Particle spectrograph

Wave operator and propagator

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

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

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

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^-}^{\#1}$
$\sigma_{0^+}^{\#1}{}^{\dagger}$	$\frac{8\beta_1}{\alpha_0{}^2-4\alpha_0\beta_1+8\alpha_6\beta_1 k^2}$	$-\frac{i\sqrt{2}(\alpha_0-4\beta_1)}{\alpha_0(\alpha_0-4\beta_1)k+8\alpha_6\beta_1 k^3}$	0	0
$\tau_{0^+}^{\#1}{}^{\dagger}$	$\frac{i\sqrt{2}(\alpha_0-4\beta_1)}{\alpha_0(\alpha_0-4\beta_1)k+8\alpha_6\beta_1 k^3}$	$-\frac{\alpha_0-4\beta_1+2\alpha_6 k^2}{k^2(\alpha_0{}^2-4\alpha_0\beta_1+8\alpha_6\beta_1 k^2)}$	0	0
$\tau_{0^+}^{\#2}{}^{\dagger}$	0	0	0	0
$\sigma_{0^-}^{\#1}{}^{\dagger}$	0	0	0	$\frac{2}{\alpha_0-4\beta_1}$

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

Source constraints/gauge generators

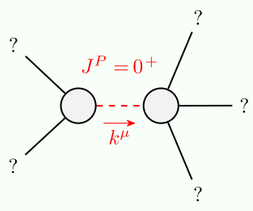
SO(3) irreps	Multiplicities
$\tau_{0^+}^{\#2}==0$	1
$\tau_{1^-}^{\#2\alpha}+2i k\,\sigma_{1^-}^{\#2\alpha}==0$	3
$\tau_{1^-}^{\#1\alpha}==0$	3
$\tau_{1^+}^{\#1\alpha\beta}+i k\,\sigma_{1^+}^{\#2\alpha\beta}==0$	3
Total constraints:	10

Quadratic (free) action

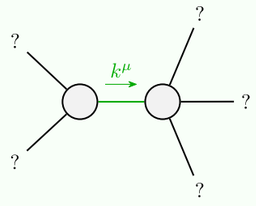
$$
\begin{aligned}
S_F == \int\int\int & (-\tfrac{1}{2}(\alpha_0-4\beta_1)\,\omega^{\alpha\beta}{}_{\alpha}\,\omega_{\beta}{}^{\chi}{}_{\chi}-2\beta_1\,\omega_{\alpha}{}^{\chi\delta}\,\omega_{\chi\delta}{}^{\alpha}+f^{\alpha\beta}\,\tau_{\alpha\beta}+\omega^{\alpha\beta\chi}\,\sigma_{\alpha\beta\chi}-2\beta_1 \\
& \omega_{\alpha}{}^{\chi}{}_{\chi}+\alpha_0\,\partial_{\beta}\omega^{\alpha\beta}{}_{\alpha}+2\beta_1\,\omega_{\beta}{}^{\chi}{}_{\chi}\,\partial^{\beta}f^{\alpha}{}_{\alpha}+ \\
& \omega_{\alpha}{}^{\chi}{}_{\chi}\,\partial_{\beta}f^{\alpha\beta}-2\beta_1\,\omega_{\alpha}{}^{\delta}{}_{\delta}\,\partial_{\beta}f^{\alpha\beta}-\alpha_0\,f^{\alpha\beta}\,\partial_{\beta}\omega_{\alpha}{}^{\chi}{}_{\chi}+ \\
& 2\beta_1\,\omega_{\beta}{}^{\delta}{}_{\delta}\,\partial^{\beta}f^{\alpha}{}_{\alpha}-2\beta_1\,\partial_{\beta}f^{\chi}{}_{\chi}\,\partial^{\beta}f^{\alpha}{}_{\alpha}+\alpha_0\,f^{\alpha\beta}\,\partial_{\chi}\omega_{\alpha}{}^{\chi}{}_{\beta}+ \\
& \omega_{\alpha\chi\beta}(-\tfrac{1}{2}\alpha_0\,\omega^{\alpha\beta\chi}+4\beta_1\,\partial^{\chi}f^{\alpha\beta})+\beta_1\,\partial_{\chi}f_{\beta}{}^{\delta}\,\partial^{\chi}f_{\delta}{}^{\beta}+ \\
& 4\beta_1\,\partial^{\beta}f^{\alpha}{}_{\alpha}\,\partial_{\delta}f_{\beta}{}^{\delta}-2\beta_1\,\partial_{\beta}f_{\chi}{}^{\beta}\,\partial_{\delta}f^{\chi\delta}+\tfrac{2}{3}\alpha_6\,\partial_{\beta}\omega^{\alpha\beta}{}_{\alpha}\,\partial_{\delta}\omega^{\chi\delta}{}_{\chi}-\beta_1\,\partial^{\chi}f_{\zeta}{}^{\beta}\,\partial^{\zeta}f_{\beta\chi}- \\
& \beta_1\,\partial^{\chi}f_{\zeta}{}^{\beta}\,\partial^{\zeta}f_{\chi\beta}+\beta_1\,\partial^{\chi}f_{\delta\zeta}\,\partial^{\zeta}f^{\delta}{}_{\chi}-\beta_1\,\partial^{\chi}f_{\zeta\delta}\,\partial^{\zeta}f^{\delta}{}_{\chi})[t,x,y,z]\,dz\,dy\,dx\,dt
\end{aligned}
$$

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^-}^{\#1}$
$\omega_{0^+}^{\#1}{}^{\dagger}$	$\frac{\alpha_0}{2}-2\beta_1+\alpha_6 k^2$	$-\frac{i(\alpha_0-4\beta_1)k}{\sqrt{2}}$	0	$\frac{1}{2}(\alpha_0-4\beta_1)$
$f_{0^+}^{\#1}{}^{\dagger}$	$\frac{i(\alpha_0-4\beta_1)k}{\sqrt{2}}$	$-4\beta_1 k^2$	0	0
$f_{0^+}^{\#2}{}^{\dagger}$	0	0	0	0
$\omega_{0^-}^{\#1}{}^{\dagger}$	$\frac{1}{2}(\alpha_0-4\beta_1)$	0	0	0

Massive and massless spectra



Massive particle	
Pole residue:	$\frac{1}{\alpha_0}+\frac{1}{\alpha_6}-\frac{1}{4\beta_1}>0$
Polarisations:	1
Square mass:	$-\frac{\alpha_0(\alpha_0-4\beta_1)}{8\alpha_6\beta_1}>0$
Spin:	0
Parity:	Even



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

Unitarity conditions

$\alpha_0>0$ && $\alpha_6>0$ && $\beta_1<0$ || $\beta_1>\frac{\alpha_0}{4}$