TF04: Scattering amplitudes

Conveners: Zvi Bern and Jaroslav Trnka

Overview

- **We are seeking input from the community.**
- **Goal is to make sure that the final P5 report emphasizes that theory is an essential component of particle physics.**
- **We are *not* here to set funding priorities or rank topics.**
- **We are here to provide a roadmap to the future, identify important topics, especially those that can lead to future advances, especially those outside our subfield.**
- **We are here to gauge community support and enthusiasm for a topic.**
- **What are the most exciting topics that need to be emphasized in our report?**
- **We need help to generate a paper trail documenting the support and ideas for the future in order to refer to in our final write up.**

Short Description

- Collider Physics: Scattering amplitudes are a key arena where quantum field theory directly confronts experiment and where a precise understanding can be crucial for identifying Beyond Standard Model signals at particle colliders such as the LHC.

- Mathematical Structures: At the same time, scattering amplitudes have revealed beautiful and intriguing mathematical structures and patterns that suggest that our fundamental understanding of quantum field theory is far from complete. The Amplituhedron and exciting connections to geometry and combinatorics.

- Wide Applications: The study of scattering amplitudes has been a growing area of research over the past decade, with applications ranging from precision calculations for the LHC, new approaches to gauge and gravity theories, LIGO physics.

Proposed Subtopics

- **Analytic properties of perturbative scattering amplitudes, IR and UV divergences, loop integration techniques, differential equations, application to QCD and collider physics.**
- **Efficient methods to construct scattering amplitudes in general quantum field theories, generalized unitarity, recursion relations.**
- **Geometric picture for amplitudes: hidden symmetries, on-shell diagrams, positive Grassmannian, Amplituhedron, cluster algebras, hexagon bootstrap, symbols and co-products.**
- **Connections to string theory, CHY constructions.**
- **Color-kinematics duality, web of theories, construction of gravity multi-loop integrands, including those for classical gravitational wave problems.**
- **New applications of amplitude methods to problems of direct importance to LIGO physics and to Standard Model Effective field theory.**

What else should we include?

Mechanisms to help

If you think something is important that should be emphasized you should send us a document.

Letters of Interest.

- **Public, but not arxiv, 2 pages max. 1 page is plenty.**
- **If possible, put this on letterhead and sign it.**
- **"Dear Jara and Zvi, I am very excited about the recent advances in xxx. Then a few paragraphs explaining the advance in semi-technical language. A summary of where it can lead.**
- **Applications outside our subfield should be emphasized. e.g. N =4 sYM -> QCD -> collider physics. If you foresee ultimate applications towards experimental programs state it.**
- **Can be sent any time before July. Earlier is better!**

Mechanisms to help

Whitepapers:

- **More substantive and organized. Multiple authors, more details. 5 pages.**
- **Will go on arxiv.**
- **Broader, e.g new techniques.**
- **Multiple people can join forces if sufficient overlap.**
- **Can solicit additional co-signers.**
- **Lance Dixon has volunteered to write an *N*=4 sYM whitepaper. Please speak to him if you are interested in this topic.**
- **Need people to volunteer.**
- **Jara and I can help you organize a whitepaper and put you in contact with others.**
- **Due in July. Earlier is better.**

Non-US based scientists are more than welcome to write LOIs, whitepapers or co-sign.

Topics

Suggested whitepaper or LOI topics:

- **N = 4 sYM (Please contact Lance.)**

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- **Amplituhedron, Grassmannians**
- **Gravitational Waves**
- **QCD multiloops, collider physics**
- **SMEFT and amplitude methods.**
- **CHY, ambitwistor strings. Connections to string theory.**
- **Double Copy, web of theories.**
- **Resurrect Simons proposals as whitepapers.**
- **Etc**

Question, comments or suggestion?

You can also contact me or Jaroslav directly via e-mail

Note: we can try to use slack channel #tf04-amplitudes