RGESolver

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Chapter 1

<tt>RGESolver</tt>

A C++ library to perform renormalization group evolution of SMEFT coefficients, both numerically and with the leading-log approximation. The general flavour case at dimension-six level is considered. Operators that violate lepton and/or baryon number conservation are not considered. The documentation for this library can be found here

RGESolver is a free software under the copyright of the GNU General Public License.

1.1 Dependencies

- BOOST : BOOST is a C++ library which can be obtained from the BOOST website or from Linux package managers or Mac ports. RGESolver only requires the BOOST headers, not the full libraries, so a header-only installation is sufficient.
- GSL : The GNU Scientific Library (GSL) is a C library for numerical computations. It can be found on the GSL website. Most Linux package managers will have a stable version as will any ports for Mac.
- C++11 : A compiler that supports at least C++11 standard is required.

1.2 Installation

The installation of RGESolver requires the availability of CMake in the system (version 3.1 or greater). A description of CMake and the instructions for its installation can be found in the CMakewebsite. Clone the repository with

```
git clone https://github.com/silvest/RGESolver --recursively
```

The installation can be performed writhing the following lines in a terminal session (in the RGESolver directory):

```
mkdir build && cd $_
cmake .. <options>
cmake --build .
cmake --install .
```

Note that depending on the setting of installation prefix (see below) the user might need root privileges to be able to install RGESolver.

1.2.1 Command line options for the installation

- -DLOCAL_INSTALL:BOOL=<ON or OFF> : to install RGESolver in the directory build/install (default: OFF).
- -DCMAKE_INSTALL_PREFIX:PATH=<RGESolver installation directory> : the directory in which RGESolver will be installed (default: /usr/local). This variable cannot be modified when -DLOCAL INSTALL ALL=ON is set.
- -DDEBUG_MODE:BOOL=<ON or OFF> : to enable the debug mode (default: OFF).
- -DBOOST_INCLUDE_DIR:PATH=<include path>/boost/ : CMakechecks for BOOST headers availability in the system and fails if they are not installed. Thus, if BOOST is not installed in the predefined search path, the user can specify where it is with this option. The path must end with the boost/directory which contains the headers.
- -DGSL_CONFIG_DIR:PATH=<gsl-config directory> : RGESolver uses gsl-config to get the GSL parameters. If this is not in the predefined search path, the user can specify it with this option.

1.3 Usage

The rgesolver-config script is available in the <CMAKE_INSTALL_PREFIX>/bin directory (default: /usr/local), which can be invoked with the following options:

- --cflags: to obtain the include path needed for compilation against the RGESolver.
- --libs: to obtain the flags needed for linking against the RGESolver.

If the path <CMAKE_INSTALL_PREFIX>/bin is not in the predefined search path, the compilation will (most likely) fail. if the user wants to use the compilation command above, it is suggested to add <CMAKE_INSTA↩ LL_PREFIX>/bin to the $PATH variable. Alternatively, the script can be invoked from a terminal session in <CMAKE_INSTALL_PREFIX>/bin to visualize the paths to the library and to the headers.

After the installation, the example program Example1.cpp (available in the Examples directory) can be compiled with the command

```
g++ -o app Example1.cpp `rgesolver-config --cflags` `rgesolver-config --libs`
```

1.4 Uninstall

The user can uninstall the library typing in a terminal session in the build directory:

```
cmake --build . --target uninstall
```

Also in this case, depending on the setting of installation prefix, the user might need root privileges to be able to uninstall RGESolver.

Chapter 2

Class Index

2.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

Chapter 3

Class Documentation

3.1 RGESolver Class Reference

A class that performs renormalization group evolution in the context of the SMEFT.

`#include <RGESolver.h>`

Public Member Functions

- RGESolver ()
  The default constructor. It initializes to 0 all the SMEFT coefficients.
- ~RGESolver ()
  The default destructor.

Parameters related to the numeric integration.

- double epsrel ()
  Getter for the relative error used in the numerical integration.
- double epsabs ()
  Getter for the absolute error used in the numerical integration.
- void Setepsrel (double epsrel)
  Setter for the relative error used in the numerical integration (default value = 0.005)
- void Setepsabs (double epsabs)
  Setter for the absolute error used in the numerical integration (default value = e-13)

Evolution

- void Evolve (std::string method, double muI, double muF)
  Performs the RGE evolution.
- void EvolveToBasis (std::string method, double muI, double muF, std::string basis)
  Performs the RGE evolution and performs the back rotation on the coefficients with flavour indices.
- void GenerateSMInitialConditions (double mu, std::string basis, std::string method)
  Generates the initial conditions for Standard Model's parameters (gauge couplings, Yukawa coupling, quartic coupling and Higgs' boson mass) at the scale `mu` (in GeV), using one-loop pure SM beta functions. At such scale, the CKM matrix is computed.
- void GenerateSMInitialConditions (double muIn, double muFin, std::string basis, std::string method, double g1in, double g2in, double g3in, double lambdain, double mh2in, double Muin[3], double Mdin[3], double Mein[3], double s12in, double s13in, double s23in, double deltain)

Generates the initial conditions for Standard Model's parameters (gauge couplings, Yukawa coupling, quartic coupling and Higgs' boson mass) at the scale mu (in GeV), using one-loop pure SM beta functions.

- void EvolveSMOnly (std::string method, double muI, double muF)

  Same as Evolve, but only for the SM parameters. The user should use this method instead of Evolve when interested in pure SM running. Using this function is the same of using Evolve with all the SMEFT coefficients set to 0, but it is faster since it does compute only the evolution for the SM parameters.

Input/output

- double GetCKMAngle (std::string name)

  Getter function for the CKM matrix angles $\theta_{12}, \theta_{13}, \theta_{23}$.
- double GetCKMRealPart (int i, int j)

  Getter function for the CKM matrix (real part)
- double GetCKMImagPart (int i, int j)

  Getter function for the CKM matrix (imaginary part)
- double GetCKMPhase ()

  Getter function for the CKM matrix phase δ.
- void SetCoefficient (std::string name, double val)

  Setter function for scalar/0F parameters (no flavour indices).
- void SetCoefficient (std::string name, double val, int i, int j)

  Setter function for 2F parameters (2 flavour indices).
- void SetCoefficient (std::string name, double val, int i, int j, int k, int l)

  Setter function for 4F parameters (4 flavour indices).
- double GetCoefficient (std::string name)

  Getter function for scalar/0F parameters (no flavour indices).
- double GetCoefficient (std::string name, int i, int j)

  Getter function for 2F parameters (2 flavour indices).
- double GetCoefficient (std::string name, int i, int j, int k, int l)

  Getter function for 4F parameters (4 flavour indices). one of the inserted indices is outside the [0:2] range, an error message is printed and the value 0 is returned.
- void Reset ()

  Resets all the SMEFT coefficients to 0 and the SM parameters to their default value. ϵ_{abs} and ϵ_{rel} are reset to their default value.
- void SaveOutputFile (std::string filename, std::string format)

  Saves the current values of parameters in a file.

3.1.1 Detailed Description

A class that performs renormalization group evolution in the context of the SMEFT.

The class solves the Renormalization Group Equations (RGEs) both numerically and in the leading-log approximation. Only operators up to dimension six that preserve lepton and baryon numbers are considered. The operator basis is the Warsaw basis, defined in https://arxiv.org/abs/1008.4884. The class splits real and imaginary part of each complex parameter.

The numerical integration is performed with an adaptive step-size routine (the explicit embedded Runge-Kutta-Fehlberg method), using the tools in the GNU Scientific Library. See https://www.gnu.org/software/gsl/doc/html/ode-initval.html for all the details.
The accuracy level of the numerical integration can be tuned selecting the parameters $\epsilon_{rel}, \epsilon_{abs}$ and the integration step using the dedicated setter functions.

All the SMEFT coefficients are set using the SetCoefficient methods and accessed with the GetCoefficient methods. There exist three different signatures for each method, depending on the number of flavour indices of the parameter (0,2,4).

These two routines must be used also for the SM parameters $g_1, g_2, g_3, \lambda, m_h^2, \mathrm{Re}(\mathcal{Y}_u), \mathrm{Im}(\mathcal{Y}_u), \mathrm{Re}(\mathcal{Y}_d), \mathrm{Im}(\mathcal{Y}_d), \mathrm{Re}(\mathcal{Y}_e), \mathrm{Im}(\mathcal{Y}_e)$ (we follow https://arxiv.org/abs/1308.2627 for what concerns the conventions in the Higgs' sector).
A complete list of the keys that must be used to correctly invoke setter/getter methods are given in tables 3.1, 3.2, 3.3 and 3.4.
A summary of the operators symmetry classes is given in table 3.5.

We follow http://www.utfit.org/UTfit/Formalism for what concerns the conventions for the CKM matrix.

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Table 3.1 Standard Model parameters. The labels in the left column must be used with the GetCoefficient method, the ones in the right column must be used with GetCKMAngle methods.

Parameter	Name
g_1	g1
g_2	g2
g_3	g3
λ	lambda
m_h^2 [GeV^2]	mh2
$\mathrm{Re}(\mathcal{Y}_u)$	YuR
$\mathrm{Im}(\mathcal{Y}_u)$	YuI
$\mathrm{Re}(\mathcal{Y}_d)$	YdR
$\mathrm{Im}(\mathcal{Y}_d)$	YdI
$\mathrm{Re}(\mathcal{Y}_e)$	YeR
$\mathrm{Im}(\mathcal{Y}_e)$	YeI

Parameter	Name
$\sin(\theta_{12})$	s12
$\sin(\theta_{13})$	s13
$\sin(\theta_{23})$	s23

Table 3.2 Scalar (and real) SMEFT operators.

Classes 1-3 Coefficient	Name
C_G	CG
$C_{\tilde{G}}$	CGtilde
C_W	CW
$C_{\tilde{W}}$	CWtilde
C_H	CH
$C_{H\Box}$	CHbox
C_{HD}	CHD

Class 4 Coefficient	Name
C_{HG}	CHG
$C_{H\tilde{G}}$	CHGtilde
C_{HW}	CHW
$C_{H\tilde{W}}$	CHWtilde
C_{HB}	CHB
$C_{H\tilde{B}}$	CHBtilde
C_{HWB}	CHWB
$C_{H\tilde{W}B}$	CHWtildeB

Table 3.3 2F SMEFT operators.

Class 5 Coefficient	Name	Symmetry
$\mathrm{Re}(C_{eH})$	CeHR	WC1
$\mathrm{Im}(C_{eH})$	CeHI	WC1
$\mathrm{Re}(C_{uH})$	CuHR	WC1
$\mathrm{Im}(C_{uH})$	CuHI	WC1
$\mathrm{Re}(C_{dH})$	CdHR	WC1
$\mathrm{Im}(C_{dH})$	CdHI	WC1

Class 6 Coefficient	Name	Symmetry
$\mathrm{Re}(C_{eW})$	CeWR	WC1
$\mathrm{Im}(C_{eW})$	CeWI	WC1
$\mathrm{Re}(C_{eB})$	CeBR	WC1
$\mathrm{Im}(C_{eB})$	CeBI	WC1
$\mathrm{Re}(C_{uG})$	CuGR	WC1
$\mathrm{Im}(C_{uG})$	CuGI	WC1
$\mathrm{Re}(C_{uW})$	CuWR	WC1
$\mathrm{Im}(C_{uW})$	CuWI	WC1
$\mathrm{Re}(C_{uB})$	CuBR	WC1
$\mathrm{Im}(C_{uB})$	CuBI	WC1
$\mathrm{Re}(C_{dG})$	CdGR	WC1
$\mathrm{Im}(C_{dG})$	CdGI	WC1
$\mathrm{Re}(C_{dW})$	CdWR	WC1
$\mathrm{Im}(C_{dW})$	CdWI	WC1
$\mathrm{Re}(C_{dB})$	CdBR	WC1
$\mathrm{Im}(C_{dB})$	CdBI	WC1

Class 7 Coefficient	Name	Symmetry
$\mathrm{Re}(C_{Hl1})$	C↩ Hta11R	WC2R
$\mathrm{Im}(C_{Hl1})$	CHl1I	WC2I
$\mathrm{Re}(C_{Hl3})$	CHl3R	WC2R
$\mathrm{Im}(C_{Hl3})$	CHl3I	WC2I
$\mathrm{Re}(C_{He})$	CHeR	WC2R
$\mathrm{Im}(C_{He})$	CHeI	WC2I
$\mathrm{Re}(C_{Hq1})$	CHq1R	WC2R
$\mathrm{Im}(C_{Hq1})$	CHq1I	WC2I
$\mathrm{Re}(C_{Hq3})$	CHq3R	WC2R
$\mathrm{Im}(C_{Hq3})$	CHq3I	WC2I
$\mathrm{Re}(C_{Hu})$	CHuR	WC2R
$\mathrm{Im}(C_{Hu})$	CHuI	WC2I
$\mathrm{Re}(C_{Hd})$	CHdR	WC2R
$\mathrm{Im}(C_{Hd})$	CHdI	WC2I
$\mathrm{Re}(C_{Hud})$	CHudR	WC1
$\mathrm{Im}(C_{Hud})$	CHudI	WC1

Table 3.4 4F SMEFT Operators.

Class 8 $(\bar{L}L)(\bar{L}L)$		
Coefficient	**Name**	**Symmetry**
$\mathrm{Re}(C_{ll})$	`CllR`	WC6R
$\mathrm{Im}(C_{ll})$	`CllI`	WC6I
$\mathrm{Re}(C_{qq1})$	`Cqq1R`	WC6R
$\mathrm{Im}(C_{qq1})$	`Cqq1I`	WC6I
$\mathrm{Re}(C_{qq3})$	`Cqq3R`	WC6R
$\mathrm{Im}(C_{qq3})$	`Cqq3I`	WC6I
$\mathrm{Re}(C_{lq1})$	`Clq1R`	WC7R
$\mathrm{Im}(C_{lq1})$	`Clq1I`	WC7I
$\mathrm{Re}(C_{lq3})$	`Clq3R`	WC7R
$\mathrm{Im}(C_{lq3})$	`Clq3I`	WC7I

Class 8 $(\bar{L}R)(\bar{L}R)$		
Coefficient	**Name**	**Symmetry**
$\mathrm{Re}(C_{quqd1})$	`Cquqd1R`	WC5
$\mathrm{Im}(C_{quqd1})$	`Cquqd1I`	WC5
$\mathrm{Re}(C_{quqd8})$	`Cquqd8R`	WC5
$\mathrm{Im}(C_{quqd8})$	`Cquqs8I`	WC5
$\mathrm{Re}(C_{lequ1})$	`Clequ1R`	WC5
$\mathrm{Im}(C_{lequ1})$	`Clequ1I`	WC5
$\mathrm{Re}(C_{lequ3})$	`Clequ3R`	WC5
$\mathrm{Im}(C_{lequ3})$	`Clequ3I`	WC5

Class 8 $(\bar{R}R)(\bar{R}R)$		
Coefficient	**Name**	**Symmetry**
$\mathrm{Re}(C_{ee})$	`CeeR`	WC8R
$\mathrm{Im}(C_{ee})$	`CeeI`	WC8I
$\mathrm{Re}(C_{uu})$	`CuuR`	WC6R
$\mathrm{Im}(C_{uu})$	`CuuI`	WC6I
$\mathrm{Re}(C_{dd})$	`CddR`	WC6R
$\mathrm{Im}(C_{dd})$	`CddI`	WC6I
$\mathrm{Re}(C_{eu})$	`CeuR`	WC7R
$\mathrm{Im}(C_{eu})$	`CeuI`	WC7I
$\mathrm{Re}(C_{ed})$	`CedR`	WC7R
$\mathrm{Im}(C_{ed})$	`CedI`	WC7I
$\mathrm{Re}(C_{ud1})$	`Cud1R`	WC7R
$\mathrm{Im}(C_{ud1})$	`Cud1I`	WC7I
$\mathrm{Re}(C_{ud8})$	`Cud8R`	WC7R
$\mathrm{Im}(C_{ud8})$	`Cud8I`	WC7I

Class 8 $(\bar{L}R)(\bar{R}L)$		
Coefficient	**Name**	**Symmetry**
$\mathrm{Re}(C_{ledq})$	`CledqR`	WC5
$\mathrm{Im}(C_{ledq})$	`CledqI`	WC5

Class 8 $(\bar{L}L)(\bar{R}R)$		
Coefficient	**Name**	**Symmetry**
$\mathrm{Re}(C_{le})$	`CleR`	WC7R
$\mathrm{Im}(C_{le})$	`CleI`	WC7I
$\mathrm{Re}(C_{lu})$	`CluR`	WC7R
$\mathrm{Im}(C_{lu})$	`CluI`	WC7I
$\mathrm{Re}(C_{ld})$	`CldR`	WC7R
$\mathrm{Im}(C_{ld})$	`CldI`	WC7I
$\mathrm{Re}(C_{qe})$	`CqeR`	WC7R
$\mathrm{Im}(C_{qe})$	`CqeI`	WC7I
$\mathrm{Re}(C_{qu1})$	`Cqu1R`	WC7R
$\mathrm{Im}(C_{qu1})$	`Cqu1I`	WC7I
$\mathrm{Re}(C_{qu8})$	`Cqu8R`	WC7R
$\mathrm{Im}(C_{qu8})$	`Cqu8I`	WC7I
$\mathrm{Re}(C_{qd1})$	`Cqd1R`	WC7R
$\mathrm{Im}(C_{qd1})$	`Cqd1I`	WC7I
$\mathrm{Re}(C_{qd8})$	`Cqd8R`	WC7R
$\mathrm{Im}(C_{qd8})$	`Cqd8I`	WC7I

Table 3.5 Symmetry categories for operators in the SMEFT. nF indicates the number of flavour indices for each category.

Parameter	Name
0	0F scalar object
WC1	2F generic real matrix
WC2R	2F Hermitian matrix (real part)
WC2I	2F Hermitian matrix (imaginary part)
WC5	4F generic real object
WC6R	4F two identical $\bar{\psi}\psi$ currents (real part)
WC6I	4F two identical $\bar{\psi}\psi$ currents (imaginary part)
WC7R	4F two independent $\bar{\psi}\psi$ currents (real part)

Parameter	Name
WC7I	4F two independent $\bar{\psi}\psi$ currents (imaginary part)
WC8R	$\mathcal{C}_{ee}$ (real part)
WC8I	$\mathcal{C}_{ee}$ (imaginary part)

Table 3.6 SM parameters used by default to generate SM initial conditions at an arbitrary scale. The scale at which these parameters are given is $\mu = 173.65$ GeV. We follow http://www.utfit.org/UTfit/Formalism for what concerns the conventions for the CKM matrix.

Parameter	Value
g_1	0.3573
g_2	0.6511
g_3	1.161
λ	0.1297
m_h^2 [GeV^2]	15650
$\sin(\theta_{12})$	0.225
$\sin(\theta_{13})$	0.042
$\sin(\theta_{23})$	0.003675
δ [rad]	1.1676

Parameter	Value [GeV]
m_u	0.0012
m_c	0.640
m_t	162.0
m_d	0.0027
m_s	0.052
m_b	2.75
m_e	0.000511
m_μ	0.1057
m_τ	1.776

3.1.2 Member Function Documentation

3.1.2.1 Evolve()

```
void RGESolver::Evolve (
            std::string method,
            double muI,
            double muF )
```

Performs the RGE evolution.

RGEs are solved with the chosen method from `muI` to `muF`. Currently, the available methods are "Numeric" and "Leading-Log".
The evolutor takes as initial values the current values of the parameters, set with the SetCoefficient functions. After completing the evolution the values of the parameters are updated and are accessible with the GetCoefficients function.

Parameters

method	resolution method
muI	initial energy scale (in GeV)
muF	final energy scale (in GeV)

3.1.2.2 EvolveSMOnly()

```
void RGESolver::EvolveSMOnly (
            std::string method,
            double muI,
            double muF )
```

Same as Evolve, but only for the SM parameters. The user should use this method instead of Evolve when interested in pure SM running. Using this function is the same of using Evolve with all the SMEFT coefficients set to 0, but it is faster since it does compute only the evolution for the SM parameters.

Parameters

method	resolution method
muI	initial energy scale (in GeV)
muF	final energy scale (in GeV)

3.1.2.3 EvolveToBasis()

```
void RGESolver::EvolveToBasis (
            std::string method,
            double muI,
            double muF,
            std::string basis )
```

Performs the RGE evolution and performs the back rotation on the coefficients with flavour indices.

After the evolution, the CKM matrix is computed. A flavour rotation is performed on the coefficients to go in the chosen basis.

Parameters

method	resolution method
muI	initial energy scale (in GeV)
muF	final energy scale (in GeV)
basis	flavour basis after the evolution ("UP" or "DOWN").

3.1.2.4 GenerateSMInitialConditions() [1/2]

```
void RGESolver::GenerateSMInitialConditions (
            double mu,
            std::string basis,
            std::string method )
```

Generates the initial conditions for Standard Model's parameters (gauge couplings, Yukawa coupling, quartic coupling and Higgs' boson mass) at the scale `mu` (in GeV), using one-loop pure SM beta functions. At such scale, the CKM matrix is computed.

The initial conditions are generated at the scale `mu` starting from the values at $\mu = 173.65$ GeV in table 3.6.

Parameters

mu	Scale (in GeV) at which the initial conditions are generated
basis	Flavour basis (`"UP"` or `"DOWN"`)
method	Method used by RGESolver to run the SM parameters to the scale `mu` (`"Numeric"` or `"Leading-Log"`)

3.1.2.5 GenerateSMInitialConditions() [2/2]

```
void RGESolver::GenerateSMInitialConditions (
            double muIn,
            double muFin,
            std::string basis,
            std::string method,
            double g1in,
            double g2in,
            double g3in,
            double lambdain,
            double mh2in,
            double Muin[3],
            double Mdin[3],
            double Mein[3],
            double s12in,
            double s13in,
            double s23in,
            double deltain )
```

Generates the initial conditions for Standard Model's parameters (gauge couplings, Yukawa coupling, quartic coupling and Higgs' boson mass) at the scale `mu` (in GeV), using one-loop pure SM beta functions.

The initial conditions are generated at the scale `muFin` starting from the inserted parameters at the scale `muIn`. This method should be used with usual fermion hierarchy (smallest mass for the 1st generation and greatest mass for the 3rd withoud mass degeneracy for all up and down quarks and for charged leptons). The generation of the initial conditions is performed only if all the masses are non-negative and if $\sin\theta_{ij} \in (0,1)$, $\delta \in (\pi, \pi]$.

Parameters

muIn	Low-energy input scale (in GeV)
muIn	Scale (in GeV) at which the initial conditions are generated

Parameters

basis	Flavour basis ("UP" or "DOWN")
method	Method used by RGESolver to run the SM parameters to the scale mu ("Numeric" or "Leading-Log")
g1in	g_1
g2in	g_2
g3in	g_3
lambdain	λ
mh2in	m_h^2 (in GeV^2)
Muin	Array containing the masses of the up-type quarks in GeV in the order (m_u, m_c, m_t)
Mdin	Array containing the masses of the down-type quarks in GeV in the order (m_d, m_s, m_b)
Mein	Array containing the masses of the charged leptons in GeV in the order (m_e, m_μ, m_τ)
s12in	The sine of the CKM matrix angle $\sin\theta_{12}$
s13in	The sine of the CKM matrix angle $\sin\theta_{13}$
s23in	The sine of the CKM matrix angle $\sin\theta_{23}$
deltain	The CKM matrix phase δ

3.1.2.6 GetCKMAngle()

```
double RGESolver::GetCKMAngle (
            std::string name )
```

Getter function for the CKM matrix angles $\theta_{12}, \theta_{13}, \theta_{23}$.

This method should be called only after methods that choose a specific flavour basis (as GenerateSMInitialConditions or EvolveToBasis), otherwise the CKM matrix is not updated.

Parameters

name	of the angle (see table 3.1)

Returns

The selected CKM angle.

3.1.2.7 GetCKMImagPart()

```
double RGESolver::GetCKMImagPart (
            int i,
            int j )  [inline]
```

Getter function for the CKM matrix (imaginary part)

This method should be called only after methods that choose a specific flavour basis (as GenerateSMInitialConditions or EvolveToBasis), otherwise the CKM matrix is not updated.

Returns

The imaginary part of the selected CKM matrix element.

3.1.2.8 GetCKMPhase()

```
double RGESolver::GetCKMPhase ( )
```

Getter function for the CKM matrix phase δ.

This method should be called only after methods that choose a specific flavour basis (as GenerateSMInitialConditions or EvolveToBasis), otherwise the CKM matrix is not updated.

Returns

The CKM matrix phase δ.

3.1.2.9 GetCKMRealPart()

```
double RGESolver::GetCKMRealPart (
            int i,
            int j )  [inline]
```

Getter function for the CKM matrix (real part)

This method should be called only after methods that choose a specific flavour basis (as GenerateSMInitialConditions or EvolveToBasis), otherwise the CKM matrix is not updated.

Returns

The real part of the selected CKM matrix element.

3.1.2.10 GetCoefficient() [1/3]

```
double RGESolver::GetCoefficient (
            std::string name )
```

Getter function for scalar/0F parameters (no flavour indices).

Parameters

name	name of the parameter (see table 3.2)

Returns

the requested parameter

3.1.2.11 GetCoefficient() [2/3]

```
double RGESolver::GetCoefficient (
            std::string name,
            int i,
            int j )
```

Getter function for 2F parameters (2 flavour indices).

If at least one of the inserted indices is outside the [0:2] range, an error message is printed and the value 0 is returned.

Parameters

name	name of the parameter (see table 3.3)
i	first flavour index
j	second flavour index

Returns

the requested parameter

3.1.2.12 GetCoefficient() [3/3]

```
double RGESolver::GetCoefficient (
            std::string name,
            int i,
            int j,
            int k,
            int l )
```

Getter function for 4F parameters (4 flavour indices). one of the inserted indices is outside the [0:2] range, an error message is printed and the value 0 is returned.

Parameters

name	name of the parameter (see table 3.4)
i	first flavour index
j	second flavour index
k	third flavour index
l	fourth flavour index

Returns

the requested parameter

3.1.2.13 SaveOutputFile()

```
void RGESolver::SaveOutputFile (
            std::string filename,
            std::string format )
```

Saves the current values of parameters in a file.

Currently, only "SLHA" format is implemented

Parameters

filename	Name of the output file
format	Format of the output file

3.1.2.14 SetCoefficient() [1/3]

```
void RGESolver::SetCoefficient (
            std::string name,
            double val )
```

Setter function for scalar/0F parameters (no flavour indices).

Parameters

name	name of the parameter (see table 3.2)
val	its value

3.1.2.15 SetCoefficient() [2/3]

```
void RGESolver::SetCoefficient (
            std::string name,
            double val,
            int i,
            int j )
```

Setter function for 2F parameters (2 flavour indices).

If at least one of the inserted indices is outside the [0:2] range, an error message is printed and no assignation is performed.

Parameters

name	name of the parameter (see table 3.3)
val	its value
i	first flavour index
j	second flavour index

3.1.2.16 SetCoefficient() [3/3]

```
void RGESolver::SetCoefficient (
            std::string name,
            double val,
            int i,
            int j,
            int k,
            int l )
```

Setter function for 4F parameters (4 flavour indices).

If at least one of the inserted indices is outside the [0:2] range, an error message is printed and no assignation is performed.

Parameters

name	name of the parameter (see table 3.4)
val	its value
i	first flavour index
j	second flavour index
k	third flavour index
l	fourth flavour index

The documentation for this class was generated from the following files:

- Solver/src/RGESolver.h
- Solver/src/RGESolver.cpp
- Solver/src/StaticMembers.cpp
- Solver/src/BetaFunction.cpp
- Solver/src/SettersAndGetters.cpp

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