

Particle spectrograph

Wave operator and propagator

$\Delta_{1^+}^{\#1} \dagger \alpha \beta$	$\Delta_{1^+}^{\#2} \dagger \alpha \beta$	$\Delta_{1^+}^{\#3} \dagger \alpha \beta$	$\Delta_{1^+}^{\#1} \alpha$	$\Delta_{1^+}^{\#2} \alpha$	$\Delta_{1^+}^{\#3} \alpha$	$\Delta_{1^+}^{\#4} \alpha$	$\Delta_{1^+}^{\#5} \alpha$	$\Delta_{1^+}^{\#6} \alpha$	$\mathcal{T}_{1^+}^{\#1} \alpha$
$\Delta_{1^+}^{\#1} \dagger \alpha \beta$	0	$-\frac{2\sqrt{2}}{a_0}$	0	0	0	0	0	0	0
$\Delta_{1^+}^{\#2} \dagger \alpha \beta$	$-\frac{2\sqrt{2}}{a_0}$	$\frac{2}{a_0}$	0	0	0	0	0	0	0
$\Delta_{1^+}^{\#3} \dagger \alpha \beta$	0	0	$\frac{4}{a_0}$	0	0	0	0	0	0
$\Delta_{1^+}^{\#1} \alpha$	0	0	0	$\frac{\sqrt{2}(4+k^2)}{a_0(2+k^2)}$	$-\frac{2k^2}{\sqrt{3}a_0(2+k^2)}$	0	$\frac{\sqrt{\frac{2}{3}}k^2}{a_0(2+k^2)}$	0	$-\frac{2i\sqrt{2}k}{a_0(2+k^2)}$
$\Delta_{1^+}^{\#2} \alpha$	0	0	$\frac{\sqrt{2}(4+k^2)}{a_0(2+k^2)}$	$\frac{(4+k^2)^2}{2a_0(2+k^2)^2}$	$\frac{k^2(2+k^2)}{2\sqrt{6}a_0(2+k^2)^2}$	$-\frac{\sqrt{\frac{5}{6}}k^2}{4a_0+2a_0k^2}$	$\frac{k^2(5+2k^2)}{\sqrt{3}a_0(2+k^2)^2}$	$-\frac{k^2}{\sqrt{6}a_0(2+k^2)}$	$-\frac{ik(4+k^2)}{a_0(2+k^2)^2}$
$\Delta_{1^+}^{\#3} \alpha$	0	0	$-\frac{2k^2}{\sqrt{3}(2a_0+a_0k^2)}$	$\frac{k^2(2+k^2)}{2\sqrt{6}a_0(2+k^2)^2}$	$\frac{76+52k^2+3k^4}{12a_0(2+k^2)^2}$	$\frac{\sqrt{5}(10+3k^2)}{12a_0(2+k^2)}$	$\frac{-2+k^2}{3\sqrt{2}a_0(2+k^2)^2}$	$\frac{1}{-2a_0-2+3k^2}$	$\frac{ik(6+5k^2)}{\sqrt{6}a_0(2+k^2)^2}$
$\Delta_{1^+}^{\#4} \alpha$	0	0	0	$-\frac{\sqrt{\frac{5}{6}}k^2}{4a_0+2a_0k^2}$	$\frac{\sqrt{5}(10+3k^2)}{12a_0(2+k^2)}$	$\frac{1}{12a_0}$	$-\frac{\sqrt{\frac{5}{2}}}{6a_0+3a_0k^2}$	$-\frac{\sqrt{5}}{6a_0}$	$-\frac{i\sqrt{\frac{5}{6}}k}{a_0(2+k^2)}$
$\Delta_{1^+}^{\#5} \alpha$	0	0	0	$\frac{k^2(5+2k^2)}{\sqrt{3}a_0(2+k^2)^2}$	$\frac{k^2(2+k^2)}{\sqrt{3}a_0(2+k^2)^2}$	$-\frac{\sqrt{\frac{5}{2}}}{6a_0+3a_0k^2}$	$-\frac{\sqrt{2}(7+3k^2)}{3a_0(2+k^2)^2}$	$-\frac{\sqrt{2}(7+3k^2)}{3a_0(2+k^2)^2}$	$\frac{2ik(3+k^2)}{\sqrt{3}a_0(2+k^2)^2}$
$\Delta_{1^+}^{\#6} \alpha$	0	0	0	$-\frac{k^2}{\sqrt{6}(2a_0+a_0k^2)}$	$-\frac{1}{-2a_0-2+3k^2}$	$-\frac{\sqrt{5}}{6a_0}$	$-\frac{\sqrt{2}(7+3k^2)}{3a_0(2+k^2)^2}$	$\frac{5}{3a_0}$	$-\frac{i\sqrt{\frac{2}{3}}k}{a_0(2+k^2)}$
$\mathcal{T}_{1^+}^{\#1} \alpha$	0	0	0	$\frac{2i\sqrt{2}k}{2a_0+a_0k^2}$	$-\frac{ik(6+5k^2)}{\sqrt{6}a_0(2+k^2)^2}$	$\frac{i\sqrt{\frac{5}{6}}k}{2a_0+a_0k^2}$	$-\frac{2ik(3+k^2)}{\sqrt{3}a_0(2+k^2)^2}$	$\frac{i\sqrt{\frac{2}{3}}k}{2a_0+a_0k^2}$	$\frac{2k^2}{a_0(2+k^2)^2}$

$\Delta_{0^+}^{\#1} \dagger$	$\Delta_{0^+}^{\#2} \dagger$	$\Delta_{0^+}^{\#3} \dagger$	$\Delta_{0^+}^{\#4} \dagger$	$\mathcal{T}_{0^+}^{\#1} \dagger$	$\Delta_{0^+}^{\#1} \dagger$	$\Delta_{0^+}^{\#2} \dagger$	$\Delta_{0^+}^{\#3} \dagger$	$\Delta_{0^+}^{\#4} \dagger$	$\Delta_{0^+}^{\#5} \dagger$
$\Delta_{0^+}^{\#1} \dagger$	0	$-\frac{4\sqrt{6}}{16a_0+3a_0k^2}$	$-\frac{4\sqrt{\frac{2}{3}}}{16a_0+3a_0k^2}$	$-\frac{8}{\sqrt{3}(16a_0+3a_0k^2)}$	$-\frac{2i\sqrt{2}}{a_0k}$	$-\frac{2i\sqrt{6}k}{16a_0+3a_0k^2}$	0	0	0
$\Delta_{0^+}^{\#2} \dagger$	$\frac{4\sqrt{6}}{16a_0+3a_0k^2}$	$-\frac{144}{a_0(16+3k^2)^2}$	$-\frac{16(19+3k^2)}{a_0(16+3k^2)^2}$	$-\frac{8\sqrt{2}(10+3k^2)}{a_0(16+3k^2)^2}$	$-\frac{8i\sqrt{3}}{16a_0k+3a_0k^3}$	$\frac{72ik}{a_0(16+3k^2)^2}$	0	0	0
$\Delta_{0^+}^{\#3} \dagger$	$-\frac{4\sqrt{\frac{2}{3}}}{16a_0+3a_0k^2}$	$-\frac{16(19+3k^2)}{a_0(16+3k^2)^2}$	$-\frac{16(35+6k^2)}{3a_0(16+3k^2)^2}$	$-\frac{8\sqrt{2}(22+3k^2)}{3a_0(16+3k^2)^2}$	$\frac{8i}{\sqrt{3}(16a_0k+3a_0k^3)}$	$-\frac{8ik(19+3k^2)}{a_0(16+3k^2)^2}$	0	0	0
$\Delta_{0^+}^{\#4} \dagger$	$-\frac{8}{\sqrt{3}(16a_0+3a_0k^2)}$	$-\frac{8\sqrt{2}(10+3k^2)}{a_0(16+3k^2)^2}$	$-\frac{8\sqrt{2}(22+3k^2)}{3a_0(16+3k^2)^2}$	$-\frac{32(13+3k^2)}{3a_0(16+3k^2)^2}$	$\frac{8i\sqrt{\frac{2}{3}}}{16a_0k+3a_0k^3}$	$\frac{4i\sqrt{2}k(10+3k^2)}{a_0(16+3k^2)^2}$	0	0	0
$\mathcal{T}_{0^+}^{\#1} \dagger$	$\frac{2i\sqrt{2}}{a_0k}$	$-\frac{8i\sqrt{3}}{16a_0k+3a_0k^3}$	$-\frac{8i}{\sqrt{3}(16a_0k+3a_0k^3)}$	$-\frac{4}{a_0k^2}$	0	$\frac{4\sqrt{3}}{16a_0+3a_0k^2}$	0	0	0
$\mathcal{T}_{0^+}^{\#2} \dagger$	$\frac{2i\sqrt{6}k}{16a_0+3a_0k^2}$	$-\frac{72ik}{a_0(16+3k^2)^2}$	$-\frac{8ik(19+3k^2)}{a_0(16+3k^2)^2}$	$-\frac{4i\sqrt{2}k(10+3k^2)}{a_0(16+3k^2)^2}$	$\frac{4\sqrt{3}}{16a_0+3a_0k^2}$	$-\frac{36k^2}{a_0(16+3k^2)^2}$	0	0	0
$\Delta_{0^+}^{\#1} \dagger$	0	0	0	0	0	0	$-\frac{2}{a_0}$	0	0

$\Delta_{3^-}^{\#1} \alpha \beta \chi$

$\Delta_3^{\#1} \dagger \alpha \beta \chi$

$-\frac{2}{a_0}$

$\Gamma_{3^-}^{\#1} \alpha \beta \chi$

$\Gamma_3^{\#1} \dagger \alpha \beta \chi$

$-\frac{a_0}{2}$

$\Gamma_{2^+}^{\#1} \dagger \alpha \beta$	$\Gamma_{2^+}^{\#2} \dagger \alpha \beta$	$\Gamma_{2^+}^{\#3} \dagger \alpha \beta$	$h_{2^+}^{\#1} \dagger \alpha \beta$	$\Gamma_{2^+}^{\#1} \alpha \beta \chi$	$\Gamma_{2^+}^{\#2} \alpha \beta \chi$
$\Gamma_{2^+}^{\#1} \dagger \alpha \beta$	$\frac{a_0}{4}$	0	0	$\frac{ia_0k}{4\sqrt{2}}$	0
$\Gamma_{2^+}^{\#2} \dagger \alpha \beta$	0	$-\frac{a_0}{2}$	0	$\frac{ia_0k}{4\sqrt{3}}$	0
$\Gamma_{2^+}^{\#3} \dagger \alpha \beta$	0	0	$\frac{a_0}{4}$	$-\frac{ia_0k}{4\sqrt{6}}$	0
$h_{2^+}^{\#1} \dagger \alpha \beta$	$-\frac{ia_0k}{4\sqrt{2}}$	$-\frac{ia_0k}{4\sqrt{3}}$	$\frac{ia_0k}{4\sqrt{6}}$	0	0
$\Gamma_{2^+}^{\#1} \alpha \beta \chi$	0	0	0	$\frac{a_0}{4}$	0
$\Gamma_{2^+}^{\#2} \alpha \beta \chi$	0	0	0	0	$\frac{a_0}{4}$

$\Gamma_{1^+}^{\#1} \dagger \alpha \beta$	$\Gamma_{1^+}^{\#2} \dagger \alpha \beta$	$\Gamma_{1^+}^{\#3} \dagger \alpha \beta$	$\Gamma_{1^+}^{\#4} \dagger \alpha \beta$	$\Gamma_{1^+}^{\#5} \dagger \alpha \beta$	$\Gamma_{1^+}^{\#6} \dagger \alpha \beta$	$h_{1^+}^{\#1} \dagger \alpha \beta$
$\Gamma_{1^+}^{\#1} \dagger \alpha \beta$	$-\frac{a_0}{4}$	0	0	0	0	0
$\Gamma_{1^+}^{\#2} \dagger \alpha \beta$	$-\frac{a_0}{2\sqrt{2}}$	0	0	0	0	0
$\Gamma_{1^+}^{\#3} \dagger \alpha \beta$	0	$\frac{a_0}{4}$	0	0	0	0
$\Gamma_{1^+}^{\#1} \alpha$	0	0	$-\frac{a_0}{2\sqrt{2}}$	0	0	$-\frac{ia_0k}{4\sqrt{2}}$
$\Gamma_{1^+}^{\#2} \alpha$	0	0	$\frac{a_0}{2\sqrt{2}}$	0	0	$\frac{ia_0k}{4\sqrt{2}}$
$\Gamma_{1^+}^{\#3} \alpha$	0	0	0	$-\frac{a_0}{3}$	$-\frac{a_0}{6\sqrt{2}}$	$-\frac{ia_0k}{4\sqrt{6}}$
$\Gamma_{1^+}^{\#4} \alpha$	0	0	$\frac{\sqrt{5}a_0}{6}$	$-\frac{a_0}{6\sqrt{2}}$	$-\frac{\sqrt{5}a_0}{6}$	$\frac{ia_0k}{4\sqrt{3}}$
$\Gamma_{1^+}^{\#5} \alpha$	0	0	$-\frac{a_0}{6\sqrt{2}}$	$-\frac{1}{6}\sqrt{\frac{5}{2}}$	$-\frac{\sqrt{5}a_0}{6}$	$-\frac{1}{4}i\sqrt{\frac{5}{6}}a_0k$
$\Gamma_{1^+}^{\#6} \alpha$	0	0	$-\frac{a_0}{6}$	$-\frac{a_0}{6}$	$\frac{a_0}{6\sqrt{2}}$	$\frac{ia_0k}{4\sqrt{6}}$
$h_{1^+}^{\#1} \alpha$	0	0	$-\frac{ia_0k}{4\sqrt{2}}$	$-\frac{ia_0k}{4\sqrt{6}}$	$-\frac{ia_0k}{4\sqrt{3}}$	0

$\Gamma_{2^+}^{\#1} \alpha \beta$

$\Gamma_{2^+}^{\#2} \alpha \beta$

$\Gamma_{2^+}^{\#3} \alpha \beta$

$h_{2^+}^{\#1} \alpha \beta$

$\Gamma_{2^+}^{\#1} \alpha \beta \chi$

$\Gamma_{2^+}^{\#2} \alpha \beta \chi$

Quadratic (free) action

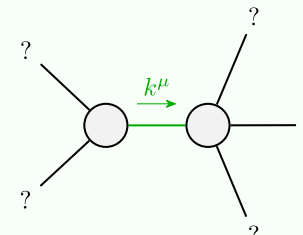
$$S = \iiint \int (\frac{1}{4} (2 a_0 \Gamma_a^{\alpha \beta} \Gamma_{\beta \chi}^{\alpha} + 4 h^{\alpha \beta} \mathcal{T}_{\alpha \beta} + \Gamma^{\alpha \beta \chi} (-2 a_0 \Gamma_{\beta \chi \alpha} + 4 \Delta_{\alpha \beta \chi}) - a_0 h_{\chi}^{\alpha} \partial_{\beta} \Gamma_a^{\alpha \beta} + a_0 h_{\chi}^{\alpha} \partial_{\beta} \Gamma_a^{\alpha \beta} - 2 a_0 h_{\alpha \chi} \partial_{\beta} \Gamma^{\alpha \beta \chi} + 2 a_0 h_{\beta \chi} \partial^{\chi} \Gamma_a^{\alpha \beta})) [t, x, y, z] d z d y d x d t$$

$\Gamma_{0^+}^{\#1} \dagger$	$\Gamma_{0^+}^{\#2} \dagger$	$\Gamma_{0^+}^{\#3} \dagger$	$\Gamma_{0^+}^{\#4} \dagger$	$h_{0^+}^{\#1} \dagger$	$h_{0^+}^{\#2} \dagger$	$\Gamma_{0^+}^{\#1} \dagger$
$\Gamma_{0^+}^{\#1} \dagger$	$-\frac{a_0}{2}$	0	0	$-\frac{ia_0k}{2\sqrt{2}}$	0	0
$\Gamma_{0^+}^{\#2} \dagger$	0	0	$\frac{a_0}{2}$	$-\frac{a_0}{2\sqrt{2}}$	0	0
$\Gamma_{0^+}^{\#3} \dagger$	0	$\frac{a_0}{2}$	0	$-\frac{a_0}{2\sqrt{2}}$	$\frac{ia_0k}{4\sqrt{3}}$	0
$\Gamma_{0^+}^{\#4} \dagger$	0	$-\frac{a_0}{2\sqrt{2}}$	$-\frac{a_0}{2\sqrt{2}}$	$\frac{a_0}{2}$	$-\frac{ia_0k}{4\sqrt{6}}$	0
$h_{0^+}^{\#1} \dagger$	$\frac{ia_0k}{2\sqrt{2}}$	0	$-\frac{ia_0k}{4\sqrt{3}}$	$\frac{ia_0k}{4\sqrt{6}}$	0	0
$h_{0^+}^{\#2} \dagger$	0	$\frac{ia_0k}{4}$	$-\frac{ia_0k}{4\sqrt{2}}$	0	0	0
$\Gamma_{0^+}^{\#1} \dagger$	0	0	0	0	0	$-\frac{a_0}{2}$

$\Delta_{2^+}^{\#1} \dagger \alpha \beta$	$\Delta_{2^+}^{\#2} \dagger \alpha \beta$	$\Delta_{2^+}^{\#3} \dagger \alpha \beta$	$\mathcal{T}_{2^+}^{\#1} \dagger \alpha \beta$	$\Delta_{2^+}^{\#1} \alpha \beta \chi$	$\Delta_{2^+}^{\#2} \alpha \beta \chi$
$\Delta_{2^+}^{\#1} \dagger \alpha \beta$	0	$\frac{2\sqrt{\frac{2}{3}}}{a_0}$	$\frac{4}{\sqrt{3}a_0}$	$\frac{4i\sqrt{2}}{a_0k}$	0
$\Delta_{2^+}^{\#2} \dagger \alpha \beta$	$\frac{2\sqrt{\frac{2}{3}}}{a_0}$	$-\frac{8}{3a_0}$	$-\frac{2\sqrt{2}}{3a_0}$	$-\frac{4i}{\sqrt{3}a_0k}$	0
$\Delta_{2^+}^{\#3} \dagger \alpha \beta$	$\frac{4}{\sqrt{3}a_0}$	$-\frac{2\sqrt{2}}{3a_0}$	$\frac{8}{3a_0}$	$-\frac{4i\sqrt{\frac{2}{3}}}{a_0k}$	0
$\mathcal{T}_{2^+}^{\#1} \dagger \alpha \beta$	$-\frac{4i\sqrt{2}}{a_0k}$	$\frac{4i}{\sqrt{3}a_0k}$	$\frac{4i\sqrt{\frac{2}{3}}}{a_0k}$	$-\frac{8}{a_0k^2}$	0
$\Delta_{2^+}^{\#1} \alpha \beta \chi$	0	0	0	$\frac{4}{a_0}$	0
$\Delta_{2^+}^{\#2} \alpha \beta \chi$	0	0	0	0	$\frac{4}{a_0}$

Source constraints	Fundamental fields	Multiplicities
SO(3) irreps		
$2 \mathcal{T}_{0^+}^{\#2} - i k \Delta_{0^+}^{\#2} == 0$	$2 \partial_{\beta} \partial_{\alpha} \mathcal{T}^{\alpha \beta} == \partial_{\chi} \partial_{\beta} \partial_{\alpha} \Delta^{\alpha \beta \chi}$	1
$\Delta_{0^+}^{\#3} + 2 \Delta_{0^+}^{\#4} + 3 \Delta_{0^+}^{\#2} == 0$	$\partial_a \Delta^{\alpha \beta}{}_{\beta} == 0$	1
$6 \mathcal{T}_{1^+}^{\#1 \alpha} - i k (3 \Delta_{1^+}^{\#2 \alpha} - \Delta_{1^+}^{\#5 \alpha} + \Delta_{1^+}^{\#3 \alpha}) == 0$	$2 \partial_{\chi} \partial_{\beta} \partial^{\alpha} \mathcal{T}^{\beta \chi} + \partial_{\delta} \partial^{\alpha} \partial_{\chi} \partial_{\beta} \Delta^{\beta \alpha \chi} == 2 \partial_{\chi} \partial^{\chi} \partial_{\beta} \mathcal{T}^{\alpha \beta} + \partial_{\delta} \partial_{\chi} \partial_{\beta} \partial^{\alpha} \Delta^{\beta \chi \delta}$	3
$2 \Delta_{1^+}^{\#6 \alpha} + \Delta_{1^+}^{\#4 \alpha} + 2 \Delta_{1^+}^{\#5 \alpha} + \Delta_{1^+}^{\#3 \alpha} == 0$	$\partial_{\beta} \partial^{\alpha} \Delta^{\beta \chi}{}_{\chi} == \partial_{\chi} \partial^{\chi} \Delta^{\alpha \beta}{}_{\beta}$	3
Total constraints/gauge generators:		8

Massive and massless spectra



Quadratic pole

Pole residue: $-\frac{1}{a_0} > 0$

Polarisations: 2

(No massive particles)

Unitarity conditions

$a_0 < 0$