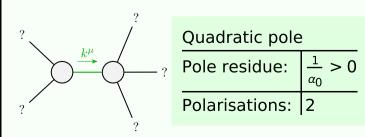
Particle spectrograph

Wave operator and propagator

| _ | | | | | | | | | | | | $\mathcal{A}_0^{\#1}$ | + | f_{i} | $f_0^{"+}$ f | `#2 0+ <i>9</i> (| #1 0 ⁻ | | | | | | | | | | | | | | | | |
|---|---|--|--|--|---|--------------------------|---|-------------------------------|--------------------|---|---|--|--|---|----------------|----------------------|-----------------------------|---|---|---|----------------------------------|--|---------------------------|-------------------------|---|--|--|--|--|--------------------------------------|--|---|--|
| | | | | ⁴ 2 | $\frac{1}{2}$ | | $\frac{(1 k^2)}{(2)^2}$ | ${\mathscr R}_0^{\sharp 1}$: | $+\frac{1}{2}$ | $\frac{1}{2} (\alpha_0 + 4 (\alpha_1 + \alpha_2 + 3 \alpha_3) k^2)$ | | | | | ro k | |) | | $\sigma_0^{\!\#}$ | : <u>1</u> + | τ ₀ ^{#1} | | | $	au_0^{\#}$ | ² σ ₀ ^{#1} | ĺ | | $\mathcal{A}_{2}^{\#1}_{\alpha\beta}$ | | | $\mathcal{A}_{2^{-}\alpha\beta\chi}^{\#1}$ | 1 | |
| $	au_{1}^{\#2}$ | 0 | 0 | 0 | $\frac{4ik}{\alpha_0 + 2\alpha_0k^2}$ | $\frac{\sqrt{2} k(\alpha_0 + 4 \alpha_1 k)}{(\alpha_0 + 2 \alpha_0 k^2)^2}$ | 0 | $\frac{4k^2(\alpha_0+4\alpha_1k^2)}{(\alpha_0+2\alpha_0k^2)^2}$ | $f_{0+}^{\#1}$ | + | | | $\frac{i \alpha_0}{\sqrt{2}}$ | <u>k</u> | (|) | 0 (|) | $\sigma_{0}^{\#1}$ † | t o | | | $-\frac{i\sqrt{2}}{\alpha_0 k}$ | | 0 | 0 | $\mathcal{A}_{2}^{\sharp 1} \dagger^{lphaeta}$ | $\frac{1}{4}\left(-\alpha_0+\alpha_0\right)$ | | $(\alpha_2) k^2$ $\frac{i}{2}$ | $\frac{\alpha_0 k}{\sqrt{2}}$ | 0 | | |
| | | | | | $\frac{2i\sqrt{2}}{\alpha_0}$ | | $-\frac{4k^2}{(\alpha_0)}$ | $f_{0+}^{#2}$ | † | | | 0 | | (|) | |) | $	au_{0}^{\#1}$ † | $+ \left \frac{i \sqrt{\alpha_0}}{\alpha_0} \right $ | $\frac{\overline{2}}{k} - \frac{\alpha}{2}$ | α ₀ +4 (α | $\frac{\alpha_1 + \alpha_2}{\alpha_0^2 k^2}$ | +3 α ₃), 2 | $\frac{k^2}{2} 0$ | 0 | $f_{2+}^{#1}\dagger^{\alpha\beta}$ | - | $-\frac{i \alpha_0 k}{2 \sqrt{2}}$ | | 0 | 0 | | |
| ${\mathfrak l}_{1}^{\#1}{}_{lpha}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | $\mathscr{R}_0^{\sharp_1}$ - | † | | | 0 | | | 0 | $0 \frac{\alpha}{3}$ | <u>0</u> 2 | $	au_{0}^{\#2}$ † | | | | 0 | | 0 | | $\mathcal{A}_{2}^{\#1}\dagger^{\alpha\beta\chi}$ | | 0 | | 0 | $-\frac{\alpha_0}{4}$ | | |
| | | | | <u>.7</u> | $\frac{k^2}{2^{3/2}}$ | | $\frac{\alpha_1 k^2}{1}$ | | ies | | | | | | | | | $\sigma_0^{\#1}$ † | † 0 | | 0 | | 0 | $\frac{2}{\alpha_0}$ | | | | | | | | | |
| $\sigma_{1^-}^{\#2}{}_{lpha}$ | 0 | 0 | 0 | $\frac{2\sqrt{2}}{\alpha_0 + 2\alpha_0 k^2}$ | $\frac{2(\alpha_0 + 4\alpha_1 k^2)}{(\alpha_0 + 2\alpha_0 k^2)^2}$ | 0 | $i \sqrt{2} k (\alpha_0 + 4 \alpha_1 k^2) $ $(\alpha_0 + 2 \alpha_0 k^2)^2$ | | Multiplicities | | | | | | | 7. | 3 | | | | $i \alpha_0 k$ | | | • | | | | | | | | | |
| | | | | - | $\frac{2(c)}{\alpha_0}$ | | $\frac{2i\sqrt{2}}{(\alpha_0)}$ | | Mult | | М | ω | 8 | | 10 | £#2 | | | <i>-</i> | 0 | $-\frac{1}{2}$ | 0 | 0 | 0 | | | χ χ - (θ) - (γ) - | $\frac{\delta}{3}\chi$) + |]((^x | | | | |
| α | | 0 | 0 | 0 | $\frac{2\sqrt{2}}{\alpha_0 + 2\alpha_0 k^2}$ | 0 | $\frac{4ik}{\alpha_0 + 2\alpha_0k^2}$ | | | | $\beta \chi$ | | | | | f#1 | , _ | > c | > | 0 | 0 : | 0 | 0 | 0 | | | $f^{\alpha\beta} \partial_{\beta} \mathcal{A}_{\alpha}^{X}$ $a \partial_{x} \mathcal{A}^{\beta X}$ | $_{lpha}^{3}$) $\partial_{\delta}\mathcal{H}_{eta}^{\ \delta}$ | $\partial_\zeta \mathcal{H}_{\delta}^{\ \ \ \ }$ | | | | |
| $\sigma_{1}^{\#1}$ | 0 |) |) |) | - 2 - 2 | | $\frac{4}{\alpha_0+2}$ | | | | $\partial_\delta\partial^\delta\partial_\chi\partial_\beta\sigma^{lphaeta\chi}$ | | > | - | | £ 2 | - C | | > | 0 | $-\frac{\alpha_0}{2\sqrt{2}}$ | 0 | 0 | 0 | | | $2 f^{\alpha\beta}$ $f^{\alpha} \hat{o}$ | $\mathcal{A}^{\alpha\beta}_{\alpha}$ | $\mathcal{A}^{eta\chi}$) | | | | |
| | | $\frac{\alpha_2(k^2)}{2}$ | $\frac{\alpha_2(k^2)}{2}$ | | | | | | | | 0,000 | | rβ + σκ | $2 \partial_{\delta}\partial_{\chi}\partial^{\alpha}\sigma^{\mu\lambda}^{\lambda} + 2 \partial_{\delta}\partial^{\nu}\partial_{\chi}\sigma^{\mu\nu}^{\lambda}$ $\partial^{\alpha}\tau^{\chi\beta} + \partial_{\chi}\partial^{\beta}\tau^{\alpha\chi} +$ $\partial_{\nu}\partial^{\chi}\tau^{\beta\alpha} + 2 \partial_{\delta}\partial_{\nu}\partial^{\beta}\sigma^{\alpha\chi}^{\delta}$ | | # ₁ | | | 5 | 0 | $+ \alpha_1 k^2$ | $\frac{\alpha_0}{2\sqrt{2}}$ | 0 | $\frac{i\alpha_0 k}{2}$ | | | $\beta x + 2$ $\beta x + 2$ $\beta x + 2$ | ^χ -2 <i>∂</i> × <i>A</i> ^{αβ} | $lpha_{2} (\partial_{\chi} \mathcal{A}_{\delta}^{\ \zeta} \partial^{\delta} \mathcal{A}^{eta\chi}_{\ eta} + (\partial_{eta} \mathcal{A}^{eta\chi\delta} - 2 \partial^{\delta} \mathcal{A}^{eta\chi}_{\ eta}) \partial_{\zeta} \mathcal{A}_{\delta\chi}^{\ \zeta}))]$ | | | | |
| ${\mathfrak r}_1^{\#1}{}_{\!$ | $\frac{2i\sqrt{2}k}{\alpha_0 + \alpha_0 k^2}$ | $\frac{+2(\alpha_1-\alpha_1-\alpha_2)}{2(1+k^2)}$ | $\frac{+2(\alpha_1-}{2(1+k^2)}$ | 0 | 0 | 0 | 0 | | ,, | , | $^{\alpha\beta}$ + 2 | βα | $\partial_{\chi}\partial^{\chi}\tau^{c}$ | $2 \partial_{\delta} \partial^{\alpha} + + \partial^{\beta} \sigma^{\alpha} $ | | | | | | | $\frac{\alpha_0}{4}$ + | - 2 | | <u> </u> | | | $\alpha \beta \alpha \beta \alpha \beta \beta$ | $+ (\partial_{\alpha} \mathcal{A}^{\alpha\beta\chi})^{-}$ | $_{3}\mathcal{A}^{eta\chi\delta}$ | | | | |
| ~ | a | $\frac{2ik(\alpha_0+2(\alpha_1-\alpha_2)k^2)}{\alpha_0^2(1+k^2)^2}$ | $\frac{2k^2(\alpha_0+2(\alpha_1-\alpha_2)k^2)}{\alpha_0^2(1+k^2)^2}$ | | | | | : | Fundamental fields | | $=\partial_{\chi}\partial^{\chi}\partial_{\beta}\tau^{\alpha\beta}+2$ | $\partial_{\chi}\partial^{\chi}\partial_{\beta}\tau^{etalpha}$ | $-\partial_{\chi}\partial^{\beta}t^{\chi\alpha} + \partial_{\chi}\partial^{\chi}t^{\alpha\beta} +$ | $_{\chi}\partial^{lpha}\sigma^{ u}\chi^{lpha}+2\partial_{\delta}\partial^{ u}\partial_{\gamma}$ $^{i}+\partial_{\chi}\partial^{eta}\tau^{lpha\chi}+$ $^{i}\beta^{lpha}+2\partial_{\delta}\partial_{\gamma}\partial^{eta}\sigma^{lpha\chi\delta}$ | :s | $f_{1}^{\#1}$ | | 2 √2 | > | 0 | 0 | 0 | 0 | 0 | | | т | \sim | $^{\lambda}$ | > | < | | |
| - | | • | | | | | | | ental | \circ \Box | χ == <i>δ</i> , | 3χ == <i>∂</i> , | $+ \partial_{\chi} \partial^{\beta}$ | $(\partial_{\chi}\partial^{\alpha}G^{\dagger})^{-1}$ | generators: | A#2 | $\frac{\alpha_0}{\alpha_0}$ | 2 √2 | > | 0 | 0 | 0 | 0 | 0 | | | $\mathcal{A}^{\alpha_l}_{\alpha}$ | $lpha_1 \left(\partial_\chi \mathcal{A}_eta^{~~\delta}_{~~\delta} \partial^\chi \mathcal{A}^{lphaeta}_{~~lpha} ight) \ 4 ~ lpha_3 \partial_eta \mathcal{A}^{lphaeta}_{~~lpha} \partial_\delta \mathcal{A}^{\chi\delta} .$ | i 35 A ^{BX} y dix dit | $\sigma_{2}^{\#1}$ $\alpha eta \chi$ | 0 | 0 | $-\frac{4}{\alpha_0}$ |
| $\sigma_{1}^{\#2}$ | $\frac{2\sqrt{2}}{\alpha_0 + \alpha_0 k^2}$ | $\frac{(\alpha_1 - \alpha_2)}{(1 + k^2)^2}$ | $\frac{2(\alpha_1 - \alpha_2)}{1 + k^2)^2}$ | 0 | 0 | 0 | 0 | | ndan | $\partial_{eta}\partial_{lpha}$ | $\partial_{\chi}\partial_{\beta}\partial^{\alpha}\tau^{eta\chi}$ | $\partial_{\chi}\partial_{\beta}\partial^{\alpha}\tau^{\beta\chi}==\dot{\alpha}$ | $+\chi_{g}^{1} {}_{\nu} e^{\chi} e$ | $2\partial_{\delta}\partial_{\chi}$ $\partial_{\chi}\partial^{\alpha}\mathbf{t}^{\chi\beta}$. $\partial_{\lambda}\partial^{\chi}\mathbf{t}^{f}$ | gene | (A) | | | | | | | | | | $^{\prime}$ $\sigma_{lphaeta\chi}$ | $\mathcal{A}_{\alpha\chi\beta}\mathcal{A}^{\alpha}$ $2\partial_{\beta}\mathcal{A}^{\alpha\beta}$ | ABOS | As E | | | 2) k ²) | |
| σ_1^{\dagger} | $\frac{2}{\alpha_0^+}$ | $\frac{2(\alpha_0 + 2(\alpha_1 - \alpha_2))}{\alpha_0^2(1 + k^2)^2}$ | $\frac{2ik(\alpha_0+2(\alpha_1-\alpha_2)k^2)}{\alpha_0^2(1+k^2)^2}$ | | | | | | 교 | ∂_{β} | 0 | ∂_{χ} | 0 | | Jauge | 9 | $\perp \alpha \rho$ | 11 - 42) | 101 | <u> </u> | | | | | | ee) action $\tau_{\alpha\beta} + \mathcal{A}^{\alpha\beta\chi}$ | $rac{1}{2} \alpha_0 \left(\mathcal{A}_{\alpha\chi\beta} \right)$ | $lpha_1 \left(\partial_\chi \mathcal{H}_{eta}^{\ \delta} _{\ \delta} ight) \ 4 \ lpha_3 \partial_{eta} \mathcal{H}_{eta}^{lpha}$ | $lpha_2 \left(\partial_\chi \mathcal{A}_{arsigma_\zeta^\zeta} ight) \ t, x, y, z] dz dy$ | τ_{2}^{*1} | $\frac{2i\sqrt{2}}{\alpha_0 k}$ | $\frac{2(\alpha_0-2(\alpha_1+\alpha_2)k^2)}{\alpha_0^2k^2}$ | 0 |
| etax | | | _ | | | | | raints | | | $\frac{#2}{1}^{\alpha} ==$ | | , + αβ == | | ints/g | #1 + 1 | | | 2 \(\frac{7}{2} \) | $-\frac{2\sqrt{2}}{2\sqrt{2}}$ | 0 | 0 | 0 | 0 | | ee) ac $\tau_{\alpha\beta}$ + | | | t, ,, | | | 2 (a0-2 | |
| $\sigma_{1}^{\#1}$ | 0 | $\frac{2\sqrt{2}}{\alpha_0 + \alpha_0 k^2}$ | $-\frac{2i\sqrt{2}k}{\alpha_0+\alpha_0k^2}$ | 0 | 0 | 0 | 0 | Source constraints | reps | | $\tau_1^{\#2^\alpha} + 2ik \ \sigma_1^{\#2^\alpha}$ | 0 | $+ik\sigma_{1+}^{\#2}\alpha \beta$: | | | | $\frac{1}{2}$ | 4 \ \(\frac{4}{4} \) | | | | | | | | Quadratic (free) action $S == \iiint (f^{\alpha\beta} \tau_{\alpha\beta} + \mathcal{A}^{\alpha\beta})$ | | | | $\sigma_{2}^{\#1}$ | 0 | $\frac{2i\sqrt{2}}{\alpha_0k}$ | 0 |
| _ | $\sigma_1^{\#1} +^{lphaeta}$ | $\sigma_1^{\#2} + \alpha \beta$ | $\tau_{1}^{\#1} + \alpha \beta$ | $\sigma_{1}^{\#1} +^{lpha}$ | $\sigma_{1}^{#2} + \alpha$ | $\tau_{1}^{#1} + \alpha$ | $\tau_1^{\#2} + \alpha$ | onrce | SO(3) irreps | $\tau_0^{\#2} = 0$ | -zα+ '. | $\tau_{1}^{\#1}{}^{\alpha} == 0$ | | | talcc | | $a = 1 + \alpha \beta$ | \mathcal{A}_{1}^{+} \mathcal{A}_{2}^{+} | _ ~ | f_1^{*} † † $^{\mu \rho}$ | $\mathcal{A}_{1}^{\#1} +^{lpha}$ | $\mathcal{A}_{1}^{\#2} \dagger^{\alpha}$ | $f_{1}^{#1} + \alpha$ | $f_1^{\#2} + \alpha$ | | uadra == ∭ | | | | J | $\sigma_{2}^{\#1} + ^{\alpha\beta}$ | $\tau_2^{#1} + \alpha \beta$ | $\alpha \beta \chi$ |
| | $\sigma_{1}^{\#}$ | $\sigma_{1}^{\#,}$ | 1,4 | \mathcal{P}_{L} | \mathcal{J}_1 | $	au_1^{\sharp}$ | τ_1^{\pm} | SC |) | 1 1 1 1 1 1 1 1 1 1 | 1,1 | $	au_1^{\#}$ | $\tau_1^{\#}$ | | 16 | | # | F # # | ζ_{1} | $f_{1}^{\#}$ | \mathcal{L}_{1} | \mathcal{L}_{L} | f_1^{\sharp} | f_1^{\sharp} | | الم الم | | | | | $\sigma_{2}^{\#1}$ | $\tau_2^{\#1}$ | $\sigma_{2^{-}}^{\#1} +^{lphaeta\chi}$ |

Massive and massless spectra



(No massive particles)

Unitarity conditions