}\,\omega_{\prime}{}^{\kappa}{}_{\kappa}\,\omega^{\alpha\prime}{}_{\alpha} + 3\,f^{\alpha\beta}\,\tau_{\alpha\beta} + 3\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} + 4\,t_3\,\omega^{\kappa}{}_{\alpha}{}^{\kappa}\,\partial_{\prime}f^{\alpha\prime} - 4\,t_3\,\omega_{\prime}{}^{\kappa}{}_{\kappa}\,\partial^{\prime}f^{\alpha}{}_{\alpha} + 2\,t_3\,\partial_{\prime}f^{\kappa}{}_{\kappa}\,\partial^{\prime}f^{\alpha}{}_{\alpha} - 4\,r_1\,\partial_{\beta}\omega_{\alpha\prime\theta}\,\partial^{\theta}\omega^{\alpha\beta\prime} + 2\,r_1\,\partial_{\beta}\omega_{\alpha\beta\prime}\,\partial^{\theta}\omega^{\alpha\beta\prime} - 8\,r_1\,\partial_{\beta}\omega_{\prime\theta\alpha}\,\partial^{\theta}\omega^{\alpha\beta\prime} - 2\,r_1\,\partial_{\prime}\omega_{\alpha\beta\theta}\,\partial^{\theta}\omega^{\alpha\beta\prime} + 2\,r_1\,\partial_{\theta}\omega_{\alpha\prime\beta}\,\partial^{\theta}\omega^{\alpha\beta\prime} + 3\,r_5\,\partial_{\prime}\omega_{\theta}{}^{\kappa}{}_{\kappa}\,\partial^{\theta}\omega^{\alpha\prime}{}_{\alpha} - 3\,r_5\,\partial_{\theta}\omega_{\prime}{}^{\kappa}{}_{\kappa}\,\partial^{\theta}\omega^{\alpha\prime}{}_{\alpha} + 2\,t_3\,\partial_{\prime}f^{\alpha\prime}\,\partial_{\kappa}f^{\kappa}{}_{\alpha} - 4\,t_3\,\partial^{\prime}f^{\alpha}{}_{\alpha}\,\partial_{\kappa}f^{\kappa}{}_{\prime} - 3\,r_5\,\partial_{\alpha}\omega^{\alpha\theta}\,\partial_{\kappa}\omega^{\kappa}{}_{\theta} + 6\,r_5\,\partial^{\theta}\omega^{\alpha\prime}{}_{\theta}\,\partial_{\kappa}\omega^{\kappa}{}_{\prime} + 3\,r_5\,\partial_{\alpha}\omega^{\alpha\prime\theta}\,\partial_{\kappa}\omega^{\kappa}{}_{\theta} - 6\,r_5\,\partial^{\theta}\omega^{\alpha\prime}{}_{\alpha}\,\partial_{\kappa}\omega_{\prime}{}^{\kappa}{}_{\theta})\,)[t,\,x,\,y,\,z]\,dz\,dy\,dx\,dt$$

	$\omega_{1^+}^{\#1\,\alpha\beta}$	$\omega_{1^+}^{\#2\,\alpha\beta}$	$f_{1^+}^{\#1\,\alpha\beta}$	$\omega_{1^-}^{\#1\,\alpha}$	$\omega_{1^-}^{\#2\,\alpha}$	$f_{1^-}^{\#1\,\alpha}$	$f_{1^-}^{\#2\,\alpha}$
$\omega_{1^+}^{\#1\,\dagger\,\alpha\beta}$	$k^2\,(2\,r_1+r_5)$	0	0	0	0	0	0
$\omega_{1^+}^{\#2\,\dagger\,\alpha\beta}$	0	0	0	0	0	0	0
$f_{1^+}^{\#1\,\dagger\,\alpha\beta}$	0	0	0	0	0	0	0
$\omega_{1^-}^{\#1\,\dagger\,\alpha}$	0	0	0	$k^2\,(r_1+r_5)+\frac{2\,t_3}{3}$	$-\frac{\sqrt{2}\,t_3}{3}$	$-\frac{2}{3}\,i\,k\,t_3$	$\frac{2\,k^2\,t_3}{3}$
$\omega_{1^-}^{\#2\,\dagger\,\alpha}$	0	0	0	$-\frac{\sqrt{2}\,t_3}{3}$	$\frac{t_3}{3}$	$\frac{1}{3}\,i\,\sqrt{2}\,k\,t_3$	0
$f_{1^-}^{\#1\,\dagger\,\alpha}$	0	0	0	0	0	0	$-\frac{1}{3}\,i\,\sqrt{2}\,k\,t_3$
$f_{1^-}^{\#2\,\dagger\,\alpha}$	0	0	0	$\frac{2\,i\,k\,t_3}{3}$	$-\frac{1}{3}\,i\,\sqrt{2}\,k\,t_3$	0	$\frac{2\,k^2\,t_3}{3}$

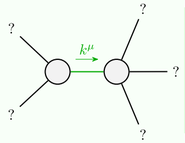
	$\omega_{2^+}^{\#1\,\alpha\beta}$	$f_{2^+}^{\#1\,\alpha\beta}$	$\omega_{2^-}^{\#1\,\alpha\beta\chi}$
$\omega_{2^+}^{\#1\,\dagger\,\alpha\beta}$	0	0	0
$f_{2^+}^{\#1\,\dagger\,\alpha\beta}$	0	0	0
$\omega_{2^-}^{\#1\,\dagger\,\alpha\beta\chi}$	0	0	$k^2\,r_1$

	$\sigma_{2^+}^{\#1\,\alpha\beta}$	$\tau_{2^+}^{\#1\,\alpha\beta}$	$\sigma_{2^-}^{\#1\,\alpha\beta\chi}$
$\sigma_{2^+}^{\#1\,\dagger\,\alpha\beta}$	0	0	0
$\tau_{2^+}^{\#1\,\dagger\,\alpha\beta}$	0	0	0
$\sigma_{2^-}^{\#1\,\dagger\,\alpha\beta\chi}$	0	0	$\frac{1}{k^2\,r_1}$

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1\,\dagger}$	$\frac{1}{(1+2\,k^2)^2\,t_3}$	$-\frac{i\,\sqrt{2}\,k}{(1+2\,k^2)^2\,t_3}$	0	0
$\tau_{0^+}^{\#1\,\dagger}$	$\frac{i\,\sqrt{2}\,k}{(1+2\,k^2)^2\,t_3}$	$\frac{2\,k^2}{(1+2\,k^2)^2\,t_3}$	0	0
$\tau_{0^+}^{\#2\,\dagger}$	0	0	0	0
$\sigma_{0^-}^{\#1\,\dagger}$	0	0	0	0

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1\,\dagger}$	0	0	0	0
$f_{0^+}^{\#1\,\dagger}$	0	0	0	0
$f_{0^+}^{\#2\,\dagger}$	t_3	$-i\,\sqrt{2}\,k\,t_3$	$2\,k^2\,t_3$	0
$\omega_{0^-}^{\#1\,\dagger}$	0	$i\,\sqrt{2}\,k\,t_3$	0	0

Massive and massless spectra



Quadratic pole

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

(No massive particles)

Unitarity conditions

$r_1 < 0\,\&\&\,(r_5 < -r_1\,||\,r_5 > -2\,r_1)\,||\,r_1 > 0\,\&\&\,-2\,r_1 < r_5 < -r_1$