

Particle spectrograph

Wave operator and propagator

$\sigma_{0+}^{\#1}$	$\tau_{0+}^{\#1}$	$\tau_{0+}^{\#2}$	$\sigma_{0-}^{\#1}$
$\sigma_{0+}^{\#1} \dagger$	$-\frac{1}{(1+2\,k^2)^2\,t_1}$	$\frac{i\,\sqrt{2}\,k}{(1+2\,k^2)^2\,t_1}$	0
$\tau_{0+}^{\#1} \dagger$	$-\frac{i\,\sqrt{2}\,k}{(1+2\,k^2)^2\,t_1}$	$-\frac{2\,k^2}{(1+2\,k^2)^2\,t_1}$	0
$\tau_{0+}^{\#2} \dagger$	0	0	0
$\sigma_{0-}^{\#1} \dagger$	0	0	$\frac{1}{t_2}$

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

$\omega_{0+}^{\#1}$	$f_{0+}^{\#1}$	$f_{0+}^{\#2}$	$\omega_{0-}^{\#1}$
$\omega_{0+}^{\#1} \dagger$	$-t_1$	$i\,\sqrt{2}\,k\,t_1$	0
$f_{0+}^{\#1} \dagger$	$-i\,\sqrt{2}\,k\,t_1$	$-2\,k^2\,t_1$	0
$f_{0+}^{\#2} \dagger$	0	0	0
$\omega_{0-}^{\#1} \dagger$	0	0	t_2

Source constraints		
SO(3) irreps	Fundamental fields	Multiplicities
$\tau_{0+}^{\#2} == 0$	$\partial_\beta\partial_\alpha\tau^{\alpha\beta} == 0$	1
$\tau_{0+}^{\#1} - 2\,i\,k\,\sigma_{0+}^{\#1} == 0$	$\partial_\beta\partial_\alpha\tau^{\alpha\beta} == \partial_\beta\partial^\beta\tau^\alpha_\alpha + 2\,\partial_\chi\partial^X\partial_\beta\sigma^{\alpha\beta}_\alpha$	1
$\tau_{1-}^{\#2\,\alpha} + 2\,i\,k\,\sigma_1^{\#2\,\alpha} == 0$	$\partial_\chi\partial_\beta\partial^\alpha\tau^{\beta\chi} == \partial_\chi\partial^X\partial_\beta\tau^{\alpha\beta} + 2\,\partial_\delta\partial^\delta\partial_\chi\partial_\beta\sigma^{\alpha\beta\chi}$	3
$\tau_1^{\#1\,\alpha} == 0$	$\partial_\chi\partial_\beta\partial^\alpha\tau^{\beta\chi} == \partial_\chi\partial^X\partial_\beta\tau^{\beta\alpha}$	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
$\tau_{2+}^{\#1\,\alpha\beta} - 2\,i\,k\,\sigma_{2+}^{\#1\,\alpha\beta} == 0$	$-i\,(4\,\partial_\delta\partial_\chi\partial^\beta\partial^\alpha\tau^{\chi\delta} + 2\,\partial_\delta\partial^\delta\partial^\beta\partial^\alpha\tau^{\chi\chi} -$ $3\,\partial_\delta\partial^\delta\partial_\chi\partial^\alpha\tau^{\beta\chi} - 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\alpha\tau^{\chi\beta} -$ $3\,\partial_\delta\partial^\delta\partial_\chi\partial^\beta\tau^{\alpha\chi} - 3\,\partial_\delta\partial^\delta\partial_\chi\partial^\beta\tau^{\chi\alpha} +$ $3\,\partial_\delta\partial^\delta\partial_\chi\partial^X\tau^{\alpha\beta} + 3\,\partial_\delta\partial^\delta\partial_\chi\partial^X\tau^{\beta\alpha} +$ $4\,i\,k^X\,\partial_\epsilon\partial_X\partial^\beta\partial^\alpha\sigma^{\delta\epsilon}_\delta -$ $6\,i\,k^X\,\partial_\epsilon\partial_\delta\partial_X\partial^\alpha\sigma^{\beta\delta\epsilon} -$ $6\,i\,k^X\,\partial_\epsilon\partial_\delta\partial_X\partial^\beta\sigma^{\alpha\delta\epsilon} +$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi\tau^{\chi\delta} +$ $6\,i\,k^X\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi\sigma^{\alpha\delta\beta} +$ $6\,i\,k^X\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial_\chi\sigma^{\beta\delta\alpha} -$ $2\,\eta^{\alpha\beta}\,\partial_\epsilon\partial^\epsilon\partial_\delta\partial^\delta\tau^{\chi\chi}_\chi -$ $4\,i\,\eta^{\alpha\beta}\,k^X\,\partial_\phi\partial^\phi\partial_\epsilon\partial_\chi\sigma^{\delta\epsilon}_\delta) == 0$	5
Total constraints/gauge generators:		16

	$\omega_{1+}^{\#1}\alpha\beta$	$\omega_{1+}^{\#2}\alpha\beta$	$f_{1+}^{\#1}\alpha\beta$	$\omega_{1-}^{\#1}\alpha$	$\omega_{1-}^{\#2}\alpha$	$f_{1-}^{\#1}\alpha$	$f_{1-}^{\#2}\alpha$
$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{1}{6}\,(6\,k^2\,r_5+t_1+4\,t_2)$	$-\frac{t_1-2\,t_2}{3\,\sqrt{2}}$	$-\frac{i\,k\,(t_1-2\,t_2)}{3\,\sqrt{2}}$	0	0	0	0
$\omega_{1+}^{\#2} \dagger^{\alpha\beta}$	$-\frac{t_1-2\,t_2}{3\,\sqrt{2}}$	$\frac{t_1+t_2}{3}$	$\frac{1}{3}\,i\,k\,(t_1+t_2)$	0	0	0	0
$f_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{i\,k\,(t_1-2\,t_2)}{3\,\sqrt{2}}$	$-\frac{1}{3}\,i\,k\,(t_1+t_2)$	$\frac{1}{3}\,k^2\,(t_1+t_2)$	0	0	0	0
$\omega_{1-}^{\#1} \dagger^\alpha$	0	0	0	$k^2\,r_5-\frac{t_1}{2}$	$\frac{t_1}{\sqrt{2}}$	0	$i\,k\,t_1$
$\omega_{1-}^{\#2} \dagger^\alpha$	0	0	0	$\frac{t_1}{\sqrt{2}}$	0	0	0
$f_{1-}^{\#1} \dagger^\alpha$	0	0	0	0	0	0	0
$f_{1-}^{\#2} \dagger^\alpha$	0	0	0	$-i\,k\,t_1$	0	0	0

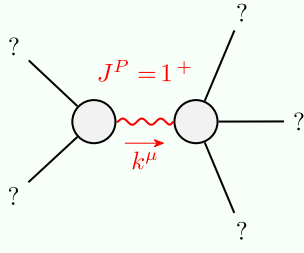
	$\sigma_{1+}^{\#1}\alpha\beta$	$\sigma_{1+}^{\#2}\alpha\beta$	$\tau_{1+}^{\#1}\alpha\beta$	$\sigma_{1-}^{\#1}\alpha$	$\sigma_{1-}^{\#2}\alpha$	$\tau_{1-}^{\#1}\alpha$	$\tau_{1-}^{\#2}\alpha$
$\sigma_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{2\,(t_1+t_2)}{3\,t_1\,t_2+2\,k^2\,r_5\,(t_1+t_2)}$	$\frac{\sqrt{2}\,(t_1-2\,t_2)}{(1+k^2)\,(3\,t_1\,t_2+2\,k^2\,r_5\,(t_1+t_2))}$	$\frac{i\,\sqrt{2}\,k\,(t_1-2\,t_2)}{(1+k^2)\,(3\,t_1\,t_2+2\,k^2\,r_5\,(t_1+t_2))}$	0	0	0	0
$\sigma_{1+}^{\#2} \dagger^{\alpha\beta}$	$\frac{\sqrt{2}\,(t_1-2\,t_2)}{(1+k^2)\,(3\,t_1\,t_2+2\,k^2\,r_5\,(t_1+t_2))}$	$\frac{6\,k^2\,r_5+t_1+4\,t_2}{(1+k^2)^2\,(3\,t_1\,t_2+2\,k^2\,r_5\,(t_1+t_2))}$	$\frac{i\,k\,(6\,k^2\,r_5+t_1+4\,t_2)}{(1+k^2)^2\,(3\,t_1\,t_2+2\,k^2\,r_5\,(t_1+t_2))}$	0	0	0	0
$\tau_{1+}^{\#1} \dagger^{\alpha\beta}$	$-\frac{i\,\sqrt{2}\,k\,(t_1-2\,t_2)}{(1+k^2)\,(3\,t_1\,t_2+2\,k^2\,r_5\,(t_1+t_2))}$	$-\frac{i\,k\,(6\,k^2\,r_5+t_1+4\,t_2)}{(1+k^2)^2\,(3\,t_1\,t_2+2\,k^2\,r_5\,(t_1+t_2))}$	$\frac{k^2\,(6\,k^2\,r_5+t_1+4\,t_2)}{(1+k^2)^2\,(3\,t_1\,t_2+2\,k^2\,r_5\,(t_1+t_2))}$	0	0	0	0
$\sigma_{1-}^{\#1} \dagger^\alpha$	0	0	0	0	$\frac{\sqrt{2}}{t_1+2\,k^2\,t_1}$	0	$\frac{2\,i\,k}{t_1+2\,k^2\,t_1}$
$\sigma_{1-}^{\#2} \dagger^\alpha$	0	0	0	$\frac{\sqrt{2}}{t_1+2\,k^2\,t_1}$	$\frac{-2\,k^2\,r_5+t_1}{(t_1+2\,k^2\,t_1)^2}$	0	$-\frac{i\,\sqrt{2}\,k\,(2\,k^2\,r_5+t_1)}{(t_1+2\,k^2\,t_1)^2}$
$\tau_{1-}^{\#1} \dagger^\alpha$	0	0	0	0	0	0	0
$\tau_{1-}^{\#2} \dagger^\alpha$	0	0	0	$-\frac{2\,i\,k}{t_1+2\,k^2\,t_1}$	$\frac{i\,\sqrt{2}\,k\,(2\,k^2\,r_5+t_1)}{(t_1+2\,k^2\,t_1)^2}$	0	$\frac{-4\,k^4\,r_5+2\,k^2\,t_1}{(t_1+2\,k^2\,t_1)^2}$

Quadratic (free) action

$$\begin{aligned} S = & \int\int\int\int\limits_0^1 (6\,t_1\,\omega_{\alpha}^{\alpha'}\,\omega_{\theta}^{\theta'} + 6\,f_{\theta}^{\alpha\beta\chi}\,\tau_{\alpha\beta\chi} + 6\,\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} - 12\,t_1\,\omega_{\alpha}^{\theta}\,\partial_{\theta}f^{\alpha'} + 12\,t_1\,\omega_{\theta}^{\alpha'}\,\partial_{\theta}f^{\alpha} - 6\,t_1\,\partial_{\theta}f^{\alpha'}\,\partial_{\theta}f^{\theta'}_{\alpha} + \\ & 12\,t_1\,\partial_{\theta}f^{\alpha}_{\alpha'}\,\partial_{\theta}f^{\theta'}_{\theta} + 4\,t_1\,\omega_{\theta\alpha}\,\omega_{\theta\alpha'}\,\partial^{\theta}f^{\alpha'} + 4\,t_2\,\omega_{\theta\alpha}\,\partial^{\theta}f^{\alpha'} - \\ & 4\,t_1\,\partial_{\alpha}f_{\theta}\,\partial^{\theta}f^{\alpha'} + 2\,t_2\,\partial_{\alpha}f_{\theta}\,\partial^{\theta}f^{\alpha'} - 4\,t_1\,\partial_{\alpha}f_{\theta}\,\partial^{\theta}f^{\alpha'} - \\ & t_2\,\partial_{\alpha}f_{\theta}\,\partial^{\theta}f^{\alpha'} + 2\,t_1\,\partial_{\theta}f_{\alpha\theta'}\,\partial^{\theta}f^{\alpha'} - t_2\,\partial_{\theta}f_{\alpha\theta'}\,\partial^{\theta}f^{\alpha'} + \\ & 4\,t_1\,\partial_{\theta}f_{\alpha\theta'}\,\partial^{\theta}f^{\alpha'} + t_2\,\partial_{\theta}f_{\alpha\theta'}\,\partial^{\theta}f^{\alpha'} + 2\,t_1\,\partial_{\theta}f_{\alpha\theta'}\,\partial^{\theta}f^{\alpha'} - \\ & t_2\,\partial_{\theta}f_{\alpha\theta'}\,\partial^{\theta}f^{\alpha'} + 2\,(t_1+t_2)\,\omega_{\alpha\theta}^{\alpha'}\,(\omega^{\alpha'\theta} + 2\,\partial^{\theta}f^{\alpha'}) + \\ & 2\,\omega_{\alpha\theta}^{\alpha'}\,((t_1-2\,t_2)\,\omega^{\alpha'\theta} + 2\,(2\,t_1-t_2)\,\partial^{\theta}f^{\alpha'}) + \\ & 6\,r_5\,\partial_{\theta}\omega_{\kappa}^{\kappa}\,\partial^{\theta}\omega_{\alpha}^{\alpha'} - 6\,r_5\,\partial_{\theta}\omega_{\kappa}^{\kappa}\,\partial^{\theta}\omega_{\alpha}^{\alpha'} - 6\,r_5\,\partial_{\alpha}\omega^{\alpha'\theta}\,\partial_{\kappa}\omega_{\theta}^{\kappa} - \\ & \partial_{\kappa}\omega_{\theta}^{\kappa}\,\partial^{\theta}\omega_{\alpha}^{\alpha'} - 12\,r_5\,\partial^{\theta}\omega_{\alpha}^{\alpha'}\,\partial_{\kappa}\omega_{\theta}^{\kappa} + 6\,r_5\,\partial_{\alpha}\omega^{\alpha'\theta}\,\partial_{\kappa}\omega_{\theta}^{\kappa} - \\ & 12\,r_5\,\partial^{\theta}\omega_{\alpha}^{\alpha'}\,\partial_{\kappa}\omega_{\theta}^{\kappa})) [t,\,x,\,y,\,z] \,dz\,dy\,dx\,dt \end{aligned}$$

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

Massive and massless spectra



Massive particle	
Pole residue:	$\frac{-3\,t_1\,t_2\,(t_1+t_2)+3\,r_5\,(t_1^2+2\,t_2^2)}{r_5\,(t_1+t_2)\,(-3\,t_1\,t_2+2\,r_5\,(t_1+t_2))} > 0$
Polarisations:	3
Square mass:	$-\frac{3\,t_1\,t_2}{2\,r_5\,t_1+2\,r_5\,t_2} > 0$
Spin:	1
Parity:	Even

(No massless particles)

Unitarity conditions

$r_5 > 0 \ \&\& \ (t_1 < 0 \ \&\& \ (t_2 < 0 \ || \ t_2 > -t_1)) \ || \ (t_1 > 0 \ \&\& \ -t_1 < t_2 < 0)$