Four-loop Konishi for β-deformed SYM

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Review on AdS/CFT integrability

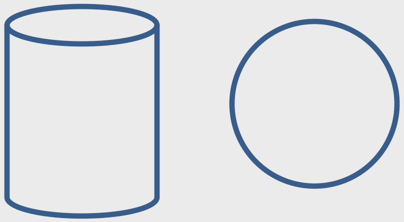
AdS/CFT duality

- **[Maldacena, Gubser-Klebanov-Polyakov, Witten (1997)]**
- Type IIB superstrings on $AdS_5 \times S^5$ are dual to 4d $\mathcal{N}$=4 SU(N) SYM
- Energies of string states = Conformal dimensions of SYM operators
- Parameter relations:

$$g_s = \frac{4\pi\lambda}{N} \qquad \text{and} \qquad \frac{R^2}{\alpha'} = \sqrt{\lambda}$$

with 't Hooft coupling

$$\lambda = N g_{\mathrm{YM}}^2$$



Planar Limit of SYM

- Free superstring theory corresponds to a planar limit of SYM

$$g_s \to 0 \qquad \equiv \qquad N \to \infty$$

- Energy of string = Conformal dimension Δ

Strong-weak coupling duality

- Quantitative check is difficult since it is a strong-weak duality
  - Classical string for $\alpha' << 1 \quad \rightarrow \quad \lambda >> 1$
  - Perturbative SYM for $\lambda << 1 \quad \rightarrow \quad \alpha' >> 1$
- Still very difficult to solve quantitatively for a general value of λ
- Need Nonperturbative method
- Breakthrough : Integrability has been discovered

Full sector Conjecture

Beisert–Staudacher

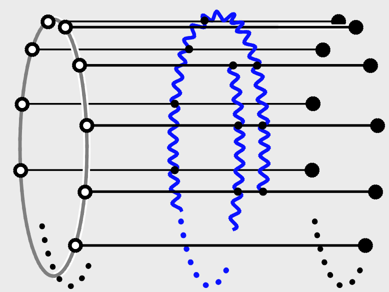
$$\mathcal{O}(x) = \mathrm{Tr}\Big[\ldots ZX \ldots ZY \ldots ZF_{\mu\nu} \ldots Z\chi^{\alpha} \ldots ZD_{\mu}Y \ldots\Big]$$

$$
\begin{aligned}
1 &= \prod_{k=1}^{M_2} \frac{u_{1j}-u_{2k}+\frac{i}{2}}{u_{1j}-u_{2k}-\frac{i}{2}} \prod_{k=1}^{M_4} \frac{1-g^2/2x_{1j}x_{4k}^{+}}{1-g^2/2x_{1j}x_{4k}^{-}} \\
1 &= \prod_{k=1}^{M_2} \frac{u_{2j}-u_{2k}-i}{u_{2j}-u_{2k}+i} \prod_{k=1}^{M_3} \frac{u_{2j}-u_{3k}+\frac{i}{2}}{u_{2j}-u_{3k}-\frac{i}{2}} \prod_{k=1}^{M_1} \frac{u_{2j}-u_{1k}+\frac{i}{2}}{u_{2j}-u_{1k}-\frac{i}{2}} \\
1 &= \prod_{k=1}^{M_2} \frac{u_{3j}-u_{2k}+\frac{i}{2}}{u_{3j}-u_{2k}-\frac{i}{2}} \prod_{k=1}^{M_4} \frac{x_{3j}-x_{4k}^{+}}{x_{3j}-x_{4k}^{-}} \\
\left(\frac{x_{4j}^{+}}{x_{4j}^{-}}\right)^{L} &= \prod_{k=1}^{M_4} \sigma^2(x_{4j},x_{4k}) \frac{x_{4j}^{+}-x_{4k}^{-}}{x_{4j}^{-}-x_{4k}^{+}} \frac{1-g^2/2x_{4j}^{+}x_{4k}^{-}}{1-g^2/2x_{4j}^{-}x_{4k}^{+}} \\
&\times \prod_{k=1}^{M_1} \frac{1-g^2/2x_{4j}^{-}x_{1k}}{1-g^2/2x_{4j}^{+}x_{1k}} \prod_{k=1}^{M_3} \frac{x_{4j}^{-}-x_{3k}}{x_{4j}^{+}-x_{3k}} \prod_{k=1}^{M_5} \frac{x_{4j}^{-}-x_{5k}}{x_{4j}^{+}-x_{5k}} \prod_{k=1}^{M_7} \frac{1-g^2/2x_{4j}^{-}x_{7k}}{1-g^2/2x_{4j}^{+}x_{7k}} \\
1 &= \prod_{k=1}^{M_6} \frac{u_{5j}-u_{6k}+\frac{i}{2}}{u_{5j}-u_{6k}-\frac{i}{2}} \prod_{k=1}^{M_4} \frac{x_{5j}-x_{4k}^{+}}{x_{5j}-x_{4k}^{-}} \\
1 &= \prod_{k=1}^{M_6} \frac{u_{6j}-u_{6k}-i}{u_{6j}-u_{6k}+i} \prod_{k=1}^{M_5} \frac{u_{6j}-u_{5k}+\frac{i}{2}}{u_{6j}-u_{5k}-\frac{i}{2}} \prod_{k=1}^{M_7} \frac{u_{6j}-u_{7k}+\frac{i}{2}}{u_{6j}-u_{7k}-\frac{i}{2}} \\
1 &= \prod_{k=1}^{M_6} \frac{u_{7j}-u_{6k}+\frac{i}{2}}{u_{7j}-u_{6k}-\frac{i}{2}} \prod_{k=1}^{M_4} \frac{1-g^2/2x_{7j}x_{4k}^{+}}{1-g^2/2x_{7j}x_{4k}^{-}}
\end{aligned}
$$

Wrapping problem

- High-order Feynman diagrams connect operators farther away
- When the length of a composite operator is shorter than the order of the perturbative expansion: unphysical(“wrapping”) interactions appear

→ nonperturbative results valid only when the length is infinite



Symmetries and Spectrum

- Symmetries: SU(2|2) x SU(2|2) [Beisert]

- Each "SU(2|2)" $\left(\begin{array}{c|c} \mathfrak{R}^a{}_b & \mathfrak{Q}^\alpha{}_b \\ \hline \mathfrak{S}^a{}_\beta & \mathfrak{L}^\alpha{}_\beta \end{array}\right)$

- Spectrum: a tensor product of two Fundamental Rep.

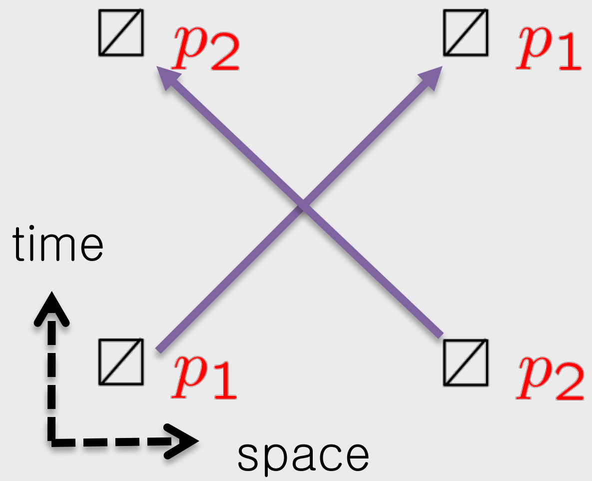
$$\boxslash = (\Box, \mathbf{1}) \oplus (\mathbf{1}, \Box) = (\phi^1, \phi^2 | \psi^1, \psi^2)$$

$$(\boxslash ; \boxslash) = \Phi_{a\dot{a}} \oplus \chi^a_{\dot{\alpha}} \oplus \chi^{\dot{a}}_{\alpha} \oplus D_{\alpha\dot{\alpha}}$$

- Focus on one SU(2|2)

S-matrix from Symmetries

- Two particle S-matrix

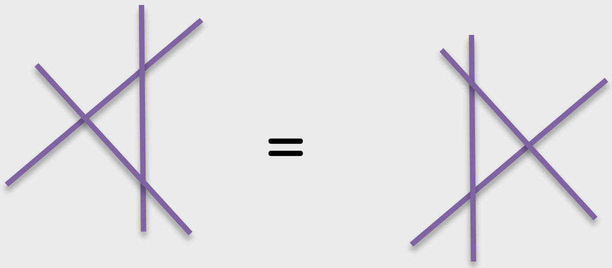


- Commutativity with SU(2|2) [Beisert]

$$\left[S(p_1,p_2), \begin{pmatrix} \mathfrak{R}^a{}_b & \mathfrak{Q}^\alpha{}_b \\ \mathfrak{S}^a{}_\beta & \mathfrak{L}^\alpha{}_\beta \end{pmatrix} \right] = 0$$

- Yang-Baxter equation [Arutyunov-Frolov-Zamaklar]

- Full sector BAE can be derived

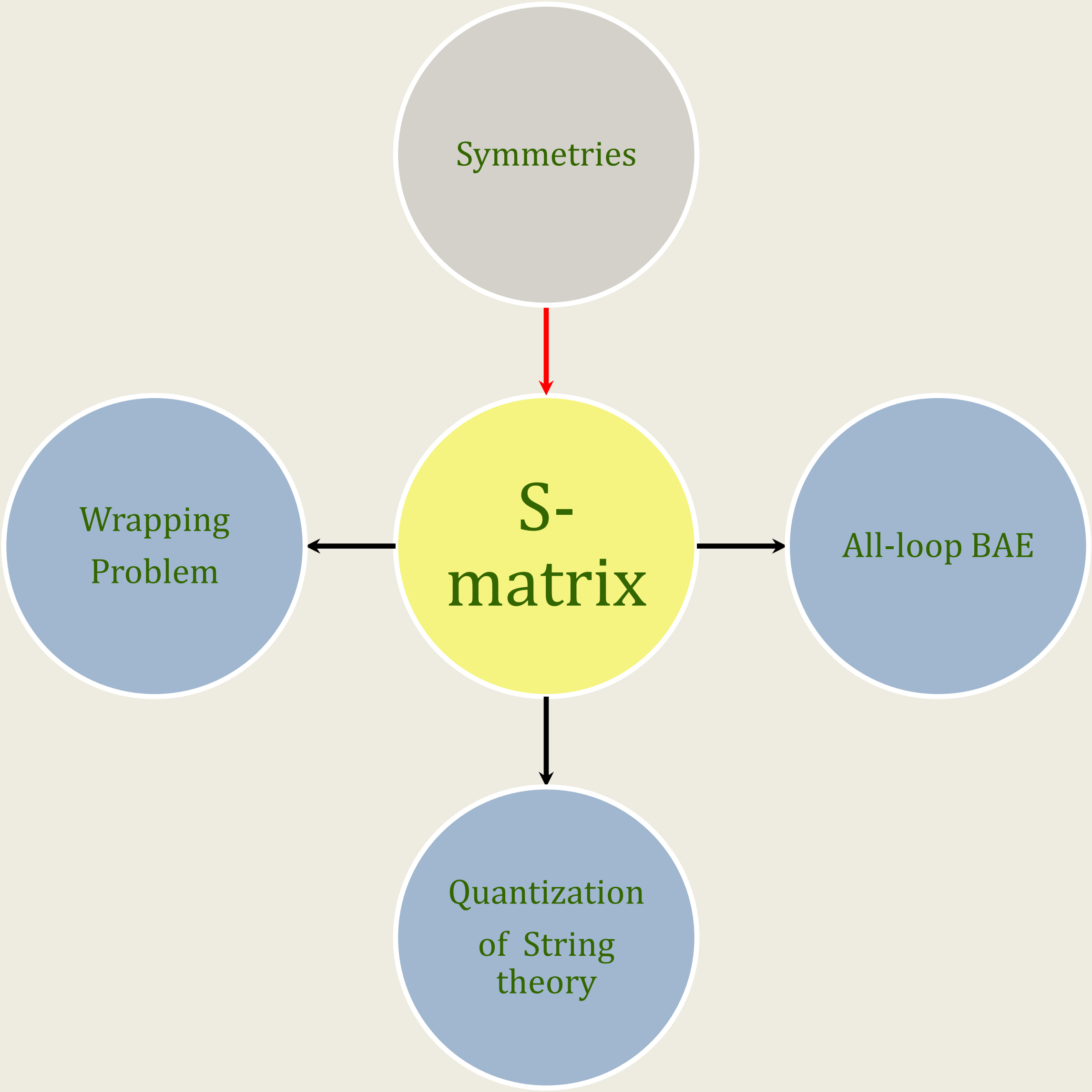


SU(2|2) S-matrix

$$
\left(\begin{array}{cccc|cccc|cccc|cccc}
a_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & a_{10} & 0 & 0 & a_6 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & a_{10} & 0 & 0 & 0 & 0 & 0 & a_6 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & -a_2 & 0 & 0 & -a_7 & 0 & 0 & a_7 & 0 & 0 & a_1+a_2 & 0 & 0 & 0 \\
\hline
0 & a_5 & 0 & 0 & a_9 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & a_3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & -a_8 & 0 & 0 & -a_4 & 0 & 0 & a_3+a_4 & 0 & 0 & a_8 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & a_9 & 0 & 0 & 0 & 0 & 0 & a_5 & 0 & 0 \\
\hline
0 & 0 & a_5 & 0 & 0 & 0 & 0 & 0 & a_9 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & a_8 & 0 & 0 & a_3+a_4 & 0 & 0 & -a_4 & 0 & 0 & -a_8 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a_3 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a_9 & 0 & 0 & a_5 & 0 \\
\hline
0 & 0 & 0 & a_1+a_2 & 0 & 0 & a_7 & 0 & 0 & -a_7 & 0 & 0 & -a_2 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & a_6 & 0 & 0 & 0 & 0 & 0 & a_{10} & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a_6 & 0 & 0 & a_{10} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & a_1
\end{array}\right)
$$

$$
a_1 = \frac{x_2^- - x_1^+}{x_2^+ - x_1^-},\ a_2 = \frac{(x_1^- - x_1^+)(x_2^- - x_2^+)(x_2^- + x_1^+)}{(x_1^- - x_2^+)(x_1^- x_2^- - x_1^+ x_2^+)}, \ldots
$$

S-matrix program



β-deformed SYM

- Superpotential:

$$W = \mathrm{tr}(e^{i\pi\beta}\phi\psi Z - e^{-i\pi\beta}\phi Z\psi)$$

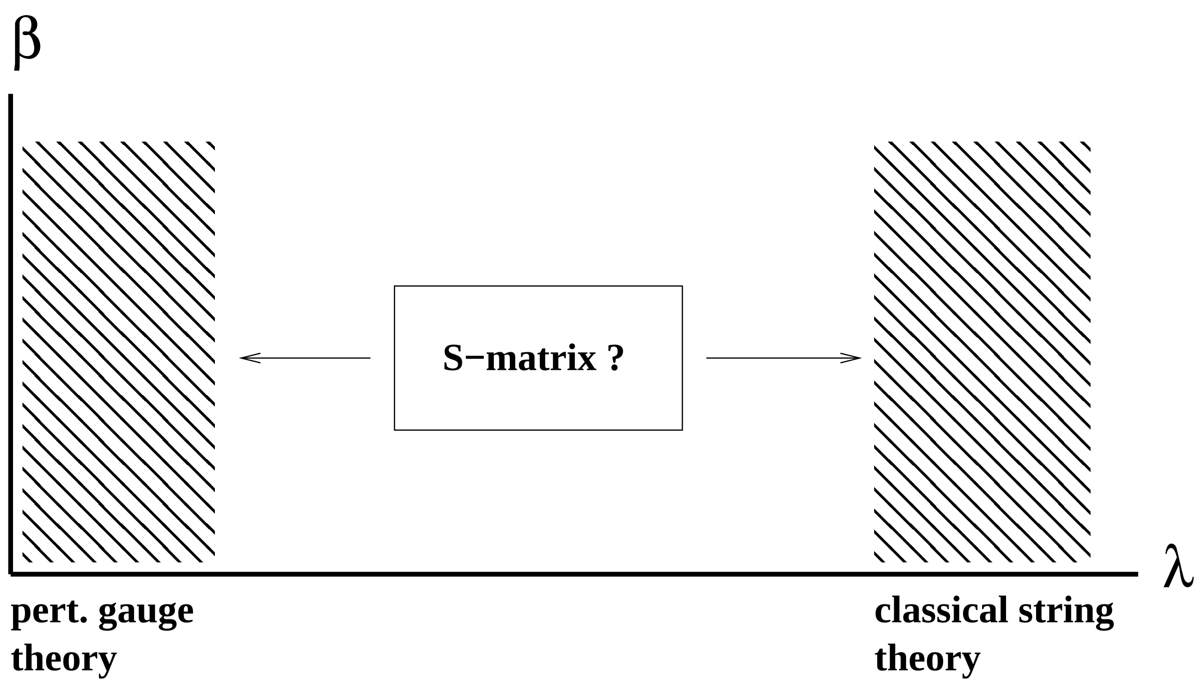
New AdS/CFT correspondence

- (Maybe) dual to type IIB string theory on TsT transformed $AdS_5 \times S^5$ (Lunin-Maldacena)

- Classical string analysis show that it still has giant magnon solution [Bykov-Frolov] and dyonic magnon solution [Bozhilov-CA]

- (Maybe) all-loop integrable: Bethe-ansatz was conjectured [Beisert-Roiban]

- What is the S-matrix, then?


β
S−matrix ?
λ
pert. gauge
theory
classical string
theory

Weak coupling of the β-deformed SYM

- Konishi operator

$$\mathrm{Tr}(\phi Z \phi Z), \quad \mathrm{Tr}(\phi\phi Z Z)$$

Fiamberti-Santambrogio-Sieg-Zanon perturbative results

$$\gamma^{(+)} = 4 + g^2\gamma_1 + g^4\gamma_2 + g^6\gamma_3 + g^8\gamma_4 + \dots$$

$$\gamma_1 = 6(1+\Delta)$$

$$\gamma_2 = -\frac{3}{\Delta} - 15 - 21\Delta - 9\Delta^2$$

$$\gamma_3 = -\frac{3}{4\Delta^3} + \frac{153}{4\Delta} + 114 + \frac{495}{4}\Delta + 54\Delta^2 + \frac{27}{4}\Delta^3$$

$$\begin{aligned}\gamma_4 &= -\frac{3}{8\Delta^5} + \frac{33}{2\Delta^3} - \frac{1701}{4\Delta} - 1230 \\ &- \frac{2427}{2}\Delta - 180\Delta^2 + 162\Delta^4 + \frac{2997}{8}\Delta^3 \\ &+ \left(-\frac{9}{\Delta} + 297 + 702\Delta + 234\Delta^2 - 405\Delta^3 - 243\Delta^4\right)\zeta(3) \\ &- 360\,(1+\Delta)^2\,\zeta(5)\end{aligned}$$

$$\gamma^{(-)} = \gamma^{(+)}(\Delta \to -\Delta), \qquad \Delta \equiv \frac{\sqrt{5 + 4\cos(4\pi\beta)}}{3}$$

Beisert-Roiban Bethe ansatz equation

$$e^{ip_1 L} = e^{2\pi i \beta L} \cdot e^{2i\theta(p_1,p_2)} \cdot \frac{u_1 - u_2 + i}{u_1 - u_2 - i}$$

$$e^{ip_2 L} = e^{2\pi i \beta L} \cdot e^{-2i\theta(p_1,p_2)} \cdot \frac{u_2 - u_1 + i}{u_2 - u_1 - i}$$

$$u_i = \frac{1}{2} \cot \frac{p_i}{2} \sqrt{1 + 16 g^2 \sin^2 \frac{p_i}{2}}$$

$$E(p_i) = \sqrt{1 + 16 g^2 \sin^2 \frac{p_i}{2}}$$

BAE cont'd

$$p_1 + p_2 = 4\pi\beta$$

$$p_1 = \tilde{p} + 2\pi\beta, \qquad p_2 = -\tilde{p} + 2\pi\beta$$

$$e^{4i\tilde{p}} = e^{2i\theta(\tilde{p}+2\pi\beta,-\tilde{p}+2\pi\beta)} \left(\frac{u(\tilde{p}+2\pi\beta) - u(-\tilde{p}+2\pi\beta) + i}{u(\tilde{p}+2\pi\beta) - u(-\tilde{p}+2\pi\beta) - i} \right)$$

$$E_{\text{total}}(\beta) = E(\tilde{p}+2\pi\beta) + E(-\tilde{p}+2\pi\beta)$$

perturbative solutions of BAE

$$\tilde{p} = \tilde{p}_0 + g^2\tilde{p}_1 + g^4\tilde{p}_2 + g^6\tilde{p}_3 + \ldots$$

$$E_{\mathrm{total}}(\beta) = 2+g^2E_1(\beta)+g^4E_2(\beta)+g^6E_3(\beta)+g^8E_4(\beta)+\ldots$$

zeroth order

$$e^{4i\tilde{p}_0} = \frac{\cot(\frac{\tilde{p}_0}{2} - \pi\beta) + \cot(\frac{\tilde{p}_0}{2} + \pi\beta) + 2i}{\cot(\frac{\tilde{p}_0}{2} - \pi\beta) + \cot(\frac{\tilde{p}_0}{2} + \pi\beta) - 2i}$$

$$\cos\tilde{p}_0 = \frac{1 - 3\Delta}{4\cos(2\pi\beta)}$$

$$E_1(\beta) = 8\sin^2\left(\frac{\tilde{p}_0}{2} - \pi\beta\right) + 8\sin^2\left(\frac{\tilde{p}_0}{2} + \pi\beta\right) = 6(1 + \Delta)$$

higher order solutions

$$E_2 = -\frac{3}{\Delta} - 15 - 21\Delta - 9\Delta^2$$

$$E_3 = -\frac{3}{4\Delta^3} + \frac{153}{4\Delta} + 114 + \frac{495}{4}\Delta + 54\Delta^2 + \frac{27}{4}\Delta^3$$

$$\begin{aligned} E_4 \;&=\; \frac{3\,(1+\Delta)^4}{8\Delta^5(1+3\Delta)^2}(-1 - 2\Delta + 49\Delta^2 + 84\Delta^3 \\ &-\; 1359\Delta^4 - 5562\Delta^5 - 2673\Delta^6 + 1944\Delta^7) \\ &+\; \left(-\frac{9}{\Delta} + 27 + 54\Delta - 90\Delta^2 - 189\Delta^3 - 81\Delta^4\right)\zeta(3) \end{aligned}$$

wrapping order correction

$$\Delta E_{\text{wrapping}} = g^8 \Big[\; - \; 54(1+\Delta)^3(-5+3\Delta)\zeta(3) - 360(1+\Delta)^2\zeta(5) + \frac{81\,(1-3\,\Delta)^2\,(1+\Delta)^4}{(1+3\,\Delta)^2} \Big]$$

Bajnok-Janik Lüscher formula for $su(2)$ Konishi operator

$$\Delta E = -\sum_{\ell=1}^{\infty}\int_{-\infty}^{\infty}\frac{dq}{2\pi}\left(\frac{z^-}{z^+}\right)^L$$
$$\times \sum_{j,j'}(-1)^{F_{(jj')}}\left[\mathcal{S}^{(\ell\mathsf{f})}(z^\pm,x_1^\pm)\mathcal{S}^{(\ell\mathsf{f})}(z^\pm,x_2^\pm)\right]_{(jj')(11)}^{(jj')(11)}$$

$$x_i^\pm = \frac{1}{4g}\left(\cot\frac{p_i}{2}\pm i\right)\left(1+\sqrt{1+16g^2\sin^2\frac{p_i}{2}}\right)$$

$$z^\pm = \frac{q+i\ell}{4g}\left(\sqrt{1+\frac{16g^2}{\ell^2+q^2}}\pm 1\right)$$

S-matrix

$$\mathcal{S}^{(\ell\mathsf{f})}(z^{\pm}, x_i^{\pm}) = S^{(\ell\mathsf{f})}_{\text{scalar}}(q, u_i)\left[\mathcal{S}^{(\ell\mathsf{f})}_{\text{matrix}}(q, u_i) \otimes \mathcal{S}^{(\ell\mathsf{f})}_{\text{matrix}}(q, u_i)\right]$$

$$\begin{aligned} & \sum_{j,j'}(-1)^{F_{(jj')}}\left[\mathcal{S}^{(\ell\mathsf{f})}(q, u_1)\mathcal{S}^{(\ell\mathsf{f})}(q, u_2)\right]^{(jj')(11)}_{(jj')(11)} \\ = \; & S^{(\ell\mathsf{f})}_{\text{scalar}}(q, u_1) S^{(\ell\mathsf{f})}_{\text{scalar}}(q, u_2) \\ \times \; & \left(\sum_{j}(-1)^{F_j}\left[\mathcal{S}^{(\ell\mathsf{f})}_{\text{matrix}}(q, u_1)\mathcal{S}^{(\ell\mathsf{f})}_{\text{matrix}}(q, u_2)\right]^{j1}_{j1}\right)^2 \end{aligned}$$

S-matrix cont'd

- ℓ: antisymmetric rep. (ℓ bound-states in the mirror space)

- Related to S-matrix in physical space

$$\mathcal{S}^{(\ell\mathsf{f})}(z^{\pm}, x^{\pm}) = S^{(\mathsf{f}\ell)}(x^{\pm}, z^{\pm})[1 \leftrightarrow 3, 2 \leftrightarrow 4]$$

deformed S-matrix elements

- Bosonic bound-states:

$$\mathcal{S}^{(\ell\mathsf{f})}{}^{j1}_{j1} = \mathcal{S}_0^{(\ell\mathsf{f})}{}^{j1}_{j1}, \quad j = 1, \ldots, 2\ell$$

- Fermionic bound-states:

$$\begin{aligned} \mathcal{S}^{(\ell\mathsf{f})}{}^{j1}_{j1} &= e^{i\pi\beta}\mathcal{S}_0^{(\ell\mathsf{f})}{}^{j1}_{j1}, \quad j = 2\ell+1, \ldots, 3\ell \\ &= e^{-i\pi\beta}\mathcal{S}_0^{(\ell\mathsf{f})}{}^{j1}_{j1}, \quad j = 3\ell+1, \ldots, 4\ell \end{aligned}$$

Lüscher corrections

- Kinematic factor:

$$\left(\frac{z^-}{z^+}\right)^4 = \frac{256 g^8}{(q^2+\ell^2)^4} + \ldots$$

- S-matrix part: only leading order is enough

- Residue calculation due to a pole at $q = i\ell$

$$\Delta E_{\mathrm{Luscher}} = \sum_{\ell=1}^{\infty} \left[\frac{f_1}{\ell^5} + \frac{f_2}{\ell^3} + f_3(\ell) \right]$$

$$\begin{aligned}
f_1 &= -\frac{2560(1+2u_1^2+2u_2^2)^2}{(4u_1^2+1)^2(4u_2^2+1)^2} \\
f_2 &= \frac{\mathrm{num}}{(4u_1^2+1)^4(4u_2^2+1)^4} \\
\mathrm{num} &= 2048\left(-1+5u_1^2+48u_1^4+96u_1^6-2u_1u_2-16u_1^3u_2-32u_1^5u_2+5u_2^2+224u_1^2u_2^2\right. \\
&+ 1024u_1^4u_2^2+1536u_1^6u_2^2+768u_1^8u_2^2-16u_1u_2^3-128u_1^3u_2^3+64u_1^8 \\
&- 256u_1^5u_2^3+48u_2^4+1024u_1^2u_2^4+3200u_1^4u_2^4+2560u_1^6u_2^4-32u_1u_2^5 \\
&- \left.256u_1^3u_2^5-512u_1^5u_2^5+96u_2^6+1536u_1^2u_2^6+2560u_1^4u_2^6+64u_2^8+768u_1^2u_2^8\right)
\end{aligned}$$

$$f_3 = 1775 \text{ terms}$$

with leading-order Bethe roots

$$u_{1,2} = \frac{(1-3\,\Delta)^2}{2\,\sqrt{-1+9\,\Delta^2}\,\left(3\,\sqrt{1-\Delta^2} \pm 2\,\sqrt{\frac{3+3\Delta}{1+3\,\Delta}}\right)}$$

$$-(512\, i\, (-5\, i + 156\, i\, Q^2 - 2120\, i\, Q^4 + 16512\, i\, Q^6 - 77952\, i\, Q^8 + 216064\, i\, Q^{10} - 317440\, i\, Q^{12} + 196608\, i\, Q^{14} - 32768\, i\, Q^{16} - 160\, Q\, u1 + 4352\, Q^3\, u1 -$$
$$50432\, Q^5\, u1 + 321408\, Q^7\, u1 - 1178624\, Q^9\, u1 + 2396160\, Q^{11}\, u1 - 2490368\, Q^{13}\, u1 + 1277952\, Q^{15}\, u1 - 262144\, Q^{17}\, u1 - 140\, i\, u1^2 +$$
$$6036\, i\, Q^2\, u1^2 - 97280\, i\, Q^4\, u1^2 + 813504\, i\, Q^6\, u1^2 - 3904512\, i\, Q^8\, u1^2 + 10729472\, i\, Q^{10}\, u1^2 - 16007168\, i\, Q^{12}\, u1^2 + 12238848\, i\, Q^{14}\, u1^2 -$$
$$4456448\, i\, Q^{16}\, u1^2 + 786432\, i\, Q^{18}\, u1^2 - 3840\, Q\, u1^3 + 109184\, Q^3\, u1^3 - 1286656\, Q^5\, u1^3 + 8186112\, Q^7\, u1^3 - 29806080\, Q^9\, u1^3 + 60510208\, Q^{11}\, u1^3 -$$
$$65617920\, Q^{13}\, u1^3 + 38076416\, Q^{15}\, u1^3 - 11403264\, Q^{17}\, u1^3 + 1048576\, Q^{19}\, u1^3 - 1700\, i\, u1^4 + 85248\, i\, Q^2\, u1^4 - 1436928\, i\, Q^4\, u1^4 +$$
$$12094720\, i\, Q^6\, u1^4 - 57501696\, i\, Q^8\, u1^4 + 155193344\, i\, Q^{10}\, u1^4 - 229015552\, i\, Q^{12}\, u1^4 + 182779904\, i\, Q^{14}\, u1^4 - 75235328\, i\, Q^{16}\, u1^4 +$$
$$13631488\, i\, Q^{18}\, u1^4 - 39040\, Q\, u1^5 + 1111040\, Q^3\, u1^5 - 12920832\, Q^5\, u1^5 + 80328704\, Q^7\, u1^5 - 284033024\, Q^9\, u1^5 + 555851776\, Q^{11}\, u1^5 -$$
$$584318976\, Q^{13}\, u1^5 + 322699264\, Q^{15}\, u1^5 - 83886080\, Q^{17}\, u1^5 + 2097152\, Q^{19}\, u1^5 - 11680\, i\, u1^6 + 614912\, i\, Q^2\, u1^6 - 10256384\, i\, Q^4\, u1^6 +$$
$$83934720\, i\, Q^6\, u1^6 - 384442368\, i\, Q^8\, u1^6 + 984932352\, i\, Q^{10}\, u1^6 - 1352138752\, i\, Q^{12}\, u1^6 + 976879616\, i\, Q^{14}\, u1^6 - 331350016\, i\, Q^{16}\, u1^6 +$$
$$27262976\, i\, Q^{18}\, u1^6 - 217600\, Q\, u1^7 + 5965824\, Q^3\, u1^7 - 66535424\, Q^5\, u1^7 + 393981952\, Q^7\, u1^7 - 1310375936\, Q^9\, u1^7 + 2346057728\, Q^{11}\, u1^7 -$$
$$2179596288\, Q^{13}\, u1^7 + 960495616\, Q^{15}\, u1^7 - 148897792\, Q^{17}\, u1^7 - 49600\, i\, u1^8 + 2532608\, i\, Q^2\, u1^8 - 40226816\, i\, Q^4\, u1^8 + 310726656\, i\, Q^6\, u1^8 -$$
$$1330298880\, i\, Q^8\, u1^8 + 3100934144\, i\, Q^{10}\, u1^8 - 3700162560\, i\, Q^{12}\, u1^8 + 2134900736\, i\, Q^{14}\, u1^8 - 486539264\, i\, Q^{16}\, u1^8 + 8388608\, i\, Q^{18}\, u1^8 -$$
$$716800\, Q\, u1^9 + 18268160\, Q^3\, u1^9 - 189792256\, Q^5\, u1^9 + 1041408000\, Q^7\, u1^9 - 3144482816\, Q^9\, u1^9 + 4859232256\, Q^{11}\, u1^9 - 3649044480\, Q^{13}\, u1^9 +$$
$$1115684864\, Q^{15}\, u1^9 - 67108864\, Q^{17}\, u1^9 - 133120\, i\, u1^{10} + 6116352\, i\, Q^2\, u1^{10} - 89391104\, i\, Q^4\, u1^{10} + 633085952\, i\, Q^6\, u1^{10} -$$
$$2452226048\, i\, Q^8\, u1^{10} + 4944297984\, i\, Q^{10}\, u1^{10} - 4777312256\, i\, Q^{12}\, u1^{10} + 1935671296\, i\, Q^{14}\, u1^{10} - 234881024\, i\, Q^{16}\, u1^{10} - 1392640\, Q\, u1^{11} +$$
$$31883264\, Q^3\, u1^{11} - 298713088\, Q^5\, u1^{11} + 1471610880\, Q^7\, u1^{11} - 3861774336\, Q^9\, u1^{11} + 4783603712\, Q^{11}\, u1^{11} - 2573205504\, Q^{13}\, u1^{11} +$$
$$469762048\, Q^{15}\, u1^{11} - 220160\, i\, u1^{12} + 8364032\, i\, Q^2\, u1^{12} - 108068864\, i\, Q^4\, u1^{12} + 678658048\, i\, Q^6\, u1^{12} - 2279079936\, i\, Q^8\, u1^{12} +$$
$$3649568768\, i\, Q^{10}\, u1^{12} - 2550136832\, i\, Q^{12}\, u1^{12} + 587202560\, i\, Q^{14}\, u1^{12} - 1474560\, Q\, u1^{13} + 29360128\, Q^3\, u1^{13} - 237502464\, Q^5\, u1^{13} +$$
$$998375424\, Q^7\, u1^{13} - 2085617664\, Q^9\, u1^{13} + 1797259264\, Q^{11}\, u1^{13} - 469762048\, Q^{13}\, u1^{13} - 204800\, i\, u1^{14} + 5734400\, i\, Q^2\, u1^{14} -$$
$$60817408\, i\, Q^4\, u1^{14} + 319029248\, i\, Q^6\, u1^{14} - 851443712\, i\, Q^8\, u1^{14} + 843055104\, i\, Q^{10}\, u1^{14} - 234881024\, i\, Q^{12}\, u1^{14} - 655360\, Q\, u1^{15} +$$
$$11010048\, Q^3\, u1^{15} - 71303168\, Q^5\, u1^{15} + 222298112\, Q^7\, u1^{15} - 234881024\, Q^9\, u1^{15} + 67108864\, Q^{11}\, u1^{15} - 81920\, i\, u1^{16} + 1376256\, i\, Q^2\, u1^{16} -$$
$$8912896\, i\, Q^4\, u1^{16} + 27787264\, i\, Q^6\, u1^{16} - 29360128\, i\, Q^8\, u1^{16} + 8388608\, i\, Q^{10}\, u1^{16} - 160\, Q\, u2 + 4352\, Q^3\, u2 - 50432\, Q^5\, u2 + 321408\, Q^7\, u2 -$$
$$1178624\, Q^9\, u2 + 2396160\, Q^{11}\, u2 - 2490368\, Q^{13}\, u2 + 1277952\, Q^{15}\, u2 - 262144\, Q^{17}\, u2 + 5112\, i\, Q^2\, u1\, u2 - 118656\, i\, Q^4\, u1\, u2 + 1138048\, i\, Q^6\, u1\, u2 -$$
$$5663744\, i\, Q^8\, u1\, u2 + 15286272\, i\, Q^{10}\, u1\, u2 - 22249472\, i\, Q^{12}\, u1\, u2 + 17924096\, i\, Q^{14}\, u1\, u2 - 7602176\, i\, Q^{16}\, u1\, u2 + 1572864\, i\, Q^{18}\, u1\, u2 -$$
$$4480\, Q\, u1^2\, u2 + 174976\, Q^3\, u1^2\, u2 - 2408960\, Q^5\, u1^2\, u2 + 16281344\, Q^7\, u1^2\, u2 - 59152896\, Q^9\, u1^2\, u2 + 117698560\, Q^{11}\, u1^2\, u2 -$$
$$129744896\, Q^{13}\, u1^2\, u2 + 79364096\, Q^{15}\, u1^2\, u2 - 26869760\, Q^{17}\, u1^2\, u2 + 3145728\, Q^{19}\, u1^2\, u2 + 122688\, i\, Q^2\, u1^3\, u2 - 2995968\, i\, Q^4\, u1^3\, u2 +$$
$$29113856\, i\, Q^6\, u1^3\, u2 - 143710208\, i\, Q^8\, u1^3\, u2 + 382468096\, i\, Q^{10}\, u1^3\, u2 - 560791552\, i\, Q^{12}\, u1^3\, u2 + 468844544\, i\, Q^{14}\, u1^3\, u2 -$$
$$220725248\, i\, Q^{16}\, u1^3\, u2 + 46137344\, i\, Q^{18}\, u1^3\, u2 - 54400\, Q\, u1^4\, u2 + 2505216\, Q^3\, u1^4\, u2 - 35850240\, Q^5\, u1^4\, u2 + 241755136\, Q^7\, u1^4\, u2 -$$
$$858062848\, Q^9\, u1^4\, u2 + 1658478592\, Q^{11}\, u1^4\, u2 - 1806041088\, Q^{13}\, u1^4\, u2 + 1094189056\, Q^{15}\, u1^4\, u2 - 325058560\, Q^{17}\, u1^4\, u2 +$$
$$14680064\, Q^{19}\, u1^4\, u2 + 1247360\, i\, Q^2\, u1^5\, u2 - 30472192\, i\, Q^4\, u1^5\, u2 + 290317312\, i\, Q^6\, u1^5\, u2 - 1384857600\, i\, Q^8\, u1^5\, u2 +$$
$$3517972480\, i\, Q^{10}\, u1^5\, u2 - 4901568512\, i\, Q^{12}\, u1^5\, u2 + 3774087168\, i\, Q^{14}\, u1^5\, u2 - 1488977920\, i\, Q^{16}\, u1^5\, u2 + 167772160\, i\, Q^{18}\, u1^5\, u2 -$$
$$373760\, Q\, u1^6\, u2 + 18141184\, Q^3\, u1^6\, u2 - 254623744\, Q^5\, u1^6\, u2 + 1650380800\, Q^7\, u1^6\, u2 - 5530009600\, Q^9\, u1^6\, u2 + 9881518080\, Q^{11}\, u1^6\, u2 -$$
$$9639165952\, Q^{13}\, u1^6\, u2 + 4859101184\, Q^{15}\, u1^6\, u2 - 945815552\, Q^{17}\, u1^6\, u2 + 33554432\, Q^{19}\, u1^6\, u2 + 6952960\, i\, Q^2\, u1^7\, u2 - 162570240\, i\, Q^4\, u1^7\, u2 +$$
$$1470644224\, i\, Q^6\, u1^7\, u2 - 6562283520\, i\, Q^8\, u1^7\, u2 + 15195176960\, i\, Q^{10}\, u1^7\, u2 - 18733858816\, i\, Q^{12}\, u1^7\, u2 + 11924406272\, i\, Q^{14}\, u1^7\, u2 -$$
$$3439329280\, i\, Q^{16}\, u1^7\, u2 + 301989888\, i\, Q^{18}\, u1^7\, u2 - 1587200\, Q\, u1^8\, u2 + 74530816\, Q^3\, u1^8\, u2 - 984940544\, Q^5\, u1^8\, u2 +$$
$$5928378368\, Q^7\, u1^8\, u2 - 18003984384\, Q^9\, u1^8\, u2 + 28163702784\, Q^{11}\, u1^8\, u2 - 22705864704\, Q^{13}\, u1^8\, u2 + 8858370048\, Q^{15}\, u1^8\, u2 -$$
$$1325400064\, Q^{17}\, u1^8\, u2 + 33554432\, Q^{19}\, u1^8\, u2 + 22906880\, i\, Q^2\, u1^9\, u2 - 491487232\, i\, Q^4\, u1^9\, u2 + 4084072448\, i\, Q^6\, u1^9\, u2 -$$
$$16451633152\, i\, Q^8\, u1^9\, u2 + 33054523392\, i\, Q^{10}\, u1^9\, u2 - 33852227584\, i\, Q^{12}\, u1^9\, u2 + 16949182464\, i\, Q^{14}\, u1^9\, u2 - 3758096384\, i\, Q^{16}\, u1^9\, u2 +$$
$$268435456\, i\, Q^{18}\, u1^9\, u2 - 4259840\, Q\, u1^{10}\, u2 + 178356224\, Q^3\, u1^{10}\, u2 - 2139226112\, Q^5\, u1^{10}\, u2 + 11541086208\, Q^7\, u1^{10}\, u2 -$$

$$30298210304\,Q^{9}\,u1^{10}\,u2 + 39352008704\,Q^{11}\,u1^{10}\,u2 - 24798822400\,Q^{13}\,u1^{10}\,u2 + 7532969984\,Q^{15}\,u1^{10}\,u2 - 939524096\,Q^{17}\,u1^{10}\,u2 +$$
$$44515328\,i\,Q^{2}\,u1^{11}\,u2 - 840368128\,i\,Q^{4}\,u1^{11}\,u2 + 6171262976\,i\,Q^{6}\,u1^{11}\,u2 - 21483225088\,i\,Q^{8}\,u1^{11}\,u2 + 35381051392\,i\,Q^{10}\,u1^{11}\,u2 -$$
$$28059893760\,i\,Q^{12}\,u1^{11}\,u2 + 10905190400\,i\,Q^{14}\,u1^{11}\,u2 - 1879048192\,i\,Q^{16}\,u1^{11}\,u2 - 7045120\,Q\,u1^{12}\,u2 + 239206400\,Q^{3}\,u1^{12}\,u2 -$$
$$2496135168\,Q^{5}\,u1^{12}\,u2 + 11556880384\,Q^{7}\,u1^{12}\,u2 - 24384634880\,Q^{9}\,u1^{12}\,u2 + 24289214464\,Q^{11}\,u1^{12}\,u2 - 11291066368\,Q^{13}\,u1^{12}\,u2 +$$
$$2348810240\,Q^{15}\,u1^{12}\,u2 + 47153152\,i\,Q^{2}\,u1^{13}\,u2 - 750256128\,i\,Q^{4}\,u1^{13}\,u2 + 4593025024\,i\,Q^{6}\,u1^{13}\,u2 - 12696158208\,i\,Q^{8}\,u1^{13}\,u2 +$$
$$15523119104\,i\,Q^{10}\,u1^{13}\,u2 - 8120172544\,i\,Q^{12}\,u1^{13}\,u2 + 1879048192\,i\,Q^{14}\,u1^{13}\,u2 - 6553600\,Q\,u1^{14}\,u2 + 157286400\,Q^{3}\,u1^{14}\,u2 -$$
$$1317011456\,Q^{5}\,u1^{14}\,u2 + 4816109568\,Q^{7}\,u1^{14}\,u2 - 6861881344\,Q^{9}\,u1^{14}\,u2 + 3841982464\,Q^{11}\,u1^{14}\,u2 - 939524096\,Q^{13}\,u1^{14}\,u2 +$$
$$20971520\,i\,Q^{2}\,u1^{15}\,u2 - 268435456\,i\,Q^{4}\,u1^{15}\,u2 + 1207959552\,i\,Q^{6}\,u1^{15}\,u2 - 1862270976\,i\,Q^{8}\,u1^{15}\,u2 + 1073741824\,i\,Q^{10}\,u1^{15}\,u2 -$$
$$268435456\,i\,Q^{12}\,u1^{15}\,u2 - 2621440\,Q\,u1^{16}\,u2 + 33554432\,Q^{3}\,u1^{16}\,u2 - 150994944\,Q^{5}\,u1^{16}\,u2 + 232783872\,Q^{7}\,u1^{16}\,u2 - 134217728\,Q^{9}\,u1^{16}\,u2 +$$
$$33554432\,Q^{11}\,u1^{16}\,u2 - 140\,i\,u2^{2} + 6036\,i\,Q^{2}\,u2^{2} - 97280\,i\,Q^{4}\,u2^{2} + 813504\,i\,Q^{6}\,u2^{2} - 3904512\,i\,Q^{8}\,u2^{2} + 10729472\,i\,Q^{10}\,u2^{2} -$$
$$16007168\,i\,Q^{12}\,u2^{2} + 12238848\,i\,Q^{14}\,u2^{2} - 4456448\,i\,Q^{16}\,u2^{2} + 786432\,i\,Q^{18}\,u2^{2} - 4480\,Q\,u1\,u2^{2} + 174976\,Q^{3}\,u1\,u2^{2} - 2408960\,Q^{5}\,u1\,u2^{2} +$$
$$16281344\,Q^{7}\,u1\,u2^{2} - 59152896\,Q^{9}\,u1\,u2^{2} + 117698560\,Q^{11}\,u1\,u2^{2} - 129744896\,Q^{13}\,u1\,u2^{2} + 79364096\,Q^{15}\,u1\,u2^{2} - 26869760\,Q^{17}\,u1\,u2^{2} +$$
$$3145728\,Q^{19}\,u1\,u2^{2} - 3880\,i\,u1^{2}\,u2^{2} + 214272\,i\,Q^{2}\,u1^{2}\,u2^{2} - 4311296\,i\,Q^{4}\,u1^{2}\,u2^{2} + 40286720\,i\,Q^{6}\,u1^{2}\,u2^{2} - 196438016\,i\,Q^{8}\,u1^{2}\,u2^{2} +$$
$$524476416\,i\,Q^{10}\,u1^{2}\,u2^{2} - 783220736\,i\,Q^{12}\,u1^{2}\,u2^{2} + 657063936\,i\,Q^{14}\,u1^{2}\,u2^{2} - 309329920\,i\,Q^{16}\,u1^{2}\,u2^{2} + 65011712\,i\,Q^{18}\,u1^{2}\,u2^{2} -$$
$$106240\,Q\,u1^{3}\,u2^{2} + 4291072\,Q^{3}\,u1^{3}\,u2^{2} - 60866560\,Q^{5}\,u1^{3}\,u2^{2} + 410987520\,Q^{7}\,u1^{3}\,u2^{2} - 1465647104\,Q^{9}\,u1^{3}\,u2^{2} + 2881683456\,Q^{11}\,u1^{3}\,u2^{2} -$$
$$3203268608\,Q^{13}\,u1^{3}\,u2^{2} + 2026110976\,Q^{15}\,u1^{3}\,u2^{2} - 631242752\,Q^{17}\,u1^{3}\,u2^{2} + 33554432\,Q^{19}\,u1^{3}\,u2^{2} - 46560\,i\,u1^{4}\,u2^{2} +$$
$$2903680\,i\,Q^{2}\,u1^{4}\,u2^{2} - 62765056\,i\,Q^{4}\,u1^{4}\,u2^{2} + 594636288\,i\,Q^{6}\,u1^{4}\,u2^{2} - 2844647424\,i\,Q^{8}\,u1^{4}\,u2^{2} + 7336697856\,i\,Q^{10}\,u1^{4}\,u2^{2} -$$
$$10593501184\,i\,Q^{12}\,u1^{4}\,u2^{2} + 8597929984\,i\,Q^{14}\,u1^{4}\,u2^{2} - 3594518528\,i\,Q^{16}\,u1^{4}\,u2^{2} + 450887680\,i\,Q^{18}\,u1^{4}\,u2^{2} - 1064960\,Q\,u1^{5}\,u2^{2} +$$
$$43145216\,Q^{3}\,u1^{5}\,u2^{2} - 606969856\,Q^{5}\,u1^{5}\,u2^{2} + 3975852032\,Q^{7}\,u1^{5}\,u2^{2} - 13518716928\,Q^{9}\,u1^{5}\,u2^{2} + 25104547840\,Q^{11}\,u1^{5}\,u2^{2} -$$
$$25783566336\,Q^{13}\,u1^{5}\,u2^{2} + 14038335488\,Q^{15}\,u1^{5}\,u2^{2} - 2984247296\,Q^{17}\,u1^{5}\,u2^{2} + 83886080\,Q^{19}\,u1^{5}\,u2^{2} - 315520\,i\,u1^{6}\,u2^{2} +$$
$$20476928\,i\,Q^{2}\,u1^{6}\,u2^{2} - 445663232\,i\,Q^{4}\,u1^{6}\,u2^{2} + 4090363904\,i\,Q^{6}\,u1^{6}\,u2^{2} - 18527879168\,i\,Q^{8}\,u1^{6}\,u2^{2} + 44340281344\,i\,Q^{10}\,u1^{6}\,u2^{2} -$$
$$57707855872\,i\,Q^{12}\,u1^{6}\,u2^{2} + 40078671872\,i\,Q^{14}\,u1^{6}\,u2^{2} - 12482248704\,i\,Q^{16}\,u1^{6}\,u2^{2} + 1023410176\,i\,Q^{18}\,u1^{6}\,u2^{2} - 5836800\,Q\,u1^{7}\,u2^{2} +$$
$$231022592\,Q^{3}\,u1^{7}\,u2^{2} - 3113418752\,Q^{5}\,u1^{7}\,u2^{2} + 19156647936\,Q^{7}\,u1^{7}\,u2^{2} - 59719417856\,Q^{9}\,u1^{7}\,u2^{2} + 98927640576\,Q^{11}\,u1^{7}\,u2^{2} -$$
$$86576726016\,Q^{13}\,u1^{7}\,u2^{2} + 36859543552\,Q^{15}\,u1^{7}\,u2^{2} - 5687476224\,Q^{17}\,u1^{7}\,u2^{2} + 67108864\,Q^{19}\,u1^{7}\,u2^{2} - 1318400\,i\,u1^{8}\,u2^{2} +$$
$$83460096\,i\,Q^{2}\,u1^{8}\,u2^{2} - 1750466560\,i\,Q^{4}\,u1^{8}\,u2^{2} + 15009816576\,i\,Q^{6}\,u1^{8}\,u2^{2} - 61943316480\,i\,Q^{8}\,u1^{8}\,u2^{2} + 131372548096\,i\,Q^{10}\,u1^{8}\,u2^{2} -$$
$$144929980416\,i\,Q^{12}\,u1^{8}\,u2^{2} + 81040244736\,i\,Q^{14}\,u1^{8}\,u2^{2} - 19293798400\,i\,Q^{16}\,u1^{8}\,u2^{2} + 838860800\,i\,Q^{18}\,u1^{8}\,u2^{2} - 18841600\,Q\,u1^{9}\,u2^{2} +$$
$$712146944\,Q^{3}\,u1^{9}\,u2^{2} - 8872656896\,Q^{5}\,u1^{9}\,u2^{2} + 49515855872\,Q^{7}\,u1^{9}\,u2^{2} - 135757168640\,Q^{9}\,u1^{9}\,u2^{2} + 190264115200\,Q^{11}\,u1^{9}\,u2^{2} -$$
$$135780106240\,Q^{13}\,u1^{9}\,u2^{2} + 45063602176\,Q^{15}\,u1^{9}\,u2^{2} - 4362076160\,Q^{17}\,u1^{9}\,u2^{2} - 3471360\,i\,u1^{10}\,u2^{2} + 202014720\,i\,Q^{2}\,u1^{10}\,u2^{2} -$$
$$3918004224\,i\,Q^{4}\,u1^{10}\,u2^{2} + 30297948160\,i\,Q^{6}\,u1^{10}\,u2^{2} - 109129236480\,i\,Q^{8}\,u1^{10}\,u2^{2} + 195700981760\,i\,Q^{10}\,u1^{10}\,u2^{2} -$$
$$175187689472\,i\,Q^{12}\,u1^{10}\,u2^{2} + 76822872064\,i\,Q^{14}\,u1^{10}\,u2^{2} - 12683575296\,i\,Q^{16}\,u1^{10}\,u2^{2} - 35717120\,Q\,u1^{11}\,u2^{2} + 1265500160\,Q^{3}\,u1^{11}\,u2^{2} -$$
$$13993246720\,Q^{5}\,u1^{11}\,u2^{2} + 67825041408\,Q^{7}\,u1^{11}\,u2^{2} - 156105703424\,Q^{9}\,u1^{11}\,u2^{2} + 174785036288\,Q^{11}\,u1^{11}\,u2^{2} - 97626619904\,Q^{13}\,u1^{11}\,u2^{2} +$$
$$23018340352\,Q^{15}\,u1^{11}\,u2^{2} - 5611520\,i\,u1^{12}\,u2^{2} + 282558464\,i\,Q^{2}\,u1^{12}\,u2^{2} - 4798283776\,i\,Q^{4}\,u1^{12}\,u2^{2} + 32089702400\,i\,Q^{6}\,u1^{12}\,u2^{2} -$$
$$95158272000\,i\,Q^{8}\,u1^{12}\,u2^{2} + 134215630848\,i\,Q^{10}\,u1^{12}\,u2^{2} - 91838480384\,i\,Q^{12}\,u1^{12}\,u2^{2} + 27246198784\,i\,Q^{14}\,u1^{12}\,u2^{2} - 36700160\,Q\,u1^{13}\,u2^{2} +$$
$$1204289536\,Q^{3}\,u1^{13}\,u2^{2} - 11200888832\,Q^{5}\,u1^{13}\,u2^{2} + 43618664448\,Q^{7}\,u1^{13}\,u2^{2} - 77594624000\,Q^{9}\,u1^{13}\,u2^{2} + 61991813120\,Q^{11}\,u1^{13}\,u2^{2} -$$
$$21139292160\,Q^{13}\,u1^{13}\,u2^{2} - 5079040\,i\,u1^{14}\,u2^{2} + 206831616\,i\,Q^{2}\,u1^{14}\,u2^{2} - 2758279168\,i\,Q^{4}\,u1^{14}\,u2^{2} + 14705229824\,i\,Q^{6}\,u1^{14}\,u2^{2} -$$
$$32015122432\,i\,Q^{8}\,u1^{14}\,u2^{2} + 28286386176\,i\,Q^{10}\,u1^{14}\,u2^{2} - 10401873920\,i\,Q^{12}\,u1^{14}\,u2^{2} - 15728640\,Q\,u1^{15}\,u2^{2} + 476053504\,Q^{3}\,u1^{15}\,u2^{2} -$$
$$3422552064\,Q^{5}\,u1^{15}\,u2^{2} + 8405385216\,Q^{7}\,u1^{15}\,u2^{2} - 7784628224\,Q^{9}\,u1^{15}\,u2^{2} + 2952790016\,Q^{11}\,u1^{15}\,u2^{2} - 1966080\,i\,u1^{16}\,u2^{2} +$$
$$59506688\,i\,Q^{2}\,u1^{16}\,u2^{2} - 427819008\,i\,Q^{4}\,u1^{16}\,u2^{2} + 1050673152\,i\,Q^{6}\,u1^{16}\,u2^{2} - 973078528\,i\,Q^{8}\,u1^{16}\,u2^{2} + 369098752\,i\,Q^{10}\,u1^{16}\,u2^{2} -$$
$$3840\,Q\,u2^{3} + 109184\,Q^{3}\,u2^{3} - 1286656\,Q^{5}\,u2^{3} + 8186112\,Q^{7}\,u2^{3} - 29806080\,Q^{9}\,u2^{3} + 60510208\,Q^{11}\,u2^{3} - 65617920\,Q^{13}\,u2^{3} +$$

$38076416\,Q^{15}\,u2^3 - 11403264\,Q^{17}\,u2^3 + 1048576\,Q^{19}\,u2^3 + 122688\,\mathrm{i}\,Q^2\,u1\,u2^3 - 2995968\,\mathrm{i}\,Q^4\,u1\,u2^3 + 29113856\,\mathrm{i}\,Q^6\,u1\,u2^3 -$
$143710208\,\mathrm{i}\,Q^8\,u1\,u2^3 + 382468096\,\mathrm{i}\,Q^{10}\,u1\,u2^3 - 560791552\,\mathrm{i}\,Q^{12}\,u1\,u2^3 + 468844544\,\mathrm{i}\,Q^{14}\,u1\,u2^3 - 220725248\,\mathrm{i}\,Q^{16}\,u1\,u2^3 +$
$46137344\,\mathrm{i}\,Q^{18}\,u1\,u2^3 - 106240\,Q\,u1^2\,u2^3 + 4291072\,Q^3\,u1^2\,u2^3 - 60866560\,Q^5\,u1^2\,u2^3 + 410987520\,Q^7\,u1^2\,u2^3 - 1465647104\,Q^9\,u1^2\,u2^3 +$
$2881683456\,Q^{11}\,u1^2\,u2^3 - 3203268608\,Q^{13}\,u1^2\,u2^3 + 2026110976\,Q^{15}\,u1^2\,u2^3 - 631242752\,Q^{17}\,u1^2\,u2^3 + 33554432\,Q^{19}\,u1^2\,u2^3 +$
$2903552\,\mathrm{i}\,Q^2\,u1^3\,u2^3 - 74315776\,\mathrm{i}\,Q^4\,u1^3\,u2^3 + 731869184\,\mathrm{i}\,Q^6\,u1^3\,u2^3 - 3550511104\,\mathrm{i}\,Q^8\,u1^3\,u2^3 + 9219604480\,\mathrm{i}\,Q^{10}\,u1^3\,u2^3 -$
$13334216704\,\mathrm{i}\,Q^{12}\,u1^3\,u2^3 + 11035213824\,\mathrm{i}\,Q^{14}\,u1^3\,u2^3 - 4747952128\,\mathrm{i}\,Q^{16}\,u1^3\,u2^3 + 620756992\,\mathrm{i}\,Q^{18}\,u1^3\,u2^3 - 1272320\,Q\,u1^4\,u2^3 +$
$60256256\,Q^3\,u1^4\,u2^3 - 890544128\,Q^5\,u1^4\,u2^3 + 5957931008\,Q^7\,u1^4\,u2^3 - 20500365312\,Q^9\,u1^4\,u2^3 + 38467600384\,Q^{11}\,u1^4\,u2^3 -$
$40603615232\,Q^{13}\,u1^4\,u2^3 + 22772973568\,Q^{15}\,u1^4\,u2^3 - 4896849920\,Q^{17}\,u1^4\,u2^3 + 83886080\,Q^{19}\,u1^4\,u2^3 + 29035520\,\mathrm{i}\,Q^2\,u1^5\,u2^3 -$
$741519360\,\mathrm{i}\,Q^4\,u1^5\,u2^3 + 7129939968\,\mathrm{i}\,Q^6\,u1^5\,u2^3 - 32999833600\,\mathrm{i}\,Q^8\,u1^5\,u2^3 + 80483188736\,\mathrm{i}\,Q^{10}\,u1^5\,u2^3 - 107314413568\,\mathrm{i}\,Q^{12}\,u1^5\,u2^3 +$
$76957089792\,\mathrm{i}\,Q^{14}\,u1^5\,u2^3 - 24159191040\,\mathrm{i}\,Q^{16}\,u1^5\,u2^3 + 1509949440\,\mathrm{i}\,Q^{18}\,u1^5\,u2^3 - 8601600\,Q\,u1^6\,u2^3 + 427540480\,Q^3\,u1^6\,u2^3 -$
$6190858240\,Q^5\,u1^6\,u2^3 + 39343603712\,Q^7\,u1^6\,u2^3 - 125750607872\,Q^9\,u1^6\,u2^3 + 212960280576\,Q^{11}\,u1^6\,u2^3 - 193497923584\,Q^{13}\,u1^6\,u2^3 +$
$83105939456\,Q^{15}\,u1^6\,u2^3 - 10787749888\,Q^{17}\,u1^6\,u2^3 + 67108864\,Q^{19}\,u1^6\,u2^3 + 158679040\,\mathrm{i}\,Q^2\,u1^7\,u2^3 - 3871539200\,\mathrm{i}\,Q^4\,u1^7\,u2^3 +$
$35056123904\,\mathrm{i}\,Q^6\,u1^7\,u2^3 - 149224685568\,\mathrm{i}\,Q^8\,u1^7\,u2^3 + 324963139584\,\mathrm{i}\,Q^{10}\,u1^7\,u2^3 - 372026376192\,\mathrm{i}\,Q^{12}\,u1^7\,u2^3 +$
$210721832960\,\mathrm{i}\,Q^{14}\,u1^7\,u2^3 - 45365592064\,\mathrm{i}\,Q^{16}\,u1^7\,u2^3 + 1207959552\,\mathrm{i}\,Q^{18}\,u1^7\,u2^3 - 35840000\,Q\,u1^8\,u2^3 + 1716748288\,Q^3\,u1^8\,u2^3 -$
$23328587776\,Q^5\,u1^8\,u2^3 + 135369457664\,Q^7\,u1^8\,u2^3 - 384555155456\,Q^9\,u1^8\,u2^3 + 556069289984\,Q^{11}\,u1^8\,u2^3 - 407248044032\,Q^{13}\,u1^8\,u2^3 +$
$128731578368\,Q^{15}\,u1^8\,u2^3 - 8455716864\,Q^{17}\,u1^8\,u2^3 + 510443520\,\mathrm{i}\,Q^2\,u1^9\,u2^3 - 11420368896\,\mathrm{i}\,Q^4\,u1^9\,u2^3 + 93729456128\,\mathrm{i}\,Q^6\,u1^9\,u2^3 -$
$352794968064\,\mathrm{i}\,Q^8\,u1^9\,u2^3 + 652228952064\,\mathrm{i}\,Q^{10}\,u1^9\,u2^3 - 609272987648\,\mathrm{i}\,Q^{12}\,u1^9\,u2^3 + 262664093696\,\mathrm{i}\,Q^{14}\,u1^9\,u2^3 -$
$32883343360\,\mathrm{i}\,Q^{16}\,u1^9\,u2^3 - 94044160\,Q\,u1^{10}\,u2^3 + 4002545664\,Q^3\,u1^{10}\,u2^3 - 49083842560\,Q^5\,u1^{10}\,u2^3 + 249555058688\,Q^7\,u1^{10}\,u2^3 -$
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$19001769984\,\mathrm{i}\,Q^4\,u1^{11}\,u2^3 + 134959071232\,\mathrm{i}\,Q^6\,u1^{11}\,u2^3 - 429182156800\,\mathrm{i}\,Q^8\,u1^{11}\,u2^3 + 637735534592\,\mathrm{i}\,Q^{10}\,u1^{11}\,u2^3 -$
$458017996800\,\mathrm{i}\,Q^{12}\,u1^{11}\,u2^3 + 132472897536\,\mathrm{i}\,Q^{14}\,u1^{11}\,u2^3 - 151388160\,Q\,u1^{12}\,u2^3 + 5217714176\,Q^3\,u1^{12}\,u2^3 - 55111057408\,Q^5\,u1^{12}\,u2^3 +$
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$2903680\,\mathrm{i}\,Q^2\,u1^2\,u2^4 - 62765056\,\mathrm{i}\,Q^4\,u1^2\,u2^4 + 594636288\,\mathrm{i}\,Q^6\,u1^2\,u2^4 - 2844647424\,\mathrm{i}\,Q^8\,u1^2\,u2^4 + 7336697856\,\mathrm{i}\,Q^{10}\,u1^2\,u2^4 -$
$10593501184\,\mathrm{i}\,Q^{12}\,u1^2\,u2^4 + 8597929984\,\mathrm{i}\,Q^{14}\,u1^2\,u2^4 - 3594518528\,\mathrm{i}\,Q^{16}\,u1^2\,u2^4 + 450887680\,\mathrm{i}\,Q^{18}\,u1^2\,u2^4 - 1272320\,Q\,u1^3\,u2^4 +$
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$40603615232\,Q^{13}\,u1^3\,u2^4 + 22772973568\,Q^{15}\,u1^3\,u2^4 - 4896849920\,Q^{17}\,u1^3\,u2^4 + 83886080\,Q^{19}\,u1^3\,u2^4 - 551040\,\mathrm{i}\,u1^4\,u2^4 +$
$38291968\,\mathrm{i}\,Q^2\,u1^4\,u2^4 - 898361344\,\mathrm{i}\,Q^4\,u1^4\,u2^4 + 8588582912\,\mathrm{i}\,Q^6\,u1^4\,u2^4 - 39826325504\,\mathrm{i}\,Q^8\,u1^4\,u2^4 + 97403863040\,\mathrm{i}\,Q^{10}\,u1^4\,u2^4 -$
$131823304704\,\mathrm{i}\,Q^{12}\,u1^4\,u2^4 + 95432998912\,\mathrm{i}\,Q^{14}\,u1^4\,u2^4 - 29720838144\,\mathrm{i}\,Q^{16}\,u1^4\,u2^4 + 1560281088\,\mathrm{i}\,Q^{18}\,u1^4\,u2^4 - 12544000\,Q\,u1^5\,u2^4 +$
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$285151854592\,Q^{13}\,u1^5\,u2^4 + 121357991936\,Q^{15}\,u1^5\,u2^4 - 13472104448\,Q^{17}\,u1^5\,u2^4 + 100663296\,Q^{19}\,u1^5\,u2^4 - 3673600\,\mathrm{i}\,u1^6\,u2^4 +$
$264124416\,\mathrm{i}\,Q^2\,u1^6\,u2^4 - 6254493696\,\mathrm{i}\,Q^4\,u1^6\,u2^4 + 57311739904\,\mathrm{i}\,Q^6\,u1^6\,u2^4 - 247359209472\,\mathrm{i}\,Q^8\,u1^6\,u2^4 + 546839855104\,\mathrm{i}\,Q^{10}\,u1^6\,u2^4 -$

$638331125760 \, i \, Q^{12} \, u1^{6} \, u2^{4} + 359359578112 \, i \, Q^{14} \, u1^{6} \, u2^{4} - 67914170368 \, i \, Q^{16} \, u1^{6} \, u2^{4} + 1509949440 \, i \, Q^{18} \, u1^{6} \, u2^{4} - 67379200 \, Q \, u1^{7} \, u2^{4} +$
$3127312384 \, Q^{3} \, u1^{7} \, u2^{4} - 43351801856 \, Q^{5} \, u1^{7} \, u2^{4} + 257122172928 \, Q^{7} \, u1^{7} \, u2^{4} - 740606083072 \, Q^{9} \, u1^{7} \, u2^{4} + 1098249142272 \, Q^{11} \, u1^{7} \, u2^{4} -$
$801154007040 \, Q^{13} \, u1^{7} \, u2^{4} + 229176770560 \, Q^{15} \, u1^{7} \, u2^{4} - 11509170176 \, Q^{17} \, u1^{7} \, u2^{4} - 15052800 \, i \, u1^{8} \, u2^{4} + 1055023104 \, i \, Q^{2} \, u1^{8} \, u2^{4} -$
$23989780480 \, i \, Q^{4} \, u1^{8} \, u2^{4} + 202081992704 \, i \, Q^{6} \, u1^{8} \, u2^{4} - 775988707328 \, i \, Q^{8} \, u1^{8} \, u2^{4} + 1469644800000 \, i \, Q^{10} \, u1^{8} \, u2^{4} -$
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$119218372608 \, Q^{5} \, u1^{9} \, u2^{4} + 627484131328 \, Q^{7} \, u1^{9} \, u2^{4} - 1537884553216 \, Q^{9} \, u1^{9} \, u2^{4} + 1848033411072 \, Q^{11} \, u1^{9} \, u2^{4} - 1002690314240 \, Q^{13} \, u1^{9} \, u2^{4} +$
$160054640640 \, Q^{15} \, u1^{9} \, u2^{4} - 38707200 \, i \, u1^{10} \, u2^{4} + 2505670656 \, i \, Q^{2} \, u1^{10} \, u2^{4} - 52119470080 \, i \, Q^{4} \, u1^{10} \, u2^{4} + 387416195072 \, i \, Q^{6} \, u1^{10} \, u2^{4} -$
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$389939200 \, Q \, u1^{11} \, u2^{4} + 16430137344 \, Q^{3} \, u1^{11} \, u2^{4} - 179572834304 \, Q^{5} \, u1^{11} \, u2^{4} + 797922295808 \, Q^{7} \, u1^{11} \, u2^{4} - 1576852783104 \, Q^{9} \, u1^{11} \, u2^{4} +$
$1427036438528 \, Q^{11} \, u1^{11} \, u2^{4} - 492813942784 \, Q^{13} \, u1^{11} \, u2^{4} - 60784640 \, i \, u1^{12} \, u2^{4} + 3448111104 \, i \, Q^{2} \, u1^{12} \, u2^{4} - 61424009216 \, i \, Q^{4} \, u1^{12} \, u2^{4} +$
$384358678528 \, i \, Q^{6} \, u1^{12} \, u2^{4} - 984038244352 \, i \, Q^{8} \, u1^{12} \, u2^{4} + 1133527433216 \, i \, Q^{10} \, u1^{12} \, u2^{4} - 513315700736 \, i \, Q^{12} \, u1^{12} \, u2^{4} -$
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$74826383360 \, Q^{7} \, u1^{15} \, u2^{4} - 48855252992 \, Q^{9} \, u1^{15} \, u2^{4} - 19660800 \, i \, u1^{16} \, u2^{4} + 731906048 \, i \, Q^{2} \, u1^{16} \, u2^{4} - 4815060992 \, i \, Q^{4} \, u1^{16} \, u2^{4} +$
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$284033024 \, Q^{9} \, u2^{5} + 555851776 \, Q^{11} \, u2^{5} - 584318976 \, Q^{13} \, u2^{5} + 322699264 \, Q^{15} \, u2^{5} - 83886080 \, Q^{17} \, u2^{5} + 2097152 \, Q^{19} \, u2^{5} +$
$1247360 \, i \, Q^{2} \, u1 \, u2^{5} - 30472192 \, i \, Q^{4} \, u1 \, u2^{5} + 290317312 \, i \, Q^{6} \, u1 \, u2^{5} - 1384857600 \, i \, Q^{8} \, u1 \, u2^{5} + 3517972480 \, i \, Q^{10} \, u1 \, u2^{5} -$
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$43145216 \, Q^{3} \, u1^{2} \, u2^{5} - 606969856 \, Q^{5} \, u1^{2} \, u2^{5} + 3975852032 \, Q^{7} \, u1^{2} \, u2^{5} - 13518716928 \, Q^{9} \, u1^{2} \, u2^{5} + 25104547840 \, Q^{11} \, u1^{2} \, u2^{5} -$
$25783566336 \, Q^{13} \, u1^{2} \, u2^{5} + 14038335488 \, Q^{15} \, u1^{2} \, u2^{5} - 2984247296 \, Q^{17} \, u1^{2} \, u2^{5} + 83886080 \, Q^{19} \, u1^{2} \, u2^{5} + 29035520 \, i \, Q^{2} \, u1^{3} \, u2^{5} -$
$741519360 \, i \, Q^{4} \, u1^{3} \, u2^{5} + 7129939968 \, i \, Q^{6} \, u1^{3} \, u2^{5} - 32999833600 \, i \, Q^{8} \, u1^{3} \, u2^{5} + 80483188736 \, i \, Q^{10} \, u1^{3} \, u2^{5} - 107314413568 \, i \, Q^{12} \, u1^{3} \, u2^{5} +$
$76957089792 \, i \, Q^{14} \, u1^{3} \, u2^{5} - 24159191040 \, i \, Q^{16} \, u1^{3} \, u2^{5} + 1509949440 \, i \, Q^{18} \, u1^{3} \, u2^{5} - 12544000 \, Q \, u1^{4} \, u2^{5} + 594911232 \, Q^{3} \, u1^{4} \, u2^{5} -$
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$121357991936 \, Q^{15} \, u1^{4} \, u2^{5} - 13472104448 \, Q^{17} \, u1^{4} \, u2^{5} + 100663296 \, Q^{19} \, u1^{4} \, u2^{5} + 284620800 \, i \, Q^{2} \, u1^{5} \, u2^{5} - 7219838976 \, i \, Q^{4} \, u1^{5} \, u2^{5} +$
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$1278423859200\, i\, Q^{8}\, u1^{13}\, u2^{5} + 871140163584\, i\, Q^{10}\, u1^{13}\, u2^{5} - 1153433600\, Q\, u1^{14}\, u2^{5} + 26910654464\, Q^{3}\, u1^{14}\, u2^{5} -$
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$43486543872\, i\, Q^{4}\, u1^{15}\, u2^{5} + 130996502528\, i\, Q^{6}\, u1^{15}\, u2^{5} - 111400714240\, i\, Q^{8}\, u1^{15}\, u2^{5} - 419430400\, Q\, u1^{16}\, u2^{5} +$
$5435817984\, Q^{3}\, u1^{16}\, u2^{5} - 16374562816\, Q^{5}\, u1^{16}\, u2^{5} + 13925089280\, Q^{7}\, u1^{16}\, u2^{5} - 11680\, i\, u2^{6} + 614912\, i\, Q^{2}\, u2^{6} - 10256384\, i\, Q^{4}\, u2^{6} +$
$83934720\, i\, Q^{6}\, u2^{6} - 384442368\, i\, Q^{8}\, u2^{6} + 984932352\, i\, Q^{10}\, u2^{6} - 1352138752\, i\, Q^{12}\, u2^{6} + 976879616\, i\, Q^{14}\, u2^{6} - 331350016\, i\, Q^{16}\, u2^{6} +$
$27262976\, i\, Q^{18}\, u2^{6} - 373760\, Q\, u1\, u2^{6} + 18141184\, Q^{3}\, u1\, u2^{6} - 254623744\, Q^{5}\, u1\, u2^{6} + 1650380800\, Q^{7}\, u1\, u2^{6} - 5530009600\, Q^{9}\, u1\, u2^{6} +$
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$315520\, i\, u1^{2}\, u2^{6} + 20476928\, i\, Q^{2}\, u1^{2}\, u2^{6} - 445663232\, i\, Q^{4}\, u1^{2}\, u2^{6} + 4090363904\, i\, Q^{6}\, u1^{2}\, u2^{6} - 18527879168\, i\, Q^{8}\, u1^{2}\, u2^{6} +$
$44340281344\, i\, Q^{10}\, u1^{2}\, u2^{6} - 57707855872\, i\, Q^{12}\, u1^{2}\, u2^{6} + 40078671872\, i\, Q^{14}\, u1^{2}\, u2^{6} - 12482248704\, i\, Q^{16}\, u1^{2}\, u2^{6} +$
$1023410176\, i\, Q^{18}\, u1^{2}\, u2^{6} - 8601600\, Q\, u1^{3}\, u2^{6} + 427540480\, Q^{3}\, u1^{3}\, u2^{6} - 6190858240\, Q^{5}\, u1^{3}\, u2^{6} + 39343603712\, Q^{7}\, u1^{3}\, u2^{6} -$
$125750607872\, Q^{9}\, u1^{3}\, u2^{6} + 212960280576\, Q^{11}\, u1^{3}\, u2^{6} - 193497923584\, Q^{13}\, u1^{3}\, u2^{6} + 83105939456\, Q^{15}\, u1^{3}\, u2^{6} - 10787749888\, Q^{17}\, u1^{3}\, u2^{6} +$
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$4737433600\,\mathbb{i}\,Q^{2}\,u1^{5}\,u2^{9} - 103530627072\,\mathbb{i}\,Q^{4}\,u1^{5}\,u2^{9} + 794451771392\,\mathbb{i}\,Q^{6}\,u1^{5}\,u2^{9} - 2634844995584\,\mathbb{i}\,Q^{8}\,u1^{5}\,u2^{9} +$
$4055334125568\,\mathbb{i}\,Q^{10}\,u1^{5}\,u2^{9} - 2740390461440\,\mathbb{i}\,Q^{12}\,u1^{5}\,u2^{9} + 551299317760\,\mathbb{i}\,Q^{14}\,u1^{5}\,u2^{9} - 1330380800\,Q\,u1^{6}\,u2^{9} +$
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$88868913152\, Q^3\, u1^6\, u2^{13} - 673974321152\, Q^5\, u1^6\, u2^{13} + 1780096172032\, Q^7\, u1^6\, u2^{13} - 1528605704192\, Q^9\, u1^6\, u2^{13} +$
$36867932160\, i\, Q^2\, u1^7\, u2^{13} - 499793264640\, i\, Q^4\, u1^7\, u2^{13} + 1848983420928\, i\, Q^6\, u1^7\, u2^{13} - 2066818793472\, i\, Q^8\, u1^7\, u2^{13} -$
$7340032000\, Q\, u1^8\, u2^{13} + 260583718912\, Q^3\, u1^8\, u2^{13} - 1445927583744\, Q^5\, u1^8\, u2^{13} + 2165502377984\, Q^7\, u1^8\, u2^{13} +$
$87115694080\, i\, Q^2\, u1^9\, u2^{13} - 847316516864\, i\, Q^4\, u1^9\, u2^{13} + 1735502331904\, i\, Q^6\, u1^9\, u2^{13} - 14092861440\, Q\, u1^{10}\, u2^{13} +$
$361448341504\, Q^3\, u1^{10}\, u2^{13} - 1054951342080\, Q^5\, u1^{10}\, u2^{13} + 101804146688\, i\, Q^2\, u1^{11}\, u2^{13} - 489894707200\, i\, Q^4\, u1^{11}\, u2^{13} -$
$14092861440\, Q\, u1^{12}\, u2^{13} + 173409304576\, Q^3\, u1^{12}\, u2^{13} + 42815455232\, i\, Q^2\, u1^{13}\, u2^{13} - 5368709120\, Q\, u1^{14}\, u2^{13} - 204800\, i\, u2^{14} +$
$5734400\, i\, Q^2\, u2^{14} - 60817408\, i\, Q^4\, u2^{14} + 319029248\, i\, Q^6\, u2^{14} - 851443712\, i\, Q^8\, u2^{14} + 843055104\, i\, Q^{10}\, u2^{14} - 234881024\, i\, Q^{12}\, u2^{14} -$
$6553600\, Q\, u1\, u2^{14} + 157286400\, Q^3\, u1\, u2^{14} - 1317011456\, Q^5\, u1\, u2^{14} + 4816109568\, Q^7\, u1\, u2^{14} - 6861881344\, Q^9\, u1\, u2^{14} +$
$3841982464\, Q^{11}\, u1\, u2^{14} - 939524096\, Q^{13}\, u1\, u2^{14} - 5079040\, i\, u1^2\, u2^{14} + 206831616\, i\, Q^2\, u1^2\, u2^{14} - 2758279168\, i\, Q^4\, u1^2\, u2^{14} +$
$14705229824\, i\, Q^6\, u1^2\, u2^{14} - 32015122432\, i\, Q^8\, u1^2\, u2^{14} + 28286386176\, i\, Q^{10}\, u1^2\, u2^{14} - 10401873920\, i\, Q^{12}\, u1^2\, u2^{14} -$
$136314880\, Q\, u1^3\, u2^{14} + 3347054592\, Q^3\, u1^3\, u2^{14} - 27665629184\, Q^5\, u1^3\, u2^{14} + 89275760640\, Q^7\, u1^3\, u2^{14} - 110595407872\, Q^9\, u1^3\, u2^{14} +$
$53351546880\, Q^{11}\, u1^3\, u2^{14} - 53084160\, i\, u1^4\, u2^{14} + 2504523776\, i\, Q^2\, u1^4\, u2^{14} - 33562820608\, i\, Q^4\, u1^4\, u2^{14} + 161673641984\, i\, Q^6\, u1^4\, u2^{14} -$
$282360545280\, i\, Q^8\, u1^4\, u2^{14} + 174818590720\, i\, Q^{10}\, u1^4\, u2^{14} - 1153433600\, Q\, u1^5\, u2^{14} + 26910654464\, Q^3\, u1^5\, u2^{14} -$
$200722612224\, Q^5\, u1^5\, u2^{14} + 507997323264\, Q^7\, u1^5\, u2^{14} - 402384748544\, Q^9\, u1^5\, u2^{14} - 301465600\, i\, u1^6\, u2^{14} + 14319353856\, i\, Q^2\, u1^6\, u2^{14} -$
$172587220992\, i\, Q^4\, u1^6\, u2^{14} + 655250948096\, i\, Q^6\, u1^6\, u2^{14} - 685651263488\, i\, Q^8\, u1^6\, u2^{14} - 5033164800\, Q\, u1^7\, u2^{14} +$
$102273908736\, Q^3\, u1^7\, u2^{14} - 606395695104\, Q^5\, u1^7\, u2^{14} + 892480782336\, Q^7\, u1^7\, u2^{14} - 996147200\, i\, u1^8\, u2^{14} + 41750102016\, i\, Q^2\, u1^8\, u2^{14} -$
$397955563520\, i\, Q^4\, u1^8\, u2^{14} + 885098807296\, i\, Q^6\, u1^8\, u2^{14} - 11744051200\, Q\, u1^9\, u2^{14} + 181999239168\, Q^3\, u1^9\, u2^{14} -$
$647466319872\, Q^5\, u1^9\, u2^{14} - 1887436800\, i\, u1^{10}\, u2^{14} + 58317602816\, i\, Q^2\, u1^{10}\, u2^{14} - 334604795904\, i\, Q^4\, u1^{10}\, u2^{14} -$
$13421772800\, Q\, u1^{11}\, u2^{14} + 118111600640\, Q^3\, u1^{11}\, u2^{14} - 1845493760\, i\, u1^{12}\, u2^{14} + 28856811520\, i\, Q^2\, u1^{12}\, u2^{14} -$
$5368709120\, Q\, u1^{13}\, u2^{14} - 671088640\, i\, u1^{14}\, u2^{14} - 655360\, Q\, u2^{15} + 11010048\, Q^3\, u2^{15} - 71303168\, Q^5\, u2^{15} + 222298112\, Q^7\, u2^{15} -$
$234881024\, Q^9\, u2^{15} + 67108864\, Q^{11}\, u2^{15} + 20971520\, i\, Q^2\, u1\, u2^{15} - 268435456\, i\, Q^4\, u1\, u2^{15} + 1207959552\, i\, Q^6\, u1\, u2^{15} -$
$1862270976\, i\, Q^8\, u1\, u2^{15} + 1073741824\, i\, Q^{10}\, u1\, u2^{15} - 268435456\, i\, Q^{12}\, u1\, u2^{15} - 15728640\, Q\, u1^2\, u2^{15} + 476053504\, Q^3\, u1^2\, u2^{15} -$
$3422552064\, Q^5\, u1^2\, u2^{15} + 8405385216\, Q^7\, u1^2\, u2^{15} - 7784628224\, Q^9\, u1^2\, u2^{15} + 2952790016\, Q^{11}\, u1^2\, u2^{15} + 419430400\, i\, Q^2\, u1^3\, u2^{15} -$
$5771362304\, i\, Q^4\, u1^3\, u2^{15} + 22548578304\, i\, Q^6\, u1^3\, u2^{15} - 29930553344\, i\, Q^8\, u1^3\, u2^{15} + 15032385536\, i\, Q^{10}\, u1^3\, u2^{15} -$
$157286400\, Q\, u1^4\, u2^{15} + 5855248384\, Q^3\, u1^4\, u2^{15} - 38520487936\, Q^5\, u1^4\, u2^{15} + 74826383360\, Q^7\, u1^4\, u2^{15} - 48855252992\, Q^9\, u1^4\, u2^{15} +$

$$3355443200\, i\, Q^{2}\, u1^{5}\, u2^{15} - 43486543872\, i\, Q^{4}\, u1^{5}\, u2^{15} + 130996502528\, i\, Q^{6}\, u1^{5}\, u2^{15} - 111400714240\, i\, Q^{8}\, u1^{5}\, u2^{15} -$$
$$838860800\, Q\, u1^{6}\, u2^{15} + 31608274944\, Q^{3}\, u1^{6}\, u2^{15} - 162135015424\, Q^{5}\, u1^{6}\, u2^{15} + 187636383744\, Q^{7}\, u1^{6}\, u2^{15} + 13421772800\, i\, Q^{2}\, u1^{7}\, u2^{15} -$$
$$139586437120\, i\, Q^{4}\, u1^{7}\, u2^{15} + 240518168576\, i\, Q^{6}\, u1^{7}\, u2^{15} - 2516582400\, Q\, u1^{8}\, u2^{15} + 79591112704\, Q^{3}\, u1^{8}\, u2^{15} -$$
$$233001975808\, Q^{5}\, u1^{8}\, u2^{15} + 26843545600\, i\, Q^{2}\, u1^{9}\, u2^{15} - 163208757248\, i\, Q^{4}\, u1^{9}\, u2^{15} - 4026531840\, Q\, u1^{10}\, u2^{15} +$$
$$76772540416\, Q^{3}\, u1^{10}\, u2^{15} + 21474836480\, i\, Q^{2}\, u1^{11}\, u2^{15} - 2684354560\, Q\, u1^{12}\, u2^{15} - 81920\, i\, u2^{16} + 1376256\, i\, Q^{2}\, u2^{16} -$$
$$8912896\, i\, Q^{4}\, u2^{16} + 27787264\, i\, Q^{6}\, u2^{16} - 29360128\, i\, Q^{8}\, u2^{16} + 8388608\, i\, Q^{10}\, u2^{16} - 2621440\, Q\, u1\, u2^{16} + 33554432\, Q^{3}\, u1\, u2^{16} -$$
$$150994944\, Q^{5}\, u1\, u2^{16} + 232783872\, Q^{7}\, u1\, u2^{16} - 134217728\, Q^{9}\, u1\, u2^{16} + 33554432\, Q^{11}\, u1\, u2^{16} - 1966080\, i\, u1^{2}\, u2^{16} +$$
$$59506688\, i\, Q^{2}\, u1^{2}\, u2^{16} - 427819008\, i\, Q^{4}\, u1^{2}\, u2^{16} + 1050673152\, i\, Q^{6}\, u1^{2}\, u2^{16} - 973078528\, i\, Q^{8}\, u1^{2}\, u2^{16} + 369098752\, i\, Q^{10}\, u1^{2}\, u2^{16} -$$
$$52428800\, Q\, u1^{3}\, u2^{16} + 721420288\, Q^{3}\, u1^{3}\, u2^{16} - 2818572288\, Q^{5}\, u1^{3}\, u2^{16} + 3741319168\, Q^{7}\, u1^{3}\, u2^{16} - 1879048192\, Q^{9}\, u1^{3}\, u2^{16} -$$
$$19660800\, i\, u1^{4}\, u2^{16} + 731906048\, i\, Q^{2}\, u1^{4}\, u2^{16} - 4815060992\, i\, Q^{4}\, u1^{4}\, u2^{16} + 9353297920\, i\, Q^{6}\, u1^{4}\, u2^{16} - 6106906624\, i\, Q^{8}\, u1^{4}\, u2^{16} -$$
$$419430400\, Q\, u1^{5}\, u2^{16} + 5435817984\, Q^{3}\, u1^{5}\, u2^{16} - 16374562816\, Q^{5}\, u1^{5}\, u2^{16} + 13925089280\, Q^{7}\, u1^{5}\, u2^{16} - 104857600\, i\, u1^{6}\, u2^{16} +$$
$$3951034368\, i\, Q^{2}\, u1^{6}\, u2^{16} - 20266876928\, i\, Q^{4}\, u1^{6}\, u2^{16} + 23454547968\, i\, Q^{6}\, u1^{6}\, u2^{16} - 1677721600\, Q\, u1^{7}\, u2^{16} + 17448304640\, Q^{3}\, u1^{7}\, u2^{16} -$$
$$30064771072\, Q^{5}\, u1^{7}\, u2^{16} - 314572800\, i\, u1^{8}\, u2^{16} + 9948889088\, i\, Q^{2}\, u1^{8}\, u2^{16} - 29125246976\, i\, Q^{4}\, u1^{8}\, u2^{16} - 3355443200\, Q\, u1^{9}\, u2^{16} +$$
$$20401094656\, Q^{3}\, u1^{9}\, u2^{16} - 503316480\, i\, u1^{10}\, u2^{16} + 9596567552\, i\, Q^{2}\, u1^{10}\, u2^{16} - 2684354560\, Q\, u1^{11}\, u2^{16} - 335544320\, i\, u1^{12}\, u2^{16})) \,/$$
$$(Q^{5}\, (-1 + 2\, Q + 2\, i\, u1)^{4}\, (1 + 2\, Q + 2\, i\, u1)^{4}\, (-i + 2\, u1)^{4}\, (i + 2\, u1)^{4}\, (-1 + 2\, Q + 2\, i\, u2)^{4}\, (1 + 2\, Q + 2\, i\, u2)^{4}\, (-i + 2\, u2)^{4}\, (i + 2\, u2)^{4})$$

summation over ℓ

$$\Delta E_{\text{Luscher}} = g^8 \Big[\; - \; 54(1+\Delta)^3(-5+3\Delta)\zeta(3) - 360(1+\Delta)^2\zeta(5) + \frac{81\,(1-3\,\Delta)^2\,(1+\Delta)^4}{(1+3\,\Delta)^2} \Big] \equiv \Delta E_{\text{wrapping}}$$

Other approach

- Y-system [Gromov-Vieira-Kazakov]

- can be extended to the β-deformed SYM [Gromov-Maslyuk]

- one-impurity Lüscher correction is correctly derived

Conclusion

- the β-deformed SYM is probably all-loop integrable
- may need some nontrivial boundary condition
- some relevant S-matrix amplitudes are known
- many open questions:
  - exact S-matrix
  - derivation of asymptotic BAE

– TBA

– strong coupling Lüscher correction