flavio

a Python package for flavour and precision phenomenology in the Standard Model and beyond

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Abstract flavio is an open source tool for phenomenological analyses in flavour physics and other precision observables in the Standard Model and beyond. It consists of a library to compute predictions for a plethora of observables in quark and lepton flavour physics and electroweak precision tests, a database of experimental measurements of these observables, a statistics package that allows to construct Bayesian and frequentist likelihoods, and of convenient plotting and visualization routines. New physics effects are parameterised as Wilson coefficients of dimension-six operators in the weak effective theory below the electroweak scale or the Standard Model EFT above it. At present, observables implemented include numerous rare $B$ decays (including angular observables of exclusive decays, lepton flavour and lepton universality violating $B$ decays), meson-antimeson mixing observables in the $B_d$, $K$, and $D$ systems, tree-level semi-leptonic $B$, $K$, and $D$ decays (including possible lepton universality violation), rare $K$ decays, lepton flavour violating $\tau$ and $\mu$ decays, $Z$ pole electroweak precision observables, the neutron electric dipole moment, and anomalous magnetic moments of leptons. Not only central values but also theory uncertainties of all observables can be computed. Input parameters and their uncertainties can be easily modified by the user. Written in Python, the code does not require compilation and can be run in an interactive session. This document gives an overview of the features as of version 1.0 but does not represent a manual. The full documentation of the code can be found in its web site.
1 Introduction

The absence of any new particles beyond the Standard Model (SM) in high-energy collisions at the LHC highlights the need to probe the SM in low-energy experiments, at the high-intensity frontier, where new physics (NP) might leave its imprint through non-standard interactions among known particles, corresponding to higher-dimensional operators in an effective field theory (EFT). In this context, flavour physics plays a pivotal role for several reasons. First, flavour-changing neutral current (FCNC) processes such as rare meson decays or meson-antimeson mixing are forbidden at tree-level in the SM, so they are particularly sensitive to NP effects. Second, flavour physics is required to determine most of the free parameters in the SM, notably the three angles and the phase of the Cabibbo-Kobayashi-Maskawa (CKM) matrix.

A major challenge in flavour physics is the disentanglement of non-perturbative strong-interaction effects, affecting many hadronic low-energy observables, from possible NP contributions. In recent years, several apparent deviations from the SM have been observed in flavour physics, e.g. in angular observables of $B \rightarrow K^* \mu^+ \mu^-$ [1] or lepton flavour universality ratios in $B \rightarrow K^{(*)} \ell^+ \ell^-$ [2,3] and $B \rightarrow D^{(*)} \ell \nu$ [4]. In all of these cases, it is important to scrutinize the SM predictions and uncertainties, but also to investigate possible NP explanations. However, often the complicated dependence of flavour physics observables on the Wilson coefficients is a major obstacle in connecting flavour phenomenology and model building. In addition, it is difficult comparing different theoretical approaches with different methods, parameter choices, and statistical frameworks. This highlights the virtue of open source codes that allow to compute predictions for observables in the flavour sector in terms of NP effects parameterised by Wilson coefficients of dimension-6 operators, properly taking into account all hadronic and other uncertainties.

flavio is an open source Python package that contains

– a vast library of observables in flavour physics, electroweak precision tests, and other low energy observables, as function of dimension-6 Wilson coefficients in an EFT above or below the electroweak scale,
– a database of experimental measurements of these observables,
– a module to automatically construct likelihoods in terms of parameters and Wilson coefficients using these measurements,
– various plotting and visualization routines.

flavio overlaps in scope with several other open source packages in HEP, most notably

– EOS [5], written in C++, that allows to compute a large number of observables in $B$ physics and contains Bayesian sampling routines,
– **HEPfit** [6], written in C++, that contains a library not only of flavour physics but also electroweak precision tests and Higgs physics, implements specific dynamical NP models, and is focused on performing Bayesian analyses,
– **SuperIso** [7], written in C, that allows to compute many observables in $B$ physics in a general EFT or specific NP models.

The focus of **flavio** is different from these packages in some respects. In particular,
– it is written entirely in Python, allowing for a relatively easy extension, modification of the code at runtime, and interactive execution,
– thanks to Python it is trivial to install, not requiring compilation,
– it aims to include as many observables as possible where NP effects can be expressed in terms of dimension-6 Wilson coefficients, not necessarily limited to $B$ (or flavour) physics,
– it focuses on NP effects purely within an EFT rather than implementing specific NP models, leaving this to dedicated programmes (see e.g. [8,9]),
– it attempts to be general when it comes to the statistical approach, not committing to a Bayesian or frequentist framework.

Clearly, all the existing packages have advantages of their own and the crosscheck between them has proven to be very useful.

First released in early 2016, **flavio** has already used in a number of publications by various groups [10–31]. This note describes **flavio** as of version 1.0. The code is in active development, which takes place in a public GitHub repository [32]. Code contributions from the community (via pull requests) are encouraged. The full documentation can be found on the **flavio** website [33]. Tables 1 and 2 list the processes and observables implemented so far along with the references that were most relevant for the implementation of the process.

## 2 Getting started

### 2.1 Installation

**flavio** requires Python version 3.5 or above and runs on Linux, Mac, and Windows. Being hosted at the Python Package Index [96], it can be installed with a single command using the Python package manager `pip`:

```bash
$ python3 -m pip install flavio --user
```

Using the sampling and plotting functionality requires additional packages that can be installed with

```bash
$ python3 -m pip install flavio[sampling,plotting] --user
```

When a new version is released, the package can be easily upgraded by the command

1 Note that this is not necessarily the reference to the first discussion of a particular observable in the literature but in some cases a review article. For original references, please consult reviews of the field, e.g. [34,35].
2 Depending on the system, the Python 3 executable might have a name different from `python3`. 
### Table 1

| Category         | Process                  | Observables | References |
|------------------|--------------------------|-------------|------------|
| **Meson mixing** | $B^0 \leftrightarrow B^0$ | $\Delta M_d$, $a_\eta^d$ | [36–38]    |
|                  | $B_s \leftrightarrow B_s$ | $\Delta M_s$, $a_\eta^s$ | [36–38]    |
|                  | $K^0 \leftrightarrow K^0$ | $|\epsilon_K|$     | [39]       |
|                  | $D^0 \leftrightarrow \bar{D}^0$ | $x$, $y$, $\phi$, $q/p$, $\bar{x}_{12}$, $y_{12}$, $\phi_{12}$, $x_{12}^{\bar{x}}$ | [40]       |
| **Non-lept. $B$ decays** | $B^0 \rightarrow \psi K_S$ | $S_{\psi K_S}$ |            |
|                  | $B^0 \rightarrow \psi \phi$ | $S_{\psi \phi}$ |            |
| **Radiative $B$ decays** | $B \rightarrow X_{e,d} \gamma$ | BR, $A_{\text{CP}}$ | [41–43]    |
|                  | $B^+ \rightarrow K^{*+} \gamma$ | BR, $A_{\text{CP}}$ | [44,45]    |
|                  | $B^0 \rightarrow K^{*0} \gamma$ | BR, $S_{K^{*0} \gamma}$, $A_{\text{CP}}$ | [44–46]    |
|                  | $B_s \rightarrow \phi \gamma$ | BR, $S_{\phi \gamma}$, $A_{\Delta \Gamma}$ | [44,45,47] |
| **Rare lept. $B$ decays** | $B_{s,d} \rightarrow \ell^+ \ell^-$ | BR, $A_{\Delta \Gamma}$ | [48–50]    |
| **Rare SL $B$ decays** | $B^+ \rightarrow \ell^+ \nu$ | BR |            |
|                  | $B^{+0} \rightarrow K^{*+0} \nu \bar{\nu}$ | BR, $F_L$ | [45,51–53] |
|                  | $B^{+0} \rightarrow K^{+0} \nu \bar{\nu}$ | BR | [45,51–53] |
|                  | $B^{+0} \rightarrow \mu^+_0 \nu \bar{\nu}$ | BR | [45,51,52] |
|                  | $B^{+0} \rightarrow \pi^+_0 \nu \bar{\nu}$ | BR | [52,54,55] |
|                  | $B^{+0} \rightarrow K^{*+0} \ell^+ \ell^-$ | BR, $S_i$, $A_i$, $P_i^{(i)}$ | [44,45,56–62] |
|                  | $B^{+0} \rightarrow K^{+0} \ell^+ \ell^-$ | BR, $F_H$, $A_{\text{FB}}$ | [57,60,62–64] |
|                  | $B_s \rightarrow \phi \ell^+ \ell^-$ | BR, $F_L$, $S_i$ | [45,61,65] |
|                  | $A_s \rightarrow A\ell^+ \ell^-$ | BR, $F_L$, $A_L^{\ell,h,\ell h}$ | [66,67]    |
| **SL tree-level $B$ decays** | $B^{0,+} \rightarrow \pi^{0,+} \nu \bar{\nu}$ | BR | [62,68]    |
|                  | $B^{0,+} \rightarrow \rho^{0,+} \nu \bar{\nu}$ | BR | [45,62]    |
|                  | $B^{0,+} \rightarrow D^{*0,+} \nu \bar{\nu}$ | BR, $BR_{L,T}$, $F_L$, $dBR/d\chi_i$ | [62,69–71] |
|                  | $B^{0,+} \rightarrow D^{*0,+} \nu \bar{\nu}$ | BR | [62,69]    |
|                  | $B^- \rightarrow \omega \ell^- \bar{\nu}$ | BR | [45,62]    |
|                  | $B_s \rightarrow K^{*+} \ell^- \bar{\nu}$ | BR | [45,62]    |
| **Lep. tree-level $B$ decays** | $B^+ \rightarrow \ell \nu$ | BR |            |
|                  | $B_s \rightarrow \ell \nu$ | BR |            |
| **Rare $K$ decays** | $K^{*-L} \rightarrow \pi^{*0} \nu \bar{\nu}$ | BR | [52,72]    |
| **Non-leptonic $K$ decay** | $K \rightarrow \pi \pi$ | $e'/e$ | [73–78]    |
| **SL tree-level $K$ decays** | $K^+ \rightarrow \ell^+ \nu$ | BR | [79,80]    |
|                  | $K^{*-L} \rightarrow \pi^{0,+} \ell^- \bar{\nu}$ | BR | [80–83]    |
| **$\pi$ decays** | $\pi^+ \rightarrow e^+ \nu$ | BR | [79,80]    |

*Abbreviations:* SL – semi-leptonic, BR – branching ratio. In all processes involving final-state leptons, arbitrary violation of lepton flavour universality or charged lepton flavour is possible.
| Category          | Process          | Observables | References |
|-------------------|------------------|-------------|------------|
| LFV $\tau$ decays| $\tau \to \ell\gamma$ | BR | [84]      |
|                   | $\tau \to 3\mu$  | BR | [84]      |
|                   | $\tau \to \mu\tau$ | BR | [84]      |
|                   | $\tau \to \rho\ell$ | BR | [85]      |
|                   | $\tau \to \phi\ell$ | BR | [85]      |
| Tree-level $\tau$ decays | $\tau \to \ell\nu$ | BR | [86] |
|                   | $\tau \to K\nu$  | BR |          |
|                   | $\tau \to \pi\nu$ | BR |          |
| LFV $\mu$ decays | $\mu \to e\gamma$ | BR | [84] |
|                   | $\mu \to 3e$     | BR | [84] |
| $Z$ prod. & decay | $Z \to f\bar{f}$ | $\Gamma_Z, \Gamma_f, A, A_{FB}, R_f$ | [87, 88] |
|                   | $e^+e^- \to Z \to q\bar{q}$ | $\sigma_{had}$ | [87, 88] |
| $W$ prod. & decay | $W \to \ell\nu$  | BR | [87, 88] |
|                   | $W \to f\bar{f}'$ | $\Gamma_W$ | [87, 88] |
|                   | $m_W$            | BR | [88] |
| EDMs              | $d_n$            | BR | [89–91] |
| MDMs              | $a_e, a_\mu, a_\tau$ | BR | [92–94] |
| other             | $\nu_\mu N \to \nu_\mu \mu^- N$ | $R_{trident}$ | [95] |

Table 2: Processes and observables beyond quark flavour physics implemented in flavio 1.0. Abbreviations: BR – branching ratio, LFV – lepton flavour violation, EDM – electric dipole moment, MDM – (anomalous) magnetic dipole moment.

```bash
$ python3 -m pip install flavio --upgrade
```

Please report any installation problems on the Github issue page\(^3\).

2.2 Using flavio

As for any Python package, there are several ways of using flavio:

- As library imported in another script,
- In a simple interactive command-line interface (obtained by calling python3 in a terminal),
- In a more sophisticated and user-friendly interactive command-line interface (IPython [97]),
- In an interactive notebook interface, similar to Mathematica notebooks, running in a browser (Jupyter Notebook [98]).

For the installation of IPython or Jupyter, please consult the respective documentations.

When using flavio in a parameter scan or similar batch operation, it is advisable to implement the loop in Python and to import the package only once, as

\(^3\)https://github.com/flav-io/flavio/issues
the loading of the experimental measurements etc. leads to a significant, one-time overhead on import.

3 Overview of features

3.1 SM predictions and uncertainties

The most basic functionality of flavio is to compute predictions for flavour observables in the Standard Model (SM) and beyond. To get started, just import the package:

```python
import flavio
```

Observables are identified by strings. For instance, the time-integrated branching ratio of $B_s \rightarrow \mu^+\mu^-$ is identified by the string `BR(Bs->mumu)`. To get the central value of its SM prediction, use

```python
flavio.sm_prediction('BR(Bs -> mumu)')
```

The complete list of observables and their string names is available in the online documentation [33].

Some observables depend on additional parameters, like a dilepton invariant mass squared $q^2$. To get the differential branching ratio of $B^+ \rightarrow K^+\mu^+\mu^-$ at $q^2 = 3 \text{ GeV}^2$, use

```python
flavio.sm_prediction('dBR/dq2 (B^+->Kmumu)', q2=3)
```

Note that all dimensionful quantities in flavio are always assumed to be in units of GeV to the appropriate power.

To get the uncertainty of the SM prediction of the $B_s \rightarrow \mu^+\mu^-$ branching ratio, use

```python
flavio.sm_uncertainty('BR(Bs -> mumu)')
```

Uncertainties are computed by drawing random values for all input parameters according to their probability distribution, computing the observable for all of them, and extracting the standard deviation of the spread of values. Since this procedure involves random numbers, its precision depends on the number of random numbers. By default, the function uses 100 iterations. This can be increased by specifying the optional parameter $N=200$, for instance. Note that the relative error of the uncertainty as a function of $N$ is given by $\frac{\Delta \sigma}{\sigma} = 1/\sqrt{2N}$.

3.2 Predictions in the presence of new physics

flavio does not implement any specific NP models. Rather, it allows the user to specify NP contributions in the form of Wilson coefficients of dimension-6 operators, either in the weak effective field theory (WET) below the electroweak scale or
in the Standard Model effective field theory (SMEFT) above it. Since version 0.28,
the renormalization group evolution, matching, and basis translation is performed
using the wilson package [99] building on the Wilson coefficient exchange format
(WCxf) [100]. The default WCxf basis used by flavio for SMEFT is Warsaw, for
WET it is flavio. Other bases can be used if a corresponding translator is defined
in the wcxf Python package.

Using the wilson package, a new “parameter point” in the space of the EFT
maps to an instance of the class wilson.Wilson\(^4\). By default, all Wilson coeffi-
cients vanish. Note that these Wilson coefficients are defined to be the new physics
contributions only, so if they vanish it means we are in the Standard Model. To go
beyond the SM, the user must specify the values of the Wilson coefficients at some
scale. For instance, to get a universal NP contribution to \(B^0\) and \(B_s\) mixing via
the operators \((\bar{q}_R \gamma^\mu b_R)^2\) with \(q = d, s\),

```python
from wilson import Wilson
w = Wilson({'CVRR_bdbd': 1e-10, 'CVRR_bsbs': 1e-10},
           scale=160, eft='WET', basis='flavio')
```

The Wilson coefficients are referred to by their names. A complete list of operators
and Wilson coefficients is available on the WCxf web site [101] or in the flavio
documentation.

Having defined a NP scenario in this way, the central value of any observable
can now be obtained by calling the function `np_prediction`, e.g.

```python
flavio.np_prediction('DeltaM_s', w)
```

### 3.3 Experimental measurements

flavio contains a database of experimental measurements that allows to compare
the computed predictions to the data and to construct sophisticated likelihoods
for parameter inference (see section 4). The measurements are defined in a central
YAML file and new measurements can be easily added by the user. Internally,
measurements are defined as (univariate or multivariate) probability distributions
in the space of observables. To make this possible, the flavio.statistics sub-
module defines a number of one- and multidimensional probability distributions.
This allows in particular to deal with non-Gaussian and correlated measurements.

A simple use of the experimental measurements is to return the probability
distribution of a single observable (combining multiple measurements if applicable)

```python
d = flavio.combine_measurements('<Rmue>(B0->K*ll)',
                              q2min=1.1, q2max=6.0)
```

The properties of this distribution can now be studied by methods such as `d.central_value`,
`d.ppf` (percent point function, i.e. the inverse cumulative distribution function),

\[^4\]The class flavio.WilsonCoefficients is a subclass of wilson.Wilson defining additional
methods for backward compatibility.
d.error_right, etc. The PDF can also be plotted using the \texttt{flavio} plots submodule:

```python
import flavio.plots as fpl
fpl.pdf_plot(d)
fpl.plt.xlabel(r'$R_{K^*}$')
```

For binned measurements of observables depending on a kinematic variable (e.g. $q^2$), there are dedicated functions to plot all existing measurements and also the theory predictions. For instance, to compare the SM prediction to an experimental measurement of the $B \to D \ell \nu$ differential branching ratio, one can use\footnote{The \texttt{divide_binwidth} option is necessary to correctly compare the (dimensional) partial branching ratios to the (dimensionful) $q^2$-differential branching ratio.}

```python
fpl.bin_plot_exp('<BR >$\langle B^+ \to D \ell \nu \rangle$', divide_binwidth=True)
fpl.bin_plot_exp('<BR >$\langle B^+ \to D \ell \nu \rangle$', divide_binwidth=True)
fpl.diff_plot_th('dBR/dq2 ($B^+ \to D \ell \nu$)', 0.01, 11.6, label='SM')
fpl.plt.legend()
```

Labels etc. can be added using the usual functions of the \texttt{matplotlib} library.

### 4 Constructing likelihoods

Since \texttt{flavio} contains a submodule with statistical routines and a database of experimental measurements, it is straightforward to construct likelihoods that can be used for Bayesian or frequentist inference and for testing NP models.
4.1 General likelihoods

The basic class for general likelihoods is the `Likelihood` class in the `flavio.statistics.likelihood` module. It provides access to a likelihood function defined as

$$L(C, \theta) = \prod_i L_i^{\text{exp}} \left( O_i^{\text{exp}}, O_i^{\text{th}}(C, \theta) \right) \times L_\theta(\theta),$$  

where

- $C$ are a set of WET or SMEFT Wilson coefficients,
- $\theta$ a set of parameters,
- $O_i^{\text{th}}$ the theory predictions for the observables,
- $O_i^{\text{exp}}$ the experimental measurements of the observables,
- $L_i^{\text{exp}}$ the probability distributions that are defined in the database of experimental measurements,
- $L_\theta(\theta)$ the probability distribution associated to a parameter that is defined in an instance of the `flavio.ParameterConstraints` class.

The simplest possibility is to include in $L_\theta(\theta)$ all the constraints present by default in `flavio` and to include all the known measurements in $L_i^{\text{exp}}$. Then, a likelihood instance can be simply defined by specifying the observables to be included, e.g.

```python
from flavio.statistics.likelihood import Likelihood
llh = Likelihood(observables=['DeltaM_d', 'DeltaM_s'])
```

The logarithm of the likelihood $\ln L$ can now be evaluated by calling the `log_likelihood` method of the instance, specifying a dictionary of parameter values and the Wilson coefficients as an instance of `wilson.Wilson`. More options are described in the online documentation. A particularly useful feature is to load likelihood definitions from a YAML file.

At this point, a word of caution is in order: using the default option to include all constraints on parameters and all existing measurements can lead to inconsistent results in several cases, e.g.

- including constraints on parameters that come from measurements included in the likelihood (e.g., the default constraint on $V_{ub}$ that comes from $B \to \pi \ell \nu$),
- including multiple measurements that are not independent of each other.

It is the responsibility of the user to ensure a consistent treatment.

4.2 Fast likelihoods

While the likelihood (1) is very general and can be used for Bayesian or frequentist analyses, it has the drawback that it depends on a large number of parameters that must be varied to correctly account for theoretical uncertainties, but might not be of prime interest, i.e., nuisance parameters. Since marginalizing or profiling over nuisance parameters can be computationally demanding, `flavio` also provides an alternative way of constructing a likelihood, the `FastLikelihood`. It is based on
the approximation of assuming the likelihood to be of the form
\[-2 \ln L(C) = \sum_i x_i^T(C) [C_{\text{exp}} + C_{\text{th}}(\theta_0)]^{-1} x_i(C), \tag{2}\]
\[x_i(C) = O_{i\text{exp}} - O_{i\text{th}}(C, \theta_0). \tag{3}\]

where $C_{\text{exp}}$ is a covariance matrix of experimental measurements and $C_{\text{th}}$ a covariance matrix of theory predictions in the SM for the central values ($\theta_0$) of the theory parameters. $C_{\text{th}}$ is obtained from randomly sampling the observables for theory parameters distributed according to their PDFs, while $C_{\text{exp}}$ is obtained from approximating the true experimental PDFs as (multivariate) Gaussians.

This approach has the main advantage that it yields a likelihood independent of nuisance parameters, but the time-consuming step (namely evaluating the theoretical covariance $C_{\text{th}}$) is independent of the data. In particular, this makes this approach very powerful for fast inference after a change in experimental data.

However, its validity relies on a number of assumptions,

– the experimental uncertainties are approximated as Gaussian,
– the theory uncertainties (at the level of observables) are approximated as Gaussian,
– the covariances are assumed to be weakly dependent on $\theta$.

The last point is by far the strongest assumption and its validity has to be checked whenever the method is employed.

This method was employed in several model-independent analyses of new physics in $b \rightarrow s\ell\ell$ transitions [13,15,60].

4.3 Fits

While the fast likelihood discussed in 4.2 allows to directly investigate the likelihood function in the space of NP Wilson coefficients without having to deal with nuisance parameters, a more proper statistical treatment of nuisance parameters is desirable and even mandatory in some cases, e.g. when one of the assumptions underlying the fast likelihood is not satisfied. One can then choose either a Bayesian or a frequentist statistical framework to deal with the nuisance parameters. \texttt{flavio}'s likelihood module is written in a general way such that both approaches are supported.

In the Bayesian approach, $L_\theta$ in (1) would be interpreted as the prior probability distribution of the parameters and the function $L$ on the left-hand side would be the posterior probability distribution, up to normalization. To obtain a distribution only for a subset of the parameters, the others have to be marginalized, i.e. integrated over. This can be done efficiently in high dimensions using Monte Carlo methods, e.g. using nested sampling or Markov chains (MCMC).

In the frequentist approach, the parameters do not have prior probabilities associated to them; however, they can be subject to external, direct measurements that enter the likelihood separately. Even constraints that are purely theoretical can be formally treated in the same way\(^6\). Then, the factor $L_\theta$ in (1) simply corresponds to this likelihood of pseudo-measurements of theory parameters. In

\(^6\)See [102] for a general discussion of the theory uncertainties in the frequentist approach.
flavio, all nuisance parameters have a probability density function associated to them and the form of this PDF can be chosen to mimick different treatments of theory uncertainties. For instance, a normal distribution would correspond to treating the theory uncertainties like a statistical uncertainty, while a uniform distribution would lead to a treatment similar to the Rfit [103] scheme.

In flavio, marginalization and profiling routines are contained in the flavio. statistics.fitters submodule. Currently, it contains

- a wrapper around the emcee [104] MCMC sampler,
- a wrapper around the pypmc [105] MCMC sampler,
- a custom frequentist likelihood profiler added in v0.22.

These routines have already been used in published papers (see e.g. [10] for an application of a Bayesian MCMC and [29] for an application of the likelihood profiler). However due to the new likelihood module introduced in version 1.0, the interface is subject to change, which is why the reader is referred to the online documentation for updated usage instructions.

5 Further information and outlook

The purpose of this document was to give an overview of the features of the flavio package at a specific point in time corresponding to the release of version 1.0. A detailed and updated documentation of the evolving package can be found on the flavio website [33]. It also contains the link to an interactive tutorial running as a Jupyter notebook on a virtual machine (powered by Binder) that allows the user to try the package in a browser without installing anything.

Since flavio is open source, code contributions and improvements are highly welcome. In particular, many precision observables are still missing as of version 1.0. Thanks to the wilson project, the scope includes not only flavour physics observables, but in fact any observable where NP effects can be parametrized as dimension-6 Wilson coefficients in the SMEFT (or the weak effective theory). Observables that can play an important role in testing the SM and are currently not included in the package include

- Non-leptonic $B$ decays,
- Rare $D$ decays,
- atomic EDMs,
- nuclear and neutron beta decays,
- dijet and dilepton contact interaction searches at LHC,
- four-lepton contact interaction searches at LEP,
- flavour-blind CP-conserving low-energy precision measurements, e.g. atomic parity violation,
- Higgs production and decay,

and many more.

Implementing more and more of these low-energy precision tests of the SM, flavio can serve as the basis of a global likelihood in EFT parameter space that can serve as a powerful tool to test extensions of the SM in the future [85].
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