

## PSALTer results panel

## Wave operator and propagator

$1^+ \mathcal{I}_a \parallel + a \beta$	$\frac{a_-}{4}$	$-\frac{a_-}{2\sqrt{2}}$	0	0	0	0	0	0	0
$1^+ \mathcal{I}_a \perp + a \beta$	$-\frac{a_-}{2\sqrt{2}}$	0	0	0	0	0	0	0	0
$1^+ \mathcal{I}_5 \perp + a \beta$	0	0	$\frac{a_-}{4}$	0	0	0	0	0	0
$1^+ \mathcal{I}_5 \perp + \alpha$	0	0	0	0	0	0	0	0	0
$1^+ \mathcal{I}_a \parallel + \alpha$	0	0	0	$\frac{7a_-}{36}$	$\frac{a_-}{18\sqrt{2}}$	$-\frac{a_-}{3\sqrt{3}}$	$-\frac{1}{3}\sqrt{\frac{5}{3}}a_-$	$-\frac{1}{3}\sqrt{\frac{2}{3}}a_-$	$-\frac{2a_-}{3\sqrt{3}}$
$1^+ \mathcal{I}_a \perp + \alpha$	0	0	0	$\frac{a_-}{18\sqrt{2}}$	$\frac{2a_-}{9}$	$\frac{a_-}{3\sqrt{6}}$	$\frac{1}{3}\sqrt{\frac{5}{6}}a_-$	$\frac{a_-}{3\sqrt{3}}$	$\frac{1}{3}\sqrt{\frac{2}{3}}a_-$
$1^+ \mathcal{I}_5 \parallel + \alpha$	0	0	0	$-\frac{a_-}{3\sqrt{3}}$	$\frac{a_-}{3\sqrt{6}}$	$\frac{1}{3}(-a_- - c_- k_-^2)$	$\frac{1}{6}\sqrt{5}(a_- - 2c_- k_-^2)$	$\frac{a_- - 4c_- k_-^2}{6\sqrt{2}}$	$\frac{1}{6}(a_- - 4c_- k_-^2)$
$1^+ \mathcal{I}_5 \perp + \alpha$	0	0	0	$-\frac{1}{3}\sqrt{\frac{5}{3}}a_-$	$\frac{1}{3}\sqrt{\frac{5}{6}}a_-$	$\frac{1}{6}\sqrt{5}(a_- - 2c_- k_-^2)$	$\frac{1}{3}(a_- - 5c_- k_-^2)$	$\frac{1}{6}\sqrt{\frac{5}{2}}(a_- - 4c_- k_-^2)$	$\frac{1}{6}\sqrt{5}(a_- - 4c_- k_-^2)$
$1^+ \mathcal{I}_5 \parallel \perp + \alpha$	0	0	0	$\frac{1}{3}\sqrt{\frac{2}{3}}a_-$	$\frac{a_-}{3\sqrt{3}}$	$\frac{a_- - 4c_- k_-^2}{6\sqrt{2}}$	$\frac{1}{3}(a_- - 2c_- k_-^2)$	$\frac{a_- - 8c_- k_-^2}{6\sqrt{2}}$	$\frac{a_- - 4c_- k_-^2}{12} - \frac{1}{3}$
$1^+ \mathcal{I}_5 \parallel \perp + \alpha$	0	0	0	$-\frac{2a_-}{3\sqrt{3}}$	$\frac{1}{3}\sqrt{\frac{2}{3}}a_-$	$\frac{1}{6}(a_- - 4c_- k_-^2)$	$\frac{1}{6}\sqrt{5}(a_- - 4c_- k_-^2)$	$\frac{1}{6}\sqrt{5}(a_- - 4c_- k_-^2)$	$\frac{5a_- - 4c_- k_-^2}{12} - \frac{1}{3}$

Spin-parity form	Covariant form	Multiplicities
$0^+ \cdot \mathcal{W}_s^{\parallel} + 3 \cdot 0^+ \cdot \mathcal{W}_s^{\perp t} = 2 \cdot 0^+ \cdot \mathcal{W}_s^{\perp h}$	$\partial_\alpha \mathcal{W}^{\alpha\beta}_{\beta} = 2(\partial_\beta \mathcal{W}^{\alpha\beta}_{\alpha} + \partial_\beta \mathcal{W}^{\alpha\beta}_{\alpha})$	1
$0^+ \mathcal{T}^{\perp} = 0$	$\partial_\beta \partial_\alpha \mathcal{T}^{\alpha\beta} = 0$	1
$2(1 \cdot \mathcal{W}_s^{\parallel h\alpha} + 1 \cdot \mathcal{W}_s^{\perp h\alpha}) = 1 \cdot \mathcal{W}_s^{\parallel t\alpha} + 1 \cdot \mathcal{W}_s^{\perp t\alpha}$	$\partial_\beta \partial^\alpha \mathcal{W}^{\beta\chi}_{\chi} + 2(\partial_\chi \partial^\alpha \mathcal{W}^{\beta\alpha}_{\beta} + \partial_\chi \partial^\alpha \mathcal{W}^{\beta\alpha}_{\beta}) = 2\partial_\chi \partial^\alpha \mathcal{W}^{\beta\chi}_{\beta} + 2\partial_\chi \partial^\alpha \mathcal{W}^{\beta\chi}_{\beta} + \partial_\chi \partial^\alpha \mathcal{W}^{\alpha\beta}_{\beta}$	3
$1 \cdot \mathcal{T}^{\perp\alpha} = 0$	$\partial_\chi \partial_\beta \partial^\alpha \mathcal{T}^{\beta\chi} = \partial_\chi \partial_\beta \mathcal{T}^{\alpha\beta}$	3
Total expected gauge generators:		8

$$\begin{aligned}
S = & \left( \left( \left( \left( \mathcal{I}^{a\beta\chi} \mathcal{W}_{a\beta\chi} + \mathcal{I}^{a\beta} h_{a\beta} + \right. \right. \right. \\
& \frac{1}{72} a_{\alpha\chi} (16 \mathcal{I}^{\alpha\beta} \mathcal{I}^{\alpha\beta}_{\beta} - 16 \mathcal{I}^{\alpha\beta}_{\alpha} \mathcal{I}^{\alpha\beta}_{\beta\chi} + 32 \mathcal{I}^{\alpha\beta}_{\alpha} \mathcal{I}^{\alpha\beta}_{\beta\chi} + \\
& 4 \mathcal{I}^{\alpha\beta}_{\alpha} \mathcal{I}^{\alpha\beta}_{\beta\chi} - 18 \mathcal{I}^{\alpha\beta}_{\chi} \partial_{\beta} \mathcal{I}^{\alpha\beta}_{\alpha} + 18 \mathcal{I}^{\alpha\beta}_{\chi} \partial_{\beta} \mathcal{I}^{\alpha\beta}_{\alpha} - 36 h_{\alpha\chi} \\
& \partial_{\beta} \mathcal{I}^{\alpha\beta} a^{\beta\chi} - 36 \mathcal{I}^{a\beta\chi} (\mathcal{I}^{\beta\chi\alpha} + \partial_{\beta} \mathcal{I}^{\alpha\chi}_{\alpha}) - 18 \mathcal{I}^{\alpha\beta}_{\alpha} \partial_{\beta} \mathcal{I}^{\alpha\beta}_{\chi} + \\
& 18 \mathcal{I}^{\alpha\beta}_{\alpha} \partial_{\beta} \mathcal{I}^{\alpha\beta}_{\chi} + 18 h^{\alpha\beta} \partial_{\beta} \partial_{\alpha} \mathcal{I}^{\alpha\beta}_{\chi} - 9 \partial_{\beta} \mathcal{I}^{\alpha\beta}_{\chi} \partial^{\beta}_{\alpha} h^{\alpha}_{\alpha} + \\
& 36 \mathcal{I}^{\alpha\beta}_{\alpha} \partial_{\chi} h^{\alpha}_{\beta} + 18 \partial^{\beta}_{\alpha} \mathcal{I}^{\alpha}_{\beta} \partial_{\chi} \mathcal{I}^{\alpha\beta}_{\beta} - 36 h^{\alpha\beta} \partial_{\chi} \partial_{\beta} h^{\alpha}_{\alpha} + \\
& 18 h^{\alpha}_{\alpha} \partial_{\chi} \partial_{\beta} \mathcal{I}^{\alpha\beta}_{\chi} + 18 h^{\alpha\beta} \partial_{\chi} \partial^{\alpha} h_{a\beta} - 18 h^{\alpha}_{\alpha} \partial_{\chi} \partial^{\alpha} h^{\alpha\beta}_{\beta} + \\
& \left. \left. \left. 36 h^{\alpha}_{\beta\chi} \partial^{\alpha}_{\chi} \mathcal{I}^{\alpha\beta}_{\alpha} - 18 \partial_{\beta} \mathcal{I}^{\alpha\beta}_{\alpha\chi} \partial^{\alpha}_{\chi} h^{\alpha\beta}_{\beta} + 9 \partial_{\chi} \mathcal{I}^{\alpha\beta}_{\alpha\beta} \partial^{\alpha}_{\chi} h^{\alpha\beta}_{\beta} \right) \right) + \right. \\
& c_1 (\partial_{\alpha} \mathcal{I}^{\mu}_{\chi} \partial^{\alpha} \mathcal{I}^{\alpha\beta}_{\beta} - \partial_{\alpha} \mathcal{I}^{\mu}_{\alpha} \partial^{\alpha} \mathcal{I}^{\alpha\beta}_{\beta} + 2 \partial_{\alpha} \mathcal{I}^{\mu}_{\beta\chi\mu} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} - \\
& 2 \partial_{\alpha} \mathcal{I}^{\mu}_{\beta\mu\chi} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} - 2 \partial_{\alpha} \mathcal{I}^{\mu}_{\chi\mu\beta} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} - \partial_{\alpha} \mathcal{I}^{\mu}_{\mu\chi\beta} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} - \\
& 2 \partial_{\beta} \mathcal{I}^{\mu}_{\alpha\chi\mu} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} + \partial_{\beta} \mathcal{I}^{\mu}_{\alpha\mu\chi} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} - \partial_{\beta} \mathcal{I}^{\mu}_{\chi\mu\alpha} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} + \\
& \partial_{\chi} \mathcal{I}^{\mu}_{\alpha\beta\mu} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} - \partial_{\chi} \mathcal{I}^{\mu}_{\alpha\mu\beta} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} + 2 \partial_{\chi} \mathcal{I}^{\mu}_{\beta\mu\alpha} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} - \\
& \partial_{\mu} \mathcal{I}^{\mu}_{\alpha\beta\chi} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} + \partial_{\mu} \mathcal{I}^{\mu}_{\alpha\chi\beta} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} + \partial_{\mu} \mathcal{I}^{\mu}_{\beta\alpha\chi} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} - \\
& 2 \partial_{\mu} \mathcal{I}^{\mu}_{\beta\chi\alpha} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} + \partial_{\mu} \mathcal{I}^{\mu}_{\chi\beta\alpha} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} + \partial_{\chi} \partial_{\beta} \mathcal{I}^{\mu}_{\alpha\mu} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} - \\
& \left. \left. \left. \partial_{\mu} \partial_{\beta} \mathcal{I}^{\mu}_{\alpha\chi} \partial^{\alpha} \mathcal{I}^{a\beta\chi}_{\alpha} \right) [t, x, y, z] d^x d^y d^z d^t \right) \right)
\end{aligned}$$

$0^+ \mathcal{I}^-$	0	0	0	0	$0^+ \mathcal{W}_5$	0	0	0	$0^+ \mathcal{W}_5$	0	$0^+ \mathcal{W}_5$	$0^+ \mathcal{W}_5$
$0^+ \mathcal{I}^-$	0	$\frac{4}{a_0 k^2}$	0	0	$0^+ \mathcal{W}_5$	0	0	0	$0^+ \mathcal{W}_5$	0	$0^+ \mathcal{W}_5$	$0^+ \mathcal{W}_5$
$0^+ \mathcal{I}^-$	0	0	$-\frac{2}{a_0}$	$\frac{\sqrt{2}}{\sqrt{3}} \frac{1}{a_0}$	$0^+ \mathcal{W}_5$	$\frac{\sqrt{2}}{\sqrt{3}} \frac{1}{a_0}$	$\frac{11}{12 a_0}$	$-\frac{13}{12 a_0}$	$0^+ \mathcal{W}_5$	0	$0^+ \mathcal{W}_5$	$0^+ \mathcal{W}_5$
$0^+ \mathcal{I}^-$	0	0	$\sqrt{\frac{2}{3}} \frac{1}{a_0}$	$\frac{11}{12 a_0}$	$0^+ \mathcal{W}_5$	$\frac{11}{12 a_0}$	$-\frac{13}{12 a_0}$	$-\frac{1}{6 \sqrt{2} a_0}$	$0^+ \mathcal{W}_5$	0	$0^+ \mathcal{W}_5$	$0^+ \mathcal{W}_5$
$0^+ \mathcal{I}^-$	0	0	$\frac{2}{\sqrt{3} a_0}$	$-\frac{1}{6 \sqrt{2} a_0}$	$0^+ \mathcal{W}_5$	$-\frac{1}{6 \sqrt{2} a_0}$	$-\frac{13}{12 a_0}$	$-\frac{1}{6 \sqrt{2} a_0}$	$0^+ \mathcal{W}_5$	0	$0^+ \mathcal{W}_5$	$0^+ \mathcal{W}_5$
$0^+ \mathcal{I}^-$	0	0	$-\frac{2}{a_0 k^2}$	$\frac{1}{6 a_0}$	$0^+ \mathcal{W}_5$	$\frac{1}{6 a_0}$	$-\frac{1}{6 a_0}$	$-\frac{1}{6 a_0}$	$0^+ \mathcal{W}_5$	0	$0^+ \mathcal{W}_5$	$0^+ \mathcal{W}_5$
$0^+ \mathcal{I}^-$	0	0	0	0	$0^+ \mathcal{W}_5$	0	0	$-\frac{2}{a_0 + 12 c_0 k^2}$	$0^+ \mathcal{W}_5$	0	$0^+ \mathcal{W}_5$	$0^+ \mathcal{W}_5$

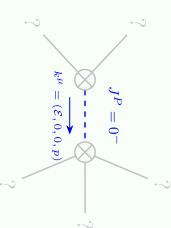
[illegible]

$0^+ \mathcal{H}^+ \parallel 0^+ \mathcal{A}_\parallel$	0	0	0	0	$0^+ \mathcal{H}_5^+ \parallel 0^+ \mathcal{A}_5^+ \mathcal{H}$	0	0	0	$0^+ \mathcal{A}_\parallel$
$0^+ \mathcal{H}^+ \parallel 0^+ \mathcal{A}_\parallel$	$\frac{a, k^2}{0}$	0	0	0	$0^+ \mathcal{H}_5^+ \parallel 0^+ \mathcal{A}_5^+ \mathcal{H}$	0	0	0	0
$0^+ \mathcal{A}_\parallel \parallel 0^+ \mathcal{A}_\parallel$	0	$\frac{a, 0}{6}$	$\frac{a, 0}{\sqrt{6}}$	$\frac{a, 0}{\sqrt{6}}$	$0^+ \mathcal{A}_5^+ \parallel 0^+ \mathcal{A}_5^+ \mathcal{H}$	$\frac{a, 0}{\sqrt{3}}$	$\frac{a, 0}{2}$	0	0
$0^+ \mathcal{A}_5^+ \parallel 0^+ \mathcal{A}_5^+ \mathcal{H}$	0	0	0	0	$0^+ \mathcal{A}_5^+ \parallel 0^+ \mathcal{A}_5^+ \mathcal{H}$	$\frac{a, 0}{2\sqrt{2}}$	$\frac{a, 0}{2}$	0	0
$0^+ \mathcal{A}_5^+ \parallel 0^+ \mathcal{A}_5^+ \mathcal{H}$	0	0	$\frac{a, 0}{\sqrt{6}}$	$\frac{a, 0}{2}$	$0^+ \mathcal{A}_5^+ \parallel 0^+ \mathcal{A}_5^+ \mathcal{H}$	0	$\frac{a, 0}{2\sqrt{2}}$	0	0
$0^+ \mathcal{A}_5^+ \parallel 0^+ \mathcal{A}_5^+ \mathcal{H}$	0	0	$\frac{a, 0}{\sqrt{3}}$	$\frac{a, 0}{2\sqrt{2}}$	$0^+ \mathcal{A}_5^+ \parallel 0^+ \mathcal{A}_5^+ \mathcal{H}$	$\frac{a, 0}{2}$	$\frac{a, 0}{2}$	0	0
$0^+ \mathcal{A}_\parallel \parallel 0^+ \mathcal{A}_\parallel$	0	0	0	0	$0^+ \mathcal{A}_\parallel \parallel 0^+ \mathcal{A}_\parallel$	$-\frac{a, 0}{2}$	$-\frac{a, 0}{2}$	$-\frac{a, 0}{2}$	$-\frac{a, 0}{2}$

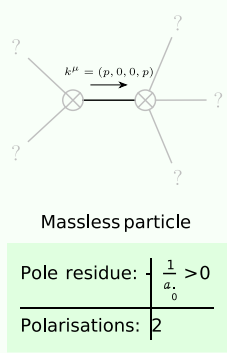
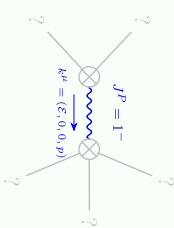
	$2^+h_{\alpha\beta}^{\parallel}$	$2^+\mathcal{A}_{\alpha\beta}^{\parallel}$	$2^+\mathcal{S}_{\alpha\beta}^{\parallel}$	$2^+\mathcal{S}_{\alpha\beta}^{\perp}$	$2^+\mathcal{A}_{\alpha\beta\chi}^{\parallel}$	$2^+\mathcal{S}_{\alpha\beta\chi}^{\parallel}$
$2^+h^{\parallel} \dagger^{\alpha\beta}$	$\frac{a \cdot k^2}{-\frac{0}{8}}$	0	0	0	0	0
$2^+\mathcal{A}_{\alpha}^{\parallel} \dagger^{\alpha\beta}$	0	$\frac{a \cdot}{4}$	0	0	0	0
$2^+\mathcal{S}_{\alpha}^{\parallel} \dagger^{\alpha\beta}$	0	0	$-\frac{a \cdot}{2}$	0	0	0
$2^+\mathcal{S}_{\alpha}^{\perp} \dagger^{\alpha\beta}$	0	0	0	$\frac{a \cdot}{4}$	0	0
$2^+\mathcal{A}_{\alpha}^{\parallel} \dagger^{\alpha\beta\chi}$	0	0	0	0	$\frac{a \cdot}{4}$	0
$2^+\mathcal{S}_{\alpha}^{\parallel} \dagger^{\alpha\beta\chi}$	0	0	0	0	0	$\frac{a \cdot}{4}$

## Massive and massless spectra

Poleresidue:	$\frac{1}{6c_1} > 0$
Square mass:	$-\frac{a_1}{12c_1} > 0$
Spin:	0
Parity:	Odd



Pole residue:	$\frac{25}{4c_1} > 0$
Square mass:	$-\frac{3a_+}{4c_1} > 0$
Spin:	1
Parity:	Odd



## Unitarity conditions

$$a_0 < 0 \ \&\& \ c_1 > 0$$