Robert Harlander

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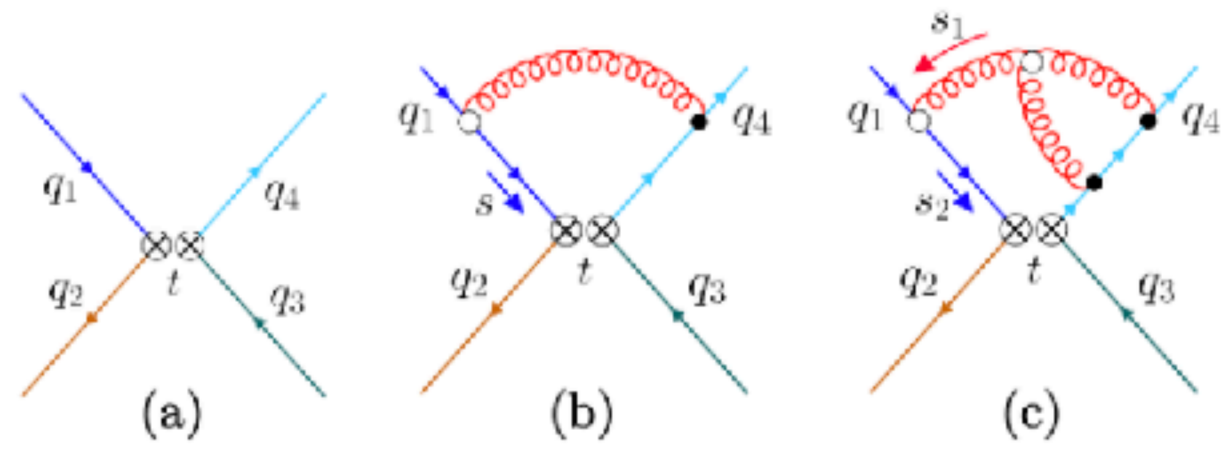
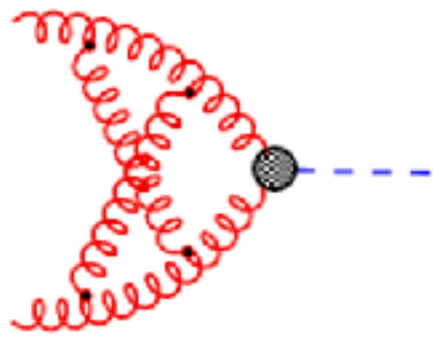


Figure 1. Sample diagrams contributing to the determination of the matching matrix $\zeta(t)$ at LO, NLO, and NNLO QCD. The circles denote "flowed vertices", lines with an arrow next to them denote "flow lines", and the label next to the arrow is a flow-time integration variable (see Ref. [15] for details). The diagrams were produced with FeynGame [20].

What's new? (older news)

- Topics for bachelor theses
  27 Jan 2022
- New preprint on flavor physics in the gradient flow formalism
  24 Jan 2022
- Proceedings contribution to Lattice 2021
  01 Dec 2021
- Podcast in "Welt der Physik" on the nature of mass (in German)
  18 Nov 2021



One of my favorite Feynman diagrams

I am a professor for theoretical particle physics at RWTH Aachen University.

My main research field is to understand and predict phenomena at particle colliders. Within the last few years, I have been mostly interested in the physics of Higgs bosons in and beyond the Standard Model. Recently, I have also become interested in improving the connection between the perturbative and the lattice approach to quantum field theory through the gradient-flow formalism.

The menu on the left should help you navigate through this page. In particular, you can find a Brief CV, and details about my Research and Teaching activities.

It is important to try to convey some of our excitement about physics to the general public, high-school students, or politicians. As you can see in the Outreach section of this page, I have been quite active in this field. If you are interested in organizing an outreach activity (public lecture, information for high-school students etc.), feel free to contact me.

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Bachelor Topics for summer term 2022

Click on the titles to see more details.

To apply, follow the instructions here, where you can also find topics from the other members of our institute.

- **Automatic construction of effective field theories**
- **Asymptotic expansions and the Gradient Flow**
- **Feynman diagrams as a parlor game**
- **Schemes for γ_5**

last updated on Jan 25, 2022 by RH

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▼ Automatic construction of effective field theories

Effective Field Theories can describe physics beyond the Standard Model in a generic way. Their construction is algorithmic, but very cumbersome. In this project, you will learn the concepts of Effective Field Theories and contribute to developing an algorithm for their construction. This will be useful for the interpretation of data collected at the LHC and future colliders, in particular in the light of possible new discoveries.

Helpful pre-requisites:

- Affinity to theoretical physics, mathematics, and possibly computer algorithms.

▶ Asymptotic expansions and the Gradient Flow

▶ Feynman diagrams as a parlor game

▶ Schemes for γ_5

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▶ **Automatic construction of effective field theories**

▼ **Asymptotic expansions and the Gradient Flow**

The gradient flow formalism has been suggested in 2010 to facilitate practical calculations in Lattice QCD. It has proven to be accessible also in perturbation theory and provides a promising link between the two approaches to strong interactions. In this project, you are going to develop means to calculate the resulting Feynman integrals in a systematic way.

The student will learn:

- The general method of the gradient flow.
- Approaches to calculating non-standard Feynman integrals.

Requirements:

- Affinity to mathematics and theoretical physics.

▶ **Feynman diagrams as a parlor game**

▶ **Schemes for γ_5**

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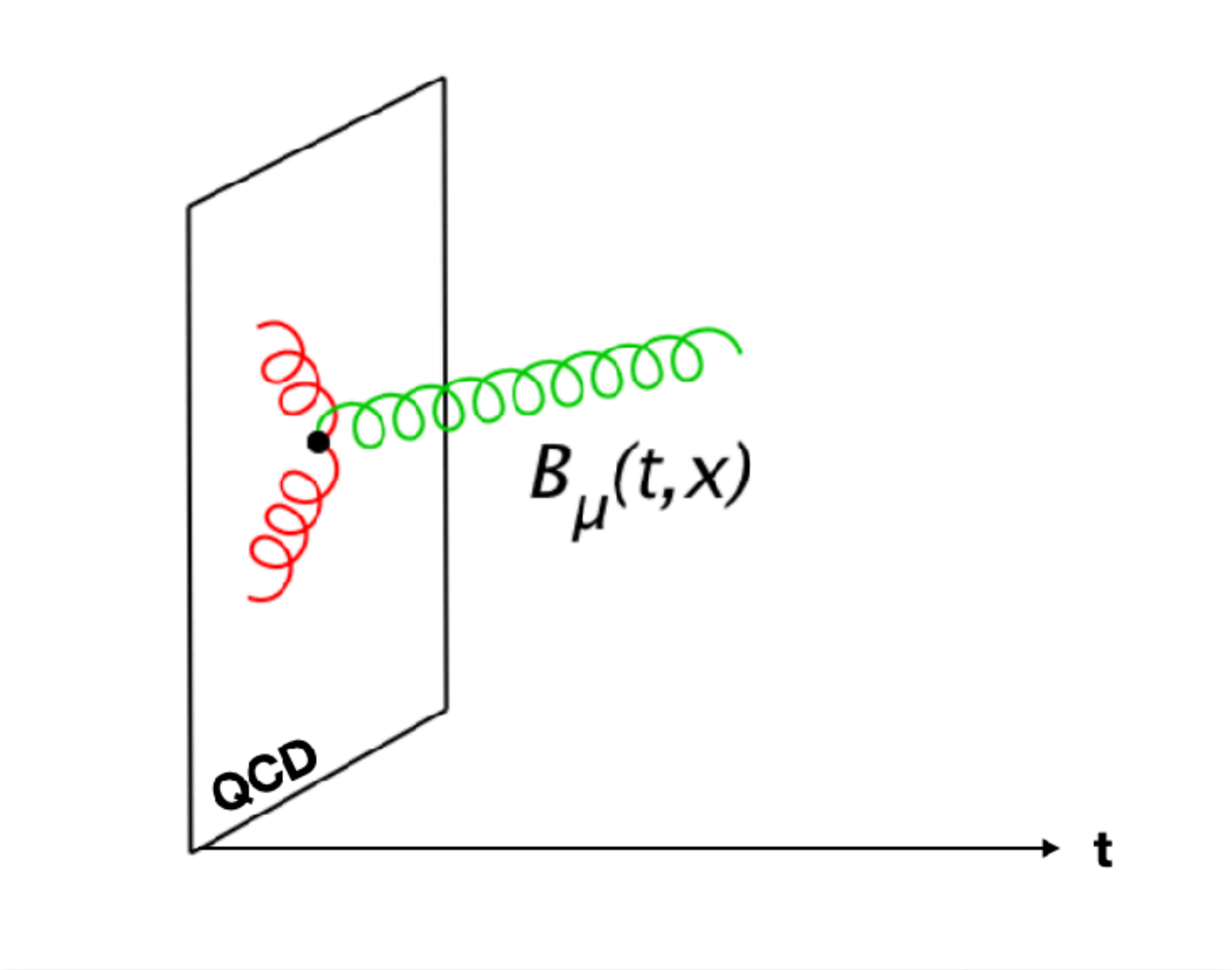

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▶ **Asymptotic expansions and the Gradient Flow**

▼ **Feynman diagrams as a parlor game**

Feynman diagrams provide a very algorithmic way to generate and represent processes in particle physics. In this project, you will devise a generalization of the parlor game Scrabble to Feynman diagrams.

The student will learn:

- The algorithmic structure of Feynman diagrams.

Requirements:

- Interest in Feynman diagrams.
- Affinity to computer programming.

▶ **Schemes for γ_5**

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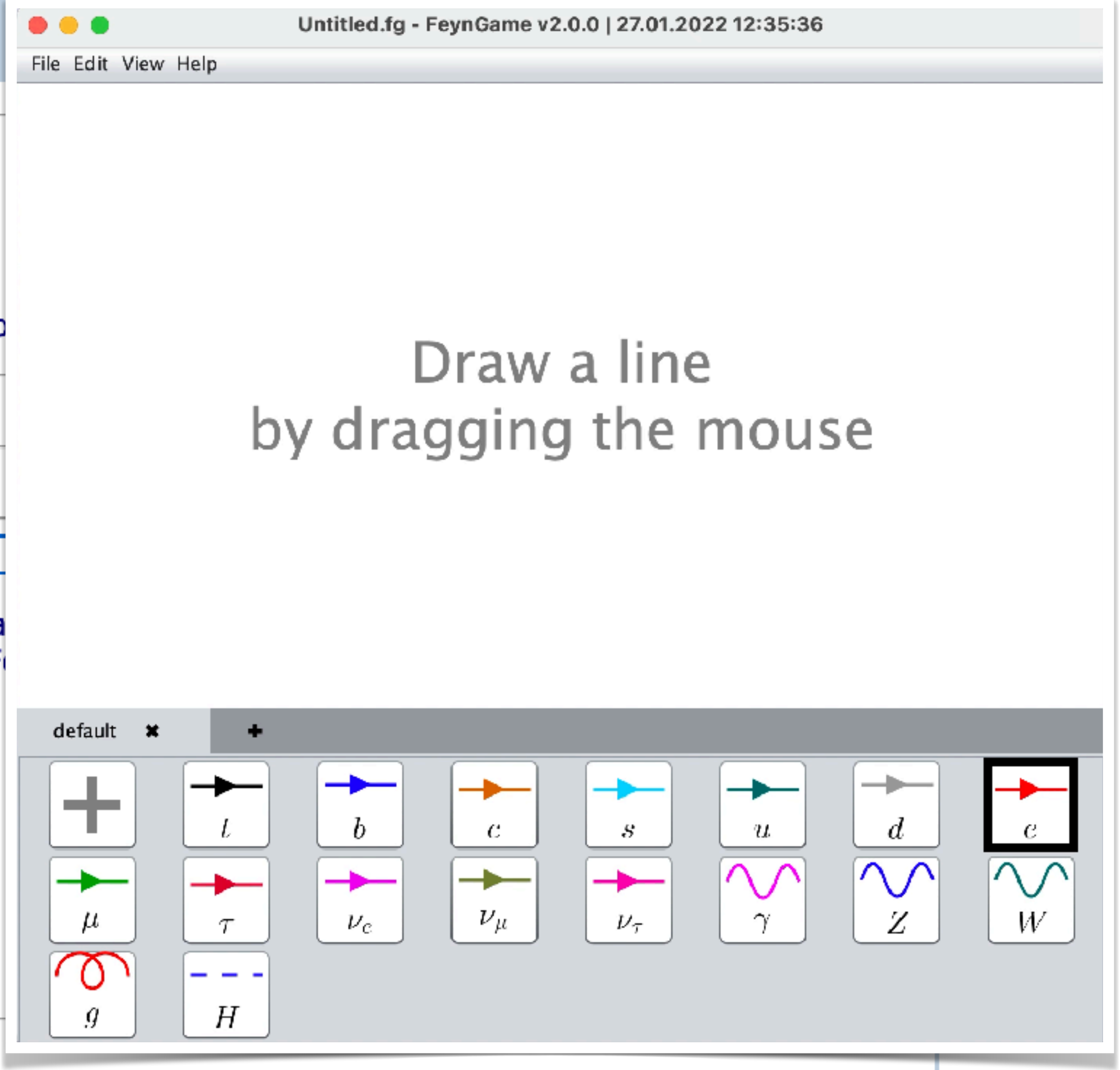

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DFG RTG

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▼ **Schemes for γ_5**

In quantum field theory, the chirality of fermions is implemented by means of projectors in the spinor space containing a tensor named γ_5. When moving from 4 to D dimensions, no natural generalization of chirality exists, and different schemes (i.e. consistent redefinitions of γ_5) may be employed to perform calculations. The implementation of such schemes in an automated computer code represents a valuable asset for modern phenomenological computations.

What to do

- Getting familiar with the concept of fermions and chirality in quantum field theory, as well as with the Kreimer scheme
- Write a computer code that applies the Kreimer scheme to a given amplitude and properly resolves Levi-Civita pseudotensors
- Apply the program to the computation of a cross section

Helpful prerequisites:

- Interest in theoretical physics.
- Basic computing skills.

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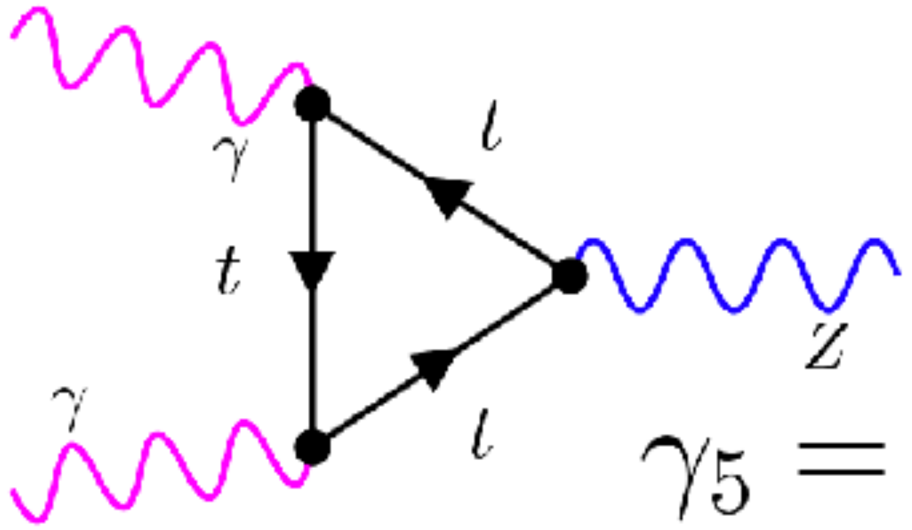

$$\gamma_5 = \frac{1}{4!}\,\epsilon_{\mu\nu\rho\sigma}\gamma^\mu\gamma^\nu\gamma^\rho\gamma^\sigma$$

$$\epsilon_{0123} = 1\,,\;\; \epsilon_{1023} = -1\,,\;\; \text{etc.}$$

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To discuss in person, join this zoom meeting on **Friday, 28 January 2022, at 4pm**, or write me an email.

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Thank you!

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