Automatic Calculations of Multiloop Feynman Amplitudes: A Brief Introduction to Package **AmpRed**

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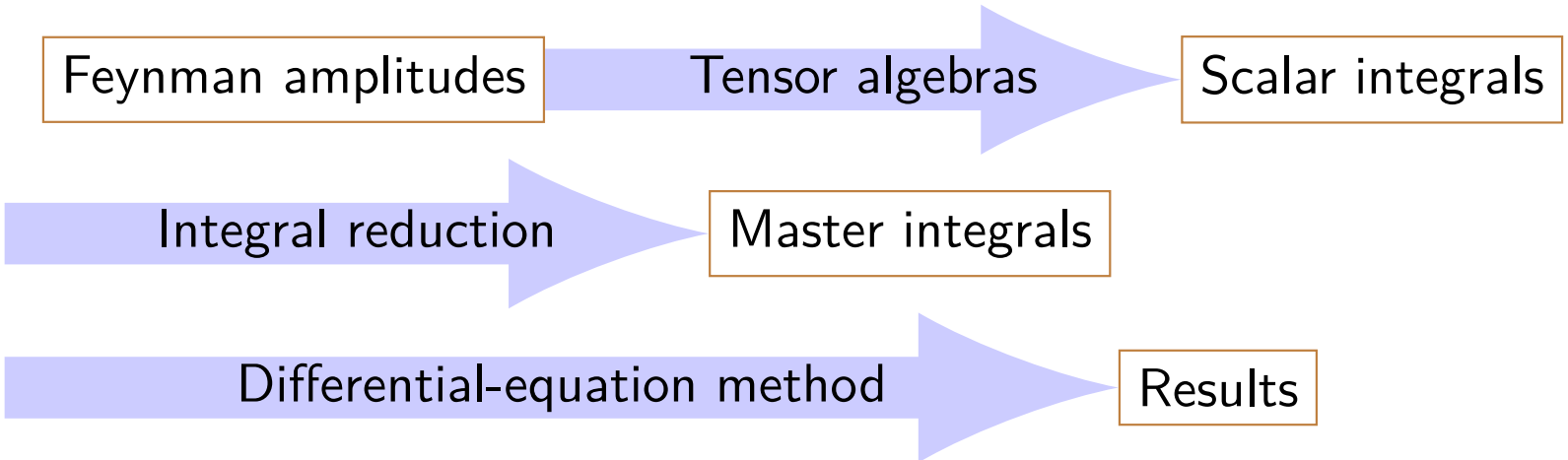
Contents

Modern techniques on amplitude calculations

Modern techniques on amplitude calculations

For one-loop calculations, see talks by Feng and Ma.



- Tensor algebras
  FORM, FormCalc, FeynCalc, ...
- IBP reductions
  FIRE, LiteRed, Reduze, KIRA, Blade, NeatIBP, ...
- Differential-equation method
  AMFlow

Foundations of **AmpRed**

- Integral reductions through the Feynman-parameter representation
  Chen (JHEP) 2020
  Chen (EPJC) 2020
  Chen (EPJC) 2021
- Recursive calculations of parametric integrals
  Chen, Luo, Yang, Zhu (JHEP) 2023

Usage of AmpRed

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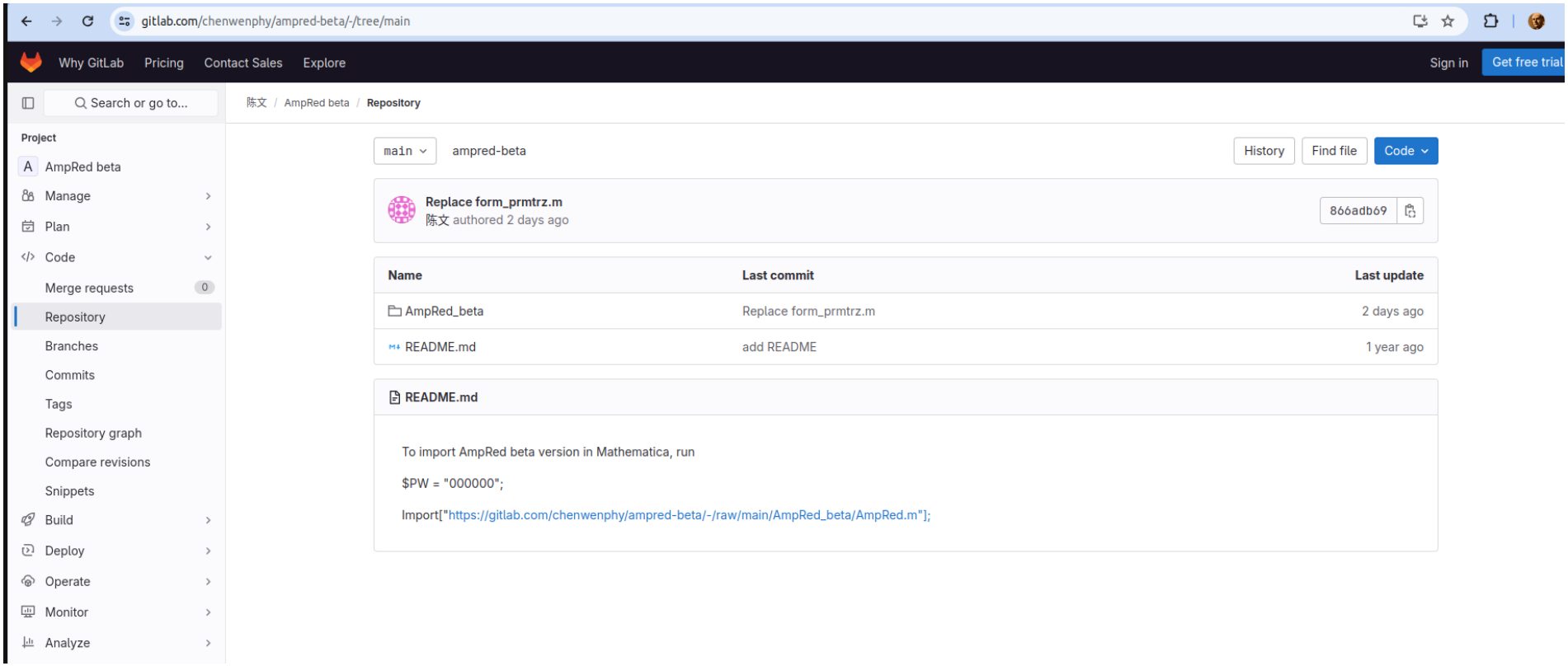


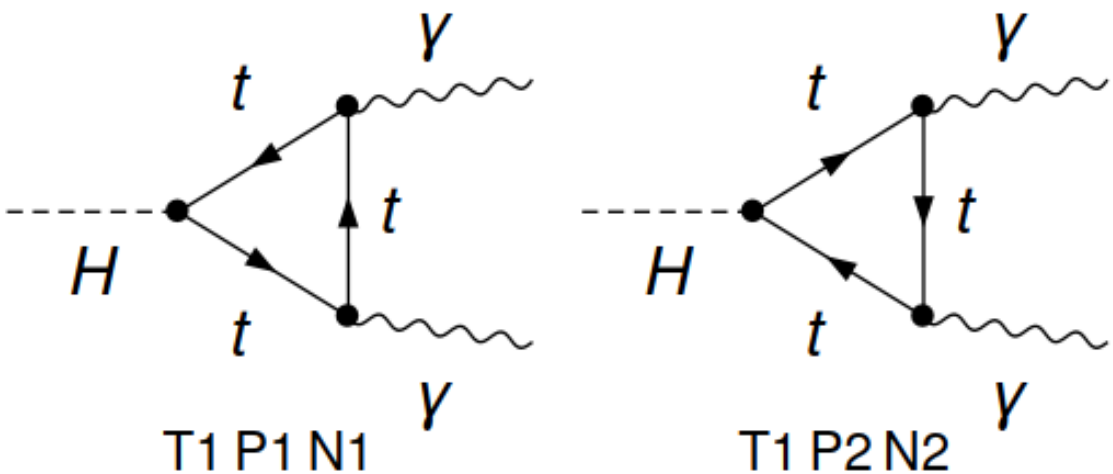
Import AmpRed

```
$PW = "000000";
Import["https://gitlab.com/chenwenphy/ampred-beta/-/raw/main/
AmpRed_beta/AmpRed.m"];
```

An example: Higgs decay

Generate amplitudes with FeynArts

$$H \to \gamma \quad \gamma$$



Define the kinematics:

```
FA["MH"] = FA["EL"] = 1; FA["MT"] = 2; FA["MW"] = 1 / 2; FA["SW"] = 1 / 2;
SetKinematics[{P} → {p[1], p[2]}, {FA["MH"]} → {0, 0}];
```

Convert amplitude:

```
amp = FA2AR[Get["HiggsDecay_Amplitude.m"], ToFeynmanInt → True] /. {_Incoming → P, Outgoing → p} // Total;
```

Tensor algebras:

```
amp1 = amp // SpinorChainSimplify;
```

Reduce Feynman integrals:

```
amp1 = AlphaReduce[amp];
```

Evaluate master integrals:

```
amp2 = AlphaIntEvaluateN[amp1, 4, PrecisionGoal → 40];
```

Result:

```
amp2[[1]] // epsSeries // Expand
```

$$2.405849879893931401263106428530777 4\, N_F\, p_1\cdot\epsilon^*_{p_2}\, p_2\cdot\epsilon^*_{p_1} +$$
$$0.005121531439332712760470582169255731\, N_F\, p_1\cdot\epsilon^*_{p_1}\, p_2\cdot\epsilon^*_{p_2} - 1.202924939946965700631553214265388 7\, N_F\, \epsilon^*_{p_1}\cdot\epsilon^*_{p_2}$$

```
SquareAmplitude[amp2[[1]]] // epsSeries
```

$$2.894056822292822074462701723327003454 7\, N_F^2$$

What else can **AmpRed** do?

- Tensor algebras in nonrelativistic theories
- Construct and solve differential equations for Feynman integrals
- Interfaces to packages, like FORM and KIRA

More examples

main / ampred-beta / AmpRed_beta / examples

History | Find file | Code

Update README
陈文 authored 3 days ago

99c33cd6

Name	Last commit	Last update
..		
Etac_Decay_Form+Kira.nb	Replace Etac_Decay_Form+Kira.nb	1 week ago
Etac_Decay_Form+Kira_2.nb	Replace Etac_Decay_Form+Kira_2.nb	1 week ago
HiggsDecay.nb	Replace HiggsDecay.nb	1 week ago
HiggsDecay_TwoLoop.nb	Replace HiggsDecay_TwoLoop.nb	1 week ago
README	Update README	3 days ago
banana.nb	Replace banana.nb	4 days ago
box.nb	Replace box.nb	4 days ago
cut_integral.nb	Replace cut_integral.nb	4 days ago
double_box.nb	Replace double_box.nb	4 days ago
four_lepton_decay.nb	Replace four_lepton_decay.nb	4 days ago
general_parametric_integrals.nb	Update General_Parametric_Integrals.nb	3 days ago

README

```
In this folder, some examples on using AmpRed are provided.
For beginners, it is suggested to start with the notebooks "HiggsDecay.nb", "box.nb", and "general_parametric_integrals.nb".
For users who're interested in the differential-equation method, it is suggested to read the notebooks "box.nb" and "banana.nb".
For some practical applications, see "Etac_Decay_Form+Kira.nb", "Etac_Decay_Form+Kira_2.nb", and "four_lepton_decay.nb".
```

Summary

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We present **AmpRed**, a package for the (semi-)automatic calculations of multiloop Feynman amplitudes. **AmpRed** implements the methods developed by the author to reduce Feynman integrals through the Feynman-parameter representation and to calculate parametric integrals recursively. Various functions on tensor algebras and loop calculations are provided by **AmpRed**. The usage is introduced through a detailed calculation of the Higgs two-photon decay.
Thanks for your attention!