

Particle spectrograph

Wave operator and propagator

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

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

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

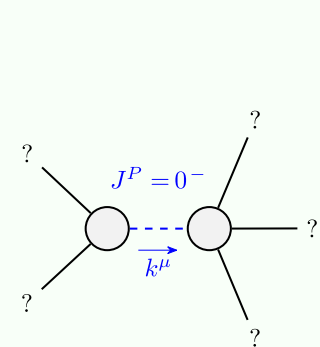
	$\omega_{1+}^{\#1} \alpha\beta$	$\omega_{1+}^{\#2} \alpha\beta$	$f_{1+}^{\#1} \alpha\beta$	$\omega_{1+}^{\#1} \alpha$	$\omega_{1+}^{\#2} \alpha$	$f_{1+}^{\#1} \alpha$	$f_{1+}^{\#2} \alpha$
$\omega_{1+}^{\#1} \dagger^{\alpha\beta}$	$\frac{1}{4}(\alpha_0-4\beta_1)$	$\frac{\alpha_0-4\beta_1}{2\sqrt{2}}$	$\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	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
$\omega_{1+}^{\#1} \alpha$	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
$\omega_{1+}^{\#2} \alpha$	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	0
$f_{1+}^{\#2} \alpha$	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
$\tau_{1+}^{\#2\alpha} + 2ik \sigma_{1+}^{\#2\alpha} == 0$	3
$\tau_{1+}^{\#1\alpha} == 0$	3
$\tau_{1+}^{\#1\alpha\beta} + ik \sigma_{1+}^{\#2\alpha\beta} == 0$	3
Total constraints:	10

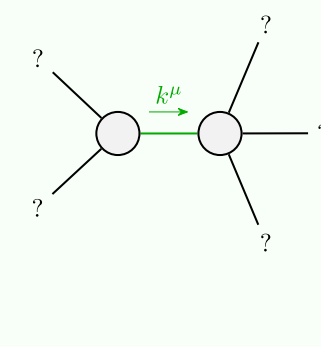
	$\omega_0^{\#1}$	$f_0^{\#2}$	$f_0^{\#1}$	$\omega_0^{\#1}$
$\omega_0^{\#1} \dagger$	0	0	$-\frac{i(\alpha_0-4\beta_1)k}{\sqrt{2}}$	$\frac{1}{2}(\alpha_0-4\beta_1)$
$f_0^{\#1} \dagger$	0	0	$-\frac{i(\alpha_0-4\beta_1)k}{\sqrt{2}}$	$\frac{1}{2}(\alpha_0-4\beta_1)$
$f_0^{\#2} \dagger$	0	0	0	0
$\omega_0^{\#1} \dagger$	0	0	0	0

Quadratic (free) Lagrangian density
$-\frac{1}{2}\alpha_0 \omega_{\alpha\chi\beta} \omega^{\alpha\beta\chi} - \frac{1}{2}\alpha_0 \omega^{\alpha\beta}{}_{\alpha} \omega_{\beta}{}^{\chi}{}_{\chi} + 2\beta_1 \omega^{\alpha\beta}{}_{\alpha} \omega_{\beta}{}^{\chi}{}_{\chi} - 2\beta_1 \omega_{\alpha}{}^{\chi\delta} \omega_{\chi\delta}{}^{\alpha} +$ $f^{\alpha\beta} \tau_{\alpha\beta} + \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - 2\beta_1 \omega_{\alpha}{}^{\chi}{}_{\chi} \partial_{\beta} f^{\alpha\beta} - 2\beta_1 \omega_{\alpha}{}^{\delta}{}_{\delta} \partial_{\beta} f^{\alpha\beta} - \alpha_0 f^{\alpha\beta} \partial_{\beta} \omega_{\alpha}{}^{\chi}{}_{\chi} +$ $\alpha_0 \partial_{\beta} \omega^{\alpha\beta}{}_{\alpha} + \frac{2}{3}\alpha_3 \partial^{\alpha} \omega^{\beta\zeta}{}_{\chi} \partial_{\beta} \omega_{\zeta\alpha}{}^{\chi} + 2\beta_1 \omega_{\beta}{}^{\chi}{}_{\chi} \partial^{\beta} f^{\alpha}{}_{\alpha} + 2\beta_1 \omega_{\beta}{}^{\delta}{}_{\delta} \partial^{\beta} f^{\alpha}{}_{\alpha} -$ $2\beta_1 \partial_{\beta} f^{\chi}{}_{\chi} \partial^{\beta} f^{\alpha}{}_{\alpha} + \alpha_0 f^{\alpha\beta} \partial_{\chi} \omega_{\alpha}{}^{\chi}{}_{\beta} - \alpha_0 f^{\alpha}{}_{\alpha} \partial_{\chi} \omega^{\beta\chi}{}_{\beta} - \frac{2}{3}\alpha_3 \partial_{\beta} \omega_{\zeta\alpha}{}^{\chi} \partial_{\chi} \omega^{\beta\zeta\alpha}{}_{\alpha} -$ $\frac{1}{3}\alpha_3 \partial_{\beta} \omega_{\zeta\alpha}{}^{\chi} \partial_{\chi} \omega^{\zeta\alpha\beta} + 4\beta_1 \omega_{\alpha\chi\beta} \partial^{\chi} f^{\alpha\beta} + \beta_1 \partial_{\chi} f_{\beta}{}^{\delta} \partial^{\chi} f_{\delta}{}^{\beta} + \beta_1 \partial_{\chi} f_{\delta}{}^{\delta} \partial^{\chi} f_{\delta}{}^{\beta} +$ $\frac{2}{3}\alpha_3 \partial_{\chi} \omega^{\beta\zeta\alpha} \partial^{\chi} \omega_{\zeta\alpha\beta} + \frac{1}{3}\alpha_3 \partial_{\chi} \omega^{\zeta\alpha\beta} \partial^{\chi} \omega_{\zeta\alpha\beta} + 4\beta_1 \partial^{\beta} f^{\alpha}{}_{\alpha} \partial_{\delta} f_{\beta}{}^{\delta} -$ $2\beta_1 \partial_{\beta} f_{\chi}{}^{\beta} \partial_{\delta} f^{\chi\delta} + \frac{2}{3}\alpha_3 \partial^{\beta} \omega_{\alpha}{}^{\delta\zeta} \partial_{\delta} \omega_{\zeta\beta}{}^{\alpha} - \frac{2}{3}\alpha_3 \partial^{\beta} \omega_{\alpha}{}^{\zeta\delta} \partial_{\delta} \omega_{\zeta\beta}{}^{\alpha} -$ $\beta_1 \partial^{\chi} f_{\zeta}{}^{\beta} \partial^{\zeta} f_{\beta\chi} - \beta_1 \partial^{\chi} f_{\zeta}{}^{\beta} \partial^{\zeta} f_{\chi\beta} + \beta_1 \partial^{\chi} f_{\delta\zeta} \partial^{\zeta} f_{\chi}{}^{\delta} - \beta_1 \partial^{\chi} f_{\zeta\delta} \partial^{\zeta} f_{\chi}{}^{\delta}$

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

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