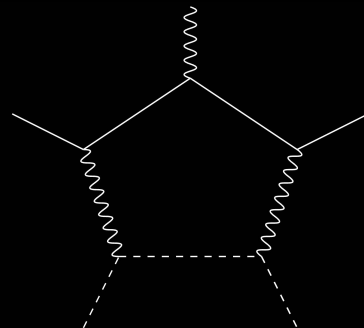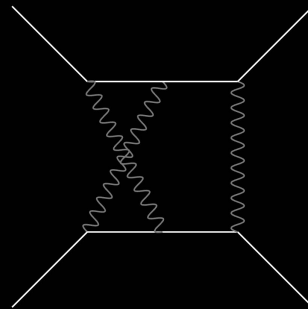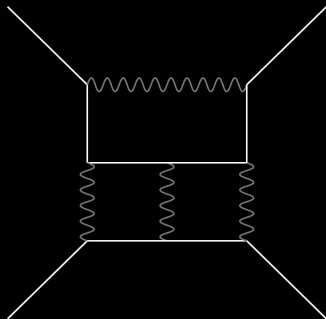# Multi-loop scattering amplitude calculations

T. Dave

In Collaboration with William J. Torres Bobadilla, Pau Petit Rosàs and Jérémy Paltrinieri
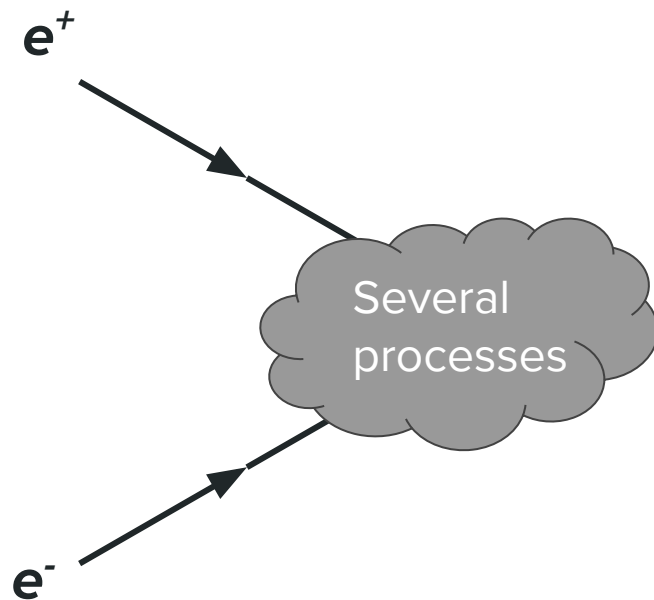
Overview

Two main areas of research currently:

- Three-Loop Massless QED processes

- Two-loop Massive Bhabha Scattering

Additionally:

- Possibly looking into the Tensor decomposition of $e^+e^- \to \pi^+\pi^-\gamma$

e^+

e^-

Several processes
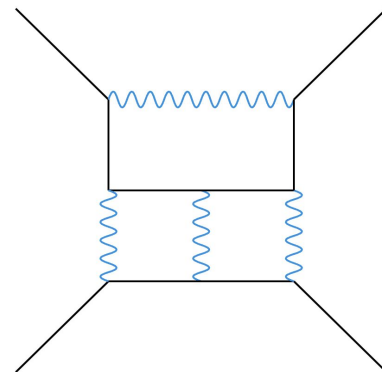
Three-loop Massless QED Processes

Aim: To compute the Helicity Amplitudes for four QED processes in at N^3LO in a massless model.
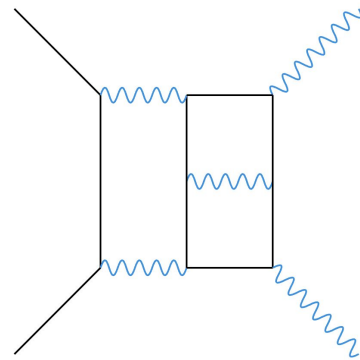
$$e^+ e^- \rightarrow \mu^+ \mu^- \, ,$$

$$e^+ \mu^- \rightarrow e^+ \mu^- \, ,$$

$$e^+ e^- \rightarrow e^+ e^- \, ,$$

$$e^+ e^- \rightarrow \gamma \gamma \, .$$

$$e^+ e^- \rightarrow \mu^+ \mu^-$$

$$e^+ e^- \rightarrow \gamma \gamma$$

Three-loop Massless QED Processes
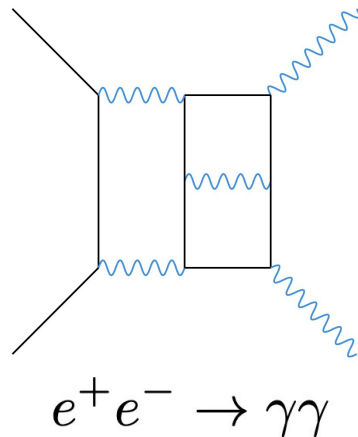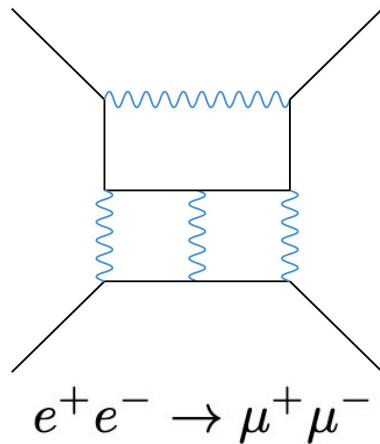
Completed:-

- Generation of diagrams and amplitudes.
- Grouping diagrams into families.
- Tensor decomposition.

In progress:-

- IBP Reduction of families.

To do:-

- Substitute analytic expressions of MIs.
- Remove Poles. https://arxiv.org/pdf/2002.09492

$$e^+e^- \rightarrow \mu^+\mu^-$$

$$e^+e^- \rightarrow \gamma\gamma$$
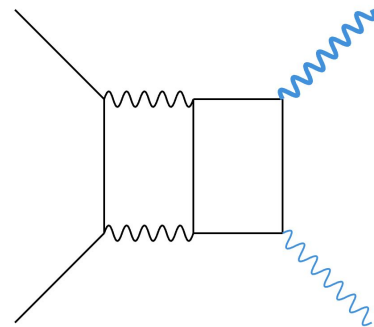
Two-loop Massive Bhabha Scattering

Aim: To construct the differential equations required to calculate the MIs at two-loop order. This will be helpful for:

- Understanding β functions required for YFS-Resummation.

$$\frac{d\sigma_{\text{soft}}(s)}{d\Omega} = \frac{d\sigma_0(s)}{d\Omega}\left|\exp\left[-\frac{\alpha}{\pi}\ln\left(\frac{E}{\Delta E}\right)\sum_{i,j}\frac{Q_iQ_j\epsilon_i\epsilon_j}{\beta_{ij}}\ln\left(\frac{1+\beta_{ij}}{1-\beta_{ij}}\right)\right]\right|^2,$$

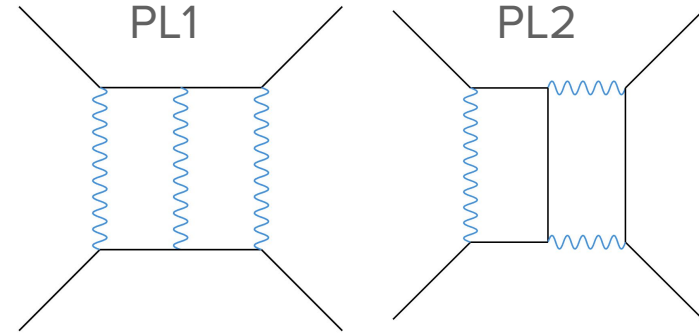- Understanding elliptic functions that appear in other processes we are interested in.

$$e^+e^- \rightarrow \gamma\gamma^*$$

Two-loop Massive Bhabha Scattering

PL1 PL2

Completed:-

- Differential equations formed for PL1 and PL2.
- Analytic expressions for MIs found (where possible) for PL1.
- Numerical values found for other MIs in PL1.
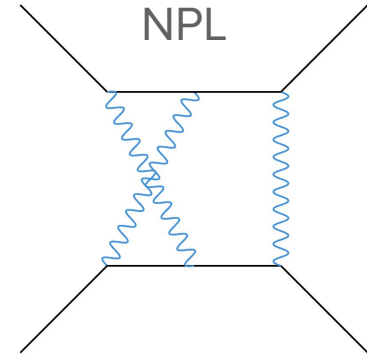- Numeric values for PL2.

In progress:-

- Analytic expressions for PL2.

NPL

To do:-

- Form differential equation for NPL.
- Find analytic/numeric expressions/values for MIs.

Tensor decomposition of e⁺e⁻ ➡ π⁺ π⁻ γ

Aim: To break the amplitudes for diagrams contributing to this process into form factors and eventually compute polarised amplitudes.

One-Loop QCD Corrections to $\bar{u}d \rightarrow t\bar{t}W$ **at** $\mathcal{O}(\varepsilon^2)$

Matteo Becchetti,[a] Maximilian Delto,[b,c] Sara Ditsch,[b,d] Philipp Alexander Kreer,[b] Mattia Pozzoli,[a] Lorenzo Tancredi[b]
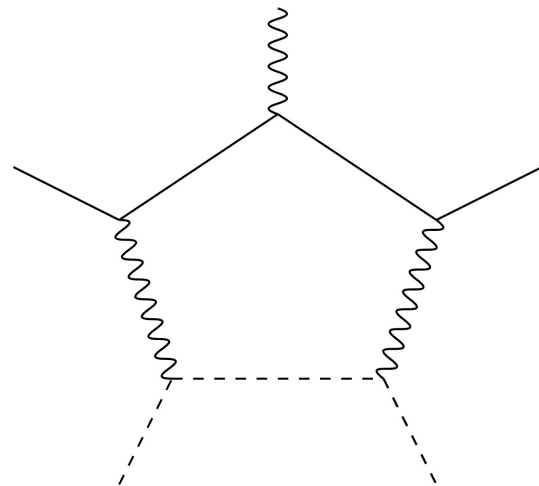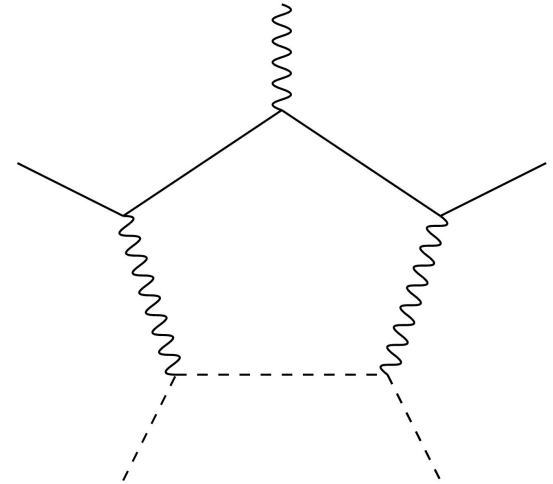
Tensor decomposition of $e^+e^- \rightarrow \pi^+ \pi^- \gamma$

Completed:-

- Find independent tensor structures for our process.
- Construct projector.

To do:-

- Apply projector to tree level amplitudes (Tests).
- Begin full process to find polarised amplitudes.

Thank you for listening and please ask any questions!