# Particle spectrograph

## Wave operator and propagator

```
xAct`PSALTer`Private`GraphicsCollage[
```

$$\left\{\begin{array}{c|cccc} & \omega_{0^+}^{\#1} & f_{0^+}^{\#1} & f_{0^+}^{\#2} & \omega_{0^-}^{\#1} \\ \hline \omega_{0^+}^{\#1}\dagger & \frac{\alpha_0}{2}+\beta_2+(\alpha_4+\alpha_6)\,k^2 & -\frac{i\,(\alpha_0+2\,\beta_2)\,k}{\sqrt{2}} & 0 & 0 \\ f_{0^+}^{\#1}\dagger & \frac{i\,(\alpha_0+2\,\beta_2)\,k}{\sqrt{2}} & 2\,\beta_2\,k^2 & 0 & 0 \\ f_{0^+}^{\#2}\dagger & 0 & 0 & 0 & 0 \\ \omega_{0^-}^{\#1}\dagger & 0 & 0 & 0 & \frac{\alpha_0}{2}+4\,\beta_3+(\alpha_2+\alpha_3)\,k^2 \end{array}\right\},$$

$$\text{Join}\left[\begin{array}{c|cccccc} & \omega_{1^+\,\alpha\beta}^{\#1} & \omega_{1^+\,\alpha\beta}^{\#2} & f_{1^+\,\alpha\beta}^{\#1} & \omega_{1^-\,\alpha}^{\#1} & \omega_{1^-\,\alpha}^{\#2} & f_{1^-\,\alpha}^{\#1} & f_{1^-\,\alpha}^{\#2} \\ \hline \omega_{1^+}^{\#1}\dagger^{\alpha\beta} & \frac{\alpha_0}{4}+\frac{1}{3}\,(\beta_1+8\,\beta_3)+(\alpha_2+\alpha_5)\,k^2 & \frac{3\,\alpha_0-4\,\beta_1+16\,\beta_3}{6\,\sqrt{2}} & \frac{i\,(3\,\alpha_0-4\,\beta_1+16\,\beta_3)\,k}{6\,\sqrt{2}} & 0 & 0 & 0 & 0 \\ \omega_{1^+}^{\#2}\dagger^{\alpha\beta} & \frac{3\,\alpha_0-4\,\beta_1+16\,\beta_3}{6\,\sqrt{2}} & \frac{2}{3}\,(\beta_1+2\,\beta_3) & \frac{2}{3}\,i\,(\beta_1+2\,\beta_3)\,k & 0 & 0 & 0 & 0 \\ f_{1^+}^{\#1}\dagger^{\alpha\beta} & -\frac{i\,(3\,\alpha_0-4\,\beta_1+16\,\beta_3)\,k}{6\,\sqrt{2}} & -\frac{2}{3}\,i\,(\beta_1+2\,\beta_3)\,k & \frac{2}{3}\,(\beta_1+2\,\beta_3)\,k^2 & 0 & 0 & 0 & 0 \\ \omega_{1^-}^{\#1}\dagger^{\alpha} & 0 & 0 & 0 & \frac{\alpha_0}{4}+\frac{1}{3}\,(\beta_1+2\,\beta_2)+(\alpha_4+\alpha_5)\,k^2 & -\frac{3\,\alpha_0-4\,\beta_1+4\,\beta_2}{6\,\sqrt{2}} & 0 & -\frac{1}{6}\,i\,(3\,\alpha_0-4\,\beta_1+4\,\beta_2)\,k \\ \omega_{1^-}^{\#2}\dagger^{\alpha} & 0 & 0 & 0 & -\frac{3\,\alpha_0-4\,\beta_1+4\,\beta_2}{6\,\sqrt{2}} & \frac{1}{3}\,(2\,\beta_1+\beta_2) & 0 & \frac{1}{3}\,i\,\sqrt{2}\,(2\,\beta_1+\beta_2)\,k \\ f_{1^-}^{\#1}\dagger^{\alpha} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ f_{1^-}^{\#2}\dagger^{\alpha} & 0 & 0 & 0 & \frac{1}{6}\,i\,(3\,\alpha_0-4\,\beta_1+4\,\beta_2)\,k & -\frac{1}{3}\,i\,\sqrt{2}\,(2\,\beta_1+\beta_2)\,k & 0 & \frac{2}{3}\,(2\,\beta_1+\beta_2)\,k^2 \end{array}\right],$$

$$\left\{\begin{array}{c|ccc} & \omega_{2^+\,\alpha\beta}^{\#1} & f_{2^+\,\alpha\beta}^{\#1} & \omega_{2^-\,\alpha\beta\chi}^{\#1} \\ \hline \omega_{2^+}^{\#1}\dagger^{\alpha\beta} & -\frac{\alpha_0}{4}+\beta_1+(\alpha_1+\alpha_4)\,k^2 & \frac{i\,(\alpha_0-4\,\beta_1)\,k}{2\,\sqrt{2}} & 0 \\ f_{2^+}^{\#1}\dagger^{\alpha\beta} & -\frac{i\,(\alpha_0-4\,\beta_1)\,k}{2\,\sqrt{2}} & 2\,\beta_1\,k^2 & 0 \\ \omega_{2^-}^{\#1}\dagger^{\alpha\beta\chi} & 0 & 0 & -\frac{\alpha_0}{4}+\beta_1+(\alpha_1+\alpha_2)\,k^2 \end{array}\right\}$$

```
{AspectRatio → Automatic}], Join[1863, {AspectRatio → Automatic}, {Null, Null}, {500}]]
```

## Massive and massless spectra

```
xAct`PSALTer`Private`GraphicsCollage[{Null, Null}, Join[1863, {AspectRatio → Automatic}, {Null, Null}, {500}]]
```

## Unitarity conditions