

Particle spectrograph

Wave operator and propagator

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

	$\sigma_{0^+}^{\#1}$	$\tau_{0^+}^{\#1}$	$\tau_{0^+}^{\#2}$	$\sigma_{0^+}^{\#1}$
$\sigma_{0^+}^{\#1} \dagger$	$\frac{8\beta_1}{\alpha_0^2-4\alpha_0\beta_1+8\alpha_6\beta_1k^2}$	$-\frac{i\sqrt{2}(\alpha_0-4\beta_1)}{\alpha_0(\alpha_0-4\beta_1)k+8\alpha_6\beta_1k^3}$	0	0
$\tau_{0^+}^{\#1} \dagger$	$\frac{i\sqrt{2}(\alpha_0-4\beta_1)}{\alpha_0(\alpha_0-4\beta_1)k+8\alpha_6\beta_1k^3}$	$-\frac{\alpha_0-4\beta_1+2\alpha_6k^2}{k^2(\alpha_0^2-4\alpha_0\beta_1+8\alpha_6\beta_1k^2)}$	0	0
$\tau_{0^+}^{\#2} \dagger$	0	0	0	0
$\sigma_{0^+}^{\#1} \dagger$	0	0	0	$\frac{2}{\alpha_0-4\beta_1}$

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

	$\omega_{2^+}^{\#1} \alpha\beta$	$f_{2^+}^{\#1} \alpha\beta$	$\omega_{2^+}^{\#1} \alpha\beta\chi$
$\omega_{2^+}^{\#1} \dagger \alpha\beta$	$-\frac{\alpha_0}{4} + \beta_1$	$\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	0
$f_{2^+}^{\#1} \dagger \alpha\beta$	$-\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	$2\beta_1k^2$	0
$\omega_{2^+}^{\#1} \dagger \alpha\beta\chi$	0	0	$-\frac{\alpha_0}{4} + \beta_1$

	$\sigma_{2^+}^{\#1} \alpha\beta$	$\tau_{2^+}^{\#1} \alpha\beta$	$\sigma_{2^+}^{\#1} \alpha\beta\chi$
$\sigma_{2^+}^{\#1} \dagger \alpha\beta$	$-\frac{16\beta_1}{\alpha_0^2-4\alpha_0\beta_1}$	$\frac{2i\sqrt{2}}{\alpha_0k}$	0
$\tau_{2^+}^{\#1} \dagger \alpha\beta$	$-\frac{2i\sqrt{2}}{\alpha_0k}$	$\frac{2}{\alpha_0k^2}$	0
$\sigma_{2^+}^{\#1} \dagger \alpha\beta\chi$	0	0	$\frac{1}{-\frac{\alpha_0}{4} + \beta_1}$

	$\omega_{0^+}^{\#1}$	$f_{0^+}^{\#1}$	$f_{0^+}^{\#2}$	$\omega_{0^+}^{\#1}$
$\omega_{0^+}^{\#1} \dagger$	$\frac{\alpha_0}{2} - 2\beta_1 + \alpha_6k^2$	$-\frac{i(\alpha_0-4\beta_1)k}{\sqrt{2}}$	0	0
$f_{0^+}^{\#1} \dagger$	$\frac{i(\alpha_0-4\beta_1)k}{\sqrt{2}}$	$-4\beta_1k^2$	0	0
$f_{0^+}^{\#2} \dagger$	0	0	0	0
$\omega_{0^+}^{\#1} \dagger$	0	0	0	$\frac{1}{2}(\alpha_0-4\beta_1)$

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

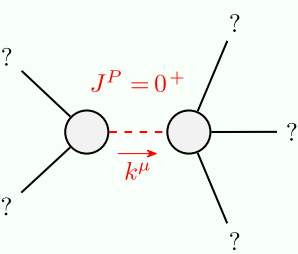
$\omega_{2^+}^{\#1} \alpha\beta$	$f_{2^+}^{\#1} \alpha\beta$	$\omega_{2^+}^{\#1} \alpha\beta\chi$
$-\frac{\alpha_0}{4} + \beta_1$	$\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	0
$-\frac{i(\alpha_0-4\beta_1)k}{2\sqrt{2}}$	$2\beta_1k^2$	0
0	0	$-\frac{\alpha_0}{4} + \beta_1$

$\sigma_{2^+}^{\#1} \alpha\beta$	$\tau_{2^+}^{\#1} \alpha\beta$	$\sigma_{2^+}^{\#1} \alpha\beta\chi$
$-\frac{16\beta_1}{\alpha_0^2-4\alpha_0\beta_1}$	$\frac{2i\sqrt{2}}{\alpha_0k}$	0
$-\frac{2i\sqrt{2}}{\alpha_0k}$	$\frac{2}{\alpha_0k^2}$	0
0	0	$\frac{1}{-\frac{\alpha_0}{4} + \beta_1}$

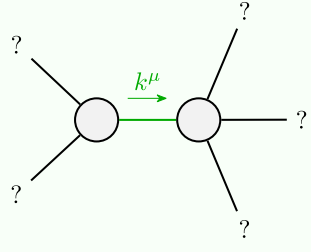
Quadratic (free) action

$$S = \iiint \left(-\frac{1}{2}(\alpha_0-4\beta_1) \omega^{\alpha\beta}_{\alpha} \omega^{\chi}_{\beta\chi} + f^{\alpha\beta} \tau_{\alpha\beta} + \omega^{\alpha\beta\chi} \sigma_{\alpha\beta\chi} - 4\beta_1 \omega^{\chi}_{\alpha\chi} \partial_{\beta} f^{\alpha\beta} - \alpha_0 f^{\alpha\beta} \partial_{\beta} \omega^{\chi}_{\alpha\chi} + \alpha_0 \partial_{\beta} \omega^{\alpha\beta}_{\alpha} + 4\beta_1 \omega^{\chi}_{\beta\chi} \partial^{\beta} f^{\alpha}_{\alpha} - 2\beta_1 \partial_{\beta} f^{\chi}_{\chi} \partial^{\beta} f^{\alpha}_{\alpha} - 2\beta_1 \partial_{\beta} f^{\alpha\beta} \partial_{\chi} f^{\chi}_{\alpha} + 4\beta_1 \partial^{\beta} f^{\alpha}_{\alpha} \partial_{\chi} f^{\chi}_{\beta} + \alpha_0 f^{\alpha\beta} \partial_{\chi} \omega^{\chi}_{\alpha\beta} - \alpha_0 f^{\alpha}_{\alpha} \partial_{\chi} \omega^{\beta\chi}_{\beta} - 2\beta_1 \partial_{\alpha} f_{\beta\chi} \partial^{\chi} f^{\alpha\beta} - \beta_1 \partial_{\alpha} f_{\chi\beta} \partial^{\chi} f^{\alpha\beta} + \beta_1 \partial_{\beta} f_{\alpha\chi} \partial^{\chi} f^{\alpha\beta} + \beta_1 \partial_{\chi} f_{\alpha\beta} \partial^{\chi} f^{\alpha\beta} + \beta_1 \partial_{\chi} f_{\beta\alpha} \partial^{\chi} f^{\alpha\beta} - \frac{1}{2} \omega_{\alpha\chi\beta} ((\alpha_0-4\beta_1) \omega^{\alpha\beta\chi} - 8\beta_1 \partial^{\chi} f^{\alpha\beta}) + \frac{2}{3} \alpha_6 \partial_{\beta} \omega^{\alpha\beta}_{\alpha} \partial_{\delta} \omega^{\chi\delta}_{\chi} \right) [t, x, y, z] dz dy dx dt$$

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

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