CERN TH retreat

Johann Usovitsch

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Early research career

2013 master thesis with Peter Uwer at Humboldt-Universität zu Berlin

- Initiated the project on Feynman integral reduction Kira

2014 - 2017 PhD with Tord Riemann at Humboldt-Universität zu Berlin

- First contact with Ayres Freitas and Janusz Gluza on Electroweak physics – 2-loop vertex integrals
- Development of my own first numerical tools for Feynman integral calculations
- First contact with Mario Prausa on QCD Higgs production – 3-loop vertex integrals
- First publication of Kira in 2017

Postdoc research career

2017 - 2019 Postdoc with Ruth Britto at Trinity College Dublin

- Development of closed form results for cut integrals and 1-loop integrals
- First contact with Francesco Moriello and Martijn Hidding on differential equations
- Second publication of Kira in 2019
- Invented the jargon of magic relations, one example arXiv:2208.05837:

$$I^B_{011011100} = \frac{1}{(m_t^2 - m_W^2)} \left(I^B_{001011100} - I^B_{100011100} \right)$$
$$- \frac{1}{s} \left(I^A_{01111(-1)100} - I^A_{011010100} - I^A_{(-1)11110100} \right)$$
$$- \frac{3}{s(m_t^2 - m_W^2)} \left(I^A_{011(-1)10100} - I^A_{01101(-1)100} \right)$$

2019 - 2021 Postdoc with Stefan Weinzierl at Johannes Gutenberg University Mainz

- Worked on ideas for algorithmic evaluation of Feynman integrals

Research career at CERN

Fellow at CERN

- Co-organized a workshop at CERN in June on future e^+e^- colliders: targets and tools
- Collaboration with Martijn Hidding on algorithmic evaluation of general Feynman integrals arXiv:2206.14790
- Collaboration with Marco Niggetiedt on new public tool for Feynman diagram generation, based on Michał Czakon's DiaGen
- Collaboration with Fabian Lange on Feynman integral reduction based on ideas of block-triangular form arXiv:1801.10523, arXiv:1912.09294

Dream set-up for perturbative quantum field theoretical calculations

Future goal is to do Electroweak physics at three- and four-loop vertex integral level

The projected uncertainty on the Z-boson width at the FCC-ee Tera-Z is 25 keV arXiv:2106.13885, with three-loop corrections we reach theoretical uncertainty of 150 keV

Feynman integral reduction

- Feynman integral reduction within Kira is essentially: solving a sparse linear system of equations

- The systems have symbolic coefficients and billions of equations for cutting edge applications

- It is possible to construct a system of equations which contains the same information, but is 5 orders of magnitude smaller in size and thus more efficient to evaluate; next feature of Kira is the construction of the block-triangular form

- Kira is a public tool applicable to more general linear system of equations

- This gives much room and a nice interface for new collaborations

- New collaborations at CERN are planned with Ben Page on Feynman reductions with extra relations

Feynman integral evaluation

- There are no general techniques that are applicable for solving integrals for all the processes in the same manner

- I solve a linear system of differential equations based on generalized series expansion ansatz reformulated by Francesco Moriello arXiv:1907.13234

- Algorithmic realization of this idea is possible with the help of auxiliary mass flow method arXiv:1711.09572, arXiv:2107.01864

- Any Feynman integral calculation is essentially just solving a linear system of equations

- I developed with Martijn Hidding an idea which is algorithmic as well but in addition reduces the linear system of equations by at least one order of magnitude arXiv:2206.14790

- With Matteo Fael at CERN we aim at some 5-loop calculations

- I aim to apply this method to three- and four-loop Electroweak integrals

Feynman integral evaluation

Collaboration with Alexander Huss

Calculating the phase space integration for cross-sections at multi-loop multi-leg level is getting more and more involved with increased number of legs.

My solution is to compute the cross section multiple times for finite negative epsilon values

Collaboration with Vitaly Magerya

After yesterdays publication arXiv:2211.03572 we aim to improve the Feynman reductions even more

Samples of diagrams you will find at my black board