Particle spectrograph

Wave operator and propagator

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

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

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

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

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

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

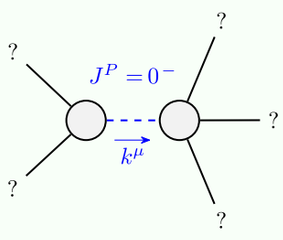
Quadratic (free) action

$$S_F == \iiint(-\tfrac{1}{2}(\alpha_0 - 4\beta_1)\,\omega^{\alpha\beta}{}_{\alpha}{}^{\chi}\,\omega_{\beta}{}^{\chi}{}_{\chi} + \omega_{\alpha\chi\beta}(-\tfrac{1}{2}\alpha_0\,\omega^{\alpha\beta\chi} + 4\beta_1\,\partial^{\chi}f^{\alpha\beta}) + \tfrac{1}{3}(-6\beta_1\,\omega_{\alpha}{}^{\chi}{}_{\chi}\,\partial_{\beta}f^{\alpha\beta} - 6\beta_1\,\omega_{\alpha}{}^{\delta}{}_{\delta}\,\partial_{\beta}f^{\alpha\beta} + 6\beta_1\,\omega_{\beta}{}^{\chi}{}_{\chi}\,\partial^{\beta}f^{\alpha}{}_{\alpha} + 6\beta_1\,\omega_{\beta}{}^{\delta}{}_{\delta}\,\partial^{\beta}f^{\alpha}{}_{\alpha} - 3\alpha_0\,\omega^{\alpha}{}_{\alpha}{}^{\chi}\,\partial_{\chi}\omega^{\beta}{}_{\beta} + \alpha_0\,\partial_{\chi}\omega_{\alpha}{}^{\chi}{}_{\beta}) - 3\alpha_0\,f^{\alpha}{}_{\alpha}\,\partial_{\chi}\omega^{\beta\chi}{}_{\beta} + 3\beta_1\,\partial_{\chi}f_{\beta}{}^{\delta}\,\partial^{\chi}f^{\beta}{}_{\delta} + 3\beta_1\,\partial_{\chi}f^{\delta}{}_{\beta}\,\partial^{\chi}f_{\delta}{}^{\beta} + 3\alpha_0\,\partial_{\beta}\omega^{\alpha\beta}{}_{\alpha}{}^{\chi}\,\partial_{\chi}\omega^{\zeta\alpha}{}_{\zeta\beta} + 12\beta_1\,\partial^{\beta}f^{\alpha}{}_{\alpha}\,\partial_{\delta}f^{\delta}{}_{\beta} - 2\alpha_3\,\partial^{\beta}\omega_{\alpha}{}^{\zeta\delta}\,\partial_{\delta}\omega_{\zeta\beta}{}^{\alpha} - 3\beta_1\,\partial^{\chi}f_{\zeta}{}^{\beta}\,\partial^{\zeta}f_{\beta\chi} - 2\alpha_3\,\partial^{\beta}\omega_{\alpha}{}^{\zeta\delta}\,\partial_{\delta}\omega_{\zeta\beta}{}^{\alpha} - 3\beta_1\,\partial^{\chi}f_{\zeta}{}^{\beta}\,\partial^{\zeta}f_{\beta\chi} + 3\alpha_0\,\partial_{\beta}\omega^{\alpha\beta}{}_{\alpha}{}^{\chi}\,\omega_{\beta}{}^{\chi}{}_{\chi} + 2\alpha_3\,\partial_{\beta}\omega^{\beta\zeta\alpha}\,\partial_{\chi}\omega_{\zeta\alpha}{}^{\chi} + 6\beta_1\,\partial_{\beta}f^{\chi}{}_{\chi}\,\partial^{\beta}f^{\alpha}{}_{\alpha} + 3f^{\alpha\beta}(\tau_{\alpha\beta} - \alpha_0\,\partial_{\beta}\omega_{\alpha\chi}{}^{\chi} + 2\alpha_3\,\partial_{\beta}\omega_{\zeta\alpha}{}^{\chi}\,\partial_{\chi}\omega^{\beta\zeta\alpha} - \alpha_3\,\partial_{\beta}\omega_{\zeta\alpha}{}^{\chi}\,\partial_{\chi}\omega^{\zeta\alpha\beta} + 2\alpha_3\,\partial_{\chi}\omega^{\beta\zeta\alpha}\,\partial^{\chi}\omega_{\zeta\alpha\beta} + \alpha_3\,\partial_{\chi}\omega^{\zeta\alpha\beta}\,\partial^{\chi}\omega_{\zeta\alpha\beta} + 6\beta_1\,\partial_{\beta}f_{\chi}{}^{\beta}\,\partial_{\delta}f^{\chi\delta} + 2\alpha_3\,\partial^{\beta}\omega_{\alpha}{}^{\delta\zeta}\,\partial_{\delta}\omega_{\zeta\beta}{}^{\alpha} - 3\beta_1\,\partial^{\chi}f_{\zeta}{}^{\beta}\,\partial^{\zeta}f^{\delta}{}_{\chi} + 3\beta_1\,\partial^{\chi}f_{\chi\beta}\,\partial^{\zeta}f_{\delta\zeta}\,\partial^{\delta}f^{\beta}{}_{\chi} - 3\beta_1\,\partial^{\chi}f_{\zeta\delta}\,\partial^{\zeta}f_{\chi}{}^{\delta}))[t, x, y, z]\,dz\,dy\,dx\,dt$$

Source constraints/gauge generators

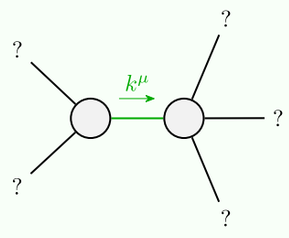
SO(3) irreps	Multiplicities
$\tau_{0^+}^{\#2} == 0$	1
$\tau_{1^-}^{\#2\,\alpha} + 2ik\,\sigma_{1^-}^{\#2\,\alpha} == 0$	3
$\tau_{1^-}^{\#1\,\alpha} == 0$	3
$\tau_{1^+}^{\#1\,\alpha\beta} + ik\,\sigma_{1^+}^{\#2\,\alpha\beta} == 0$	3
Total constraints:	10

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

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