

# One-loop multi-leg calculations in gauge theories: Golem library

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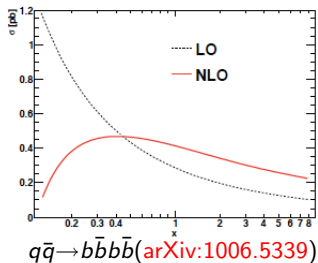
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**QCD Session**

## Why NLO?

- Calculating accurately signal and background for new physics
- Reducing the scale dependence

## Why Golem?

- Automation of 1-loop multi-leg computation :: QCD, SM and BSM



## What is golem95:

- Contains all building blocks of  $A_N^{1-loop}$  calculation
- Provides the numerical stability (if  $\det(G) \rightarrow 0$ )
- Computes IR divergent and IR finite integrals
- Calculates amplitudes with real or complex masses
- **GoSam** relies on the ability of golem95 to avoid  $\det(G)$

- **One-loop reduction:**

$$\mathcal{A}_N^d = C_4 \left[ \text{Square Diagram} \right] + C_3 \left[ \text{Triangle Diagram} \right] + C_2 \left[ \text{Bubble Diagram} \right] + C_1 \left[ \text{Bubble Diagram} \right] + \mathcal{R}$$

The diagram shows the decomposition of a general one-loop integral  $\mathcal{A}_N^d$  into a basis of four diagrams: a square, a triangle, and two different bubble diagrams. Each diagram is labeled with its coefficient ( $C_4, C_3, C_2, C_1$ ) and the number of external legs ( $d+1$  or  $j_i$ ). The last term is a remainder  $\mathcal{R}$ .

- **Basis integrals or end points of integral reduction:**

- $\left\{ I_2^d(j), I_3^d(j_1, \dots, j_r), I_3^{d+2}(j_1), I_4^{d+2}(j_1, \dots, j_r), I_4^{d+4}(j_1) \right\}$
- $d = 4 - 2\epsilon$

- **Why this choice of set of basis?**

- **The coefficients are free of  $1/\det(G)$**
- **IR divergences are isolated in  $I_3^4$**

- **golem95 integral implementation**

- **If  $\det(G)$  large: Analytical mode**
- **If  $\det(G)$  small: Numerical mode (1-dim representation)**

# Analytical vs Numerical calculation near $\det(G) = 0$

