

UV Properties of $N=8$ SUGRA at Five Loops and Beyond

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with

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hep-th/1804.09311, ongoing

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The Five-Loop Results

$$\mathcal{M}_4^{(5)} \Big|_{\text{leading}}^{D=22/5} = 0. \quad (1)$$

$$\begin{aligned} \mathcal{M}_4^{(5)} \Big|_{\text{leading}}^{D=24/5} = & -\frac{16 \times 629}{25} \left(\frac{\kappa}{2}\right)^{12} (s^2 + t^2 + u^2)^2 stu \mathcal{M}_4^{\text{tree}} \\ & \times \left(\frac{1}{48} \text{Diagram 1} + \frac{1}{16} \text{Diagram 2} \right) \end{aligned} \quad (2)$$

Diagram 1: A circle with a square inscribed inside. The four vertices of the square are connected to the center of the circle by four lines, forming a star-like shape.

Diagram 2: A circle with a square inscribed inside. The four vertices of the square are connected to the center of the circle by four lines, forming a star-like shape. Additionally, there are two diagonal lines crossing at the center of the circle, forming an 'X' shape.

Emerging Patterns

Very simple result, but it took 1000s of hours to get to. Is there a better way?

$$\left(\frac{1}{48} \text{ (circle with square and lines to center)} + \frac{1}{16} \text{ (circle with X and horizontal line)} \right)$$

Emerging Patterns

Very simple result, but it took 1000s of hours to get to. Is there a better way?

$$\left(\frac{1}{48} \text{ (square-in-circle diagram)} + \frac{1}{16} \text{ (X-in-circle diagram)} \right)$$

- Consistency with lower loops
- Integration system
- Special BCJ on sYM

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- Integration system
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Working on applying all of these to 6 loops!

Consistency with Lower Loops

Removing legs appropriately always lands on correct lower loop

$$\begin{array}{c}
 \text{Diagram 1} \rightarrow 12 \text{ Diagram 2} \quad (3)
 \end{array}$$

Diagram 1: A circle containing a square with lines connecting its corners to the center. Diagram 2: A circle containing a triangle with lines connecting its vertices to the center, and two blue dots on the bottom edge.

$$\begin{array}{c}
 \text{Diagram 3} \rightarrow 8 \text{ Diagram 4} + 4 \text{ Diagram 5} \quad (4)
 \end{array}$$

Diagram 3: A circle containing a triangle with lines connecting its vertices to the center, and two blue dots on the top edge. Diagram 4: A circle containing a triangle with lines connecting its vertices to the center, and two blue dots on the left edge. Diagram 5: A circle containing a triangle with lines connecting its vertices to the center, and two blue dots on the right edge.

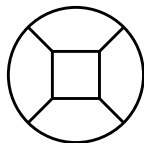
$$\begin{array}{c}
 \text{Diagram 6} \rightarrow \frac{1}{4} \text{ Diagram 2} + \frac{1}{2} \text{ Diagram 4} + \frac{1}{4} \text{ Diagram 5} \quad (5)
 \end{array}$$

Diagram 6: A circle containing four smaller circles arranged in a 2x2 grid, with a red dashed box around it. Diagram 2, 4, and 5 are the same as in the previous equations.

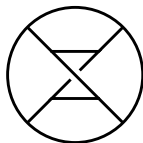
Pattern continues all the way down to one loop. Consistency with one loop requires *no triangles*. Can use to constrain ansatz at 6 loops.

Integration Patterns

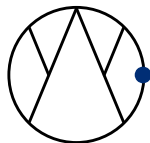
$\mathcal{N} = 8$ SUGRA IBP master integrals for five loops:



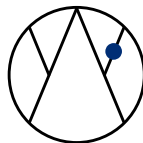
(a)



(b)



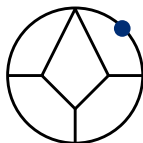
(c)



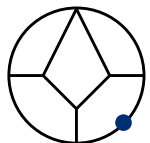
(d)



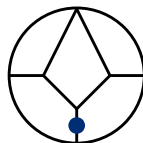
(e)



(f)



(g)



(h)

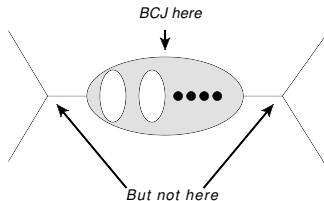
Integration systems for *both* SUGRA and sYM can be written in terms of masters with limited numerators.

Special BCJ on sYM

- Early indication of being able to determine sYM divergence using a subset of BCJ

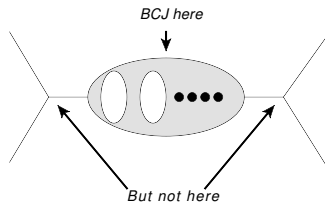
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- “Two-Point BCJ”: relations between specific diagrams



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- “Two-Point BCJ”: relations between specific diagrams



- Works up to 5 loops. Looks like it might square to gravity “divergence”.

Warming up in 6 Loop sYM,
then on to SUGRA!

Questions?