Particle spectrograph

Wave operator and propagator

Source constraints

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

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

	$\mathcal{A}^{\#1}_{2^+\,\alpha\beta}$	$f^{\#1}_{2^+\,\alpha\beta}$	$\mathcal{A}^{\#1}_{2^-\,\alpha\beta\chi}$
$\mathcal{A}^{\#1}_{2^+}{}^{\dagger\,\alpha\beta}$	$-\frac{\alpha_0}{4}$	$\frac{i \alpha_0 k}{2\sqrt{2}}$	0
$f^{\#1}_{2^+}{}^{\dagger\,\alpha\beta}$	$-\frac{i \alpha_0 k}{2\sqrt{2}}$	0	0
$\mathcal{A}^{\#1}_{2^-}{}^{\dagger\,\alpha\beta\chi}$	0	0	$-\frac{\alpha_0}{4}$

	$\sigma^{\#1}_{2^+\,\alpha\beta}$	$\tau^{\#1}_{2^+\,\alpha\beta}$	$\sigma^{\#1}_{2^-\,\alpha\beta\chi}$
$\sigma^{\#1}_{2^+}{}^{\dagger\,\alpha\beta}$	0	$\frac{2 i \sqrt{2}}{\alpha_0 k}$	0
$\tau^{\#1}_{2^+}{}^{\dagger\,\alpha\beta}$	$-\frac{2 i \sqrt{2}}{\alpha_0 k}$	$\frac{2}{\alpha_0 k^2}$	0
$\sigma^{\#1}_{2^-}{}^{\dagger\,\alpha\beta\chi}$	0	0	$-\frac{4}{\alpha_0}$

	$\sigma^{\#1}_{0^+}$	$\tau^{\#1}_{0^+}$	$\tau^{\#2}_{0^+}$	$\sigma^{\#1}_{0^-}$
$\sigma^{\#1}_{0^+}{}^\dagger$	0	$-\frac{i\sqrt{2}}{\alpha_0 k}$	0	0
$\tau^{\#1}_{0^+}{}^\dagger$	$\frac{i\sqrt{2}}{\alpha_0 k}$	$-\frac{1}{\alpha_0 k^2}$	0	0
$\tau^{\#2}_{0^+}{}^\dagger$	0	0	0	0
$\sigma^{\#1}_{0^-}{}^\dagger$	0	0	0	$\frac{2}{\alpha_0+12\alpha_1 k^2}$

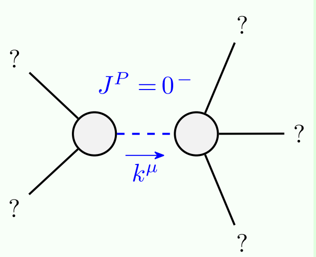
	$\mathcal{A}^{\#1}_{1^+\,\alpha\beta}$	$\mathcal{A}^{\#2}_{1^+\,\alpha\beta}$	$f^{\#1}_{1^+\,\alpha\beta}$	$\mathcal{A}^{\#1}_{1^-\,\alpha}$	$\mathcal{A}^{\#2}_{1^-\,\alpha}$	$f^{\#1}_{1^-\,\alpha}$	$f^{\#2}_{1^-\,\alpha}$
$\mathcal{A}^{\#1}_{1^+}{}^{\dagger\,\alpha\beta}$	$\frac{\alpha_0}{4}$	$\frac{\alpha_0}{2\sqrt{2}}$	$\frac{i \alpha_0 k}{2\sqrt{2}}$	0	0	0	0
$\mathcal{A}^{\#2}_{1^+}{}^{\dagger\,\alpha\beta}$	$\frac{\alpha_0}{2\sqrt{2}}$	0	0	0	0	0	0
$f^{\#1}_{1^+}{}^{\dagger\,\alpha\beta}$	$-\frac{i \alpha_0 k}{2\sqrt{2}}$	0	0	0	0	0	0
$\mathcal{A}^{\#1}_{1^-}{}^{\dagger\,\alpha}$	0	0	0	$\frac{\alpha_0}{4}$	$-\frac{\alpha_0}{2\sqrt{2}}$	0	$-\frac{1}{2} i \alpha_0 k$
$\mathcal{A}^{\#2}_{1^-}{}^{\dagger\,\alpha}$	0	0	0	$-\frac{\alpha_0}{2\sqrt{2}}$	0	0	0
$f^{\#1}_{1^-}{}^{\dagger\,\alpha}$	0	0	0	0	0	0	0
$f^{\#2}_{1^-}{}^{\dagger\,\alpha}$	0	0	0	$\frac{i \alpha_0 k}{2}$	0	0	0

	$\mathcal{A}^{\#1}_{0^+}$	$f^{\#1}_{0^+}$	$f^{\#2}_{0^+}$	$\mathcal{A}^{\#1}_{0^-}$
$\mathcal{A}^{\#1}_{0^+}{}^\dagger$	$\frac{\alpha_0}{2}$	$-\frac{i \alpha_0 k}{\sqrt{2}}$	0	0
$f^{\#1}_{0^+}{}^\dagger$	$\frac{i \alpha_0 k}{\sqrt{2}}$	0	0	0
$f^{\#2}_{0^+}{}^\dagger$	0	0	0	0
$\mathcal{A}^{\#1}_{0^-}{}^\dagger$	0	0	0	$\frac{\alpha_0}{2} + 6\alpha_1 k^2$

Quadratic (free) action

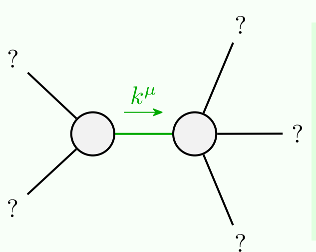
$$\mathcal{S} == \iiiint \Big(f^{\alpha\beta}\ \tau_{\alpha\beta} + \mathcal{A}^{\alpha\beta\chi}\ \sigma_{\alpha\beta\chi} - \frac{1}{2}\alpha_0 \big(\mathcal{A}_{\alpha\chi\beta}\ \mathcal{A}^{\alpha\beta\chi} + \mathcal{A}^{\alpha\beta}{}_{\alpha}\ \mathcal{A}_{\beta}{}^{\chi}{}_{\chi} + 2 f^{\alpha\beta}\ \partial_\beta\mathcal{A}_{\alpha}{}^{\chi}{}_{\chi} - 2\,\partial_\beta\mathcal{A}^{\alpha\beta}{}_{\alpha} - 2 f^{\alpha\beta}\ \partial_\chi\mathcal{A}_{\alpha}{}^{\chi}{}_{\beta} + 2 f^{\alpha}{}_{\alpha}\ \partial_\chi\mathcal{A}^{\beta\chi}{}_{\beta} \big) + 2\alpha_1 \big(4\,\partial_\beta\mathcal{A}_{\alpha\chi\delta} - 2\,\partial_\beta\mathcal{A}_{\alpha\delta\chi} + 2\,\partial_\beta\mathcal{A}_{\chi\delta\alpha} - \partial_\chi\mathcal{A}_{\alpha\beta\delta} + \partial_\delta\mathcal{A}_{\alpha\beta\chi} - 2\,\partial_\delta\mathcal{A}_{\alpha\chi\beta} \big)\,\partial^\delta\mathcal{A}^{\alpha\beta\chi} \Big)[t, x, y, z]\, dz\, dy\, dx\, dt$$

Massive and massless spectra



Massive particle

Pole residue:	$-\frac{1}{6\alpha_1} > 0$
Polarisations:	1
Square mass:	$-\frac{\alpha_0}{12\alpha_1} > 0$
Spin:	0
Parity:	Odd



Quadratic pole

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

Unitarity conditions

$\alpha_0 > 0\ \&\&\ \alpha_1 < 0$