FeynRules at NLO

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FeynRules 2012 workshop - towards NLO

In collaboration with B. Fuks

BAEF

FNRS

Outline

1. Introduction
2. R_2
   - Definition
   - How does it work?
   - Checks
3. UV counterterms
4. Conclusion

Outline

Automation of the NLO BSM computation requires :

- Real emissions :

  Tree-level vertices ✓

- Virtual contributions :

  1. Tree-level vertices ✓
  2. R_2 rational terms
  3. UV counterterms

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} d-regularization

Computed once from the Lagrangian

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What are the R_2 rational terms?

$$\bar{A}(\bar{q}) = \frac{1}{(2\pi)^4} \int d^d\bar{q} \frac{\bar{N}(\bar{q})}{\bar{D}_0 \bar{D}_1 \ldots \bar{D}_{m-1}}, \qquad \bar{D}_i = (\bar{q} + p_i)^2 - m_i^2$$

Finite (< 4 legs) set of vertices computed once for all!

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$$\bar{N}(\bar{q}) = N(q) + \widetilde{N}(\tilde{q}, q, \epsilon)$$

where $\bar{X}$ lives in d dimension, X in 4, $\widetilde{X}$ in ϵ.

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R_2 definition

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Assumptions

- For renormalizable theories :

  Only vertices with < 4 legs

- In Feynman gauge :

  All bosons are treated in the same way

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In practice

```
FeynRulesPath =
SetDirectory["~/trunk/feynrules-development"];
<< FeynRules`
LoadModel["R2/SMQI.fr"]
SetDirectory["/FeynArts-3.6/Models"];
WriteFeynArtsOutput[LSM, Output -> "SMQI",
GenericFile -> False, FlavorExpand -> SU2W]

Quit[]

SetDirectory["/FeynArts-3.6"];
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SetDirectory["~/trunk/feynrules-development/R2"];
<< R2`
WriteR2["SMQI/SMQI", "Lorentz", "SM"]
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← Model, generic, output

Output

```
SetDirectory["~/trunk/feynrules-development/R2"];
Get["SM.fr2"];

R2$Model = SMQI/SMQI;
R2$GenericModel = Lorentz;
R2$vertlist = {{{{S[1], 1}}, ((-I/32)*ee^2*(cw^4*
MZ^2 + MZ^2* sw^4 + 2*cw^2*(MW^2 + MZ^2*sw^2))*v)/
(cw^2*Pi^2*sw^2)}, ...};
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`R2$vertlist` contains the list of R_2 vertices

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Except for the color (No explicite index summation)

Time?

SM takes approx. 1h

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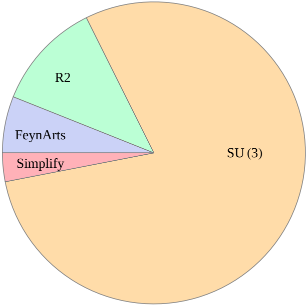

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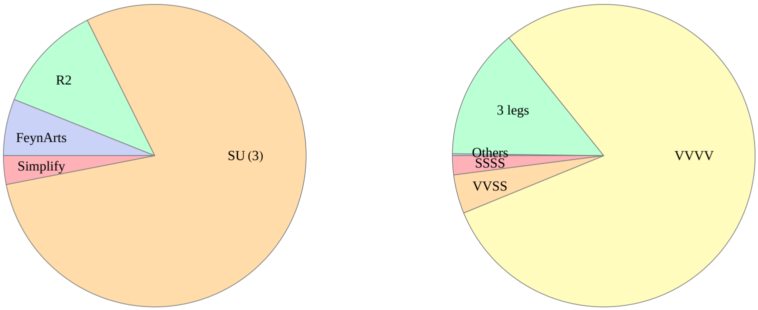

Checks

QCD : Draggiotis, P. et al. JHEP 0904 (2009) 072.

EW : Garzelli, M.V. et al. JHEP 1001 (2010) 040, Erratum-ibid. 1010 (2010) 097.

- 1-leg vertices : H only but not mentioned in the article
- 2-leg vertices : Done and agree up to $-1/i$ factors (definition of $A, \phi^{\pm}$)
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- 4-legs vertices : to do

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UV counterterms

Automatic renormalization in the MS-scheme with FeynRules :

1. Automated extraction of the renormalized Lagrangian ✓
2. Modification of the FeynArts interface to include counterterms ✓
3. Calculation of the renormalization constants with FormCalc

   Self-energies : 80% done

   Vertices
4. Re-injection in FeynRules

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