

DOS Extraction

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Chapter 1

Index

1.1 Introduction

This program allows to extract the Density of States (DoS), assessed by means of capacitance-voltage measurements, in an organic semiconductor device. Simulated values are fitted to experimental data.

All source and header files are written in C++11 language.

The software is intended to be used on a Unix-like operating system.

1.2 Dependancies

The program requires the following software to be installed on your system:

- **CMake** (version 2.8 or above), a cross-platform configuration tool;
- **Make** (version 3.8.1 or above), a tool used to build executables;
- **GCC** (version 4.8 or above), the GNU Compiler Collection;
- **Eigen** (version 3.2 or above), to handle with matrices, vectors and linear algebra;
- **Gnuplot** (version 4.6.4 or above), a graphical utility to generate plots (the package **gnuplot-x11**, a terminal for X servers, is also required for the interactive interface);
- **Boost** (version 1.50 or above), a set of libraries used by [gnuplot-iostream](#).

It also uses the following libraries, shipped in the *include/* folder:

- **GetPot** (version 1.1.18), to parse command-line and configuration files;
- **gnuplot-iostream** (version 2), a C++ interface for [Gnuplot](#).

Parallel computing capabilities are provided through the **OpenMP** library, shipped together with **GCC**.

1.3 Compile

In order to generate the executable, first open the *CMakeLists.txt* file (in the top-level folder) and, if necessary, edit it to your needs.

Then create a build directory and move into it:

```
$ mkdir build
$ cd build
```

Now you're ready to configure your system:

```
$ cmake ..
```

Note

or, should you want the compiler to produce also debug symbols:

```
$ cmake -DCMAKE_BUILD_TYPE=Debug ..
```

and finally:

```
$ make
```

will build the *simulate_dos* executable and the *dosextraction* shared library under the *bin/* and *lib/* directories (or the ones specified in *CMakeLists.txt*) respectively.

If you wish to install:

- the executable, into */usr/local/bin/*;
- the shared library, into */usr/local/lib/*;
- the header files, into */usr/local/include/dosextraction/*;

just type:

```
# make install
```

while:

```
# make uninstall
```

will remove them.

If **Doxygen** (version 3.8.6 or above) and **GraphViz** are found, the following command will generate the present documentation under the *doc/* folder (or the one specified in *CMakeLists.txt*):

```
$ make doc
```

1.4 Set up the configurations

Note

The default configuration directory is *config/*.

Before you can run the executable, you have to set up the configuration file (default: *config.pot*). Within it you can find a list of parameters, each of which is commented out to explain what modifying it will entail.

Particularly, the variables *input_params* and *input_experim* can be set, i.e. the filenames where to find input fitting parameters and experimental data respectively. It's recommended (but not compulsory) to put these files in the same directory as the configuration file (otherwise you can specify a relative or absolute path to them).

Warning

The program never checks that the input values are numeric but will always cast them to floating point numbers, then please pay attention while setting up the variable *skipHeaders*.

You can create multiple configuration files, each with different parameter values: the one you aim to use can be specified in the command-line before running.

1.5 Run!

To run by using the default configuration filename (*config.pot*) simply move into the directory where the executable is located in and type:

```
$ ./simulate_dos
```

By default, the configuration file is searched in *../config*.

To specify a different configuration file previously saved in the configuration directory:

```
$ ./simulate_dos -f configuration_filename
```

or:

```
$ ./simulate_dos --file configuration_filename
```

The variable *configuration_filename* should **not** contain the path.

Warning

Furthermore, if you run the program from a different folder or if you chose a different configuration directory, you have also to manually specify the path to the configuration directory (either absolute or relative to the current directory) by using:

```
$ ./simulate_dos -d configuration_directory
```

or:

```
$ ./simulate_dos --directory configuration_directory
```

Once complete, the results of the simulation(s) will be saved in the output directory (relative to the current folder) specified in the configuration file (default: *output*).

[Gnuplot](#) scripts are saved too for later re-use under the *gnuplot/* subdirectory; you can run them through:

```
$ gnuplot name_of_the_script
```


Chapter 2

Namespace Index

2.1 Namespace List

Here is a list of all documented namespaces with brief descriptions:

constants	Numerical constants	13
numerics	Namespace for generic numeric algorithms	13
utility	Namespace for utilities and auxiliary functions	16

Chapter 3

Hierarchical Index

3.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

Charge	22
ExponentialCharge	32
GaussianCharge	40
ChargeFactory	24
ExponentialChargeFactory	35
GaussianChargeFactory	42
CsvParser	26
DosModel	29
NonLinearPoisson1D	48
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PdeSolver1D	52
Bim1D	19
QuadratureRule	54
GaussHermiteRule	36
GaussLaguerreRule	44
QuadratureRuleFactory	56
GaussHermiteRuleFactory	38
GaussLaguerreRuleFactory	46

Chapter 4

Class Index

4.1 Class List

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

Bim1D	Class derived from PdeSolver1D , providing a finite volume Box Integration Method (BIM) solver	19
Charge	Abstract class providing methods to calculate total electric charge (the rhs in the Poisson equation)	22
ChargeFactory	Abstract factory to handle the constitutive relation for the Density of States	24
CsvParser	Class providing methods to read numeric content from a .csv file and to store it in Eigen matrices or vectors	26
DosModel	Class providing methods to process a simulation to extract the Density of States starting from a parameter list	29
ExponentialCharge	Class derived from Charge , under the hypothesis that Density of States is a single exponential	32
ExponentialChargeFactory	Concrete factory to handle a single exponential DOS constitutive relation	35
GaussHermiteRule	Class derived from QuadratureRule providing the Gauss-Hermite quadrature rule	36
GaussHermiteRuleFactory	Concrete factory to handle a Gauss-Hermite quadrature rule	38
GaussianCharge	Class derived from Charge , under the hypothesis that Density of States is a combination of gaussians	40
GaussianChargeFactory	Concrete factory to handle a multiple gaussians DOS constitutive relation	42
GaussLaguerreRule	Class derived from QuadratureRule providing the Gauss-Laguerre quadrature rule	44
GaussLaguerreRuleFactory	Concrete factory to handle a Gauss-Laguerre quadrature rule	46
NonLinearPoisson1D	Provide a solver for a non-linear Poisson equation	48
ParamList	Class providing methods to handle a list of parameters	50
PdeSolver1D	Abstract class providing methods to assemble matrices to solve one-dimensional PDEs	52
QuadratureRule	Abstract class providing a quadrature rule	54

QuadratureRuleFactory	
Abstract factory to handle a quadrature rule	56

Chapter 5

File Index

5.1 File List

Here is a list of all documented files with brief descriptions:

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DosExtraction/test/ simulate_dos.cc	
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Chapter 6

Namespace Documentation

6.1 constants Namespace Reference

Numerical constants.

Variables

- const [Real Q](#) = 1.602176530000000e-19
Electron charge [C].
- const [Real Q2](#) = [Q](#) * [Q](#)
Electron charge squared [C²].
- const [Real K_B](#) = 1.380650500000000e-23
Boltzmann's constant [J · K⁻¹].
- const [Real EPS0](#) = 8.854187817e-12
Vacuum electrical permittivity [C · V⁻¹ · m⁻¹].
- const [Real T](#) = 300
Reference temperature [K].
- const [Real V_TH](#) = [K_B](#) * [T](#) / [Q](#)
Threshold voltage [V].
- const [Index PARAMS_NO](#) = 26
Number of parameters required in input file.
- const [Real PI](#) = [M_PI](#)
 π .
- const [Real SQRT_PI](#) = std::sqrt([PI](#))
 $\sqrt{\pi}$.
- const [Real PI_M4](#) = 0.7511255444649425
 $\pi^{-\frac{1}{4}}$.
- const [Real SQRT_2](#) = std::sqrt(2)
 $\sqrt{2}$.

6.1.1 Detailed Description

Numerical constants.

6.2 numerics Namespace Reference

Namespace for generic numeric algorithms.

Functions

- `template<typename ScalarType >
VectorX< ScalarType > sort (const VectorX< ScalarType > &vector)`
Function to sort [Eigen](#) vectors.
- `template<typename ScalarType >
VectorXpair< ScalarType > sort_pair (const VectorX< ScalarType > &vector)`
Function to sort [Eigen](#) vectors, keeping track of indexes.
- `Real trapz (const VectorXr &x, const VectorXr &y)`
Function to compute approximate integral of y with spacing increment specified by x, using trapezoidal rule.
- `Real trapz (const VectorXr &y)`
Compute the approximate integral of y with unit spacing, using trapezoidal rule.
- `VectorXr deriv (const VectorXr &, const VectorXr &)`
Compute the numeric derivative: $\frac{dy}{dx}$.
- `Real interp1 (const VectorXr &, const VectorXr &, const Real &)`
Linear 1D interpolation. Interpolate y, defined at points x, at the point xNew.
- `VectorXr interp1 (const VectorXr &, const VectorXr &, const VectorXr &)`
Linear 1D interpolation. Interpolate y, defined at points x, at the points xNew.
- `Real error_L2 (const VectorXr &, const VectorXr &, const VectorXr &, const Real &)`
Compute the L^2 -norm error between simulated and interpolated values, using trapz.

6.2.1 Detailed Description

Namespace for generic numeric algorithms.

6.2.2 Function Documentation

6.2.2.1 `VectorX< ScalarType > sort (const VectorX< ScalarType > & vector)`

Function to sort [Eigen](#) vectors.

Template Parameters

<i>ScalarType</i>	: the scalar type.
-------------------	--------------------

Parameters

<i>in</i>	<i>vector</i>	: the vector to be sorted.
-----------	---------------	----------------------------

Returns

the sorted vector.

Definition at line 103 of file numerics.h.

6.2.2.2 `VectorXpair< ScalarType > sort_pair (const VectorX< ScalarType > & vector)`

Function to sort [Eigen](#) vectors, keeping track of indexes.

Template Parameters

<i>ScalarType</i>	: the scalar type.
-------------------	--------------------

Parameters

in	<i>vector</i>	: the vector to be sorted.
----	---------------	----------------------------

Returns

an [Eigen](#) vector of pairs: (sorted value, corresponding index in the unsorted vector).

Definition at line 112 of file numerics.h.

6.2.2.3 Real trapz (const VectorXr & x, const VectorXr & y)

Function to compute approximate integral of *y* with spacing increment specified by *x*, using trapezoidal rule.

Parameters

in	<i>x</i>	: the vector of the discrete domain;
in	<i>y</i>	: the vector of values to integrate.

Returns

the approximate integral value.

Definition at line 17 of file numerics.cc.

6.2.2.4 Real trapz (const VectorXr & y)

Compute the approximate integral of *y* with unit spacing, using trapezoidal rule.

Parameters

in	<i>y</i>	: the vector of values to integrate.
----	----------	--------------------------------------

Returns

the approximate integral value.

Definition at line 33 of file numerics.cc.

6.2.2.5 VectorXr deriv (const VectorXr & y, const VectorXr & x)

Compute the numeric derivative: $\frac{dy}{dx}$.

Parameters

in	<i>y</i>	: the vector of values to differentiate;
in	<i>x</i>	: the vector of the discrete domain.

Returns

a vector of the same length as *y* containing the approximate derivative.

Definition at line 38 of file numerics.cc.

6.2.2.6 Real interp1 (const VectorXr & x, const VectorXr & y, const Real & xNew)

Linear 1D interpolation. Interpolate *y*, defined at points *x*, at the point *xNew*.

Parameters

in	<i>y</i>	: the vector of values to interpolate;
in	<i>x</i>	: the vector of the discrete domain;
in	<i>xNew</i>	: the point to interpolate at.

Returns

a scalar containing the interpolated value.

Definition at line 58 of file numerics.cc.

6.2.2.7 VectorXr interp1 (const VectorXr & x, const VectorXr & y, const VectorXr & xNew)

Linear 1D interpolation. Interpolate *y*, defined at points *x*, at the points *xNew*.

Parameters

in	<i>y</i>	: the vector of values to interpolate;
in	<i>x</i>	: the vector of the discrete domain;
in	<i>xNew</i>	: the vector of points to interpolate at.

Returns

a vector of the same length as *xNew* containing the interpolated values.

Definition at line 79 of file numerics.cc.

6.2.2.8 Real error_L2 (const VectorXr & interp, const VectorXr & simulated, const VectorXr & V, const Real & V_shift)

Compute the L^2 -norm error between simulated and interpolated values, using *trapz*.

Parameters

in	<i>interp</i>	: the interpolated values;
in	<i>simulated</i>	: the simulated values;
in	<i>V</i>	: the vector of the electric potential;
in	<i>V_shift</i>	: shift to the electric potential.

Returns

the value of the L^2 -norm error.

Definition at line 94 of file numerics.cc.

6.3 utility Namespace Reference

Namespace for utilities and auxiliary functions.

Functions

- `std::string full_path (const std::string &, const std::string &)`
Auxiliary function to return the full path to a file.
- `void print_block (const char *, std::ostream &=std::cout)`
Auxiliary function to print a string inside a block.
- `void print_done (std::ostream &=std::cout)`
Auxiliary function to print a "DONE!" string.

6.3.1 Detailed Description

Namespace for utilities and auxiliary functions.

6.3.2 Function Documentation

6.3.2.1 `std::string full_path (const std::string & filename, const std::string & relative_directory)`

Auxiliary function to return the full path to a file.

Parameters

in	<i>filename</i>	: the filename;
in	<i>relative_ - directory</i>	: the directory for a relative path.

Returns

the variable *filename*, if it contains an absolute path; otherwise returns the concatenation of *relative_directory* and *filename* (i.e. the relative path to *filename*).

Definition at line 17 of file typedefs.cc.

6.3.2.2 `void print_block (const char * string, std::ostream & os = std::cout)`

Auxiliary function to print a string inside a block.

Parameters

in	<i>string</i>	: the string to print;
out	<i>os</i>	: output stream.

Definition at line 22 of file typedefs.cc.

6.3.2.3 `void print_done (std::ostream & os = std::cout)`

Auxiliary function to print a "DONE!" string.

Parameters

out	<i>os</i>	: output stream.
-----	-----------	------------------

Definition at line 47 of file typedefs.cc.

Chapter 7

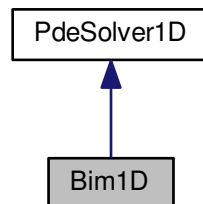
Class Documentation

7.1 Bim1D Class Reference

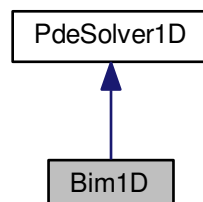
Class derived from [PdeSolver1D](#), providing a finite volume Box Integration Method (BIM) solver.

```
#include <solvers.h>
```

Inheritance diagram for Bim1D:



Collaboration diagram for Bim1D:



Public Member Functions

- [Bim1D](#) ()=delete
Default constructor (deleted since it is required to specify the mesh).
- [Bim1D](#) ([VectorXr](#) &)
Constructor.
- virtual [~Bim1D](#) ()=default
Destructor (defaulted).
- virtual void [assembleAdvDiff](#) (const [VectorXr](#) &, const [VectorXr](#) &, const [VectorXr](#) &, const [VectorXr](#) &) override
Assemble the matrix for an advection-diffusion term.
- virtual void [assembleStiff](#) (const [VectorXr](#) &, const [VectorXr](#) &) override
Assemble the matrix for a diffusion term.
- virtual void [assembleMass](#) (const [VectorXr](#) &, const [VectorXr](#) &) override
Assemble the matrix for a reaction term.

Static Public Member Functions

- static [VectorXr](#) [log_mean](#) (const [VectorXr](#) &, const [VectorXr](#) &)
Compute the element-wise logarithmic mean of two vectors.
- static std::pair< [VectorXr](#),
[VectorXr](#) > [bernoulli](#) (const [VectorXr](#) &)
Compute the values of the Bernoulli function.

Additional Inherited Members

7.1.1 Detailed Description

Class derived from [PdeSolver1D](#), providing a finite volume Box Integration Method (BIM) solver.

Matrices are held in a sparse format.

Definition at line 117 of file solvers.h.

7.1.2 Constructor & Destructor Documentation

7.1.2.1 [Bim1D](#) ([VectorXr](#) & *mesh*)

Constructor.

Parameters

<code>in</code>	<code>mesh</code>	: the mesh coordinates.
-----------------	-------------------	-------------------------

Definition at line 20 of file solvers.cc.

7.1.3 Member Function Documentation

7.1.3.1 [VectorXr](#) [log_mean](#) (const [VectorXr](#) & *x1*, const [VectorXr](#) & *x2*) [static]

Compute the element-wise logarithmic mean of two vectors.

$$M_{\log}(x_1, x_2) = \frac{x_2 - x_1}{\log x_2 - \log x_1} = \frac{x_2 - x_1}{\log \left(\frac{x_2}{x_1} \right)}.$$

Parameters

in	<i>x1</i>	: the first vector;
in	<i>x2</i>	: the second vector.

Returns

the vector of the logarithmic means.

Definition at line 23 of file solvers.cc.

7.1.3.2 `std::pair< VectorXr, VectorXr > bernoulli (const VectorXr & x) [static]`

Compute the values of the Bernoulli function.

$$\mathfrak{B}(x) = \frac{x}{e^x - 1}.$$

Parameters

in	<i>x</i>	: the vector of the values to compute the Bernoulli function at.
----	----------	--

Returns

the pair $(\mathfrak{B}(x), \mathfrak{B}(-x))$.

Definition at line 54 of file solvers.cc.

7.1.3.3 `void assembleAdvDiff (const VectorXr & alpha, const VectorXr & gamma, const VectorXr & eta, const VectorXr & beta) [override], [virtual]`

Assemble the matrix for an advection-diffusion term.

Build the Scharfetter-Gummel stabilized stiffness matrix for: $-\nabla \cdot (\alpha \cdot \gamma (\eta \nabla u - \beta u)) = f$.

Parameters

in	<i>alpha</i>	: α , an element-wise constant function;
in	<i>gamma</i>	: γ , an element-wise linear function;
in	<i>eta</i>	: η , an element-wise linear function;
in	<i>beta</i>	: β , an element-wise constant function.

Implements [PdeSolver1D](#).

Definition at line 113 of file solvers.cc.

7.1.3.4 `void assembleStiff (const VectorXr & eps, const VectorXr & kappa) [override], [virtual]`

Assemble the matrix for a diffusion term.

Build the standard finite element stiffness matrix for the diffusion problem: $-\nabla \cdot (\varepsilon \cdot \kappa \nabla u) = f$.

Parameters

in	<i>eps</i>	: ε , an element-wise constant function;
----	------------	--

<code>in</code>	<code>kappa</code>	: κ , an element-wise linear function.
-----------------	--------------------	---

Implements [PdeSolver1D](#).

Definition at line 173 of file solvers.cc.

7.1.3.5 `void assembleMass (const VectorXr & delta, const VectorXr & zeta)` `[override],[virtual]`

Assemble the matrix for a reaction term.

Build the lumped finite element mass matrix for the reaction problem: $\delta \cdot \zeta u = f$.

Parameters

<code>in</code>	<code>delta</code>	: δ , an element-wise constant function;
<code>in</code>	<code>zeta</code>	: ζ , an element-wise linear function.

Implements [PdeSolver1D](#).

Definition at line 182 of file solvers.cc.

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

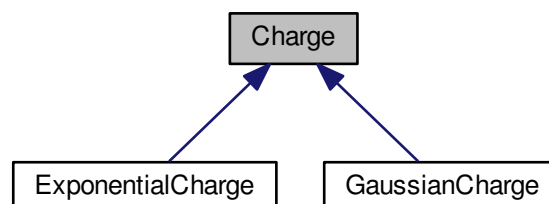
- DosExtraction/src/[solvers.h](#)
- DosExtraction/src/[solvers.cc](#)

7.2 Charge Class Reference

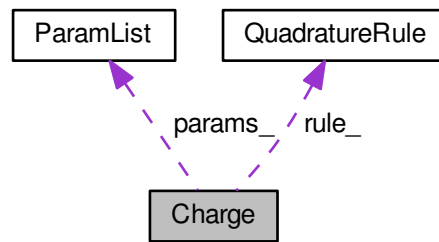
Abstract class providing methods to calculate total electric charge (the rhs in the Poisson equation).

```
#include <charge.h>
```

Inheritance diagram for Charge:



Collaboration diagram for Charge:



Public Member Functions

- [Charge](#) ()=delete
Default constructor (deleted since it is required to specify a [ParamList](#) and a [QuadratureRule](#)).
- [Charge](#) (const [ParamList](#) &, const [QuadratureRule](#) &)
Constructor.
- virtual [~Charge](#) ()=default
Destructor (defaulted).
- virtual [VectorXr](#) charge (const [VectorXr](#) &phi)=0
Compute the total charge density.
- virtual [VectorXr](#) dcharge (const [VectorXr](#) &phi)=0
Compute the derivative of the total charge density with respect to the electric potential.

Protected Attributes

- const [ParamList](#) & [params_](#)
Parameter list handler.
- const [QuadratureRule](#) & [rule_](#)
Quadrature rule handler.

7.2.1 Detailed Description

Abstract class providing methods to calculate total electric charge (the rhs in the Poisson equation).

Definition at line 30 of file charge.h.

7.2.2 Constructor & Destructor Documentation

7.2.2.1 [Charge](#) (const [ParamList](#) & *params*, const [QuadratureRule](#) & *rule*)

Constructor.

Parameters

in	<i>params</i>	: a list of simulation parameters;
in	<i>rule</i>	: a quadrature rule.

Definition at line 19 of file charge.cc.

7.2.3 Member Function Documentation

7.2.3.1 virtual VectorXr charge (const VectorXr & *phi*) [pure virtual]

Compute the total charge density.

Parameters

in	<i>phi</i>	: the electric potential φ .
----	------------	--------------------------------------

Returns

the total charge density $q(\varphi)$ $[C \cdot m^{-3}]$.

Implemented in [ExponentialCharge](#), and [GaussianCharge](#).

7.2.3.2 virtual VectorXr dcharge (const VectorXr & *phi*) [pure virtual]

Compute the derivative of the total charge density with respect to the electric potential.

Parameters

in	<i>phi</i>	: the electric potential φ .
----	------------	--------------------------------------

Returns

the derivative: $\frac{dq(\varphi)}{d\varphi}$ $[C \cdot m^{-3} \cdot V^{-1}]$.

Implemented in [ExponentialCharge](#), and [GaussianCharge](#).

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

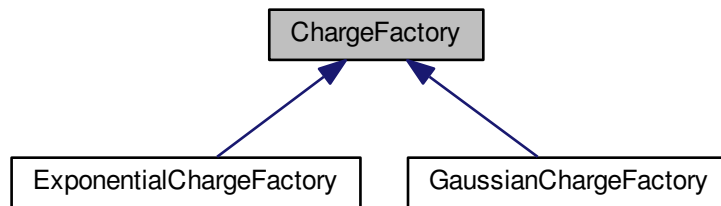
- DosExtraction/src/[charge.h](#)
- DosExtraction/src/[charge.cc](#)

7.3 ChargeFactory Class Reference

Abstract factory to handle the constitutive relation for the Density of States.

```
#include <factory.h>
```


Inheritance diagram for ChargeFactory:



Public Member Functions

- [ChargeFactory](#) ()=default
Default constructor (defaulted).
- virtual [~ChargeFactory](#) ()=default
Destructor (defaulted).
- virtual [Charge](#) * [BuildCharge](#) (const [ParamList](#) ¶ms, const [QuadratureRule](#) &rule)=0
Factory method to build an abstract [Charge](#) object.

7.3.1 Detailed Description

Abstract factory to handle the constitutive relation for the Density of States.

Definition at line 30 of file factory.h.

7.3.2 Member Function Documentation

7.3.2.1 virtual [Charge](#)* [BuildCharge](#) (const [ParamList](#) ¶ms, const [QuadratureRule](#) &rule) [pure virtual]

Factory method to build an abstract [Charge](#) object.

Parameters

in	<i>params</i>	: a list of simulation parameters;
in	<i>rule</i>	: a quadrature rule.

Returns

a pointer to [Charge](#).

Implemented in [ExponentialChargeFactory](#), and [GaussianChargeFactory](#).

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

- `DosExtraction/src/factory.h`

7.4 CsvParser Class Reference

Class providing methods to read **numeric** content from a .csv file and to store it in [Eigen](#) matrices or vectors.

```
#include <csvParser.h>
```

Public Member Functions

- [CsvParser](#) ()=delete
Default constructor (deleted since it is required to specify at least a filename).
- [CsvParser](#) (const std::string &, const bool &=true)
Constructor: load the input file and check its compatibility with the code.
- virtual [~CsvParser](#) ()
Destructor: close the input file.
- [RowVectorXr importRow](#) (const [Index](#) &)
Method to import a row from the input file.
- [MatrixXr importRows](#) (const std::initializer_list< [Index](#) > &)
Method to import multiple rows from the input file.
- [MatrixXr importFirstRows](#) (const [Index](#) &)
Method to import the first nRows rows from the input file.
- [VectorXr importCol](#) (const [Index](#) &)
Method to import a column from the input file.
- [MatrixXr importCols](#) (const std::initializer_list< [Index](#) > &)
Method to import multiple columns from the input file.
- [MatrixXr importFirstCols](#) (const [Index](#) &)
Method to import the first nCols columns from the input file.
- [Real importCell](#) (const [Index](#) &, const [Index](#) &)
Method to import a single cell from the input file.
- [MatrixXr importAll](#) ()
Method to import the whole input file.

Getter methods

- const [Index](#) & **nRows** () const
- const [Index](#) & **nCols** () const

Private Member Functions

- void [reset](#) ()
Reset all the flags for input_ and go back to the beginning of file (possibly by ignoring headers).

Private Attributes

- bool [hasHeaders_](#)
bool to determine if first row contains headers or not.
- [Index](#) [nRows_](#)
Number of rows in the input file.
- [Index](#) [nCols_](#)
Number of columns in the input file.
- std::ifstream [input_](#)
Input stream to input_ filename.

- `std::string line_`
Auxiliary variable to store currently processed line.
- `char separator_`
The separator character detected.

7.4.1 Detailed Description

Class providing methods to read **numeric** content from a .csv file and to store it in [Eigen](#) matrices or vectors.

Definition at line 34 of file csvParser.h.

7.4.2 Constructor & Destructor Documentation

7.4.2.1 CsvParser (const std::string & input_filename, const bool & hasHeaders = true)

Constructor: load the input file and check its compatibility with the code.

Parameters

<code>in</code>	<code>input_filename</code>	: the name of the input file;
<code>in</code>	<code>hasHeaders</code>	: bool to specify if first row contains headers or not; if true , first row is always ignored.

Definition at line 24 of file csvParser.cc.

7.4.3 Member Function Documentation

7.4.3.1 RowVectorXr importRow (const Index & index)

Method to import a row from the input file.

Parameters

<code>in</code>	<code>index</code>	: the row index.
-----------------	--------------------	------------------

Returns

a row vector containing the content read.

Definition at line 96 of file csvParser.cc.

7.4.3.2 MatrixXr importRows (const std::initializer_list< Index > & indexes)

Method to import multiple rows from the input file.

Parameters

<code>in</code>	<code>indexes</code>	: initializer list containing the row indexes (e.g. something like {1, 3, 4}).
-----------------	----------------------	--

Returns

a matrix containing the content read (row by row).

Definition at line 127 of file csvParser.cc.

7.4.3.3 MatrixXr importFirstRows (const Index & nRows)

Method to import the first *nRows* rows from the input file.

Parameters

<i>in</i>	<i>nRows</i>	: the number of rows to import.
-----------	--------------	---------------------------------

Returns

a matrix containing the content read (row by row).

Definition at line 144 of file csvParser.cc.

7.4.3.4 VectorXr importCol (const Index & index)

Method to import a column from the input file.

Parameters

<i>in</i>	<i>index</i>	: the column index.
-----------	--------------	---------------------

Returns

a column vector containing the content read.

Definition at line 158 of file csvParser.cc.

7.4.3.5 MatrixXr importCols (const std::initializer_list< Index > & indexes)

Method to import multiple columns from the input file.

Parameters

<i>in</i>	<i>indexes</i>	: initializer list containing the column indexes (e.g. something like {1, 3, 4}).
-----------	----------------	---

Returns

a matrix containing the content read (column by column).

Definition at line 185 of file csvParser.cc.

7.4.3.6 MatrixXr importFirstCols (const Index & nCols)

Method to import the first *nCols* columns from the input file.

Parameters

<i>in</i>	<i>nCols</i>	: the number of columns to import.
-----------	--------------	------------------------------------

Returns

a matrix containing the content read (column by column).

Definition at line 202 of file csvParser.cc.

7.4.3.7 Real importCell (const Index & rowIndex, const Index & colIndex)

Method to import a single cell from the input file.

Parameters

in	<i>rowIndex</i>	: the cell row index.
in	<i>colIndex</i>	: the cell column index.

Returns

a scalar containing the value read.

Definition at line 216 of file csvParser.cc.

7.4.3.8 MatrixXr importAll ()

Method to import the whole input file.

Returns

a matrix containing the content read (cell by cell).

Definition at line 224 of file csvParser.cc.

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

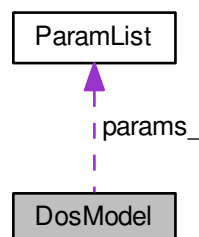
- DosExtraction/src/[csvParser.h](#)
- DosExtraction/src/[csvParser.cc](#)

7.5 DosModel Class Reference

Class providing methods to process a simulation to extract the Density of States starting from a parameter list.

```
#include <dosModel.h>
```

Collaboration diagram for DosModel:



Public Member Functions

- [DosModel](#) ()
Default constructor.
- [DosModel](#) (const [ParamList](#) &)
Explicit conversion constructor.

- virtual `~DosModel()`=default
Destructor (defaulted).
- const `ParamList & params()` const
Getter method.
- void `simulate` (const `GetPot &`, const `std::string &`, const `std::string &`, const `std::string &`, const `std::string &`)
Perform the simulation.
- void `post_process` (const `GetPot &`, const `std::string &`, `std::ostream &`, `std::ostream &`, const `Real &`, const `Real &`, const `VectorXr &`, const `VectorXr &`, const `VectorXr &`, const `VectorXr &`)
Perform post-processing.
- void `gnuplot_commands` (const `std::string &`, `std::ostream &`) const
Defines commands to generate `Gnuplot` output files.
- void `save_plot` (const `std::string &`, const `std::string &`, const `std::string &`, const `std::string &`) const
Save the `Gnuplot` output files.

Private Attributes

- bool `initialized_`
bool to determine if `DosModel` `param_` has been properly initialized.
- `ParamList` `params_`
The parameter list.
- `Real` `V_shift_`
Peak shift between experimental data and simulated values $[V]$.

7.5.1 Detailed Description

Class providing methods to process a simulation to extract the Density of States starting from a parameter list.

Definition at line 42 of file `dosModel.h`.

7.5.2 Constructor & Destructor Documentation

7.5.2.1 `DosModel (const ParamList & params) [explicit]`

Explicit conversion constructor.

Parameters

<code>in</code>	<code>params</code>	: a parameter list.
-----------------	---------------------	---------------------

Definition at line 26 of file `dosModel.cc`.

7.5.3 Member Function Documentation

7.5.3.1 `void simulate (const GetPot & config, const std::string & input_experim, const std::string & output_directory, const std::string & output_plot_subdir, const std::string & output_filename)`

Perform the simulation.

Parameters

in	<i>config</i>	: the GetPot configuration object;
in	<i>input_experim</i>	: the file containing experimental data;
in	<i>output_directory</i>	: directory where to store output files;
in	<i>output_plot_ - subdir</i>	: sub-directory where to store Gnuplot files;
in	<i>output_filename</i>	: prefix for the output filename.

Definition at line 29 of file dosModel.cc.

7.5.3.2 void post_process (const GetPot & *config*, const std::string & *input_experim*, std::ostream & *output_fitting*, std::ostream & *output_CV*, const Real & *A_semic*, const Real & *C_sb*, const VectorXr & *x_semic*, const VectorXr & *dens*, const VectorXr & *V_simulated*, const VectorXr & *C_simulated*)

Perform post-processing.

Parameters

in	<i>config</i>	: the GetPot configuration object;
in	<i>input_experim</i>	: the file containing experimental data;
out	<i>output_fitting</i>	: output file containing infos about fitting experimental data;
out	<i>output_CV</i>	: output file containing infos about capacitance-voltage data;
in	<i>A_semic</i>	: area of the semiconductor;
in	<i>C_sb</i>	: stray border capacitance (see ParamList);
in	<i>x_semic</i>	: the mesh corresponding to the semiconductor domain;
in	<i>dens</i>	: charge density $[C \cdot m^{-3}]$;
in	<i>V_simulated</i>	: simulated voltage values;
in	<i>C_simulated</i>	: simulated capacitance values.

Definition at line 275 of file dosModel.cc.

7.5.3.3 void gnuplot_commands (const std::string & *output_CV_filename*, std::ostream & *os*) const

Defines commands to generate [Gnuplot](#) output files.

Parameters

in	<i>output_CV_ - filename</i>	: output CV filename;
out	<i>os</i>	: output stream.

Definition at line 366 of file dosModel.cc.

7.5.3.4 void save_plot (const std::string & *output_directory*, const std::string & *output_plot_subdir*, const std::string & *output_CV_filename*, const std::string & *output_filename*) const

Save the [Gnuplot](#) output files.

Parameters

in	<i>output_directory</i>	: directory where to store output files;
in	<i>output_plot_ - subdir</i>	: sub-directory where to store Gnuplot files;
in	<i>output_CV_ - filename</i>	: output CV filename;

<code>in</code>	<code>output_filename</code>	: prefix for the output filename.
-----------------	------------------------------	-----------------------------------

Definition at line 400 of file dosModel.cc.

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

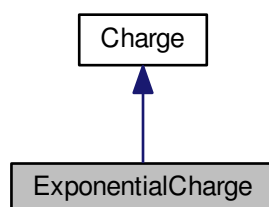
- DosExtraction/src/dosModel.h
- DosExtraction/src/dosModel.cc

7.6 ExponentialCharge Class Reference

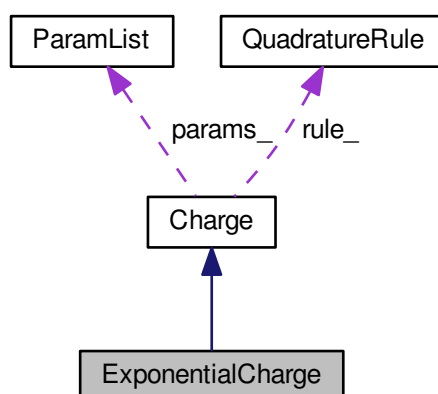
Class derived from [Charge](#), under the hypothesis that Density of States is a single exponential.

```
#include <charge.h>
```

Inheritance diagram for ExponentialCharge:



Collaboration diagram for ExponentialCharge:



Public Member Functions

- [ExponentialCharge](#) ()=delete

Default constructor (deleted since it is required to specify a [ParamList](#) and a [QuadratureRule](#)).

- [ExponentialCharge](#) (const [ParamList](#) &, const [QuadratureRule](#) &)

Constructor.

- virtual [~ExponentialCharge](#) ()=default

Destructor (defaulted).

- virtual [VectorXr charge](#) (const [VectorXr](#) &) override

Compute the total charge density.

- virtual [VectorXr dcharge](#) (const [VectorXr](#) &) override

Compute the derivative of the total charge density with respect to the electric potential.

Private Member Functions

- [Real n_approx](#) (const [Real](#) &, const [Real](#) &, const [Real](#) &) const

Compute electrons density (per unit volume).

- [Real dn_approx](#) (const [Real](#) &, const [Real](#) &, const [Real](#) &) const

Compute the approximate derivative of electrons density (per unit volume) with respect to the electric potential.

Additional Inherited Members

7.6.1 Detailed Description

Class derived from [Charge](#), under the hypothesis that Density of States is a single exponential.

Provide methods to compute total electric charge and its derivative under the hypothesis that Density of States is a single exponential, whose parameter is got by the constructor, of the form:

$$\frac{N_0}{\lambda} \exp\left(-\frac{(\cdot)}{\lambda}\right).$$

Definition at line 127 of file charge.h.

7.6.2 Constructor & Destructor Documentation

7.6.2.1 ExponentialCharge (const ParamList & params, const QuadratureRule & rule)

Constructor.

Parameters

in	<i>params</i>	: a list of simulation parameters;
in	<i>rule</i>	: a quadrature rule.

Definition at line 112 of file charge.cc.

7.6.3 Member Function Documentation

7.6.3.1 VectorXr charge (const VectorXr & phi) [override],[virtual]

Compute the total charge density.

Parameters

<i>in</i>	<i>phi</i>	: the electric potential φ .
-----------	------------	--------------------------------------

Returns

the total charge density $q(\varphi)$ $[C \cdot m^{-3}]$.

Implements [Charge](#).

Definition at line 143 of file charge.cc.

7.6.3.2 VectorXr dcharge (const VectorXr & *phi*) [override],[virtual]

Compute the derivative of the total charge density with respect to the electric potential.

Parameters

<i>in</i>	<i>phi</i>	: the electric potential φ .
-----------	------------	--------------------------------------

Returns

the derivative: $\frac{dq(\varphi)}{d\varphi}$ $[C \cdot m^{-3} \cdot V^{-1}]$.

Implements [Charge](#).

Definition at line 155 of file charge.cc.

7.6.3.3 Real n_approx (const Real & *phi*, const Real & *N0*, const Real & *lambda*) const [private]

Compute electrons density (per unit volume).

Parameters

<i>in</i>	<i>phi</i>	: the electric potential φ ;
<i>in</i>	<i>N0</i>	: the exponential N_0 ;
<i>in</i>	<i>lambda</i>	: the exponential λ .

Returns

the electrons density $n(\varphi)$ $[m^{-3}]$.

Definition at line 115 of file charge.cc.

7.6.3.4 Real dn_approx (const Real & *phi*, const Real & *N0*, const Real & *lambda*) const [private]

Compute the approximate derivative of electrons density (per unit volume) with respect to the electric potential.

Parameters

<i>in</i>	<i>phi</i>	: the electric potential φ ;
<i>in</i>	<i>N0</i>	: the exponential N_0 ;
<i>in</i>	<i>lambda</i>	: the exponential λ .

Returns

the derivative: $\frac{dn(\varphi)}{d\varphi}$ $[m^{-3} \cdot V^{-1}]$.

Definition at line 129 of file charge.cc.

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

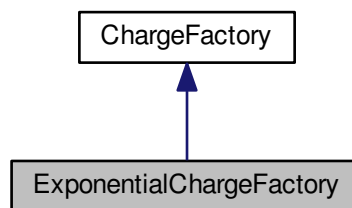
- [DosExtraction/src/charge.h](#)
- [DosExtraction/src/charge.cc](#)

7.7 ExponentialChargeFactory Class Reference

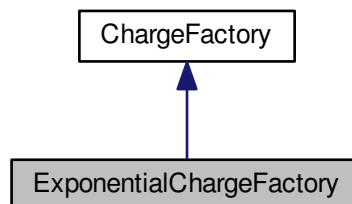
Concrete factory to handle a single exponential DOS constitutive relation.

```
#include <factory.h>
```

Inheritance diagram for ExponentialChargeFactory:



Collaboration diagram for ExponentialChargeFactory:



Public Member Functions

- [ExponentialChargeFactory](#) ()=default
Default constructor (defaulted).
- virtual [~ExponentialChargeFactory](#) ()=default
Destructor (defaulted).
- virtual [Charge](#) * [BuildCharge](#) (const [ParamList](#) &, const [QuadratureRule](#) &) override
Factory method to build a concrete [Charge](#) object.

7.7.1 Detailed Description

Concrete factory to handle a single exponential DOS constitutive relation.

Definition at line 84 of file factory.h.

7.7.2 Member Function Documentation

7.7.2.1 `Charge * BuildCharge (const ParamList & params, const QuadratureRule & rule)` `[override]`,
`[virtual]`

Factory method to build a concrete [Charge](#) object.

Parameters

in	<i>params</i>	: a list of simulation parameters;
in	<i>rule</i>	: a quadrature rule.

Returns

a pointer to [ExponentialCharge](#).

Implements [ChargeFactory](#).

Definition at line 22 of file factory.cc.

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

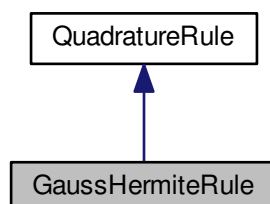
- [DosExtraction/src/factory.h](#)
- [DosExtraction/src/factory.cc](#)

7.8 GaussHermiteRule Class Reference

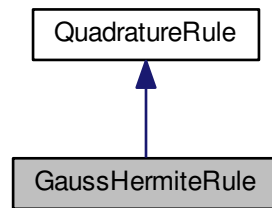
Class derived from [QuadratureRule](#) providing the Gauss-Hermite quadrature rule.

```
#include <quadratureRule.h>
```

Inheritance diagram for GaussHermiteRule:



Collaboration diagram for GaussHermiteRule:



Public Member Functions

- `GaussHermiteRule ()=delete`
Default constructor (deleted since it is required to specify the number of nodes).
- `GaussHermiteRule (const Index &)`
Constructor.
- `virtual ~GaussHermiteRule ()=default`
Destructor (defaulted).
- `virtual void apply () override`
Apply the quadrature rule in order to compute the nodes and weights.
- `virtual void apply (const GetPot &) override`
Apply the quadrature rule reading parameters from a configuration file.
- `void apply_iterative_algorithm (const Index &=1000, const Real &=1.0e-14)`
Compute nodes and weights using an adapted version of the algorithm presented in: William H. Press, Saul A. Teukolsky, William T. Vetterling, and Brian P. Flannery. 2007. Numerical Recipes: The Art of Scientific Computing (3rd edition). Cambridge University Press, New York, NY, USA.
- `void apply_using_eigendecomposition ()`
Compute nodes and weights using an eigendecomposition-based algorithm.

Additional Inherited Members

7.8.1 Detailed Description

Class derived from `QuadratureRule` providing the Gauss-Hermite quadrature rule.

Compute nodes and weights for the `nNodes_`-points approximation of:

$$\int_{-\infty}^{+\infty} w(x)f(x) \, dx$$

where $w(x) = e^{-x^2}$.

Definition at line 94 of file `quadratureRule.h`.

7.8.2 Constructor & Destructor Documentation

7.8.2.1 GaussHermiteRule (const Index & nNodes)

Constructor.

Parameters

<i>in</i>	<i>nNodes</i>	: the number of nodes to be used for the quadrature rule.
-----------	---------------	---

Definition at line 28 of file quadratureRule.cc.

7.8.3 Member Function Documentation

7.8.3.1 void apply (const GetPot & *config*) [override],[virtual]

Apply the quadrature rule reading parameters from a configuration file.

Parameters

<i>in</i>	<i>config</i>	: the GetPot configuration object.
-----------	---------------	------------------------------------

Implements [QuadratureRule](#).

Definition at line 36 of file quadratureRule.cc.

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

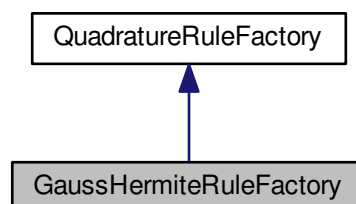
- [DosExtraction/src/quadratureRule.h](#)
- [DosExtraction/src/quadratureRule.cc](#)

7.9 GaussHermiteRuleFactory Class Reference

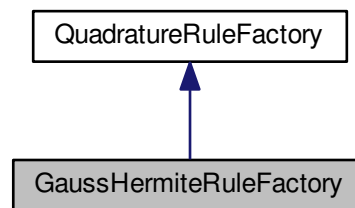
Concrete factory to handle a Gauss-Hermite quadrature rule.

```
#include <factory.h>
```

Inheritance diagram for GaussHermiteRuleFactory:



Collaboration diagram for GaussHermiteRuleFactory:



Public Member Functions

- [GaussHermiteRuleFactory](#) ()=default
Default constructor (defaulted).
- virtual [~GaussHermiteRuleFactory](#) ()=default
Destructor (defaulted).
- virtual [QuadratureRule](#) * [BuildRule](#) (const [Index](#) &) override
Factory method to build a concrete [QuadratureRule](#) object.

7.9.1 Detailed Description

Concrete factory to handle a Gauss-Hermite quadrature rule.

Definition at line 137 of file `factory.h`.

7.9.2 Member Function Documentation

7.9.2.1 [QuadratureRule](#) * [BuildRule](#) (const [Index](#) & *nNodes*) [override], [virtual]

Factory method to build a concrete [QuadratureRule](#) object.

Parameters

<code>in</code>	<code>nNodes</code>	: the number of nodes to be used for the quadrature rule.
-----------------	---------------------	---

Returns

a pointer to [GaussHermiteRule](#).

Implements [QuadratureRuleFactory](#).

Definition at line 27 of file `factory.cc`.

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

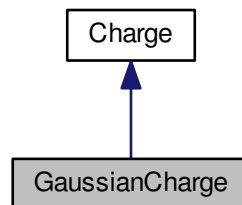
- `DosExtraction/src/factory.h`
- `DosExtraction/src/factory.cc`

7.10 GaussianCharge Class Reference

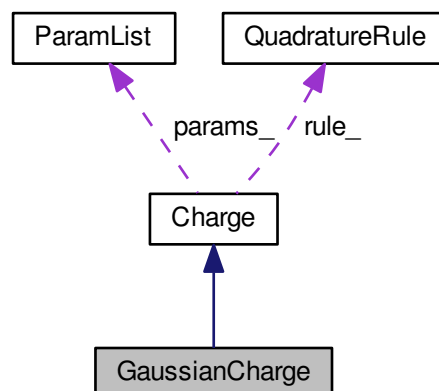
Class derived from [Charge](#), under the hypothesis that Density of States is a combination of gaussians.

```
#include <charge.h>
```

Inheritance diagram for GaussianCharge:



Collaboration diagram for GaussianCharge:



Public Member Functions

- [GaussianCharge](#) ()=delete
Default constructor (deleted since it is required to specify a [ParamList](#) and a [QuadratureRule](#)).
- [GaussianCharge](#) (const [ParamList](#) &, const [QuadratureRule](#) &)
Constructor.
- virtual [~GaussianCharge](#) ()=default
Destructor (defaulted).
- virtual [VectorXr](#) [charge](#) (const [VectorXr](#) &) override
Compute the total charge density.
- virtual [VectorXr](#) [dcharge](#) (const [VectorXr](#) &) override

Compute the derivative of the total charge density with respect to the electric potential.

Private Member Functions

- [Real n_approx](#) (const [Real](#) &, const [Real](#) &, const [Real](#) &) const
Compute electrons density (per unit volume).
- [Real dn_approx](#) (const [Real](#) &, const [Real](#) &, const [Real](#) &) const
Compute the approximate derivative of electrons density (per unit volume) with respect to the electric potential.

Additional Inherited Members

7.10.1 Detailed Description

Class derived from [Charge](#), under the hypothesis that Density of States is a combination of gaussians.

Provide methods to compute total electric charge and its derivative under the hypothesis that Density of States is a linear combination of multiple gaussians, whose parameters are read from a [ParamList](#) object, of the form:

$$\frac{N_0}{\sqrt{2\pi\sigma^2}} \exp\left(-\frac{(\cdot)^2}{2\sigma^2}\right).$$

Definition at line 76 of file charge.h.

7.10.2 Constructor & Destructor Documentation

7.10.2.1 GaussianCharge (const ParamList & params, const QuadratureRule & rule)

Constructor.

Parameters

in	<i>params</i>	: a list of simulation parameters;
in	<i>rule</i>	: a quadrature rule.

Definition at line 22 of file charge.cc.

7.10.3 Member Function Documentation

7.10.3.1 VectorXr charge (const VectorXr & phi) [override],[virtual]

Compute the total charge density.

Parameters

in	<i>phi</i>	: the electric potential φ .
----	------------	--------------------------------------

Returns

the total charge density $q(\varphi)$ [$C \cdot m^{-3}$].

Implements [Charge](#).

Definition at line 53 of file charge.cc.

7.10.3.2 VectorXr dcharge (const VectorXr & phi) [override],[virtual]

Compute the derivative of the total charge density with respect to the electric potential.

Parameters

in	<i>phi</i>	: the electric potential φ .
----	------------	--------------------------------------

Returns

the derivative: $\frac{dq(\varphi)}{d\varphi} [C \cdot m^{-3} \cdot V^{-1}]$.

Implements [Charge](#).

Definition at line 80 of file charge.cc.

7.10.3.3 Real n_approx (const Real & *phi*, const Real & *N0*, const Real & *sigma*) const [private]

Compute electrons density (per unit volume).

Parameters

in	<i>phi</i>	: the electric potential φ ;
in	<i>N0</i>	: the gaussian mean N_0 ;
in	<i>sigma</i>	: the gaussian standard deviation σ .

Returns

the electrons density $n(\varphi) [m^{-3}]$.

Definition at line 25 of file charge.cc.

7.10.3.4 Real dn_approx (const Real & *phi*, const Real & *N0*, const Real & *sigma*) const [private]

Compute the approximate derivative of electrons density (per unit volume) with respect to the electric potential.

Parameters

in	<i>phi</i>	: the electric potential φ ;
in	<i>N0</i>	: the gaussian mean N_0 ;
in	<i>sigma</i>	: the gaussian standard deviation σ .

Returns

the derivative: $\frac{dn(\varphi)}{d\varphi} [m^{-3} \cdot V^{-1}]$.

Definition at line 39 of file charge.cc.

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

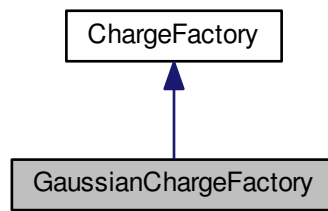
- DosExtraction/src/[charge.h](#)
- DosExtraction/src/[charge.cc](#)

7.11 GaussianChargeFactory Class Reference

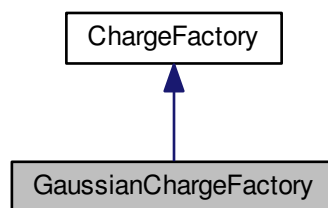
Concrete factory to handle a multiple gaussians DOS constitutive relation.

```
#include <factory.h>
```

Inheritance diagram for GaussianChargeFactory:



Collaboration diagram for GaussianChargeFactory:



Public Member Functions

- `GaussianChargeFactory()`=default
Default constructor (defaulted).
- virtual `~GaussianChargeFactory()`=default
Destructor (defaulted).
- virtual `Charge * BuildCharge (const ParamList &, const QuadratureRule &)` override
Factory method to build a concrete `Charge` object.

7.11.1 Detailed Description

Concrete factory to handle a multiple gaussians DOS constitutive relation.

Definition at line 57 of file `factory.h`.

7.11.2 Member Function Documentation

7.11.2.1 `Charge * BuildCharge (const ParamList & params, const QuadratureRule & rule)` [override],
[virtual]

Factory method to build a concrete `Charge` object.

Parameters

in	<i>params</i>	: a list of simulation parameters;
in	<i>rule</i>	: a quadrature rule.

Returns

a pointer to [GaussianCharge](#).

Implements [ChargeFactory](#).

Definition at line 17 of file `factory.cc`.

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

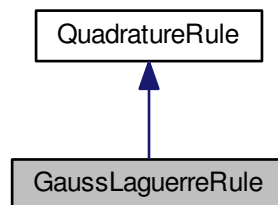
- `DosExtraction/src/factory.h`
- `DosExtraction/src/factory.cc`

7.12 GaussLaguerreRule Class Reference

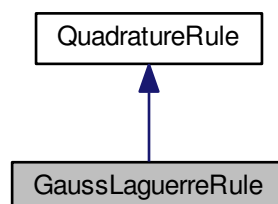
Class derived from [QuadratureRule](#) providing the Gauss-Laguerre quadrature rule.

```
#include <quadratureRule.h>
```

Inheritance diagram for GaussLaguerreRule:



Collaboration diagram for GaussLaguerreRule:



Public Member Functions

- [GaussLaguerreRule](#) ()=delete
Default constructor (deleted since it is required to specify the number of nodes).
- [GaussLaguerreRule](#) (const [Index](#) &)
Constructor.
- virtual [~GaussLaguerreRule](#) ()=default
Destructor (defaulted).
- virtual void [apply](#) () override
Apply the quadrature rule in order to compute the nodes and weights.
- virtual void [apply](#) (const [GetPot](#) &) override
Apply the quadrature rule reading parameters from a configuration file.
- void [apply_iterative_algorithm](#) (const [Index](#) &=1000, const [Real](#) &=1.0e-14)
*Compute nodes and weights using an adapted version of the algorithm presented in:
William H. Press, Saul A. Teukolsky, William T. Vetterling, and Brian P. Flannery. 2007.
Numerical Recipes: The Art of Scientific Computing (3rd edition).
Cambridge University Press, New York, NY, USA.*
- void [apply_using_eigendecomposition](#) ()
Compute nodes and weights using an eigendecomposition-based algorithm.

Static Public Member Functions

- static [Real](#) [log_gamma](#) (const [Real](#) &)
Auxiliary function to compute $\log \Gamma(x)$.

Additional Inherited Members

7.12.1 Detailed Description

Class derived from [QuadratureRule](#) providing the Gauss-Laguerre quadrature rule.

Compute nodes and weights for the $nNodes_$ -points approximation of:

$$\int_0^{+\infty} w(x) f(x) \, dx$$

where $w(x) = e^{-x}$.

Definition at line 137 of file quadratureRule.h.

7.12.2 Constructor & Destructor Documentation

7.12.2.1 GaussLaguerreRule (const [Index](#) & $nNodes$)

Constructor.

Parameters

in	$nNodes$: the number of nodes to be used for the quadrature rule.
--------------------	----------	---

Definition at line 148 of file quadratureRule.cc.

7.12.3 Member Function Documentation

7.12.3.1 [Real](#) [log_gamma](#) (const [Real](#) & x) [static]

Auxiliary function to compute $\log \Gamma(x)$.

Parameters

<code>in</code>	<code>x</code>	: the point to compute the function at.
-----------------	----------------	---

Returns

the natural logarithm of the gamma function evaluated at x .

Definition at line 151 of file `quadratureRule.cc`.

7.12.3.2 `void apply (const GetPot & config)` `[override],[virtual]`

Apply the quadrature rule reading parameters from a configuration file.

Parameters

<code>in</code>	<code>config</code>	: the GetPot configuration object.
-----------------	---------------------	------------------------------------

Implements [QuadratureRule](#).

Definition at line 183 of file `quadratureRule.cc`.

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

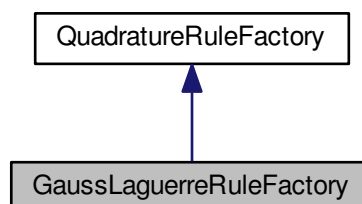
- `DosExtraction/src/quadratureRule.h`
- `DosExtraction/src/quadratureRule.cc`

7.13 GaussLaguerreRuleFactory Class Reference

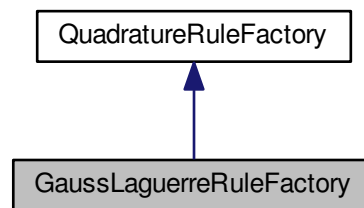
Concrete factory to handle a Gauss-Laguerre quadrature rule.

```
#include <factory.h>
```

Inheritance diagram for GaussLaguerreRuleFactory:



Collaboration diagram for GaussLaguerreRuleFactory:



Public Member Functions

- [GaussLaguerreRuleFactory](#) ()=default
Default constructor (defaulted).
- virtual [~GaussLaguerreRuleFactory](#) ()=default
Destructor (defaulted).
- virtual [QuadratureRule](#) * [BuildRule](#) (const [Index](#) &) override
Factory method to build a concrete [QuadratureRule](#) object.

7.13.1 Detailed Description

Concrete factory to handle a Gauss-Laguerre quadrature rule.

Definition at line 163 of file `factory.h`.

7.13.2 Member Function Documentation

7.13.2.1 [QuadratureRule](#) * [BuildRule](#) (const [Index](#) & *nNodes*) [override],[virtual]

Factory method to build a concrete [QuadratureRule](#) object.

Parameters

<code>in</code>	<code>nNodes</code>	: the number of nodes to be used for the quadrature rule.
-----------------	---------------------	---

Returns

a pointer to [GaussLaguerreRule](#).

Implements [QuadratureRuleFactory](#).

Definition at line 32 of file `factory.cc`.

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

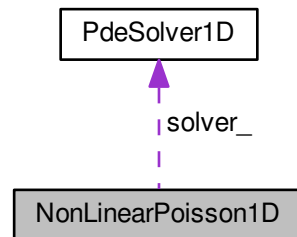
- `DosExtraction/src/factory.h`
- `DosExtraction/src/factory.cc`

7.14 NonLinearPoisson1D Class Reference

Provide a solver for a non-linear Poisson equation.

```
#include <solvers.h>
```

Collaboration diagram for NonLinearPoisson1D:



Public Member Functions

- [NonLinearPoisson1D](#) ()=delete
Default constructor (deleted since it is required to specify the solver to be used).
- [NonLinearPoisson1D](#) (const [PdeSolver1D](#) &, const [Index](#) &=100, const [Real](#) &=1.0e-6)
Constructor.
- virtual [~NonLinearPoisson1D](#) ()=default
Destructor (defaulted).
- void [apply](#) (const [VectorXr](#) &, const [VectorXr](#) &, [Charge](#) &)
Apply a Newton method to the equation and then discretize it using the solver specified.

Getter methods

- const [VectorXr](#) & [phi](#) () const
- const [VectorXr](#) & [norm](#) () const
- const [Real](#) & [qTot](#) () const
- const [Real](#) & [cTot](#) () const

Private Member Functions

- [SparseXr](#) [computeJac](#) (const [VectorXr](#) &) const
Compute the Jacobi matrix.

Private Attributes

- const [PdeSolver1D](#) & [solver_](#)
Solver handler.
- [Index](#) [maxIterationsNo_](#)
Maximum number of iterations.
- [Real](#) [tolerance_](#)

- Tolerance.*
- [VectorXr phi_](#)
The electric potential.
- [VectorXr norm_](#)
Vector holding L^∞ -norm errors for each iteration.
- [Real qTot_](#)
Total charge.
- [Real cTot_](#)
Total capacitance.

7.14.1 Detailed Description

Provide a solver for a non-linear Poisson equation.

A Newton method is applied in order to solve:

$$-\frac{d}{dz} \left(\epsilon(z) \cdot \frac{d\varphi}{dz}(z) \right) = -q \cdot \frac{N_0}{\sqrt{\pi}} \int_{-\infty}^{+\infty} \exp(-\alpha^2) \left(1 + \exp \left(\frac{\sqrt{2}\sigma\alpha - q\varphi(z)}{K_B \cdot T} \right) \right)^{-1} d\alpha.$$

Definition at line 194 of file solvers.h.

7.14.2 Constructor & Destructor Documentation

7.14.2.1 NonLinearPoisson1D (const PdeSolver1D & solver, const Index & maxIterationsNo = 100, const Real & tolerance = 1.0e-6)

Constructor.

Parameters

in	<i>solver</i>	: the solver to be used;
in	<i>maxIterationsNo</i>	: maximum number of iterations desired;
in	<i>tolerance</i>	: tolerance desired.

Definition at line 204 of file solvers.cc.

7.14.3 Member Function Documentation

7.14.3.1 void apply (const VectorXr & mesh, const VectorXr & init_guess, Charge & charge_fun)

Apply a Newton method to the equation and then discretize it using the solver specified.

Parameters

in	<i>mesh</i>	: the mesh;
in	<i>init_guess</i>	: initial guess for the Newton algorithm;
in	<i>charge_fun</i>	: an object of class Charge specifying how to compute total electric charge.

Definition at line 211 of file solvers.cc.

7.14.3.2 SparseXr computeJac (const VectorXr & x) const `[private]`

Compute the Jacobi matrix.

Parameters

<code>in</code>	<code>x</code>	: the vector where to start from.
-----------------	----------------	-----------------------------------

Returns

the Jacobi matrix in a sparse format.

Definition at line 332 of file solvers.cc.

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

- DosExtraction/src/[solvers.h](#)
- DosExtraction/src/[solvers.cc](#)

7.15 ParamList Class Reference

Class providing methods to handle a list of parameters.

```
#include <paramList.h>
```

Public Member Functions

- [ParamList](#) ()=default
Default constructor (defaulted).
- [ParamList](#) (const [RowVectorXr](#) &)
Explicit conversion constructor.
- virtual [~ParamList](#) ()=default
Destructor (defaulted).

Getter methods

- const [Index](#) & **simulationNo** () const
- const [Real](#) & **t_semic** () const
- const [Real](#) & **t_ins** () const
- const [Real](#) & **eps_semic** () const
- const [Real](#) & **eps_ins** () const
- const [Real](#) & **Wf** () const
- const [Real](#) & **Ea** () const
- const [Real](#) & **N0** () const
- const [Real](#) & **sigma** () const
- const [Real](#) & **N0_2** () const
- const [Real](#) & **sigma_2** () const
- const [Real](#) & **shift_2** () const
- const [Real](#) & **N0_3** () const
- const [Real](#) & **sigma_3** () const
- const [Real](#) & **shift_3** () const
- const [Real](#) & **N0_4** () const
- const [Real](#) & **sigma_4** () const
- const [Real](#) & **shift_4** () const
- const [Real](#) & **N0_exp** () const
- const [Real](#) & **lambda_exp** () const
- const [Real](#) & **A_semic** () const
- const [Real](#) & **C_sb** () const
- const [Index](#) & **nNodes** () const
- const [Index](#) & **nSteps** () const
- const [Real](#) & **V_min** () const
- const [Real](#) & **V_max** () const

Private Attributes

- [Index simulationNo_](#)
Simulation number index.
- [Real t_semic_](#)
Thickness of the semiconductor layer [m].
- [Real t_ins_](#)
Thickness of the insulator layer [m].
- [Real eps_semic_](#)
Relative electrical permittivity of the semiconductor layer [].
- [Real eps_ins_](#)
Relative electrical permittivity of the insulator layer [].
- [Real Wf_](#)
Work-function (normalized by Q) [V].
- [Real Ea_](#)
Electron affinity (normalized by Q) [V].
- [Real N0_](#)
1st gaussian N_0 [m^{-3}].
- [Real sigma_](#)
1st gaussian standard deviation σ (normalized by $K_B \cdot T$) [].
- [Real N0_2_](#)
2nd gaussian N_0 [m^{-3}].
- [Real sigma_2_](#)
2nd gaussian standard deviation σ (normalized by $K_B \cdot T$) [].
- [Real shift_2_](#)
2nd gaussian shift with respect to the 1st gaussian electric potential (normalized by $-Q$) [V].
- [Real N0_3_](#)
3rd gaussian N_0 [m^{-3}].
- [Real sigma_3_](#)
3rd gaussian standard deviation σ (normalized by $K_B \cdot T$) [].
- [Real shift_3_](#)
3rd gaussian shift with respect to the 1st gaussian electric potential (normalized by $-Q$) [V].
- [Real N0_4_](#)
4th gaussian N_0 [m^{-3}].
- [Real sigma_4_](#)
4th gaussian standard deviation σ (normalized by $K_B \cdot T$) [].
- [Real shift_4_](#)
4th gaussian shift with respect to the 1st gaussian electric potential (normalized by $-Q$) [V].
- [Real N0_exp_](#)
Exponential N_0 [m^{-3}].
- [Real lambda_exp_](#)
Exponential λ (normalized by $K_B \cdot T$) [].
- [Real A_semic_](#)
Area of the semiconductor [m^2].
- [Real C_sb_](#)
Equivalent capacitance of the series semiconductor-insulator (stray-border capacitance) [F].
- [Index nNodes_](#)
Number of nodes that form the mesh.
- [Index nSteps_](#)
Number of steps to simulate.
- [Real V_min_](#)
Minimum voltage [V].
- [Real V_max_](#)
Maximum voltage [V].

Friends

- class **GaussianCharge**
- class **ExponentialCharge**
- class **DosModel**

7.15.1 Detailed Description

Class providing methods to handle a list of parameters.

It can include up to 4 gaussians (later combined to compute total charge) and an exponential.

Definition at line 30 of file paramList.h.

7.15.2 Constructor & Destructor Documentation

7.15.2.1 ParamList (const RowVectorXr & list) [explicit]

Explicit conversion constructor.

Parameters

<i>in</i>	<i>list</i>	: a row vector containing a list of parameters (for example got by a CsvParser object). Parameters should be sorted in the same order as specified above.
-----------	-------------	---

Definition at line 19 of file paramList.cc.

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

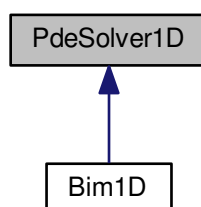
- DosExtraction/src/[paramList.h](#)
- DosExtraction/src/[paramList.cc](#)

7.16 PdeSolver1D Class Reference

Abstract class providing methods to assemble matrices to solve one-dimensional PDEs.

```
#include <solvers.h>
```

Inheritance diagram for PdeSolver1D:



Public Member Functions

- [PdeSolver1D](#) ()=delete

Default constructor (deleted since it is required to specify the mesh).

- [PdeSolver1D](#) ([VectorXr](#) &)

Constructor.

- virtual [~PdeSolver1D](#) ()=default

Destructor (defaulted).

- virtual void [assembleAdvDiff](#) (const [VectorXr](#) &alpha, const [VectorXr](#) &gamma, const [VectorXr](#) &eta, const [VectorXr](#) &beta)=0

Assemble the matrix for an advection-diffusion term.

- virtual void [assembleStiff](#) (const [VectorXr](#) &eps, const [VectorXr](#) &kappa)=0

Assemble the matrix for a diffusion term.

- virtual void [assembleMass](#) (const [VectorXr](#) &delta, const [VectorXr](#) &zeta)=0

Assemble the matrix for a reaction term.

Getter methods

- const [SparseXr](#) & **AdvDiff** () const
- const [SparseXr](#) & **Stiff** () const
- const [SparseXr](#) & **Mass** () const

Protected Attributes

- [VectorXr](#) [mesh_](#)

The mesh.

- [Index](#) [nNodes_](#)

Number of nodes that form the mesh.

- [SparseXr](#) [AdvDiff_](#)

Matrix for an advection-diffusion term.

- [SparseXr](#) [Stiff_](#)

Stiffness matrix.

- [SparseXr](#) [Mass_](#)

Mass matrix.

Friends

- class **NonLinearPoisson1D**

7.16.1 Detailed Description

Abstract class providing methods to assemble matrices to solve one-dimensional PDEs.

Matrices are held in a sparse format.

Definition at line 36 of file solvers.h.

7.16.2 Constructor & Destructor Documentation

7.16.2.1 [PdeSolver1D](#) ([VectorXr](#) & *mesh*)

Constructor.

Parameters

<code>in</code>	<code>mesh</code>	: the mesh.
-----------------	-------------------	-------------

Definition at line 17 of file solvers.cc.

7.16.3 Member Function Documentation

7.16.3.1 `virtual void assembleAdvDiff (const VectorXr & alpha, const VectorXr & gamma, const VectorXr & eta, const VectorXr & beta)` `[pure virtual]`

Assemble the matrix for an advection-diffusion term.

Build the matrix for the advection-diffusion problem: $-\nabla \cdot (\alpha \cdot \gamma (\eta \nabla u - \beta u)) = f$.

Parameters

<code>in</code>	<code>alpha</code>	: α , an element-wise constant function;
<code>in</code>	<code>gamma</code>	: γ , an element-wise linear function;
<code>in</code>	<code>eta</code>	: η , an element-wise linear function;
<code>in</code>	<code>beta</code>	: β , an element-wise constant function.

Implemented in [Bim1D](#).

7.16.3.2 `virtual void assembleStiff (const VectorXr & eps, const VectorXr & kappa)` `[pure virtual]`

Assemble the matrix for a diffusion term.

Build the matrix for the diffusion problem: $-\nabla \cdot (\varepsilon \cdot \kappa \nabla u) = f$.

Parameters

<code>in</code>	<code>eps</code>	: ε , an element-wise constant function;
<code>in</code>	<code>kappa</code>	: κ , an element-wise linear function.

Implemented in [Bim1D](#).

7.16.3.3 `virtual void assembleMass (const VectorXr & delta, const VectorXr & zeta)` `[pure virtual]`

Assemble the matrix for a reaction term.

Build the mass matrix for the reaction problem: $\delta \cdot \zeta u = f$.

Parameters

<code>in</code>	<code>delta</code>	: δ , an element-wise constant function;
<code>in</code>	<code>zeta</code>	: ζ , an element-wise linear function.

Implemented in [Bim1D](#).

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

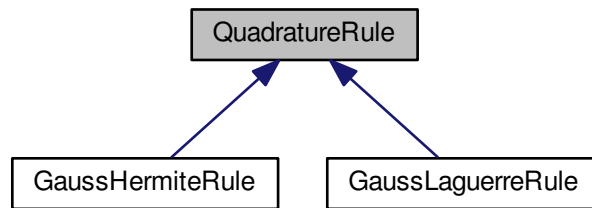
- [DosExtraction/src/solvers.h](#)
- [DosExtraction/src/solvers.cc](#)

7.17 QuadratureRule Class Reference

Abstract class providing a quadrature rule.

```
#include <quadratureRule.h>
```

Inheritance diagram for QuadratureRule:



Public Member Functions

- `QuadratureRule ()=delete`
Default constructor (deleted since it is required to specify the number of nodes).
- `QuadratureRule (const Index &)`
Constructor.
- `virtual ~QuadratureRule ()=default`
Destructor (defaulted).
- `virtual void apply ()=0`
Apply the quadrature rule in order to compute the nodes and weights.
- `virtual void apply (const GetPot &config)=0`
Apply the quadrature rule reading parameters from a configuration file.

Getter methods

- `const Index & nNodes () const`
- `const VectorXr & nodes () const`
- `const VectorXr & weights () const`

Protected Attributes

- `Index nNodes_`
Number of nodes of quadrature.
- `VectorXr nodes_`
Vector containing the computed nodes coordinates.
- `VectorXr weights_`
Vector containing the computed weights.

Friends

- class `GaussianCharge`
- class `ExponentialCharge`

7.17.1 Detailed Description

Abstract class providing a quadrature rule.

Approximate the integral:

$$\int_a^b f(x) \, dx$$

with the finite sum:

$$\sum_{i=1}^{nNodes} w_i \cdot f(x_i)$$

where $\{x_i\}_{i=1}^{nNodes}$ and $\{w_i\}_{i=1}^{nNodes}$ are called respectively nodes and weights.

Definition at line 34 of file quadratureRule.h.

7.17.2 Constructor & Destructor Documentation

7.17.2.1 QuadratureRule (const Index & nNodes)

Constructor.

Parameters

<code>in</code>	<code>nNodes</code>	: the number of nodes to be used for the quadrature rule.
-----------------	---------------------	---

Definition at line 19 of file quadratureRule.cc.

7.17.3 Member Function Documentation

7.17.3.1 virtual void apply (const GetPot & config) [pure virtual]

Apply the quadrature rule reading parameters from a configuration file.

Parameters

<code>in</code>	<code>config</code>	: the GetPot configuration object.
-----------------	---------------------	------------------------------------

Implemented in [GaussLaguerreRule](#), and [GaussHermiteRule](#).

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

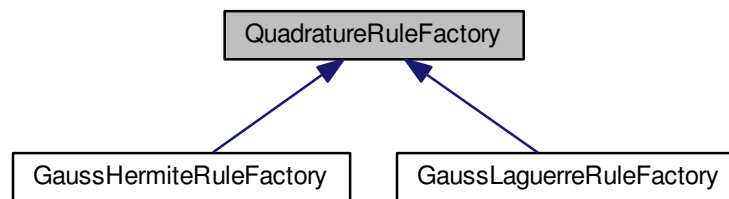
- [DosExtraction/src/quadratureRule.h](#)
- [DosExtraction/src/quadratureRule.cc](#)

7.18 QuadratureRuleFactory Class Reference

Abstract factory to handle a quadrature rule.

```
#include <factory.h>
```


Inheritance diagram for QuadratureRuleFactory:



Public Member Functions

- [QuadratureRuleFactory](#) ()=default
Default constructor (defaulted).
- virtual [~QuadratureRuleFactory](#) ()=default
Destructor (defaulted).
- virtual [QuadratureRule](#) * [BuildRule](#) (const [Index](#) &nNodes)=0
Factory method to build an abstract [QuadratureRule](#) object.

7.18.1 Detailed Description

Abstract factory to handle a quadrature rule.

Definition at line 111 of file factory.h.

7.18.2 Member Function Documentation

7.18.2.1 virtual [QuadratureRule](#)* [BuildRule](#) (const [Index](#) & *nNodes*) [pure virtual]

Factory method to build an abstract [QuadratureRule](#) object.

Parameters

<i>in</i>	<i>nNodes</i>	: the number of nodes to be used for the quadrature rule.
-----------	---------------	---

Returns

a pointer to [QuadratureRule](#).

Implemented in [GaussLaguerreRuleFactory](#), and [GaussHermiteRuleFactory](#).

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

- DosExtraction/src/[factory.h](#)

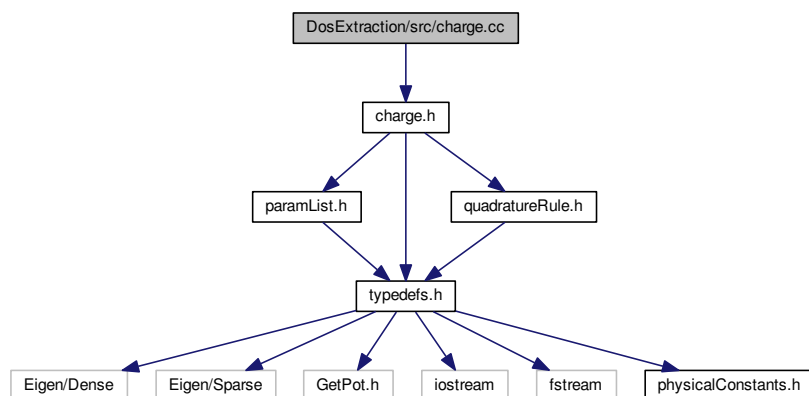
Chapter 8

File Documentation

8.1 DosExtraction/src/charge.cc File Reference

```
#include "charge.h"
```

Include dependency graph for charge.cc:



8.1.1 Detailed Description

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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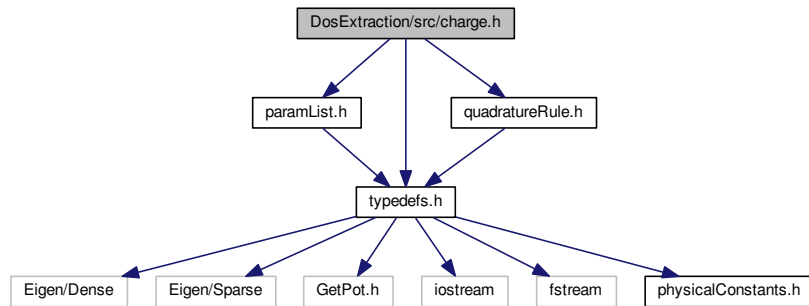
Definition in file [charge.cc](#).

8.2 DosExtraction/src/charge.h File Reference

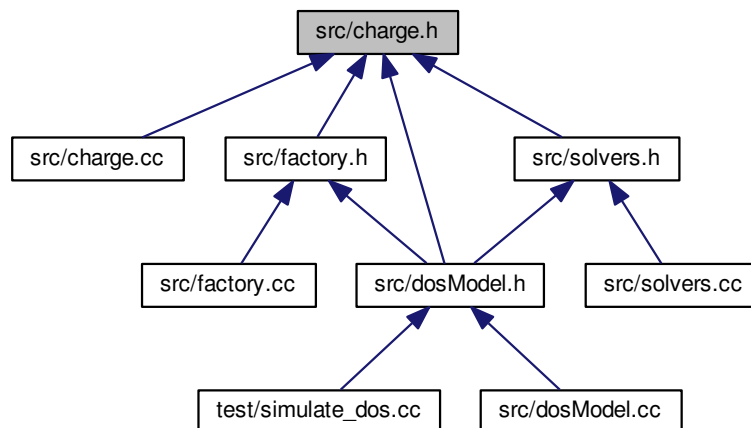
Classes for computing total electric charge.

```
#include "paramList.h"
#include "quadratureRule.h"
#include "typedefs.h"
```

Include dependency graph for charge.h:



This graph shows which files directly or indirectly include this file:



Classes

- class [Charge](#)

Abstract class providing methods to calculate total electric charge (the rhs in the Poisson equation).

- class [GaussianCharge](#)

Class derived from [Charge](#), under the hypothesis that Density of States is a combination of gaussians.

- class [ExponentialCharge](#)

Class derived from [Charge](#), under the hypothesis that Density of States is a single exponential.

8.2.1 Detailed Description

Classes for computing total electric charge.

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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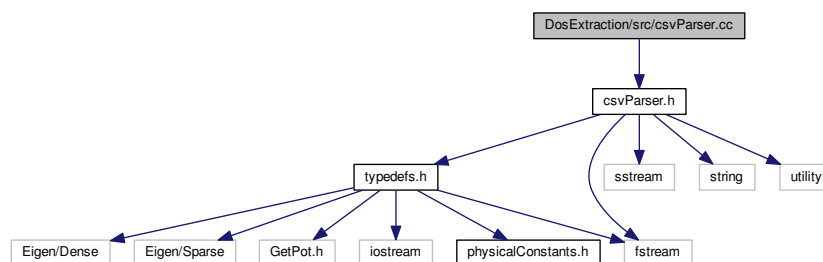
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Definition in file [charge.h](#).

8.3 DosExtraction/src/csvParser.cc File Reference

```
#include "csvParser.h"
```

Include dependency graph for csvParser.cc:



8.3.1 Detailed Description

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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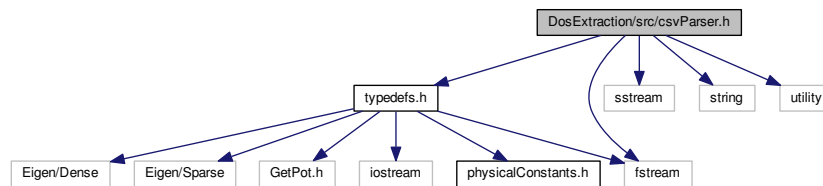
Definition in file [csvParser.cc](#).

8.4 DosExtraction/src/csvParser.h File Reference

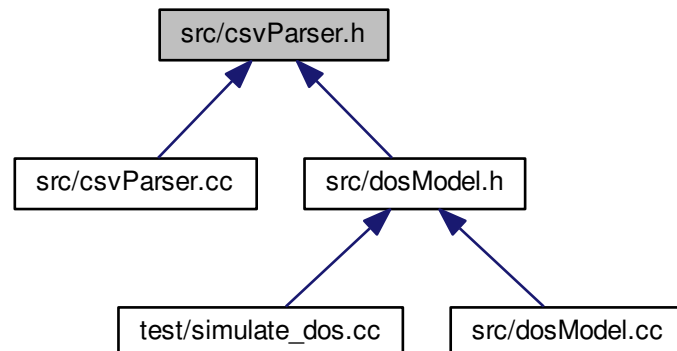
Tools to store content from a .csv file in matrices or vectors.

```
#include "typedefs.h"
#include <fstream>
#include <sstream>
#include <string>
#include <utility>
```

Include dependency graph for csvParser.h:



This graph shows which files directly or indirectly include this file:



Classes

- class [CsvParser](#)

*Class providing methods to read **numeric** content from a .csv file and to store it in [Eigen](#) matrices or vectors.*

8.4.1 Detailed Description

Tools to store content from a .csv file in matrices or vectors.

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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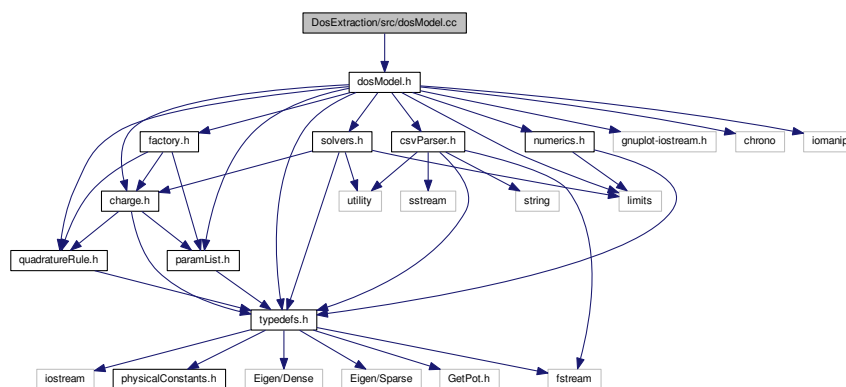
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Definition in file [csvParser.h](#).

8.5 DosExtraction/src/dosModel.cc File Reference

```
#include "dosModel.h"
```

Include dependency graph for dosModel.cc:



8.5.1 Detailed Description

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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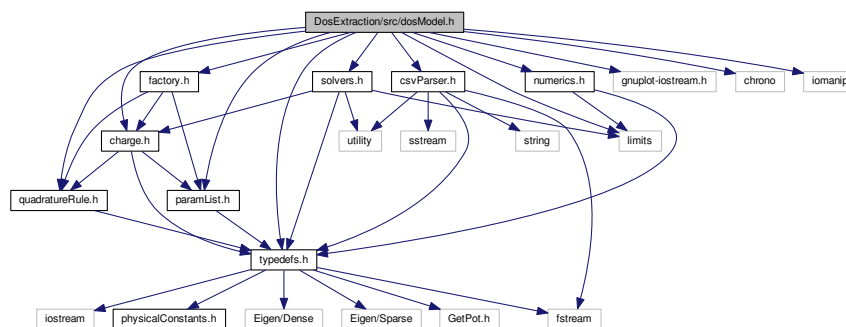
Definition in file [dosModel.cc](#).

8.6 DosExtraction/src/dosModel.h File Reference

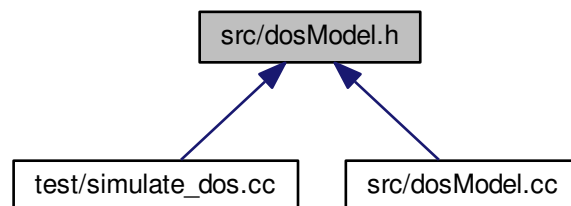
Mathematical model for Density of States extraction.

```
#include "charge.h"
#include "csvParser.h"
#include "factory.h"
#include "numerics.h"
#include "paramList.h"
#include "quadratureRule.h"
#include "solvers.h"
#include "typedefs.h"
#include "gnuplot-iostream.h"
#include <chrono>
#include <iomanip>
#include <limits>
```

Include dependency graph for dosModel.h:



This graph shows which files directly or indirectly include this file:



Classes

- class [DosModel](#)

Class providing methods to process a simulation to extract the Density of States starting from a parameter list.

8.6.1 Detailed Description

Mathematical model for Density of States extraction.

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

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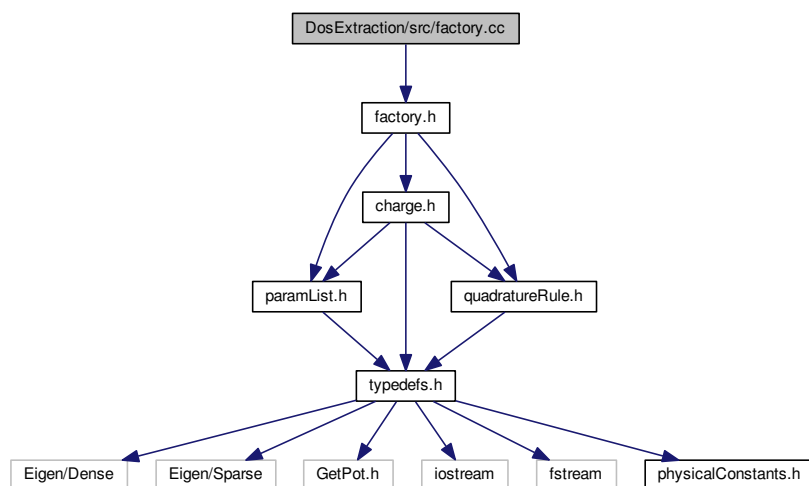
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Definition in file [dosModel.h](#).

8.7 DosExtraction/src/factory.cc File Reference

```
#include "factory.h"
```

Include dependency graph for factory.cc:



8.7.1 Detailed Description

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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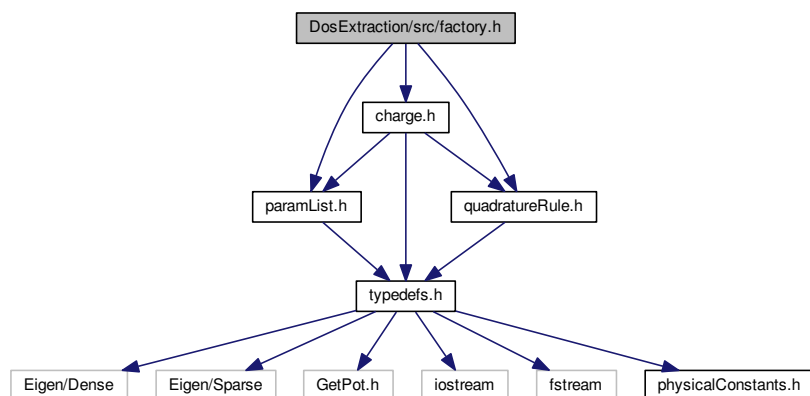
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Definition in file [factory.cc](#).

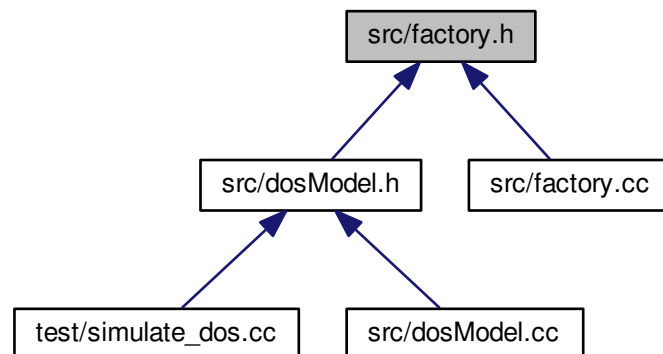
8.8 DosExtraction/src/factory.h File Reference

Abstract factory design patterns.

```
#include "charge.h"  
#include "paramList.h"  
#include "quadratureRule.h"  
Include dependency graph for factory.h:
```



This graph shows which files directly or indirectly include this file:



Classes

- class [ChargeFactory](#)
Abstract factory to handle the constitutive relation for the Density of States.
- class [GaussianChargeFactory](#)
Concrete factory to handle a multiple gaussians DOS constitutive relation.
- class [ExponentialChargeFactory](#)
Concrete factory to handle a single exponential DOS constitutive relation.
- class [QuadratureRuleFactory](#)
Abstract factory to handle a quadrature rule.
- class [GaussHermiteRuleFactory](#)
Concrete factory to handle a Gauss-Hermite quadrature rule.
- class [GaussLaguerreRuleFactory](#)
Concrete factory to handle a Gauss-Laguerre quadrature rule.

8.8.1 Detailed Description

Abstract factory design patterns.

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

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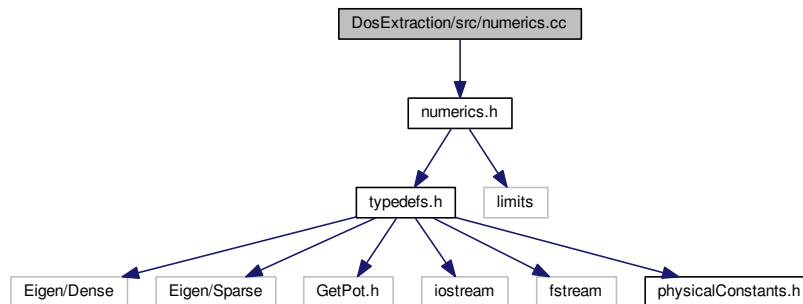
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Definition in file [factory.h](#).

8.9 DosExtraction/src/numerics.cc File Reference

```
#include "numerics.h"
```

Include dependency graph for numerics.cc:



8.9.1 Detailed Description

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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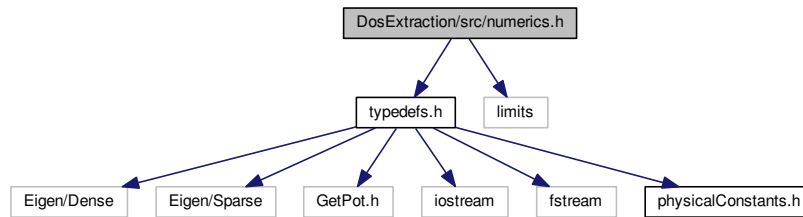
Definition in file [numerics.cc](#).

8.10 DosExtraction/src/numerics.h File Reference

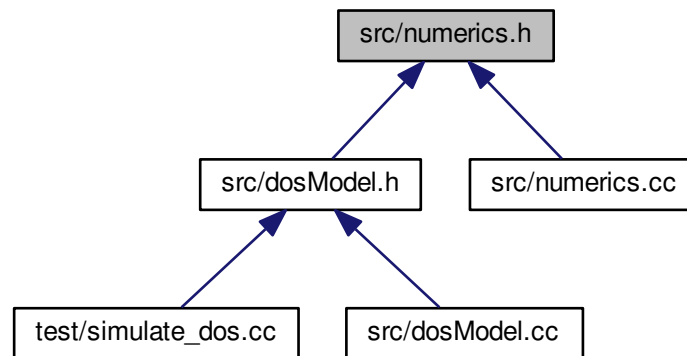
Generic numeric algorithms.

```
#include "typedefs.h"  
#include <limits>
```

Include dependency graph for numerics.h:



This graph shows which files directly or indirectly include this file:



Namespaces

- [numerics](#)

Namespace for generic numeric algorithms.

Functions

- `template<typename ScalarType >`
`VectorX< ScalarType > sort (const VectorX< ScalarType > &vector)`
Function to sort [Eigen](#) vectors.
- `template<typename ScalarType >`
`VectorXpair< ScalarType > sort_pair (const VectorX< ScalarType > &vector)`
Function to sort [Eigen](#) vectors, keeping track of indexes.
- `Real trapz (const VectorXr &x, const VectorXr &y)`
Function to compute approximate integral of y with spacing increment specified by x, using trapezoidal rule.
- `Real trapz (const VectorXr &y)`
Compute the approximate integral of y with unit spacing, using trapezoidal rule.
- `VectorXr deriv (const VectorXr &, const VectorXr &)`

- Compute the numeric derivative: $\frac{dy}{dx}$.
 • `Real interp1` (const `VectorXr` &, const `VectorXr` &, const `Real` &)
 Linear 1D interpolation. Interpolate y , defined at points x , at the point x_{New} .
- `VectorXr interp1` (const `VectorXr` &, const `VectorXr` &, const `VectorXr` &)
 Linear 1D interpolation. Interpolate y , defined at points x , at the points x_{New} .
- `Real error_L2` (const `VectorXr` &, const `VectorXr` &, const `VectorXr` &, const `Real` &)
 Compute the L^2 -norm error between simulated and interpolated values, using trapz.

8.10.1 Detailed Description

Generic numeric algorithms.

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

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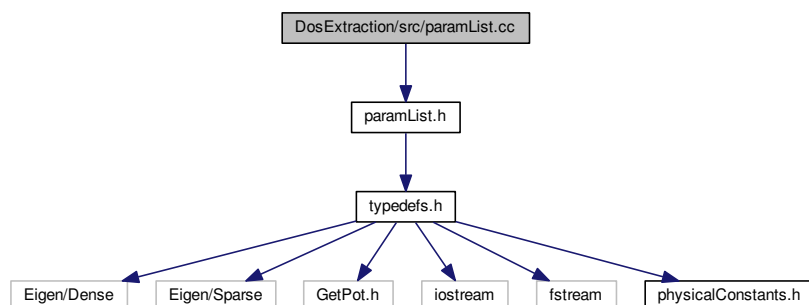
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Definition in file [numerics.h](#).

8.11 DosExtraction/src/paramList.cc File Reference

```
#include "paramList.h"
```

Include dependency graph for paramList.cc:



8.11.1 Detailed Description

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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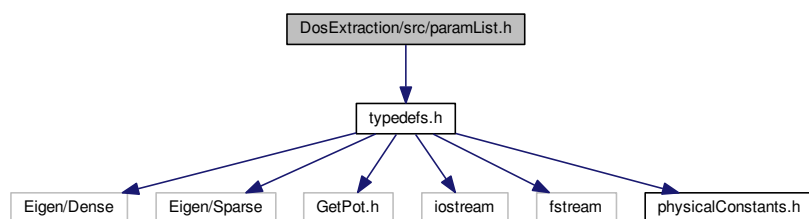
Definition in file [paramList.cc](#).

8.12 DosExtraction/src/paramList.h File Reference

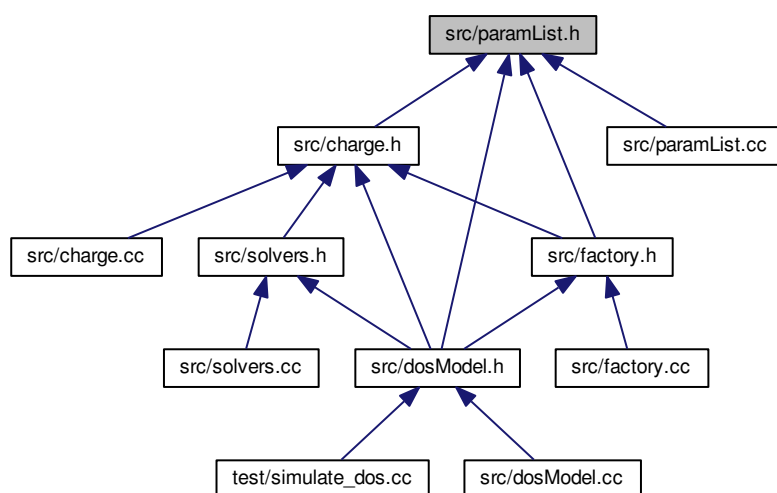
Interface to process a list of simulation parameters.

```
#include "typedefs.h"
```

Include dependency graph for paramList.h:



This graph shows which files directly or indirectly include this file:



Classes

- class [ParamList](#)

Class providing methods to handle a list of parameters.

8.12.1 Detailed Description

Interface to process a list of simulation parameters.

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

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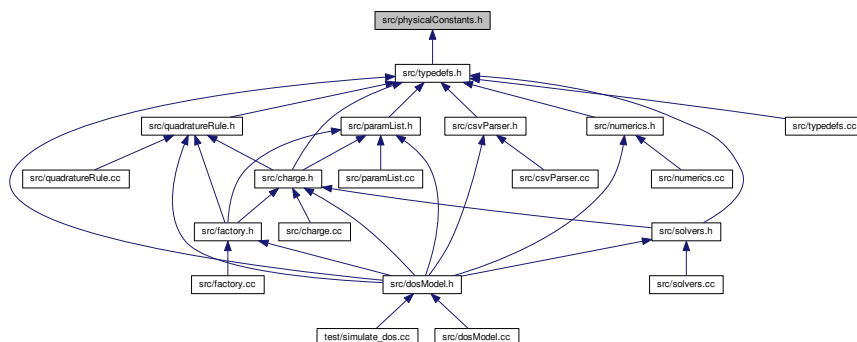
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Definition in file [paramList.h](#).

8.13 DosExtraction/src/physicalConstants.h File Reference

Physical constants.

This graph shows which files directly or indirectly include this file:



Namespaces

- [constants](#)

Numerical constants.

Variables

- const **Real** **Q** = 1.602176530000000e-19
Electron charge [C].
- const **Real** **Q2** = Q * Q
Electron charge squared [C²].
- const **Real** **K_B** = 1.380650500000000e-23
Boltzmann's constant [J · K⁻¹].
- const **Real** **EPS0** = 8.854187817e-12
Vacuum electrical permittivity [C · V⁻¹ · m⁻¹].
- const **Real** **T** = 300
Reference temperature [K].
- const **Real** **V_TH** = K_B * T / Q
Threshold voltage [V].

8.13.1 Detailed Description

Physical constants.

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

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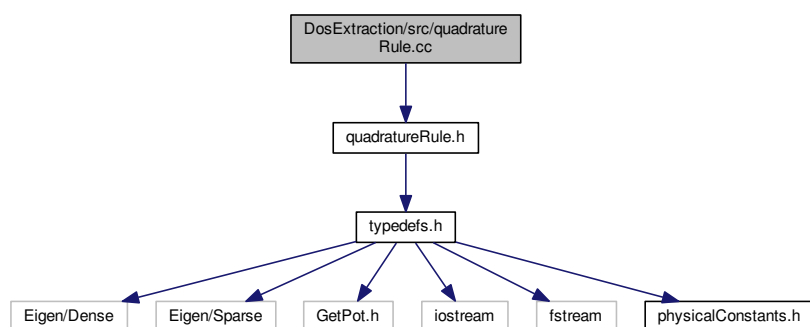
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Definition in file [physicalConstants.h](#).

8.14 DosExtraction/src/quadratureRule.cc File Reference

```
#include "quadratureRule.h"
```

Include dependency graph for quadratureRule.cc:



8.14.1 Detailed Description

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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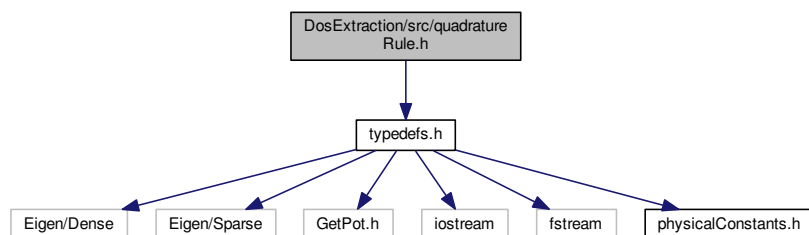
Definition in file [quadratureRule.cc](#).

8.15 DosExtraction/src/quadratureRule.h File Reference

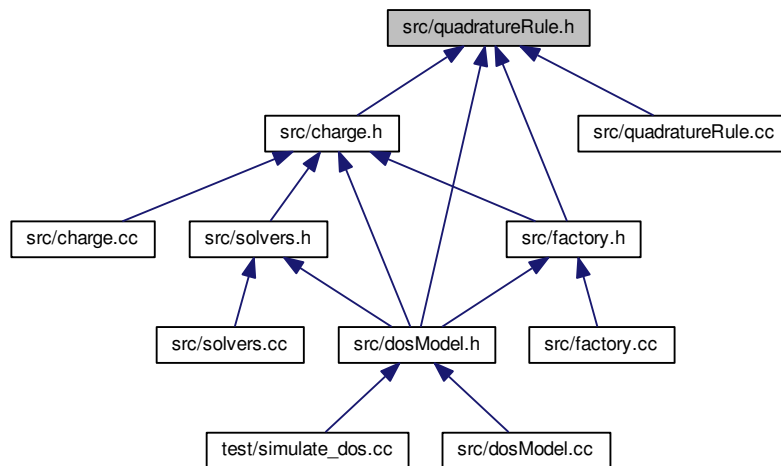
Quadrature rules.

```
#include "typedefs.h"
```

Include dependency graph for quadratureRule.h:



This graph shows which files directly or indirectly include this file:



Classes

- class [QuadratureRule](#)
Abstract class providing a quadrature rule.
- class [GaussHermiteRule](#)
Class derived from [QuadratureRule](#) providing the Gauss-Hermite quadrature rule.
- class [GaussLaguerreRule](#)
Class derived from [QuadratureRule](#) providing the Gauss-Laguerre quadrature rule.

8.15.1 Detailed Description

Quadrature rules.

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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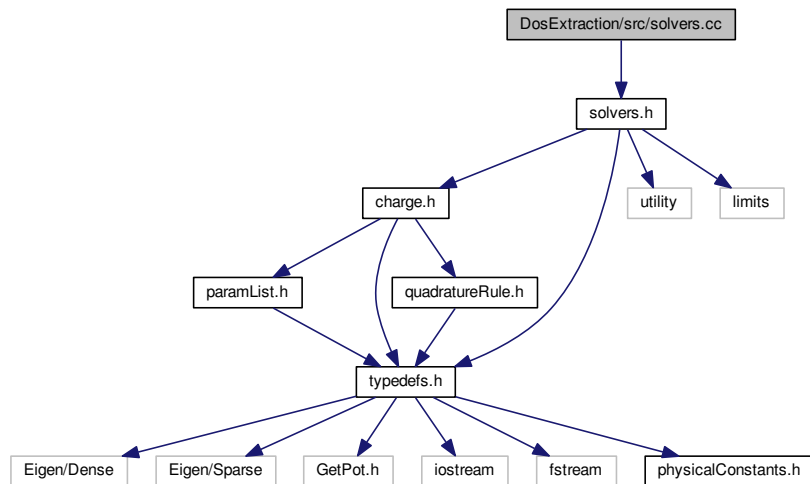
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Definition in file [quadratureRule.h](#).

8.16 DosExtraction/src/solvers.cc File Reference

```
#include "solvers.h"
Include dependency graph for solvers.cc:
```



8.16.1 Detailed Description

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

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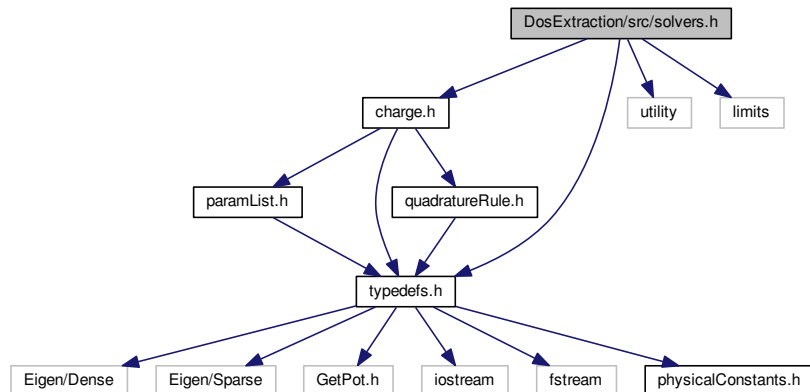
Definition in file [solvers.cc](#).

8.17 DosExtraction/src/solvers.h File Reference

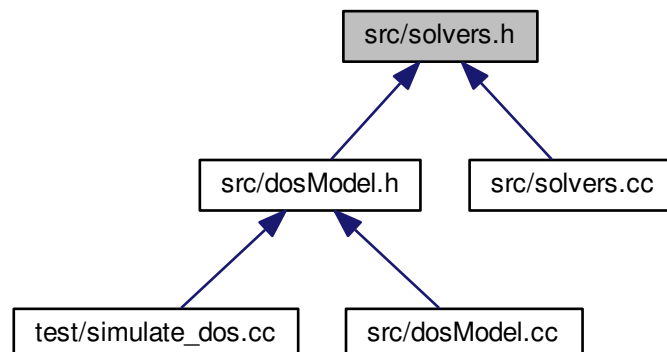
Generic solvers for PDEs.

```
#include "charge.h"
#include "typedefs.h"
#include <utility>
#include <limits>
```

Include dependency graph for solvers.h:



This graph shows which files directly or indirectly include this file:



Classes

- class [PdeSolver1D](#)
Abstract class providing methods to assemble matrices to solve one-dimensional PDEs.
- class [Bim1D](#)
Class derived from [PdeSolver1D](#), providing a finite volume Box Integration Method (BIM) solver.
- class [NonLinearPoisson1D](#)
Provide a solver for a non-linear Poisson equation.

8.17.1 Detailed Description

Generic solvers for PDEs.

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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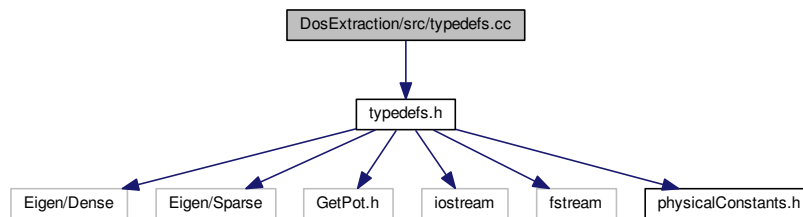
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Definition in file [solvers.h](#).

8.18 DosExtraction/src/typedefs.cc File Reference

```
#include "typedefs.h"
```

Include dependency graph for typedefs.cc:



8.18.1 Detailed Description

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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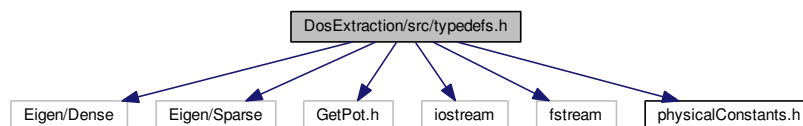
Definition in file [typedefs.cc](#).

8.19 DosExtraction/src/typedefs.h File Reference

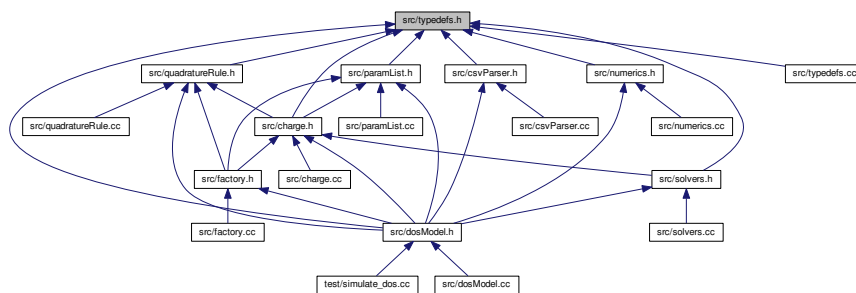
Typedefs and utility functions.

```
#include <Eigen/Dense>
#include <Eigen/Sparse>
#include "GetPot.h"
#include <iostream>
#include <fstream>
#include "physicalConstants.h"
```

Include dependency graph for typedefs.h:



This graph shows which files directly or indirectly include this file:



Namespaces

- [constants](#)
Numerical constants.
- [utility](#)
Namespace for utilities and auxiliary functions.

Macros

- `#define` [Real](#) double
Pre-processor macro for real numbers.
- `#define` [Index](#) ptrdiff_t
Pre-processor macro for indexing variables.

Typedefs

- `typedef` Matrix< [Real](#), Dynamic,
Dynamic > [MatrixXr](#)

- *Typedef for dense real-valued dynamic-sized matrices.*
 • typedef Matrix< [Real](#), Dynamic, 1 > [VectorXr](#)
Typedef for dense real-valued dynamic-sized column vectors.
- typedef Matrix< [Real](#), 1, Dynamic > [RowVectorXr](#)
Typedef for dense real-valued dynamic-sized row vectors.
- typedef SparseMatrix< [Real](#) > [SparseXr](#)
Typedef for sparse real-valued dynamic-sized matrices.
- template<typename ScalarType >
 using [VectorX](#) = Matrix< ScalarType, Dynamic, 1 >
Template alias for [Eigen](#) vectors.
- template<typename T >
 using [VectorXpair](#) = [VectorX](#)< std::pair< T, [Index](#) > >
Template alias for an [Eigen](#) vector of pairs: (ScalarType, Index).

Functions

- std::string [full_path](#) (const std::string &, const std::string &)
Auxiliary function to return the full path to a file.
- void [print_block](#) (const char *, std::ostream &=std::cout)
Auxiliary function to print a string inside a block.
- void [print_done](#) (std::ostream &=std::cout)
Auxiliary function to print a "DONE!" string.

Variables

- const [Index](#) [PARAMS_NO](#) = 26
Number of parameters required in input file.
- const [Real](#) [PI](#) = M_PI
 π .
- const [Real](#) [SQRT_PI](#) = std::sqrt(PI)
 $\sqrt{\pi}$.
- const [Real](#) [PI_M4](#) = 0.7511255444649425
 $\pi^{-\frac{1}{4}}$.
- const [Real](#) [SQRT_2](#) = std::sqrt(2)
 $\sqrt{2}$.

8.19.1 Detailed Description

Typedefs and utility functions.

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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Definition in file [typedefs.h](#).

8.19.2 Typedef Documentation

8.19.2.1 using VectorX = Matrix<ScalarType, Dynamic, 1>

Template alias for [Eigen](#) vectors.

Template Parameters

<i>ScalarType</i>	: the scalar type.
-------------------	--------------------

Definition at line 46 of file typedefs.h.

8.19.2.2 using VectorXpair = VectorX<std::pair<T, Index> >

Template alias for an [Eigen](#) vector of pairs: (*ScalarType*, *Index*).

Template Parameters

<i>ScalarType</i>	: the scalar type.
-------------------	--------------------

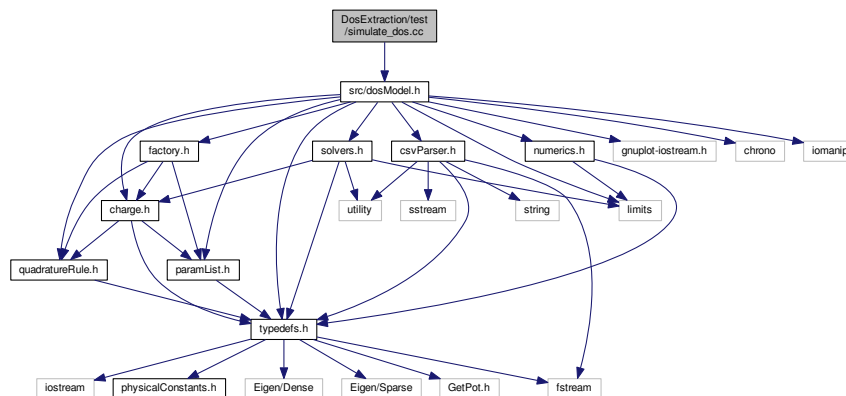
Definition at line 53 of file typedefs.h.

8.20 DosExtraction/test/simulate_dos.cc File Reference

A test file.

```
#include "src/dosModel.h"
```

Include dependency graph for simulate_dos.cc:



Functions

- int [main](#) (const int argc, const char *const *argv, const char *const *envp)
The **main** function.

8.20.1 Detailed Description

A test file.

Author

Pasquale Claudio Africa pasquale.africa@gmail.com

Date

2014

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Definition in file [simulate_dos.cc](#).

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