Particle spectrograph

Wave operator and propagator

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}$ †	$\frac{1}{2}(\alpha_0 - 4\beta_1)$	$-\frac{i(\alpha_0-4\beta_1)k}{\sqrt{2}}$	0	0
$f_{0^+}^{\#1}$ †	$\frac{i(\alpha_0-4\beta_1)k}{\sqrt{2}}$	$-4\beta_1 k^2$	0	0
$f_{0^+}^{\#2}$ †	0	0	0	0
$\omega_{0^-}^{\#1}$ †	0	0	0	$\frac{\alpha_0}{2} - 2\beta_1 + \alpha_3 k^2$

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1}$ †	$\frac{8\beta_1}{\alpha_0{}^2 - 4\alpha_0\beta_1}$	$-\frac{i\sqrt{2}}{\alpha_0 k}$	0	0
$\tau_{0^+}^{\#1}$ †	$\frac{i\sqrt{2}}{\alpha_0 k}$	$-\frac{1}{\alpha_0 k^2}$	0	0
$\tau_{0^+}^{\#2}$ †	0	0	0	0
$\sigma_{0^-}^{\#1}$ †	0	0	0	$\frac{2}{\alpha_0 - 4\beta_1 + 2\alpha_3 k^2}$

	$\omega_{2^+}^{\#1}{}^{\alpha\beta}$	$f_{2^+}^{\#1}{}^{\alpha\beta}$	$\omega_{2^-}^{\#1}{}^{\alpha\beta\chi}$
$\omega_{2^+}^{\#1}{}^{\alpha\beta}$ †	$-\frac{\alpha_0}{4} + \beta_1$	$\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	0
$f_{2^+}^{\#1}{}^{\alpha\beta}$ †	$-\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	$2\beta_1 k^2$	0
$\omega_{2^-}^{\#1}{}^{\alpha\beta\chi}$ †	0	0	$-\frac{\alpha_0}{4} + \beta_1$

	$\omega_{1^+}^{\#1}{}^{\alpha\beta}$	$\omega_{1^+}^{\#2}{}^{\alpha\beta}$	$f_{1^+}^{\#1}{}^{\alpha\beta}$	$\omega_{1^-}^{\#1}{}^{\alpha}$	$\omega_{1^-}^{\#2}{}^{\alpha}$	$f_{1^-}^{\#1}{}^{\alpha}$	$f_{1^-}^{\#2}{}^{\alpha}$
$\omega_{1^+}^{\#1}{}^{\alpha\beta}$ †	$\frac{1}{4}(\alpha_0 - 4\beta_1)$	$\frac{\alpha_0-4\beta_1}{2\sqrt{2}}$	$-\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	0	0	0	0
$\omega_{1^+}^{\#2}{}^{\alpha\beta}$ †	$\frac{\alpha_0-4\beta_1}{2\sqrt{2}}$	0	0	0	0	0	0
$f_{1^+}^{\#1}{}^{\alpha\beta}$ †	$-\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	0	0	0	0	0	0
$\omega_{1^-}^{\#1}{}^{\alpha}$ †	0	0	0	$\frac{1}{4}(\alpha_0 - 4\beta_1)$	$-\frac{\alpha_0-4\beta_1}{2\sqrt{2}}$	0	0
$\omega_{1^-}^{\#2}{}^{\alpha}$ †	0	0	0	$-\frac{\alpha_0-4\beta_1}{2\sqrt{2}}$	0	0	0
$f_{1^-}^{\#1}{}^{\alpha}$ †	0	0	0	0	0	0	$\frac{1}{2} i (\alpha_0 - 4\beta_1) k$
$f_{1^-}^{\#2}{}^{\alpha}$ †	0	0	0	0	0	$\frac{1}{2} i (\alpha_0 - 4\beta_1) k$	0

	$\sigma_{1^+}^{\#1}{}^{\alpha\beta}$	$\sigma_{1^+}^{\#2}{}^{\alpha\beta}$	$\tau_{1^+}^{\#1}{}^{\alpha\beta}$	$\sigma_{1^-}^{\#1}{}^{\alpha}$	$\sigma_{1^-}^{\#2}{}^{\alpha}$	$\tau_{1^-}^{\#1}{}^{\alpha}$	$\tau_{1^-}^{\#2}{}^{\alpha}$
$\sigma_{1^+}^{\#1}{}^{\alpha\beta}$ †	0	$\frac{2\sqrt{2}}{(\alpha_0-4\beta_1)(1+k^2)}$	$-\frac{2i\sqrt{2}\,k}{(\alpha_0-4\beta_1)(1+k^2)}$	0	$-\frac{2\sqrt{2}}{(\alpha_0-4\beta_1)(1+2k^2)}$	0	$-\frac{4ik}{(\alpha_0-4\beta_1)(1+2k^2)}$
$\sigma_{1^+}^{\#2}{}^{\alpha\beta}$ †	$\frac{2\sqrt{2}}{(\alpha_0-4\beta_1)(1+k^2)}$	$\frac{2}{(\alpha_0-4\beta_1)(1+k^2)}$	$-\frac{2ik}{(\alpha_0-4\beta_1)(1+k^2)}$	$-\frac{2\sqrt{2}}{(\alpha_0-4\beta_1)(1+2k^2)}$	$-\frac{2}{(\alpha_0-4\beta_1)(1+2k^2)}$	0	$-\frac{2i\sqrt{2}\,k}{(\alpha_0-4\beta_1)(1+2k^2)}$
$\tau_{1^+}^{\#1}{}^{\alpha\beta}$ †	$-\frac{2i\sqrt{2}\,k}{(\alpha_0-4\beta_1)(1+k^2)}$	$-\frac{2ik}{(\alpha_0-4\beta_1)(1+k^2)}$	$-\frac{2k^2}{(\alpha_0-4\beta_1)(1+k^2)}$	0	0	0	$-\frac{4k^2}{(\alpha_0-4\beta_1)(1+2k^2)}$
$\sigma_{1^-}^{\#1}{}^{\alpha}$ †	0	0	0	0	$\frac{2\sqrt{2}}{(\alpha_0-4\beta_1)(1+2k^2)}$	0	$\frac{4ik}{(\alpha_0-4\beta_1)(1+2k^2)}$
$\sigma_{1^-}^{\#2}{}^{\alpha}$ †	0	0	0	$\frac{2\sqrt{2}}{(\alpha_0-4\beta_1)(1+2k^2)}$	$\frac{2}{(\alpha_0-4\beta_1)(1+2k^2)}$	0	$\frac{2i\sqrt{2}\,k}{(\alpha_0-4\beta_1)(1+2k^2)}$
$\tau_{1^-}^{\#1}{}^{\alpha}$ †	0	0	0	0	0	0	0
$\tau_{1^-}^{\#2}{}^{\alpha}$ †	0	0	0	$\frac{4ik}{(\alpha_0-4\beta_1)(1+2k^2)}$	$\frac{2i\sqrt{2}\,k}{(\alpha_0-4\beta_1)(1+2k^2)}$	0	$\frac{4k^2}{(\alpha_0-4\beta_1)(1+2k^2)}$

Quadratic (free) action

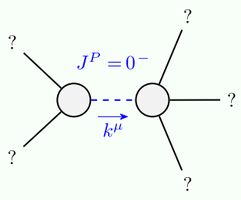
$$S == \iiint\!\!\int (f^{\alpha\beta}\,\tau_{\alpha\beta} + \omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi} - \tfrac{1}{2}\alpha_0\,(\omega_{\alpha\chi\beta}\,\omega^{\alpha\chi\beta\chi} + \omega^{\alpha\beta}{}_{\alpha}\,\omega_{\beta}{}^{\chi}{}_{\chi} + 2\,f^{\alpha\beta}\,\partial_{\beta}\omega_{\alpha}{}^{\chi}{}_{\chi} - 2\,\partial_{\beta}\omega^{\alpha\beta}{}_{\alpha} - 2\,f^{\alpha\beta}\,\partial_{\chi}\omega_{\alpha}{}^{\chi}{}_{\beta} + 2\,f^{\alpha}{}_{\alpha}\,\partial_{\chi}\omega^{\beta\chi}{}_{\beta}) + \beta_1\,(2\,\omega^{\alpha\beta}{}_{\alpha}\,\omega_{\beta}{}^{\chi}{}_{\chi} - 4\,\omega_{\alpha}{}^{\chi}{}_{\chi}\,\partial_{\beta}f^{\alpha\beta} + 4\,\omega_{\beta}{}^{\chi}{}_{\chi}\,\partial^{\beta}f^{\alpha}{}_{\alpha} - 2\,\partial_{\beta}f^{\chi}{}_{\chi}\,\partial^{\beta}f^{\alpha}{}_{\alpha} - 2\,\partial^{\beta}f^{\alpha}{}_{\alpha}\,\partial_{\chi}f^{\chi}{}_{\beta} - 2\,\partial_{\alpha}f_{\beta\chi}\,\partial^{\chi}f^{\alpha\beta} - \partial_{\alpha}f_{\chi\beta}\,\partial^{\chi}f^{\alpha\beta} + \partial_{\beta}f_{\alpha\chi}\,\partial^{\chi}f^{\alpha\beta} + \partial_{\chi}f_{\alpha\beta}\,\partial^{\chi}f_{\beta\alpha} + \partial^{\chi}f^{\alpha\beta} + \partial_{\chi}f_{\beta\alpha}\,\partial^{\chi}f^{\alpha\beta}) + \tfrac{1}{3}\alpha_3\,(4\,\partial_{\beta}\omega_{\alpha\chi\delta}\,\partial^{\beta}\omega^{\alpha\chi\delta} - 2\,\partial_{\beta}\omega_{\alpha\chi\delta}\,\partial^{\alpha}\omega^{\beta\chi\delta} + 2\,\partial_{\beta}\omega_{\alpha\delta\chi}\,\partial^{\alpha}\omega^{\beta\delta\chi} - \partial_{\chi}\omega_{\alpha\beta\delta}\,\partial^{\delta}\omega^{\alpha\beta\chi} - 2\,\partial_{\delta}\omega_{\alpha\chi\beta}\,\partial^{\delta}\omega^{\alpha\beta\chi})\,[t,\,x,\,y,\,z]\,dz\,dy\,dx\,dt$$

Source constraints

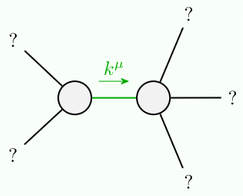
SO(3) irreps	Fundamental fields	Multiplicities
$\tau_{0^+}^{\#2} == 0$	$\partial_\beta\partial_\alpha\tau^{\alpha\beta} == 0$	1
$\tau_{1^-}^{\#2\,\alpha} + 2\,i\,k\,\sigma_{1^-}^{\#2\,\alpha} == 0$	$\partial_\chi\partial_\beta\partial^\alpha\tau^{\beta\chi} == \partial_\chi\partial^\chi\partial_\beta\tau^{\alpha\beta} + 2\,\partial_\delta\partial^\delta\partial_\chi\partial_\beta\sigma^{\alpha\beta\chi}$	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
$\tau_{1^+}^{\#1\,\alpha\beta} + i\,k\,\sigma_{1^+}^{\#2\,\alpha\beta} == 0$	$\partial_\chi\partial^\alpha\tau^{\beta\chi} + \partial_\chi\partial^\beta\tau^{\chi\alpha} + \partial_\chi\partial^\chi\tau^{\alpha\beta} + 2\,\partial_\delta\partial^\alpha\sigma^{\beta\chi\delta} + 2\,\partial_\delta\partial^\beta\sigma^{\alpha\chi\delta} + 2\,\partial_\delta\partial^\delta\sigma^{\alpha\beta\chi} == \partial_\chi\partial^\alpha\tau^{\chi\beta} + \partial_\chi\partial^\beta\tau^{\alpha\chi} + \partial_\chi\partial^\chi\tau^{\beta\alpha} + 2\,\partial_\delta\partial^\delta\sigma^{\alpha\beta\chi} + 2\,\partial_\delta\partial_\chi\partial^\beta\sigma^{\alpha\chi\delta}$	3
Total constraints/gauge generators:		10

	$\sigma_{2^+}^{\#1}{}^{\alpha\beta}$	$\tau_{2^+}^{\#1}{}^{\alpha\beta}$	$\sigma_{2^-}^{\#1}{}^{\alpha\beta\chi}$
$\sigma_{2^+}^{\#1}{}^{\alpha\beta}$ †	$-\frac{16\beta_1}{\alpha_0{}^2 - 4\alpha_0\beta_1}$	$\frac{2i\sqrt{2}}{\alpha_0 k}$	0
$\tau_{2^+}^{\#1}{}^{\alpha\beta}$ †	$-\frac{2i\sqrt{2}}{\alpha_0 k}$	$\frac{2}{\alpha_0 k^2}$	0
$\sigma_{2^-}^{\#1}{}^{\alpha\beta\chi}$ †	0	0	$\frac{1}{-\frac{\alpha_0}{4} + \beta_1}$

Massive and massless spectra



Massive particle	
Pole residue:	$-\frac{1}{\alpha_3} > 0$
Polarisations:	1
Square mass:	$-\frac{\alpha_0 - 4\beta_1}{2\alpha_3} > 0$
Spin:	0
Parity:	Odd



Quadratic pole	
Pole residue:	$\frac{1}{\alpha_0} > 0$
Polarisations:	2

Unitarity conditions

$\alpha_0 > 0$ && $\alpha_3 < 0$ && $\beta_1 < \frac{\alpha_0}{4}$