

FeynRules 2010 Workshop on Automatization for BSM Physics.

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Summary talk

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FeynRules 2010 Workshop @ Mont Sainte-Odile
March 14-19, 2010

Outline.

- 1 Activities of the working group zero - the unexpected.
- 2 Development of new quantum field theory functionalities.
- 3 Development of the FEYNRULES interfaces.
- 4 Model implementation, validation and diffusion.
- 5 Physics projects.
- 6 Summary - outlook.

Automatized cooking.

- **Bouchées vs. croustades.**



- **Properties.**

- * Canonical commutation rules.

$$\left[Croustade, Bouchée \right] = mushrooms(1 - \delta_{Croustade Bouchée})$$

- * **Non zero commutator \Rightarrow they are not the same!**

Automatized GPS localization.

- Localization in the Vosgian mountains.



- * Requires a bunch of **physicists** and a **map**.
- * **Precision:** $\mathcal{O}(1\text{km})$.
- * **Real GPS does not help** to reduce the error bars...

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Development of new quantum field theory functionalities.

- ① **Superfields.**
- ② **Mass matrices.**
- ③ **Higher dimensional operators.**
- ④ **FEYNRULES Java interface.**
- ⑤ **Automatic Validation Package from the Web.**

Implementation of superfields in FEYNRULES.

- **People:** Benj, Claude, Thomas.
- **Status:** The Wess and Zumino model is implemented and correct.

* Lagrangian:

$$\begin{aligned} \mathcal{L} &= \Phi_a^\dagger \Phi_a^a \Big|_{\theta^2 \bar{\theta}^2} + W(\Phi) \Big|_{\theta^2} + W^*(\Phi^\dagger) \Big|_{\bar{\theta}^2} \\ &= \partial_\mu \phi^\dagger \partial^\mu \phi + \frac{i}{2} (\psi \sigma^\mu \partial_\mu \bar{\psi} - \partial_\mu \psi \sigma^\mu \bar{\psi}) + F^\dagger F - \alpha_a F^a - \frac{1}{2} m_{ab} (\phi^a F^b + \\ &\quad \phi^b F^a + \psi^a \cdot \psi^b) - \frac{1}{6} \lambda_{abc} (\phi^a \phi^b F^c + \phi^a \phi^c F^b + \phi^b \phi^c F^a + \phi^a \psi^b \cdot \psi^c + \\ &\quad \phi^b \psi^c \cdot \psi^a + \phi^c \psi^a \cdot \psi^b) + \text{h.c.} \end{aligned}$$

* Implementation in FEYNRULES:

```
GetGrassmanCoefficient[ HC[LCSF[z,xi,f,aa]]*LCSF[z,xi,f,aa], 2,2] +
GetGrassmanCoefficient[ SuperW, 2,0] + GetGrassmanCoefficient[ HC[SuperW], 0,2]
```

- **To-do list:**
 - * Vector superfields (50%) plus some Grassman algebra.
 - * Re-implementation of the MSSM.
 - * Validation (together with FEYNARTS).

Mass matrices diagonalization issue.

- **People:** Martin, Neil, Benj, David, Thomas, Olivier, Christian.
- **Current workflow:** input → MC (dependent parameters, diagrams,...).
 - * MC tools computes **dependent parameters with their own routines**.
 - * The mass matrices are **not diagonalized automatically**.
 - * **Not all input parameters are independent** (e.g. rotation matrices).
- **New workflow:** input → calculator (dependent params) → MC (diagrams).
 - * The calculator is a **C library generated by FEYNRULES**.
 - * Two options:
 - ◇ The calculator **resolves all the dependencies**.
 - ◇ The MC **resolves the simple dependencies** (and overwrite them).
 - * FEYNRULES **links the calculator and the MC tool**.
- **Declaration in FEYNRULES.**

$$\{A[mu], Z[mu]\} == UW.\{W[mu, 3], B[mu]\} .$$

The calculator calculates UW from the Lagrangian.

Higher-dimensional operators.

- **People:** Claude, Fabio, Christian, Sasha.
- **Derivation of an iterative reduction algorithm:**
 - * **From n -point to $n - 3$ -point vertices.**
 - * Can be **easily proven.**
 - * **Limited application.**
 - ◇ Transport of Lorentz indices along auxiliary lines.
 - ◇ Need for spin > 2 fields.
- **To do:** full implementation.

Web-based tools (1).

- **People:**

- * Java interface: Neil, Christian.
- * Web-based automated validation package: Claude, Neil, Benj.

- **Status of the Java interface:**

- * **α -version of the Java interface** exists.
- * **Staged development proposed.**
 - ◇ Stage 1: representations and continuous symmetry groups (90%).
 - ◇ Stage 2: model info, (gauge) fields, local symmetry representations.
 - ◇ Stage 3: the Lagrangian.
 - ◇ Stage 4: ...
- * **Development not scheduled before the summer** (see FR-2011).

- **Status of the validation kit:** in discussion.

- * **Development is starting** (more to come).

Web-based tools (2).

- **New ticketing system on the FEYNRULES wiki.**
- **Components of the tickets.**
 - * Claude: FEYNRULES, SM.
 - * Neil: 3-site, CALCHEP-interface, mass diagonalization.
 - * Benj: MSSM, superfields, validation tools.
 - * Céline: FEYNARTS-interface.
 - * David: HERWIG-interface.
 - * Priscila: LED, UED.
 - * Olivier: PYTHON-interface.
 - * Christian: WHIZARD-interface.
- **For any given created ticket:**
 - * The **responsible is advertised.**
 - * **Please update your profile on the wiki.**
- There are still **strange stuff** to be fixed.
 - * **The submitter can force the assignment of his ticket.**

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Development of the FEYNRULES interfaces.

- 1 PYTHON **interface**.
- 2 HELAS **routines**.
- 3 FEYNARTS **interface**.

PYTHON interface.

- **People:** Claude, David, Olivier, Will.
- **Status:**
 - * To be used by **HERWIG and MADGRAPH**.
 - * A model is a **PYTHON package** with objects.
 - ◇ Particles.
 - ◇ Parameters.
 - ◇ ...
 - * **Self-contained**.
 - ◇ Everything is included with respect to the interface requirements.
 - * **Toy model:** simplified Hidden Abelian Higgs.
- **To do:**
 - * Some PYTHON routines, e.g., $\sqrt{\quad}$, \sin , ...
 - * Implementation of matrices as matrices (rather than components).
 - * Vertices and couplings management.
 - * Herwig part of the interface.

Automatized generation of the HELAS routines.

- **People:** Olivier, Claude, Will, Priscila, David.
- **Status:**
 - * To be used by **HERWIG** (C++) and **MADGRAPH** (FORTRAN).
 - * The **FEYNRULES output format is defined**.
 - * **Some automatically generated routines have been produced**.
 - * **Validation** is ongoing.
- **To do:**
 - * Speed optimization.
 - * Automatized generation (and comparison) of all existing HELAS routines.
 - * Complex couplings.
 - * C library for **PYTHIA**.

FEYNARTS interface.

- **People:** Céline, Thomas.
- **Status:**
 - * Inclusion of **higher-dimensional operators** in FEYNARTS.
 - * Dirac indices are **mandatory**.
 - ◇ Their format is defined in FEYNRULES.
 - ◇ They are almost implemented in FEYNARTS.
 - * **Validation** is ongoing (EFT-QCD, composite top, BFSM).
- **To do:**
 - * Discussions about the format of the Levi-Civita tensor.
 - * Automated generation of the FEYNARTS declaration file.
 - * Validation of other models.

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Model implementation, validation and diffusion.

- 1 **Survey of the existing/missing models.**
(see feynrules/wiki/SurveyModels).
- 2 **Les Houches validation scheme: application to FEYNRULES and LANCHEP.**
- 3 **FEYNRULES web-based model database.**

Model required to reach ★★☆☆ (1).

● The MSSM.

- * **People:** Benj, Sasha, Steffen, Christian.
- * **Discrepancies** in the CALCHEP-stock model.
- * **(Major) discrepancies** in SHERPA (the tool, not the models).
- * The **WHIZARD validation** is ongoing (well, up-to-now).

● Randall-Sundrum.

- * **People:** Neil, Sasha, Priscila, Christian.
- * Goal: a FEYNRULES-LANHEP joint validation.

● Walking technicolor.

- * **People:** Sasha, Fabio, Claude.
- * Goal: a FEYNRULES-LANHEP joint validation.

Model required to reach ★★☆☆ (2).

- **Little Higgs with T -parity conservation.**

- * **People:** Fabio, Sasha, Céline, Claude, Christian.
- * FEYNRULES-LANHEP-WHIZARD joint validation.

- **Lepto-quarks.**

- * **People:** Fabio, Sasha, Claude, Christian, Benj.
- * Implementation in FEYNRULES to be started.
- * FEYNRULES-LANHEP-joint validation.

- **Background field method.**

- * **People:** Fabio, Benj, Céline.
- * Implementation in FEYNRULES performed and checked.
- * Validation vs. literature and vs. FEYNARTS.

Model database.

● Model Database.

- * One **unique tag** for each model, e.g., model:1003.0123.
- * **Basic info**: authors, title, abstract, ...
- * **Validation info** (what has been done...)
- * **Version numbers** \Rightarrow tool chain ID maker.
- * Plots, tables, including the tool chain ID.
- * Pointers to relate papers, citation handling system.
- * Licensing.
- * Features allowing for corrections (see arXiv).
- * **Search engine**.

● Toolchain tagging for a (long) list of versioned software.

- * Two options:
 - ◇ A **central, unique, unchangeable tag** \Leftrightarrow retrieval of the chain.
 - ◇ A **decentral user-specific hashing** \Leftrightarrow hard retrieval.
- * Longer chain cans contain tags corresponding to (included) shorter chains.
- * Unique ID for **reproducible** workflow.
- * **Search engine**.

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Model implementation, validation and diffusion.

- ① Spin two physics.
- ② MC event generator for Z' including soft-gluon resummation.

Spin two physics.

- **People:** Sasha, Neil, Priscila, Christian.
- **Goals:**
 - * Validation of the **Large Extra Dimensions** (LED) model in FEYNRULES.
 - * Implementation of the **Randall-Sundrum I** (RSI) model in FEYNRULES.
 - * **Validation** against stock versions and LANHEP implementation.
 - * Use of the validated model to **study KK-graviton production**.
- **Status:**
 - * **LED-FR** is debugged.
 - * **RSI-FR** is implemented.
 - * **The CALCHEP-interface** can now handle spin two fields.
 - * **The WHIZARD-interface** can now handle spin two fields.
 - * **The LANHEP-implementation** is ongoing.
- **To-do:**
 - * Achieve the validation.
 - * Perform the physics study.

Z' physics.

- **People:** Sasha, Benj.
- **Goals:**
 - * Provide a **MC generator including QCD resummation for Z' production.**
 - * Investigate the **three universal** resummation formalisms.
- **Status:**
 - * **Resummed analytical formulas** are almost there.
- **To-do:**
 - * Perform the implementation (dealing with different integration spaces).
 - * Perform physics studies for various Z' models.

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Summary (1)

- **A lot of projects have started.**

- * Working group 1:

- ◇ Superfields.
- ◇ Mass matrices.
- ◇ Higher-dimensional operators.
- ◇ Web-based tools.

- * Working group 2:

- ◇ PYTHON-interface.
- ◇ HELAS routines.
- ◇ FEYNARTS-interface.

- * Working group 3:

- ◇ Survey of existing models.
- ◇ Implementation of new models (and validation).
- ◇ FEYNRULES web-based model database.

- * Working group 4:

- ◇ Spin two physics.
- ◇ Z' physics.

Summary (2)

- **This was a very productive workshop.**
 - * **More than one project per person.**
 - * Please **keep the wiki updated.**
- **It is not over → proceedings.**
 - * Contributions expected for **June 18th.**
 - * To be submitted **during the summer.**
- **Next workshop.**
 - * March-April 2011, on a cruise boat....
 - ◇ A new place every day.
 - ◇ Not really practical for the Internet.
 - * **March-April 2011, in Durham (?).**
 - ◇ To be confirmed...

Thanks

- **Thanks to all of you for coming.**
 - * We have managed to start a lot of exciting projects.
 - * The LHC is now running with two **3.5 TeV** beams!
 - * **Decent period to achieve all what we are doing!**
- **Thanks to the (not present) organizers.**
 - * Leila Ninous (from the IPHC).
 - * Nicolas Rudolff (IT department).
 - * Renate Bousquet and the Monastery people.
- **Thanks to the IPHC lab for support.**

Thanks again for coming!