LATField 2.0 documentation

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Contents

Chapter 1

Main Page

1.1 Introduction

LATField 2.0, the second version of the LATfield library, a simple framework to ease field based simulation on the lattice.

Version 2.0 changes:

- the parallelization have been rebuilt to distribute 2 lattice dimension into a 2-dimensional MPI process grid.
- A FFT wrapper exist for 3d cubic lattices.
- HDF5 can be used for Fields I/O
- An I/O server have been implemented. (Beta)

1.2 Downloads

The current stable version can be downloaded at:

For user who would like to contribute to LATfield, the library git repository is on gitHub: `https://github.-com/daverio/LATfield2.git`

1.3 Getting Started

The best way to start with LATfield is to jump into the examples starting with the "getting started" example. The FFT example will explain the usage of the PlanFFT class and the IOserver example the IO server. There is a forth example which show how to build a poisson solver, but this example is currently not documented.

Chapter 2

Hierarchical Index

2.1 Class Hierarchy

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

Chapter 3

Class Index

3.1 Class List

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

Chapter 4

File Index

4.1 File List

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

Chapter 5

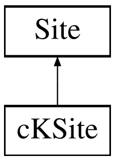
Class Documentation

5.1 cKSite Class Reference

A child of Site, built to work with the fourier space lattices for complex to complex transforms.

```
#include <LATfield2_Site.hpp>
```

Inheritance diagram for cKSite:



Public Member Functions

- **cKSite** (Lattice &lattice)
- **cKSite** (Lattice &lattice, long index)
- void **initialize** (Lattice &lattice)
- void **initialize** (Lattice &lattice, long index)
- cKSite **operator+** (int asked_direction)
- cKSite **operator-** (int asked_direction)
- int **coordLocal** (int asked_direction)
- int **coord** (int asked_direction)
- int **latCoord** (int direction)
- int **latCoordLocal** (int direction)
- bool **setCoord** (int ∗r_asked)
- bool **setCoord** (int x, int y, int z)

Private Attributes

- int **directions_** [3]

Additional Inherited Members

5.1.1 Detailed Description

A child of Site, built to work with the fourier space lattices for complex to complex transforms.

A class which simplify the map of the field data array index. This class allow to get coordinate on the lattice, loop over each site of the lattice and perform displacment on the lattice.

WARNING: this site class must be used only on lattices initialized using initializeComplexFFT() method of the Lattice class.

This class have same binding that the Site class, so one can refer to the Site class for the documentation.

Examples:

FFTs.

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

- LATfield2_Site.hpp

5.2 Field< FieldType > Class Template Reference

The Field class describe a field on a given lattice.

```
#include <LATfield2_Field.hpp>
```

Public Member Functions

- Field ()

  Constructor.
- Field (Lattice &lattice, int components=1)
- Field (Lattice &lattice, int matrixRows, int matrixCols, int symmetry=unsymmetric)
- ∼Field ()

  Destructor.
- void initialize (Lattice &lattice, int components=1)
- void initialize (Lattice &lattice, int rows, int cols, int symmetry=unsymmetric)
- void alloc ()
- void alloc (long size)
- void dealloc ()
- FieldType & operator() (long index)
- FieldType & operator() (long index, int component)
- FieldType & operator() (long index, int i, int j)
- FieldType & operator() (const Site &site)
- FieldType & operator() (const Site &site, int component)
- FieldType & operator() (const Site &site, int i, int j)
- FieldType & operator() (const cKSite &site)
- FieldType & operator() (const cKSite &site, int component)
- FieldType & operator() (const cKSite &site, int i, int j)
- FieldType & operator() (const rKSite &site)
- FieldType & operator() (const rKSite &site, int component)
- FieldType & operator() (const rKSite &site, int i, int j)
- void updateHalo ()
- void write (const string filename)
- void read (const string filename)
- void fastwrite (const string filename)
- void save (const string filename, void(∗FormatFunction)(fstream &, FieldType ∗, int)=defaultFieldSave< FieldType >)
- void load (const string filename, void(∗FormatFunction)(fstream &, FieldType ∗, int)=defaultFieldLoad< FieldType >)

- void fastsave (const string filename, void(∗FormatFunction)(fstream &, FieldType ∗, int)=defaultFieldSave< FieldType >)
- void saveHDF5 (string filename)
- void loadHDF5 (string filename)
- void saveHDF5_coarseGrain3D (string filename, int ratio)
- void saveSliceHDF5 (string filename, int xcoord, int thickness=1)
- Lattice & lattice ()
- int components ()
- int rows ()
- int cols ()
- int symmetry ()
- FieldType ∗& data ()

Public Attributes

- FieldType ∗ **data_**

Protected Attributes

- Lattice ∗ **lattice_**
- int **components_**
- int **rows_**
- int **cols_**
- int **symmetry_**
- unsigned int **sizeof_fieldType_**
- int **status_**
- hid_t **type_id**
- int **array_size**

Static Protected Attributes

- static int **initialized**
- static int **allocated**

Private Member Functions

- void **updateHaloComms** ()
- void **get_h5type** ()

5.2.1 Detailed Description

template<class FieldType>class Field< FieldType >

The Field class describe a field on a given lattice.

It store the description of the field i.e. the datatype and the number of components. It also store the pointer to the field array in the memory.

As the datatype is versatil, field of structure or class can be used. But in that case, the I/O need to be modified. Indeed the I/O support only native datatype and 1d array of them.

A field can be a single element, a vector of element or a 2d matrix of elements. In the case of a matrix it is possible to define the symmetry of the matrix:

LATfield2d::unsymmetric : no symmetry.

LATfield2d::symmetric : symmetric matrix (Tij = Tji)

Examples:

FFTs, gettingStarted, and poissonSolver.

5.2.2 Constructor & Destructor Documentation

5.2.2.1 template<class FieldType > Field< FieldType >::Field (Lattice & *lattice*, int *components* = `1`)

Constructor of a "vector" field with initialization

See Also

initialize(Lattice& lattice, int components = 1);

Parameters

lattice	: lattice on witch the field is defined
components	: number of components. Default is 1.

5.2.2.2 template<class FieldType > Field< FieldType >::Field (Lattice & *lattice*, int *matrixRows*, int *matrixCols*, int *symmetry* = `unsymmetric`)

Constructor of a "matrix" field with initialization

See Also

initialize(Lattice& lattice, int components = 1);

Parameters

lattice	: lattice on witch the field is defined
matrixRows	: matrix number of row .
matrixCols	: matrix number of colomn.
symmetry	: symmetry of the matrix, default is unsymmetric. LATfield2d::symmetric can be pass to specify the symmetry.

5.2.3 Member Function Documentation

5.2.3.1 template<class FieldType > void Field< FieldType >::alloc ( )

Memory allocation. Allocate the data_ array o f this field. It allocated "components_∗lattice_->sitesLocalGross()∗sizeof(FieldType)" bytes.

5.2.3.2 template<class FieldType > void Field< FieldType >::alloc (long *size*)

Memory allocation. Allocate the data_ array of this field. It allocated "size" bytes if "size" > "components_∗lattice_->sitesLocalGross()∗sizeof(FieldType)", if not it call this->alloc() .

5.2.3.3 template<class FieldType > int Field< FieldType >::cols ( )

Return the number of columns of the component matrix.

5.2.3.4 template<class FieldType > int Field< FieldType >::components ( )

Return the number of components of the field.

5.2.3.5 template<class FieldType > FieldType ∗& Field< FieldType >::data ( )

Return the pointer to the data array of the field.

5.2.3.6 template<class FieldType > void Field< FieldType >::dealloc ( )

Free the data_ array.

5.2.3.7 template<class FieldType > void Field< FieldType >::fastsave (const string *filename*, void(∗)(fstream &, FieldType ∗, int) *FormatFunction* = `defaultFieldSave<FieldType>`)

Method to write a field in ASCII. This method use serial I/O so can be very slow, but is faster than void write(const string filename). Should never be used! but can be usefull on some architectur, where HDF5 is not installed and/or MPI parallel I/O crash the filesystem. There is no method to read back such a file. The file structur is dependent of the local geometry. This function dumb serially (in the paralle.lat_world_rank order) the data stored in each MPI process.

5.2.3.8 template<class FieldType > void Field< FieldType >::fastwrite (const string *filename*)

Method to write a field in Binary. This method use serial I/O so can be very slow, but is faster than void write(const string filename). Should never be used! but can be usefull on some architectur, where HDF5 is not installed and/or MPI parallel I/O crash the filesystem. There is no method to read back such a file. The file structur is dependent of the local geometry. This function dumb serially (in the paralle.lat_world_rank order) the data stored in each MPI process.

5.2.3.9 template<class FieldType > void Field< FieldType >::initialize (Lattice & *lattice*, int *components* = `1`)

Initialization of a "vector" field

See Also

initialize(Lattice& lattice, int components = 1);

Parameters

lattice	: lattice on witch the field is defined
components	: number of components. Default is 1.

5.2.3.10 template<class FieldType > void Field< FieldType >::initialize (Lattice & *lattice*, int *rows*, int *cols*, int *symmetry* = `unsymmetric`)

Initialization of a "matrix" field.

See Also

initialize(Lattice& lattice, int components = 1);

Parameters

lattice	: lattice on witch the field is defined
matrixRows	: matrix number of row .
matrixCols	: matrix number of colomn.
symmetry	: symmetry of the matrix, default is unsymmetric. LATfield2d::symmetric can be pass to specify the symmetry.

5.2.3.11 template<class FieldType > Lattice & Field< FieldType >::lattice ( )

Return a pointer to the lattice on which the field relise.

5.2.3.12 template<class FieldType > void Field< FieldType >::load (const string *filename*, void(∗)(fstream &, FieldType ∗, int) *FormatFunction* = `defaultFieldLoad<FieldType>`)

Method to read a field in ASCII which have been writen by the void write(const string filename) method.

5.2.3.13 template<class FieldType > void Field< FieldType >::loadHDF5 (string *filename*)

Method to load a field with HDF5. To be able to use this method the flag HDF5 need to be set at compilation (-DHDF5). This method use serial HDF5 by default. If someone want to use parallel HDF5 the flag -DH5_HAVE_-PARALLEL must be used at compilation.

5.2.3.14 template<class FieldType > FieldType & Field< FieldType >::operator() (long *index*) `[inline]`

Return the value of the field stored in data_[index]. This operator should not be used by users, but only by implementers.

5.2.3.15 template<class FieldType > FieldType & Field< FieldType >::operator() (long *index*, int *component*) `[inline]`

Return the value of the field stored in data_[component + index∗components_]. This operator should not be used by users, but only by implementers.

5.2.3.16 template<class FieldType > FieldType & Field< FieldType >::operator() (long *index*, int *i*, int *j*) `[inline]`

Return the value of the "component" field's components stored in data_[j∗rows_ + i + index∗components_]. In the symmetric case, it returns data_[abs(i-j) + min(i,j)∗(rows_+0.5-0.5∗min(i,j)) + index∗components_]. This operator should not be used by users, but only by implementers.

5.2.3.17 template<class FieldType > FieldType & Field< FieldType >::operator() (const Site & *site*) `[inline]`

Return the value of the field at the position pointed by the Site object (data_[site.index()]). This command must be used only for field with one component!

See Also

To have more detailled description see the Site class documentation.

5.2.3.18 template<class FieldType > FieldType & Field< FieldType >::operator() (const Site & *site*, int *component*) [inline]

Return the value of the "component" field's components at the position pointed by the Site object (data_[component + site.index()∗components_]).

See Also

To have more detailled description see the Site class documentation.

5.2.3.19 template<class FieldType > FieldType & Field< FieldType >::operator() (const Site & *site*, int *i*, int *j*) [inline]

Return the value of the (i,j) matrix component of the field at the position pointed by the Site object (data_[j∗rows_ + i + site.index∗components_]). In the symmetric case, it returns data_[abs(i-j) + min(i,j)∗(rows_+0.5-0.5∗min(i,j)) + site.index()∗components_].

See Also

To have more detailled description see the Site class documentation.

5.2.3.20 template<class FieldType > FieldType & Field< FieldType >::operator() (const cKSite & *site*) [inline]

Equivalent to FieldType& operator()(const Site& site) for cKsite

5.2.3.21 template<class FieldType > FieldType & Field< FieldType >::operator() (const cKSite & *site*, int *component*) [inline]

Equivalent to FieldType& operator()(const Site& site, int component) for cKsite

5.2.3.22 template<class FieldType > FieldType & Field< FieldType >::operator() (const cKSite & *site*, int *i*, int *j*) [inline]

Equivalent to FieldType& operator()(const Site& site, int i, int j) for cKsite

5.2.3.23 template<class FieldType > FieldType & Field< FieldType >::operator() (const rKSite & *site*) [inline]

Equivalent to FieldType& operator()(const Site& site) for rKsite

5.2.3.24 template<class FieldType > FieldType & Field< FieldType >::operator() (const rKSite & *site*, int *component*) [inline]

Equivalent to FieldType& operator()(const Site& site, int component) for rKsite

5.2.3.25 template<class FieldType > FieldType & Field< FieldType >::operator() (const rKSite & *site*, int *i*, int *j*) [inline]

Equivalent to FieldType& operator()(const Site& site, int i, int j) for rKsite

5.2.3.26 template<class FieldType > void Field< FieldType >::read (const string *filename*)

Method to read a field in Binary which have been writen by the void write(const string filename) method.

5.2.3.27 template< class FieldType > int Field< FieldType >::rows ( )

Return the number of rows of the component matrix.

5.2.3.28 template< class FieldType > void Field< FieldType >::save (const string *filename*, void(∗)(fstream &, FieldType ∗, int) *FormatFunction* = `defaultFieldSave<FieldType>`)

Method to write a field in ASCII. This method use serial I/O so can be very slow. Should never be used during production, but can be usefull during development.

5.2.3.29 template< class FieldType > void Field< FieldType >::saveHDF5 (string *filename*)

Method to write a field with HDF5. This method use serial HDF5 by default. If someone want to use parallel HDF5 the flag -DH5_HAVE_PARALLEL must be used at compilation.

5.2.3.30 template< class FieldType > void Field< FieldType >::saveHDF5_coarseGrain3D (string *filename*, int *ratio*)

A way to save coarse grained fields. To be able to use this method the flag HDF5 need to be set at compilation (-DHDF5). Must be use carefully, meaning you should understand the code of this function if you want to use it!!!! Work only for 3D lattice!!! developed only for LAH.

5.2.3.31 template< class FieldType > void Field< FieldType >::saveSliceHDF5 (string *filename*, int *xcoord*, int *thickness* = `1`)

Save a slice in the X direction. To be able to use this method the flag HDF5 need to be set at compilation (-DHDF5). Must be use carefully, meaning you should understand the code of this function if you want to use it!!!! Work only for 3D lattice!!! developed only for LAH.

5.2.3.32 template< class FieldType > int Field< FieldType >::symmetry ( )

return the symmetry of the component matrix

5.2.3.33 template< class FieldType > void Field< FieldType >::updateHalo ( )

Method to update the halo sites (gohst cells).

5.2.3.34 template< class FieldType > void Field< FieldType >::write (const string *filename*)

Method to write a field in Binary. This method use serial I/O so can be very slow. Should never be used during production, but can be usefull during development.

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

- LATfield2_Field.hpp

5.3 file_struct Struct Reference

A structure to describe a file for the IOserver.

`#include <LATfield2_IO_server.hpp>`

Public Attributes

- string filename

  path to the file
- char ∗ data

  data array of the file
- long long size

  size of the local part of the file
- int type

  type of the file (currently only FILETYPE_UNSTRUCTURED)

5.3.1 Detailed Description

A structure to describe a file for the IOserver.

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

- LATfield2_IO_server.hpp

5.4 Imag Class Reference

complex numbers

```
#include <Imag.hpp>
```

Public Member Functions

- **Imag** (Real a, Real b)
- Imag **operator-** ()
- Imag **operator+** (Imag z)
- Imag **operator-** (Imag z)
- Imag **operator∗** (Imag z)
- Imag **operator/** (Imag z)
- void **operator=** (Real r)
- void **operator+=** (Imag z)
- void **operator-=** (Imag z)
- void **operator∗=** (Imag z)
- void **operator+=** (Real a)
- void **operator-=** (Real a)
- void **operator∗=** (Real a)
- void **operator/=** (Real a)
- Real & **real** ()
- Real & **imag** ()
- Real **phase** ()
- Imag **conj** ()
- Real **norm** ()

Private Attributes

- Real **data** [2]
- fftwf_complex **data**
- fftw_complex **data**

Friends

- Imag **operator+** (Imag z, Real a)
- Imag **operator+** (Real a, Imag z)
- Imag **operator-** (Imag z, Real a)
- Imag **operator-** (Real a, Imag z)
- Imag **operator**∗ (Imag z, Real a)
- Imag **operator**∗ (Real a, Imag z)
- Imag **operator/** (Imag z, Real a)
- Imag **sin** (Imag z)
- Imag **cos** (Imag z)
- Imag **expi** (Real x)
- std::ostream & **operator**<< (ostream &os, Imag z)
- std::istream & **operator**>> (istream &is, Imag &z)

5.4.1 Detailed Description

complex numbers

Complex number, defined as Real[2] if FFT capability of latfield are not used, and with FFTW complex if it is use. Commun operation over complex number are also defined.

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

- Imag.hpp

5.5 IOserver Class Reference

The IOserver class handle the I/O using MPI process reserved for I/O.

`#include <LATfield2_IO_server.hpp>`

Public Member Functions

- void start ()

  Server method (only called by server nodes)
- void stop ()

  Client method (only called by compute nodes)
- int openOstream ()

  Client method (only called by compute nodes)
- void closeOstream ()

  Client method (only called by compute nodes)
- ioserver_file createFile (string filename)

  Client method (only called by compute nodes)
- void closeFile (ioserver_file fileID)

  Client method (only called by compute nodes)
- void writeBuffer (ioserver_file fileID, char ∗buffer, int size)

  Client method (only called by compute nodes)
- void initialize (int proc_size0, int proc_size1, int IOserver_size, int IO_node_size)

Protected Attributes

- char ∗ **dataBuffer**

Private Attributes

- bool **serverOn_flag**
- bool **serverReady_flag**
- bool **ostreamFile_flag**
- MPI_Group **world_group_**
- MPI_Group **IO_Group_**
- MPI_Group **computeGroup_**
- MPI_Comm **IO_Comm_**
- MPI_Comm **computeComm_**
- MPI_Group **syncLineGroup_**
- MPI_Comm **syncLineComm_**
- MPI_Group **masterClientGroup_**
- MPI_Comm **masterClientComm_**
- MPI_Group **IO_NodeGroup_**
- MPI_Comm **IO_NodeComm_**
- int **IO_Rank_**
- int **computeRank_**
- int **syncLineRank_**
- int **IO_NodeRank_**
- file_struct ∗ **files**
- int **IO_ClientSize_**
- int **IO_NodeSize_**
- int **IO_Node_**
- MPI_Request **sendRequest**

5.5.1 Detailed Description

The IOserver class handle the I/O using MPI process reserved for I/O.

This server is in beta stage, but as such a functionnality is very usefull, it have been added to the stable part of LATfield2d. An example of the usage of this class is given in the LATfield2d example on github... !!! User should never instanciate an IOserver object. The IOserver objet (IO_Server) is instanciate within the library header!!!

5.5.2 Member Function Documentation

5.5.2.1 void IOserver::closeFile (ioserver_file *fileID*)

Client method (only called by compute nodes)

```
Method to close a new file: fileID.
```

Parameters

ioserver_file	fileID: file to close.

Examples:

IOserver.

5.5.2.2 void IOserver::closeOstream ( )

Client method (only called by compute nodes)

Method to close the current Ostream. After the stream is closed, the server will start to write the files it have in memory.

Examples:

IOserver.

5.5.2.3 int IOserver::createFile (string *filename*)

Client method (only called by compute nodes)

```
Method to create a new file, it return the fileID.
```

Parameters

filename,:	name of the file (including the path...)

Returns

fileID.

Examples:

IOserver.

5.5.2.4 void IOserver::initialize (int *proc_size0,* int *proc_size1,* int *IOserver_size,* int *IO_node_size*)

Initialize the I/O server, this method is called by parallel.initialize(...). Should never be used!!!

5.5.2.5 int IOserver::openOstream ( )

Client method (only called by compute nodes)

```
Method to open an Ostream. Meaning a stream from the compute to the server processes.
```

Returns

OSTREAM_SUCCESS if the stream is open.
OSTREAM_FAIL if the stream cannot be open.

Examples:

IOserver.

5.5.2.6 void IOserver::start ( )

Server method (only called by server nodes)

Method which is called to start the server.

Examples:

IOserver.

5.5.2.7 void IOserver::stop ( )

Client method (only called by compute nodes)

Method which is called to stop the server.

Examples:

IOserver.

5.5.2.8 void IOserver::writeBuffer (ioserver_file *fileID,* char ∗ *buffer,* int *size*)

Client method (only called by compute nodes)

```
Method to write to a file.
!!! Beta, this method work only if fileID have been created and not closed!!!
```

Parameters

fileID,:	file where to write data.
buffer,:	pointer to the buffer to add to the file fileID.
size,:	size of "buffer", in byte.

Examples:

IOserver.

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

- LATfield2_IO_server.hpp

5.6 Lattice Class Reference

The Lattice class describe a n-toroidal cartesian mesh (with n>=2).

`#include <LATfield2_Lattice.hpp>`

Public Member Functions

- Lattice ()

  Constructor.
- Lattice (int dim, const int ∗size, int halo)
- Lattice (int dim, const int size, int halo)
- ∼Lattice ()

  Destructor.
- void initialize (int dim, const int ∗size, int halo)
- void initialize (int dim, const int size, int halo)
- void initializeRealFFT (Lattice &lat_real, int halo)
- void initializeComplexFFT (Lattice &lat_real, int halo)
- int dim ()
- int halo ()
- int ∗ size ()
- int size (int direction)
- int ∗ sizeLocal ()

- int sizeLocal (int direction)
- long sites ()
- long sitesGross ()
- long sitesLocal ()
- long sitesLocalGross ()
- int siteFirst ()
- int siteLast ()
- long jump (int direction)
- long sitesSkip ()
- long sitesSkip2d ()
- long ∗ coordSkip ()
- void save_arch (const string filename)
- bool is_arch_saved ()

Private Attributes

- int **status_**
- int **dim_**
- int ∗ **size_**
- long **sites_**
- long **sitesGross_**
- int **halo_**
- int ∗ **sizeLocal_**
- long **sitesLocal_**
- long **sitesLocalGross_**
- long ∗ **jump_**
- long **siteFirst_**
- long **siteLast_**
- long **sitesSkip_**
- long **sitesSkip2d_**
- long **coordSkip_** [2]
- int **arch_saved_**

Static Private Attributes

- static int **initialized**

5.6.1 Detailed Description

The Lattice class describe a n-toroidal cartesian mesh (with n>=2).

It store the global and local geometry of the mesh. The last 2 dimension of the lattice are scattered into the MPI processes grid.

Examples:

FFTs, gettingStarted, and poissonSolver.

5.6.2 Constructor & Destructor Documentation

5.6.2.1 Lattice::Lattice (int *dim,* const int ∗ *size,* int *halo*)

Constructor with initialization

See Also

initialize(int dim, const int∗ size, int halo);

Parameters

dim	: number of dimension
size	: array containing the size of each dimension.
halo	: size of the halo (same for each dimension)

5.6.2.2 Lattice::Lattice (int *dim,* const int *size,* int *halo*)

Constructor with initialization

See Also

initialize(int dim, const int size, int halo);

Parameters

dim	: number of dimension
size	: size of each dimension (same for each dimension)
halo	: size of the halo (same for each dimension)

5.6.3 Member Function Documentation

5.6.3.1 long ∗ Lattice::coordSkip ( )

Returns

long∗ , pointer to a array which store the last 2 dimension coordinate of the first local(in this MPI process) sites. !!!!!!! index 0 is for dim-1, index 1 is for dim-2 !!!!!!!

Examples:

gettingStarted.

5.6.3.2 int Lattice::dim ( )

Returns

int , number of dimension of the lattice.

5.6.3.3 int Lattice::halo ( )

Returns

int , the size of the halo.

5.6.3.4 void Lattice::initialize (int *dim*, const int ∗ *size*, int *halo*)

Initialization of a "dim"-dimension lattice. The size of each dimension are given by the array "size" which much contain "dim" numbers. The lattice have "halo" ghost cells in each dimension.

Parameters

dim	: number of dimension
size	: array containing the size of each dimension.
halo	: size of the halo (same for each dimension)

5.6.3.5 void Lattice::initialize (int *dim*, const int *size*, int *halo*)

Initialization of a "dim"-dimension cubic lattice. Each dimension have the same size given by the parameter "size". The lattice have "halo" ghost cells in each dimension. Initialization

Parameters

dim	: number of dimension
size	: array containing the size of each dimension.
halo	: size of the halo (same for each dimension)

5.6.3.6 void Lattice::initializeComplexFFT (Lattice & *lat_real*, int *halo*)

Initialization of a lattice for fourier space in case of complex to complex transform. The fourier space lattice size is defined according to the real space one.. The fourier space lattice have "halo" ghost cells in each dimension (which can be different than the halo of the real space lattice).

Parameters

lat_real	: pointer to a "real" space lattice.
halo	: size of the halo (same for each dimension)

Examples:

FFTs.

5.6.3.7 void Lattice::initializeRealFFT (Lattice & *lat_real*, int *halo*)

Initialization of a lattice for fourier space in case of real to complex transform. The fourier space lattice size is defined according to the real space one. The fourier space lattice have "halo" ghost cells in each dimension (which can be different than the halo of the real space lattice).

Parameters

lat_real	: pointer to a "real" space lattice.
halo	: size of the halo (same for each dimension)

Examples:

FFTs, and poissonSolver.

5.6.3.8 bool Lattice::is_arch_saved ( )

Returns

return true if the description of the lattice have been writen on disk.

5.6.3.9 long Lattice::jump (int *direction*)

Function which return the number of site to jump to move to the next site in a given direction.

Parameters

direction	: asked direction.

Returns

long , number of sites to jump.

5.6.3.10 void Lattice::save_arch (const string *filename*)

Function which save in serial and in ASCII a description of the Lattice, both localy and globaly

Parameters

filename	: filename of the architectur file.

5.6.3.11 int Lattice::siteFirst ( )

Returns

int , the index of the first site which is not within the halo.

5.6.3.12 int Lattice::siteLast ( )

Returns

int , the index of the last site which is not within the halo.

5.6.3.13 long Lattice::sites ( )

Returns

long , the lattice number of site (excluding halo sites).

Examples:

poissonSolver.

5.6.3.14 long Lattice::sitesGross ( )

Returns

long , the lattice number of site (including halo sites).

5.6.3.15 long Lattice::sitesLocal ( )

Returns

long , the number of site (excluding halo sites) of the sublattice stored in this MPI process.

5.6.3.16 long Lattice::sitesLocalGross ( )

Returns

long , the number of site (including halo sites) of the sublattice stored in this MPI process.

5.6.3.17 long Lattice::sitesSkip ( )

Returns

long , Number of sites before first local site in lattice (say in a file)

5.6.3.18 long Lattice::sitesSkip2d ( )

Returns

long , Number of sites before first local site in lattice (say in a file, where each proc have dump data in serial and ordered by their rank in MPI_WORLD_COMM)

5.6.3.19 int ∗ Lattice::size ( )

Returns

int∗ , pointer to the array of the size of each dimension of the lattice.

Examples:

gettingStarted, and poissonSolver.

5.6.3.20 int Lattice::size (int *direction*)

Function which return the global size of a given dimension of the lattice.

Parameters

direction	: asked dimension.

Returns

int , the global size of the asked dimension.

5.6.3.21 int ∗ Lattice::sizeLocal ( )

Returns

int∗ , pointer to the array of the size of each dimension of the sublattice stored in this MPI process.

Examples:

gettingStarted.

5.6.3.22 int Lattice::sizeLocal (int *direction*)

Function which return the size of a given dimension of the sublattice stored in this MPI process.

Parameters

direction	: asked dimension.

Returns

int , the local(in this MPI process) size of the asked dimension.

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

- LATfield2_Lattice.hpp

5.7 Parallel2d Class Reference

LATfield2d paralization handler.

```
#include <LATfield2_parallel2d.hpp>
```

Public Member Functions

- void initialize (int proc_size0, int proc_size1, int IO_total_size, int IO_node_size)
- void initialize (int proc_size0, int proc_size1)
- void abortForce ()
- void abortRequest ()
- void barrier ()
- template<class Type >
  void broadcast (Type &message, int from)
- template<class Type >
  void broadcast (Type ∗array, int len, int from)
- template<class Type >
  void broadcast_dim0 (Type &message, int from)
- template<class Type >
  void broadcast_dim0 (Type ∗array, int len, int from)
- template<class Type >
  void broadcast_dim1 (Type &message, int from)
- template<class Type >
  void broadcast_dim1 (Type ∗array, int len, int from)
- template<class Type >
  void sum (Type &number)
- template<class Type >
  void sum (Type ∗array, int len)
- template<class Type >
  void sum_dim0 (Type &number)

- template<class Type >
  void sum_dim0 (Type ∗array, int len)
- template<class Type >
  void sum_dim1 (Type &number)
- template<class Type >
  void sum_dim1 (Type ∗array, int len)
- template<class Type >
  void max (Type &number)
- template<class Type >
  void max (Type ∗array, int len)
- template<class Type >
  void max_dim0 (Type &number)
- template<class Type >
  void max_dim0 (Type ∗array, int len)
- template<class Type >
  void max_dim1 (Type &number)
- template<class Type >
  void max_dim1 (Type ∗array, int len)
- template<class Type >
  void min (Type &number)
- template<class Type >
  void min (Type ∗array, int len)
- template<class Type >
  void min_dim0 (Type &number)
- template<class Type >
  void min_dim0 (Type ∗array, int len)
- template<class Type >
  void min_dim1 (Type &number)
- template<class Type >
  void min_dim1 (Type ∗array, int len)
- template<class Type >
  void send (Type &message, int to)
- template<class Type >
  void send (Type ∗array, int len, int to)
- template<class Type >
  void send_dim0 (Type &message, int to)
- template<class Type >
  void send_dim0 (Type ∗array, int len, int to)
- template<class Type >
  void send_dim1 (Type &message, int to)
- template<class Type >
  void send_dim1 (Type ∗array, int len, int to)
- template<class Type >
  void receive (Type &message, int from)
- template<class Type >
  void receive (Type ∗array, int len, int from)
- template<class Type >
  void receive_dim0 (Type &message, int from)
- template<class Type >
  void receive_dim0 (Type ∗array, int len, int from)
- template<class Type >
  void receive_dim1 (Type &message, int from)
- template<class Type >
  void receive_dim1 (Type ∗array, int len, int from)
- template<class Type >
  void sendUp_dim0 (Type &bufferSend, Type &bufferRec, long len)

- template<class Type >
  void sendDown_dim0 (Type &bufferSend, Type &bufferRec, long len)
- template<class Type >
  void sendUpDown_dim0 (Type &bufferSendUp, Type &bufferRecUp, long lenUp, Type &bufferSendDown, Type &bufferRecDown, long lenDown)
- template<class Type >
  void sendUp_dim1 (Type &bufferSend, Type &bufferRec, long len)
- template<class Type >
  void sendDown_dim1 (Type &bufferSend, Type &bufferRec, long len)
- template<class Type >
  void sendUpDown_dim1 (Type &bufferSendUp, Type &bufferRecUp, long lenUp, Type &bufferSendDown, Type &bufferRecDown, long lenDown)
- int size ()
- int rank ()
- int world_size ()
- int world_rank ()
- int ∗ grid_size ()
- int ∗ grid_rank ()
- int root ()
- bool isRoot ()
- bool ∗ last_proc ()
- MPI_Comm lat_world_comm ()
- MPI_Comm ∗ dim0_comm ()
- MPI_Comm ∗ dim1_comm ()
- MPI_Group ∗ dim0_group ()
- MPI_Group ∗ dim1_group ()
- bool isIO ()

Private Attributes

- int **lat_world_size_**
- int **grid_size_** [2]
- int **lat_world_rank_**
- int **grid_rank_** [2]
- int **root_**
- bool **isRoot_**
- bool **last_proc_** [2]
- int **world_rank_**
- int **world_size_**
- MPI_Comm **world_comm_**
- MPI_Comm **lat_world_comm_**
- MPI_Comm ∗ **dim0_comm_**
- MPI_Comm ∗ **dim1_comm_**
- MPI_Group **world_group_**
- MPI_Group **lat_world_group_**
- MPI_Group ∗ **dim0_group_**
- MPI_Group ∗ **dim1_group_**
- bool **isIO_**

5.7.1 Detailed Description

LATfield2d paralization handler.

The parallel2d class is the handler of the parallelization of LATfield2d. LATfield2d distribute n-dimensional periodic cartesian lattices into 2-dimensional cartesian grid of MPI process, a rod decomposition. The last dimension of the lattice is scatter into the first dimension of the process grid and the last-but-on dimension of the lattice is scatter into the second dimension of the process grid. This choice have been made to increase data locality of the ghost cells (halo) to increase the efficiency of method to update them. Due to his scheme of parallelization, LATfield2d is only able to work with lattice of dimension bigger or equal to two.

The geometry of the process grid (the size of the 2 dimensions), two layers of MPI communicator and simple communication methods are enbended in the "parallel" object, which is an instance of the class Parallel. This object is instantiated but not initialized within the library header, therefor user should never declare an instance of the Parallel class. but rather use dirrectly its instance "parallel".

5.7.2 Member Function Documentation

5.7.2.1 void Parallel2d::abortForce ( )

Method to kill by force the executable.

5.7.2.2 void Parallel2d::abortRequest ( )

Method to request to kill the executable.

5.7.2.3 void Parallel2d::barrier ( )

MPI barrier

Examples:

poissonSolver.

5.7.2.4 template$<$class Type $>$ void Parallel2d::broadcast (Type & *message,* int *from*)

Method to broadcast to every compute process a variable.

Parameters

message,:	variable to send in place. meaning the reciever will have the value in that variable.
from,:	rank of the sender.

5.7.2.5 template$<$class Type $>$ void Parallel2d::broadcast (Type $*$ *array,* int *len,* int *from*)

Method to broadcast to every compute process a variable array.

Parameters

message,:	pointer to the array to send in place. meaning the reciever will have the value in that variable.
len,:	length of the array.
from,:	rank of the sender.

5.7.2.6 template<class Type > void Parallel2d::broadcast_dim0 (Type & *message,* int *from*)

Method to perform a dirrectional broadcast of a variable. The processes with grid_rank_[0]==from will broadcast the variable to every process which have same grid_rank_[1].

Parameters

message,:	variable to send in place. meaning the reciever will have the value in that variable.
from,:	rank of the sender.

5.7.2.7 template<class Type > void Parallel2d::broadcast_dim0 (Type * *array,* int *len,* int *from*)

Method to perform a dirrectional broadcast of a variable. The processes with grid_rank_[0]==from will broadcast the variable to every process which have same grid_rank_[1].

Parameters

message,:	pointer to the array to send in place. meaning the reciever will have the value in that variable.
len,:	length of the array.
from,:	rank of the sender.

5.7.2.8 template<class Type > void Parallel2d::broadcast_dim1 (Type & *message,* int *from*)

Method to perform a dirrectional broadcast of a variable. The processes with grid_rank_[1]==from will broadcast the variable to every process which have same grid_rank_[0].

Parameters

message,:	variable to send in place. meaning the reciever will have the value in that variable.
from,:	rank of the sender.

5.7.2.9 template<class Type > void Parallel2d::broadcast_dim1 (Type * *array,* int *len,* int *from*)

Method to perform a dirrectional broadcast of a variable. The processes with grid_rank_[1]==from will broadcast the variable to every process which have same grid_rank_[0].

Parameters

message,:	pointer to the array to send in place. meaning the reciever will have the value in that variable.
len,:	length of the array.
from,:	rank of the sender.

5.7.2.10 MPI_Comm* Parallel2d::dim0_comm ( ) `[inline]`

return dim0_comm_: MPI_Comm array, array of dirrectional communicator (dim 0)

5.7.2.11 MPI_Group* Parallel2d::dim0_group ( ) `[inline]`

return dim0_comm_: MPI_Group array, array of dirrectional group (dim 0)

5.7.2.12 MPI_Comm∗ Parallel2d::dim1_comm ( ) `[inline]`

return dim1_comm_: MPI_Comm array, array of dirrectional communicator (dim 1)

5.7.2.13 MPI_Group∗ Parallel2d::dim1_group ( ) `[inline]`

return dim1_comm_: MPI_Group array, array of dirrectional group (dim 1)

5.7.2.14 int∗ Parallel2d::grid_rank ( ) `[inline]`

Returns

grid_size_: array of size 2. Rank on each dimension of the process grid.

Examples:

gettingStarted, and IOserver.

5.7.2.15 int∗ Parallel2d::grid_size ( ) `[inline]`

Returns

grid_size_: array of size 2. Size of each dimension of the process grid.

Examples:

gettingStarted.

5.7.2.16 void Parallel2d::initialize (int *proc_size0,* int *proc_size1,* int *IO_total_size,* int *IO_node_size*)

Initialization when the IO server is used. (preprossessor define: -DEXTERNAL_IO)

Parameters

proc_size0,:	size of the first dimension of the MPI process grid.
proc_size1,:	size of the second dimension of the MPI process grid.
IO_total_size	: number of MPI process reserved for the IO server.
IO_node_size,:	size of 1 goupe of process reserved for the IO server. Each group will write in a seperated file.

Examples:

FFTs, gettingStarted, IOserver, and poissonSolver.

5.7.2.17 void Parallel2d::initialize (int *proc_size0,* int *proc_size1*)

Initialization used when the IO server is not used.

Parameters

proc_size0,:	size of the first dimension of the MPI process grid.
proc_size1,:	size of the second dimension of the MPI process grid.

5.7.2.18 bool Parallel2d::isIO ( ) [inline]

return isIO_: true if the process is reserved to the IO server, false if the process is a compute process.

Examples:

IOserver.

5.7.2.19 bool Parallel2d::isRoot ( ) [inline]

Returns

isRoot_: false if not the root process, True for the root process.

Examples:

poissonSolver.

5.7.2.20 bool* Parallel2d::last_proc ( ) [inline]

return last_proc_: array of size 2. rank of the last process in each dimension of the grid.

5.7.2.21 MPI_Comm Parallel2d::lat_world_comm ( ) [inline]

return lat_world_comm: MPI_Comm, the communicator which contain all compute process.

5.7.2.22 template<class Type > void Parallel2d::max (Type & *number*)

Method to find the maximum value of a variable across all the compute processes.

Parameters

number,:	number to compare, the max value will be assignent to this variable.

Examples:

poissonSolver.

5.7.2.23 template<class Type > void Parallel2d::max (Type * *array,* int *len*)

Method to find the maximum value of an array across all the compute processes.

Parameters

array,:	number to compare, the max value will be assignent to this variable.
len,:	size of the array.

5.7.2.24 template<class Type > void Parallel2d::max_dim0 (Type & *number*)

Method to find the maximum value of a variable across all the compute processes with the same grid_rank_[1].

Parameters

number,:	number to compare, the max value will be assignent to this variable.

5.7.2.25 template<class Type > void Parallel2d::max_dim0 (Type ∗ *array,* int *len*)

Method to find the maximum value of a variable across all the compute processes with the same grid_rank_[1].

Parameters

array,:	number to compare, the max value will be assignent to this variable.
len,:	size of the array.

5.7.2.26 template<class Type > void Parallel2d::max_dim1 (Type & *number*)

Method to find the maximum value of a variable across all the compute processes with the same grid_rank_[0].

Parameters

number,:	number to compare, the max value will be assignent to this variable.

5.7.2.27 template<class Type > void Parallel2d::max_dim1 (Type ∗ *array,* int *len*)

Method to find the maximum value of a variable across all the compute processes with the same grid_rank_[0].

Parameters

array,:	number to compare, the max value will be assignent to this variable.
len,:	size of the array.

5.7.2.28 template<class Type > void Parallel2d::min (Type & *number*)

Method to find the minimal value of a variable across all the compute processes.

Parameters

number,:	number to compare, the max value will be assignent to this variable.

Examples:

poissonSolver.

5.7.2.29 template<class Type > void Parallel2d::min (Type ∗ *array,* int *len*)

Method to find the minimal value of an array across all the compute processes.

Parameters

array,:	number to compare, the max value will be assignent to this variable.
len,:	size of the array.

5.7.2.30 template<class Type > void Parallel2d::min_dim0 (Type & *number*)

Method to find the minimal value of a variable across all the compute processes with the same grid_rank_[1].

Parameters

number,:	number to compare, the max value will be assignent to this variable.

5.7.2.31 template<class Type > void Parallel2d::min_dim0 (Type ∗ *array,* int *len*)

Method to find the minimal value of a variable across all the compute processes with the same grid_rank_[1].

Parameters

array,:	number to compare, the max value will be assignent to this variable.
len,:	size of the array.

5.7.2.32 template<class Type > void Parallel2d::min_dim1 (Type & *number*)

Method to find the minimal value of a variable across all the compute processes with the same grid_rank_[0].

Parameters

number,:	number to compare, the max value will be assignent to this variable.

5.7.2.33 template<class Type > void Parallel2d::min_dim1 (Type ∗ *array,* int *len*)

Method to find the maximum value of a variable across all the compute processes with the same grid_rank_[0].

Parameters

array,:	number to compare, the max value will be assignent to this variable.
len,:	size of the array.

5.7.2.34 int Parallel2d::rank ( ) `[inline]`

Returns

lat_world_rank_: rank of this process (in the compute world)

Examples:

gettingStarted, and IOserver.

5.7.2.35 template<class Type > void Parallel2d::receive (Type & *message,* int *from*)

MPI recieve method on the computes process. The method call MPI_Recv in the lat_world_comm communicator.

Parameters

message,:	variable which will be assigned to the recieve message.
from,:	rank of the sender. (in lat_world_comm)

5.7.2.36 template< class Type > void Parallel2d::receive (Type ∗ *array,* int *len,* int *from*)

MPI recieve method on the computes process. The method call MPI_Recv in the lat_world_comm communicator.

Parameters

message,:	variable which will be assigned to the recieve message.
len,:	size of the array to be recieved.
from,:	rank of the sender. (in lat_world_comm)

5.7.2.37 template< class Type > void Parallel2d::receive_dim0 (Type & *message,* int *from*)

MPI recieve method on the computes process. The method call MPI_Recv in the dirrectional communicator associate to the caller. (direction=0)

Parameters

message,:	variable which will be assigned to the recieve message.
from,:	rank of the sender.

5.7.2.38 template< class Type > void Parallel2d::receive_dim0 (Type ∗ *array,* int *len,* int *from*)

MPI recieve method on the computes process. The method call MPI_Recv in the dirrectional communicator associate to the caller. (direction=0)

Parameters

message,:	variable which will be assigned to the recieve message.
len,:	size of the array to be recieved.
from,:	rank of the sender.

5.7.2.39 template< class Type > void Parallel2d::receive_dim1 (Type & *message,* int *from*)

MPI recieve method on the computes process. The method call MPI_Recv in the dirrectional communicator associate to the caller. (direction=0)

Parameters

message,:	variable which will be assigned to the recieve message.
from,:	rank of the sender.

5.7.2.40 template< class Type > void Parallel2d::receive_dim1 (Type ∗ *array,* int *len,* int *from*)

MPI recieve method on the computes process. The method call MPI_Recv in the dirrectional communicator associate to the caller. (direction=0)

Parameters

message,:	variable which will be assigned to the recieve message.
len,:	size of the array to be recieved.
from,:	rank of the sender.

5.7.2.41 int Parallel2d::root ( ) [inline]

Returns

root_: the rank of the process which is the root of the compute process grid.

5.7.2.42 template$<$class Type $>$ void Parallel2d::send (Type & *message,* int *to*)

MPI send method on the computes process. The method call MPI_Send in the lat_world_comm communicator.

Parameters

message,:	variable to send.
to,:	rank of the reciever. (in lat_world_comm)

5.7.2.43 template$<$class Type $>$ void Parallel2d::send (Type $*$ *array,* int *len,* int *to*)

MPI send method on the computes process. The method call MPI_Send in the lat_world_comm communicator.

Parameters

array,:	variable to send.
len,:	size of the array.
to,:	rank of the reciever. (in lat_world_comm)

5.7.2.44 template$<$class Type $>$ void Parallel2d::send_dim0 (Type & *message,* int *to*)

MPI send method on the computes process. The method call MPI_Send in the dirrectional communicator associate to the caller. (direction=0)

Parameters

message,:	variable to send.
to,:	rank of the reciever. (grid_rank_[0])

5.7.2.45 template$<$class Type $>$ void Parallel2d::send_dim0 (Type $*$ *array,* int *len,* int *to*)

MPI send method on the computes process. The method call MPI_Send in the dirrectional communicator associate to the caller. (direction=0)

Parameters

array,:	variable to send.
len,:	size of the array.
to,:	rank of the reciever. (grid_rank_[0])

5.7.2.46 template$<$class Type $>$ void Parallel2d::send_dim1 (Type & *message,* int *to*)

MPI send method on the computes process. The method call MPI_Send in the dirrectional communicator associate to the caller. (direction=1)

Parameters

message,:	variable to send.
to,:	rank of the reciever. (grid_rank_[1])

5.7.2.47 template<class Type > void Parallel2d::send_dim1 (Type * *array,* int *len,* int *to*)

MPI send method on the computes process. The method call MPI_Send in the dirrectional communicator associate to the caller. (direction=1)

Parameters

array,:	variable to send.
len,:	size of the array.
to,:	rank of the reciever. (grid_rank_[1])

5.7.2.48 template<class Type > void Parallel2d::sendDown_dim0 (Type & *bufferSend,* Type & *bufferRec,* long *len*)

Method to send a message through the dim0 of the processes grid. Process of grid_rank_[0]=N will send the message to the grid_rank_[0]=N-1, with a torus topology. Therfor each process will send and recieve data.

Parameters

bufferSend,:	pointer to the data which will be send.
bufferRec,:	pointer to the array where the recieve data will be assigned.
len,:	size of the array bufferSend.

5.7.2.49 template<class Type > void Parallel2d::sendDown_dim1 (Type & *bufferSend,* Type & *bufferRec,* long *len*)

Method to send a message through the dim1 of the processes grid. Process of grid_rank_[1]=N will send the message to the grid_rank_[1]=N-1, with a torus topology. Therfor each process will send and recieve data.

Parameters

bufferSend,:	pointer to the data which will be send.
bufferRec,:	pointer to the array where the recieve data will be assigned.
len,:	size of the array bufferSend.

5.7.2.50 template<class Type > void Parallel2d::sendUp_dim0 (Type & *bufferSend,* Type & *bufferRec,* long *len*)

Method to send a message through the dim0 of the processes grid. Process of grid_rank_[0]=N will send the message to the grid_rank_[0]=N+1. With a torus topology. Therfor each process will send and recieve data.

Parameters

bufferSend,:	pointer to the data which will be send.
bufferRec,:	pointer to the array where the recieve data will be assigned.
len,:	size of the array bufferSend.

5.7.2.51 template<class Type > void Parallel2d::sendUp_dim1 (Type & *bufferSend,* Type & *bufferRec,* long *len*)

Method to send a message through the dim1 of the processes grid. Process of grid_rank_[1]=N will send the message to the grid_rank_[1]=N+1. With a torus topology. Therfor each process will send and recieve data.

Parameters

bufferSend,:	pointer to the data which will be send.
bufferRec,:	pointer to the array where the recieve data will be assigned.
len,:	size of the array bufferSend.

5.7.2.52 template< class Type > void Parallel2d::sendUpDown_dim0 (Type & *bufferSendUp,* Type & *bufferRecUp,* long *lenUp,* Type & *bufferSendDown,* Type & *bufferRecDown,* long *lenDown*)

Method to send 2 message through the dim0 of the processes grid. Process of grid_rank_[0]=N will send the bufferSendUp to the grid_rank_[0]=N+1, and the bufferSendDown to the grid_rank_[0]=N-1, with a torus topology. Therfor each process will send and recieve 2 message.

Parameters

bufferSendUp,:	pointer to the data which will be send up.
bufferRecUp,:	pointer to the array where the recieve down data will be assigned.
lenUp,:	size of the array bufferSendUp.
bufferSend-Down,:	pointer to the data which will be send down.
bufferRecDown,:	pointer to the array where the recieve up data will be assigned.
lenDown,:	size of the array bufferSendUp.

5.7.2.53 template< class Type > void Parallel2d::sendUpDown_dim1 (Type & *bufferSendUp,* Type & *bufferRecUp,* long *lenUp,* Type & *bufferSendDown,* Type & *bufferRecDown,* long *lenDown*)

Method to send 2 message through the dim1 of the processes grid. Process of grid_rank_[1]=N will send the bufferSendUp to the grid_rank_[1]=N+1, and the bufferSendDown to the grid_rank_[1]=N-1, with a torus topology. Therfor each process will send and recieve 2 message.

Parameters

bufferSendUp,:	pointer to the data which will be send up.
bufferRecUp,:	pointer to the array where the recieve down data will be assigned.
lenUp,:	size of the array bufferSendUp.
bufferSend-Down,:	pointer to the data which will be send down.
bufferRecDown,:	pointer to the array where the recieve up data will be assigned.
lenDown,:	size of the array bufferSendUp.

5.7.2.54 int Parallel2d::size ( ) `[inline]`

Returns

lat_world_size_: the number of MPI process (compute processes)

5.7.2.55 template< class Type > void Parallel2d::sum (Type & *number*)

Method to sum a number over all the compute processes. Each process will have the result assigned in the input variable. /param number: variable to sum.

Examples:

poissonSolver.

5.7.2.56 template< class Type > void Parallel2d::sum (Type ∗ *array*, int *len*)

Method to sum an array of number over all the compute processes. Each process will have the result assigned in the input array. /param number: pointer to the array to sum. /param len: size of the array.

5.7.2.57 template< class Type > void Parallel2d::sum_dim0 (Type & *number*)

Method to perform a dirrectional of a number over all the compute processes with same grid_rank_[1]. Each process will have the result assigned in the input variable. /param number: variable to sum.

5.7.2.58 template< class Type > void Parallel2d::sum_dim0 (Type ∗ *array*, int *len*)

Method to perform a dirrectional of a number over all the compute processes with same grid_rank_[1]. Each process will have the result assigned in the input array. /param number: pointer to the array to sum. /param len: size of the array.

5.7.2.59 template< class Type > void Parallel2d::sum_dim1 (Type & *number*)

Method to perform a dirrectional of a number over all the compute processes with same grid_rank_[0]. Each process will have the result assigned in the input variable. /param number: variable to sum.

5.7.2.60 template< class Type > void Parallel2d::sum_dim1 (Type ∗ *array*, int *len*)

Method to perform a dirrectional of a number over all the compute processes with same grid_rank_[0]. Each process will have the result assigned in the input array. /param number: pointer to the array to sum. /param len: size of the array.

5.7.2.61 int Parallel2d::world_rank ( ) `[inline]`

Returns

world_rank_: rank of this process (in the world = compute + IOserver)

Examples:

IOserver.

5.7.2.62 int Parallel2d::world_size ( ) `[inline]`

Returns

world_size_: the number of MPI process (compute + IOserver)

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

- LATfield2_parallel2d.hpp

5.8 PlanFFT< compType > Class Template Reference

Class which handle fourier transforms of fields on 3d cubic lattices.

`#include <LATfield2_PlanFFT.hpp>`

Public Member Functions

- PlanFFT ()

    Constructor.
- PlanFFT (Field< compType > ∗rfield, Field< compType > ∗kfield, const int mem_type=FFT_OUT_OF_PL-ACE)
- void initialize (Field< compType > ∗rfield, Field< compType > ∗kfield, const int mem_type=FFT_OUT_OF-_PLACE)
- PlanFFT (Field< double > ∗rfield, Field< compType > ∗kfield, const int mem_type=FFT_OUT_OF_PLACE)
- void initialize (Field< double > ∗rfield, Field< compType > ∗kfield, const int mem_type=FFT_OUT_OF_PL-ACE)
- **PlanFFT** (Field< compType > ∗rfield, Field< compType > ∗kfield, const int mem_type=FFT_OUT_OF_PL-ACE)
- void **initialize** (Field< compType > ∗rfield, Field< compType > ∗kfield, const int mem_type=FFT_OUT_OF-_PLACE)
- **PlanFFT** (Field< float > ∗rfield, Field< compType > ∗kfield, const int mem_type=FFT_OUT_OF_PLACE)
- void **initialize** (Field< float > ∗rfield, Field< compType > ∗kfield, const int mem_type=FFT_OUT_OF_PLA-CE)
- void execute (int fft_type)

Private Member Functions

- void transpose_0_2 (fftwf_complex ∗in, fftwf_complex ∗out, int dim_i, int dim_j, int dim_k)

    transpostion fonction
- void **transpose_0_2_last_proc** (fftwf_complex ∗in, fftwf_complex ∗out, int dim_i, int dim_j, int dim_k)
- void **implement_local_0_last_proc** (fftwf_complex ∗in, fftwf_complex ∗out, int proc_dim_i, int proc_dim_j, int proc_dim_k, int proc_size)
- void **transpose_1_2** (fftwf_complex ∗in, fftwf_complex ∗out, int dim_i, int dim_j, int dim_k)
- void **transpose_back_0_3** (fftwf_complex ∗in, fftwf_complex ∗out, int r2c, int local_r2c, int local_size_j, int local_size_k, int proc_size, int halo, int components, int comp)
- void **implement_0** (fftwf_complex ∗in, fftwf_complex ∗out, int r2c_size, int local_size_j, int local_size_k, int halo, int components, int comp)
- void **b_arrange_data_0** (fftwf_complex ∗in, fftwf_complex ∗out, int dim_i, int dim_j, int dim_k, int khalo, int components, int comp)
- void **b_transpose_back_0_1** (fftwf_complex ∗in, fftwf_complex ∗out, int r2c, int local_r2c, int local_size_j, int local_size_k, int proc_size)
- void **b_implement_0** (fftwf_complex ∗in, fftwf_complex ∗out, int r2c_size, int local_size_j, int local_size_k)
- void transpose_0_2 (fftw_complex ∗in, fftw_complex ∗out, int dim_i, int dim_j, int dim_k)

    transpostion fonction
- void **transpose_0_2_last_proc** (fftw_complex ∗in, fftw_complex ∗out, int dim_i, int dim_j, int dim_k)
- void **implement_local_0_last_proc** (fftw_complex ∗in, fftw_complex ∗out, int proc_dim_i, int proc_dim_j, int proc_dim_k, int proc_size)
- void **transpose_1_2** (fftw_complex ∗in, fftw_complex ∗out, int dim_i, int dim_j, int dim_k)
- void **transpose_back_0_3** (fftw_complex ∗in, fftw_complex ∗out, int r2c, int local_r2c, int local_size_j, int local_size_k, int proc_size, int halo, int components, int comp)
- void **implement_0** (fftw_complex ∗in, fftw_complex ∗out, int r2c_size, int local_size_j, int local_size_k, int halo, int components, int comp)
- void **b_arrange_data_0** (fftw_complex ∗in, fftw_complex ∗out, int dim_i, int dim_j, int dim_k, int khalo, int components, int comp)
- void **b_transpose_back_0_1** (fftw_complex ∗in, fftw_complex ∗out, int r2c, int local_r2c, int local_size_j, int local_size_k, int proc_size)
- void **b_implement_0** (fftw_complex ∗in, fftw_complex ∗out, int r2c_size, int local_size_j, int local_size_k)

Private Attributes

- bool **status_**
- bool **type_**
- int **mem_type_**
- int **components_**
- int **rSize_** [3]
- int **kSize_** [3]
- int **rJump_** [3]
- int **kJump_** [3]
- int **rSizeLocal_** [3]
- int **kSizeLocal_** [3]
- int **r2cSize_**
- int **r2cSizeLocal_**
- int **r2cSizeLocal_as_**
- int **rHalo_**
- int **kHalo_**
- float ∗ **rData_**
- fftwf_complex ∗ **cData_**
- fftwf_complex ∗ **kData_**
- fftwf_complex ∗ **temp_**
- fftwf_complex ∗ **temp1_**
- fftwf_plan **fPlan_i_**
- fftwf_plan **fPlan_j_**
- fftwf_plan **fPlan_k_**
- fftwf_plan **fPlan_k_real_**
- fftwf_plan **bPlan_i_**
- fftwf_plan **bPlan_j_**
- fftwf_plan **bPlan_j_real_**
- fftwf_plan **bPlan_k_**
- double ∗ **rData_**
- fftw_complex ∗ **cData_**
- fftw_complex ∗ **kData_**
- fftw_complex ∗ **temp_**
- fftw_complex ∗ **temp1_**
- fftw_plan **fPlan_i_**
- fftw_plan **fPlan_j_**
- fftw_plan **fPlan_k_**
- fftw_plan **fPlan_k_real_**
- fftw_plan **bPlan_i_**
- fftw_plan **bPlan_j_**
- fftw_plan **bPlan_j_real_**
- fftw_plan **bPlan_k_**

Static Private Attributes

- static bool **R2C**
- static bool **C2C**
- static bool **initialized**

5.8.1 Detailed Description

template<class compType>class PlanFFT< compType >

Class which handle fourier transforms of fields on 3d cubic lattices.

This class allow to perform fourier transform of real and complex fields. See poissonSolver example to have have a short intro of usage.

One should understand that first a plan is created then execute (in the FFTW fashion). The plan link to fields, one on fourier space, one on real space. Both field will be allocated by the planer. But need to be initialized.

One need to be carefull to corretly define the lattice and field.

See Also

void Lattice::initializeRealFFT(Lattice & lat_real, int halo);
void Lattice::initializeComplexFFT(Lattice & lat_real, int halo);

For more detail see the QuickStart guide.

Examples:

FFTs, and poissonSolver.

5.8.2 Constructor & Destructor Documentation

5.8.2.1 template<class compType > PlanFFT< compType >::PlanFFT (Field< compType > * *rfield*, Field< compType > * *kfield*, const int *mem_type* = FFT_OUT_OF_PLACE)

Constructor with initialization for complex to complex tranform.

See Also

initialize(Field<compType>* rfield,Field<compType>* kfield,const int mem_type = FFT_OUT_OF_PLACE);

Parameters

rfield	: real space field
kfield	: fourier space field
mem_type	: memory type (FFT_OUT_OF_PLACE or FFT_IN_PLACE). In place mean that both fourier and real space field point to the same data array.

5.8.2.2 template<class compType > PlanFFT< compType >::PlanFFT (Field< double > * *rfield*, Field< compType > * *kfield*, const int *mem_type* = FFT_OUT_OF_PLACE)

Constructor with initialization for real to complex tranform.

See Also

initialize(Field<compType>* rfield,Field<compType>* kfield,const int mem_type = FFT_OUT_OF_PLACE);

Parameters

rfield	: real space field
kfield	: fourier space field
mem_type	: memory type (FFT_OUT_OF_PLACE or FFT_IN_PLACE). In place mean that both fourier and real space field point to the same data array.

5.8.3 Member Function Documentation

5.8.3.1 template<class compType > void **PlanFFT**< compType >::execute (int *fft_type*)

Execute the fourier transform.

Parameters

fft_type,:	dirrection of the transform. Can be FFT_BACKWARD or FFT_FORWARD.

5.8.3.2 template<class compType > void **PlanFFT**< compType >::initialize (**Field**< compType > * *rfield,* **Field**< compType > * *kfield,* const int *mem_type* = `FFT_OUT_OF_PLACE`)

initialization for complex to complex tranform. For more detail see the QuickStart guide.

Parameters

rfield	: real space field
kfield	: fourier space field
mem_type	: memory type (FFT_OUT_OF_PLACE or FFT_IN_PLACE). In place mean that both fourier and real space field point to the same data array.

5.8.3.3 template<class compType > void **PlanFFT**< compType >::initialize (**Field**< double > * *rfield,* **Field**< compType > * *kfield,* const int *mem_type* = `FFT_OUT_OF_PLACE`)

initialization for real to complex tranform. For more detail see the QuickStart guide.

Parameters

rfield	: real space field
kfield	: fourier space field
mem_type	: memory type (FFT_OUT_OF_PLACE or FFT_IN_PLACE). In place mean that both fourier and real space field point to the same data array.

5.8.3.4 template<class compType > void **PlanFFT**< compType >::transpose_0_2 (fftwf_complex * *in,* fftwf_complex * *out,* int *dim_i,* int *dim_j,* int *dim_k*) `[private]`

transpostion fonction

forward real to complex

5.8.3.5 template<class compType > void **PlanFFT**< compType >::transpose_0_2 (fftw_complex * *in,* fftw_complex * *out,* int *dim_i,* int *dim_j,* int *dim_k*) `[private]`

transpostion fonction

forward real to complex

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

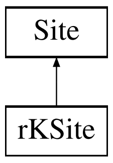
- LATfield2_PlanFFT.hpp

5.9 rKSite Class Reference

A child of Site, built to work with the fourier space lattices for real to complex transforms.

`#include <LATfield2_Site.hpp>`

Inheritance diagram for rKSite:



Public Member Functions

- **rKSite** (Lattice &lattice)
- **rKSite** (Lattice &lattice, long index)
- void **initialize** (Lattice &lattice)
- void **initialize** (Lattice &lattice, long index)
- rKSite **operator+** (int asked_direction)
- rKSite **operator-** (int asked_direction)
- int **coordLocal** (int asked_direction)
- int **coord** (int asked_direction)
- int **latCoord** (int direction)
- int **latCoordLocal** (int direction)
- bool **setCoord** (int ∗r_asked)
- bool **setCoord** (int x, int y, int z)

Private Attributes

- int **directions_** [3]

Additional Inherited Members

5.9.1 Detailed Description

A child of Site, built to work with the fourier space lattices for real to complex transforms.

A class which simplify the map of the field data array index. This class allow to get coordinate on the lattice, loop over each site of the lattice and perform displacment on the lattice.

WARNING: this site class must be used only on lattices initialized using initializeRealFFT() method of the Lattice class.

This class have same binding that the Site class, so one can refer to the Site class for the documentation.

Examples:

FFTs, and poissonSolver.

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

- LATfield2_Site.hpp

5.10 SettingsFile Class Reference

A class desinged to make reading in runtime settings easier.

`#include <LATfield2_SettingsFile.hpp>`

Public Member Functions

- SettingsFile ()

  Constructor.
- SettingsFile (const std::string filename, const int mode, const int argc=0, char ∗∗argv=NULL)
- ∼SettingsFile ()

  desctructor
- void open (const std::string filename, const int mode, const int argc=0, char ∗∗argv=NULL)
- void close ()
- void create (const std::string filename)
- template<class TemplateClass >
  void read (const std::string parameter_name, TemplateClass &parameter)
- template<class TemplateClass >
  void add (const std::string parameter_name, const TemplateClass &parameter)
- template<class TemplateClass >
  void write (const std::string parameter_name, const TemplateClass &parameter)

Static Public Attributes

- static int **noCreate**
- static int **autoCreate**

Private Member Functions

- bool **search** (const std::string search_string)

Private Attributes

- std::string **filename_**
- std::fstream **file_**
- std::stringstream **stream_**
- int **mode_**
- bool **isRoot_**

5.10.1 Detailed Description

A class desinged to make reading in runtime settings easier.

Author

M. Hindmarsh

If the command-line arguments are input via optional inputs on either the constructor or open member function, then these take president: they are effectively first in the file.

Note, when used with std::string objects, only one word is allowed per setting, ie. spaces are not allowed. This is because of the way that the >> operator works for this class. This fits nicely with the command-line override, however.

Note that the string specified followed by = is searched for in the file and then the input read. If one setting name is also the end of another that preceeds it in the file then the wrong one will be read.

Only the primary MPI process is able to create or add to the setting file in anyway. Further processes will be sent the file contents via MPI. To use this class in serial code the preprocessor defintion SERIAL must be set.

5.10.2 Constructor & Destructor Documentation

5.10.2.1 SettingsFile::SettingsFile (const std::string *filename*, const int *mode*, const int *argc* = `0`, char ∗∗ *argv* = `NULL`)

Constructor + open a file

Parameters

filename,:	path to the file.
mode,:	noCreate (the read method will exit if the parameter does not exist) or autoCreate (read will add the missing parameter).
argc	: additionnal argument number.
argv	: pointer to the additionnal arguments.

5.10.3 Member Function Documentation

5.10.3.1 template<class TemplateClass > void SettingsFile::add (const std::string *parameter_name*, const TemplateClass & *parameter*)

Method to add a parameter to the settings file. The new parameter will be just added to the end of the file, even if it allready exist.

Parameters

parameter_-name,:	string containing the name of the parameter.
parameter,:	pointer to the value of the parameter.

5.10.3.2 void SettingsFile::close ( )

close the current settings file

5.10.3.3 void SettingsFile::create (const std::string *filename*)

Create a new settings file and open it.

Parameters

filename,:	path to the file.

5.10.3.4 void SettingsFile::open (const std::string *filename*, const int *mode*, const int *argc* = `0`, char ∗∗ *argv* = `NULL`)

open an existinge settings file

Parameters

filename,:	path to the file
mode,:	noCreate (the read method will exit if the parameter does not exist) or autoCreate (read will add the missing parameter).

argc	: additionnal argument number.
argv	: pointer to the additionnal arguments.

5.10.3.5 template<class TemplateClass > void SettingsFile::read (const std::string *parameter_name*, TemplateClass & *parameter*)

Method to read a parameter.

Parameters

parameter_-name,:	string containing the name of the parameter.
parameter,:	pointer to the variable where the parameter will be assigned. If the parameter does not exite and the mode autocreate is set, this method will add the parameter to the settings file with the current value of "parameter". In the case the mode is set to nocreate, then read will exit for security, for this reason in it is always advise to set the mode to nocreate for production runs.

5.10.3.6 template<class TemplateClass > void SettingsFile::write (const std::string *parameter_name*, const TemplateClass & *parameter*)

Method to write a parameter in the settings file. If the parameter_name exist, it will overwrite the parameter. And if it does not exist in the file, it will be added at the end of the file.

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

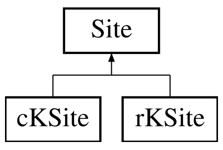
- LATfield2_SettingsFile.hpp

5.11 Site Class Reference

A small class which aim to point to given lattice site.

```
#include <LATfield2_Site.hpp>
```

Inheritance diagram for Site:



Public Member Functions

- Site ()

    Constructor.
- Site (Lattice &lattice)
- Site (Lattice &lattice, long index)
- void initialize (Lattice &lattice)
- void initialize (Lattice &lattice, long index)
- void first ()
- bool test ()
- void next ()

- void haloFirst ()
- bool haloTest ()
- void haloNext ()
- Site operator+ (int direction)
- Site operator- (int direction)
- void indexAdvance (long number)
- long index () const
- void setIndex (long new_index)
- int coord (int direction)
- int coordLocal (int direction)
- bool setCoord (int ∗r)
- bool setCoord (int x, int y, int z)
- Lattice & lattice ()

Protected Attributes

- Lattice ∗ **lattice_**
- long **index_**

5.11.1 Detailed Description

A small class which aim to point to given lattice site.

A class which simplify the map of the field data array index. This class allow to get coordinate on the lattice, loop over each site of the lattice and perform displacment on the lattice

Examples:

FFTs, gettingStarted, and poissonSolver.

5.11.2 Constructor & Destructor Documentation

5.11.2.1 Site::Site (**Lattice** & *lattice*)

Constructor with initialization.

See Also

initialize(Lattice& lattice);

Parameters

lattice,:	the lattice on which the Site is defined.

5.11.2.2 Site::Site (**Lattice** & *lattice,* long *index*)

Constructor with initialization.

See Also

initialize(Lattice& lattice, long index);

Parameters

lattice,:	the lattice on which the Site is defined.
index	: set the current index of the field.

5.11.3 Member Function Documentation

5.11.3.1 int Site::coord (int *direction*)

Method which return the site coordinate of a give dimension

Parameters

direction,:	label of the coordinate.

Returns

site coordinate of the "direction" dimension

Examples:

gettingStarted, and poissonSolver.

5.11.3.2 int Site::coordLocal (int *direction*)

Method which return the local site coordinate of a give dimension

Parameters

direction,:	label of the coordinate.

Returns

site local coordinate of the "direction" dimension

5.11.3.3 void Site::first ( )

Method to set the Site to the first site which is not within the halo. This method is used for loopping over the all lattice sites:

for(site.first();site.test();site.next());

See Also

test()
next()

Examples:

gettingStarted, and poissonSolver.

5.11.3.4 void Site::haloFirst ( )

Method to set the Site to the first site which is within the halo. This method is used for loopping over the all halo sites:

for(site.haloFirst();site.haloTest();site.haloNext());

See Also

haloTest()
haloNext()

5.11.3.5 void Site::haloNext ( )

Method to jump to the next index which is in the halo. This method is used for loopping over the all halo sites:

for(site.haloFirst();site.haloTest();site.haloNext());

See Also

haloFirst()
haloTest()

5.11.3.6 bool Site::haloTest ( )

Method to test if the Site have a smaller or equal index than the last index within the halo. This method is used for loopping over the all halo sites:

for(site.haloFirst();site.haloTest();site.haloNext());

See Also

haloFirst()
haloNext()

5.11.3.7 long Site::index ( ) const

Returns

this method return the current index pointed by the site.

5.11.3.8 void Site::indexAdvance (long *number*)

Method which add "number" to the current index.

5.11.3.9 void Site::initialize (Lattice & *lattice*)

Initialization.

Parameters

lattice,:	the lattice on which the Site is defined.

5.11.3.10 void Site::initialize (Lattice & *lattice,* long *index*)

Constructor with initialization.

Parameters

lattice,:	the lattice on which the Site is defined.
index	: set the current index of the field.

5.11.3.11 Lattice & Site::lattice ( )

Returns

Returns the pointer to the lattice on which the site is defined.

5.11.3.12 void Site::next ( )

Method to jump to the next index which is not in the halo. This method is used for loopping over the all lattice sites: for(site.first();site.test();site.next());

See Also

first()
test()

Examples:

gettingStarted, and poissonSolver.

5.11.3.13 Site Site::operator+ (int *direction*)

Overloaded operator + The + operator is used to make a displacement of +1 site the the asked direction.

Parameters

direction,:	direction of the displacement

5.11.3.14 Site Site::operator- (int *direction*)

Overloaded operator - The - operator is used to make a displacement of -1 site the the asked direction.

Parameters

direction,:	direction of the displacement

5.11.3.15 bool Site::setCoord (int ∗ *r*)

Method to set the site to a given coordinate.

Parameters

r,:	array which contain the coordinate. The array size must be equal to the number of dimension of the lattice

Returns

True: if the coordinate is local. False: if the local part of the lattice does not have this coordinate.

5.11.3.16 bool Site::setCoord (int *x*, int *y* = 0, int *z* = 0)

Method to set the site to a given coordinate for 3d lattices.

Parameters

x,:	coordinate of the 0 dimension.
y,:	coordinate of the 1 dimension.
z,:	coordinate of the 2 dimension.

Returns

True: if the coordinate is local. False: if the local part of the lattice does not have this coordinate.

5.11.3.17 void Site::setIndex (long *new_index*)

Mehtod to set the current index of the site.

Parameters

new_index,:	the site index is set to new_index.

5.11.3.18 bool Site::test ( )

Method to test if the Site have a smaller or equal index than the last index not within the halo. This method is used for loopping over the all lattice sites:

for(site.first();site.test();site.next());

See Also

first()
next()

Examples:

gettingStarted, and poissonSolver.

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

- LATfield2_Site.hpp

5.12 temporaryMemFFT Class Reference

A class wich handle the additional memory needed by the class PlanFFT; No documentation!

```
#include <LATfield2_PlanFFT.hpp>
```

Public Member Functions

- **temporaryMemFFT** (long size)
- int **setTemp** (long size)
- fftwf_complex ∗ **temp1** ()
- fftwf_complex ∗ **temp2** ()
- fftw_complex ∗ **temp1** ()
- fftw_complex ∗ **temp2** ()

Private Attributes

- fftwf_complex ∗ **temp1_**
- fftwf_complex ∗ **temp2_**
- fftw_complex ∗ **temp1_**
- fftw_complex ∗ **temp2_**
- long **allocated_**

5.12.1 Detailed Description

A class wich handle the additional memory needed by the class PlanFFT; No documentation!

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

- LATfield2_PlanFFT.hpp

Chapter 6

File Documentation

6.1 Imag.hpp File Reference

Real and Complex numbers.

Classes

- class Imag

    complex numbers

Typedefs

- typedef float Real

    real numbers

Functions

- Imag **expi** (Real x)

6.1.1 Detailed Description

Real and Complex numbers. A small definition of real and complex number with some operation. Both real and complex can be in single or double precision. Default is double, tu use single precision the flag -DSINGLE need to be use at compilation.

6.2 LATfield2.hpp File Reference

Library header.

Variables

- IOserver **IO_Server**
- Parallel2d **parallel**

6.2.1 Detailed Description

Library header.

6.3 LATfield2_Field.hpp File Reference

Field class definition.

Classes

- class Field< FieldType >

  The Field class describe a field on a given lattice.

Functions

- template<class FieldType >
  void **defaultFieldSave** (fstream &file, FieldType ∗siteData, int components)
- template<class FieldType >
  void **defaultFieldLoad** (fstream &file, FieldType ∗siteData, int components)

Variables

- int **symmetric**
- int **unsymmetric**

6.3.1 Detailed Description

Field class definition. LATfield2_Field.hpp contain the class Field definition.

6.4 LATfield2_IO_server.hpp File Reference

I/O server handler.

Classes

- struct file_struct

  A structure to describe a file for the IOserver.
- class IOserver

  The IOserver class handle the I/O using MPI process reserved for I/O.

Typedefs

- typedef int **ioserver_file**

6.4.1 Detailed Description

I/O server handler. LATfield2_IO_server.hpp contain the class IOserver definition.

6.5 LATfield2_Lattice.hpp File Reference

Lattice class definition.

Classes

- class Lattice

  The Lattice class describe a n-toroidal cartesian mesh (with n>=2).

6.5.1 Detailed Description

Lattice class definition. LATfield2_Lattice.hpp contain the class Lattice definition.

6.6 LATfield2_parallel2d.hpp File Reference

LATfield2 paralization handler.

Classes

- class Parallel2d

  LATfield2d paralization handler.

Functions

- **if** (world_rank_==0)
- **MPI_Comm_group** (world_comm_,&world_group_)
- **MPI_Group_range_incl** (world_group_, 1,&rang,&lat_world_group_)
- **MPI_Comm_create** (world_comm_, lat_world_group_,&lat_world_comm_)
- **MPI_Group_rank** (lat_world_group_,&comm_rank)
- **if** (comm_rank!=MPI_UNDEFINED)
- **if** (grid_rank_[0]==grid_size_[0]-1) last_proc_[0]
- **if** (grid_rank_[1]==grid_size_[1]-1) last_proc_[1]
- IO_Server **initialize** (proc_size0, proc_size1, IO_total_size, IO_node_size)
- **if** (lat_world_rank_==0)
- **MPI_Comm_group** (lat_world_comm_,&lat_world_group_)
- **for** (j=0;j< grid_size_[1];j++)
- **if** (root_==lat_world_rank_) isRoot_

Variables

- void Parallel2d::initialize(int
  proc_size0, int proc_size1,
  int IO_total_size, int
  IO_node_size) void Parallel2d **grid_size_** [1]
- **dim0_comm_**
- **dim1_comm_**
- **dim0_group_**
- **dim1_group_**
- int **rang** [3]
- int **i**

- int **j**
- int **comm_rank**
- **else**
- **root_**
- **grid_rank_** [1]
- **isIO_**
- else **last_proc_** [0]
- else **isRoot_**

6.6.1 Detailed Description

LATfield2 paralization handler. LATfield2_parallel2d.hpp contain the class Parallel2d definition.

6.7 LATfield2_PlanFFT.hpp File Reference

FFT wrapper.

Classes

- class temporaryMemFFT

  A class wich handle the additional memory needed by the class PlanFFT; No documentation!
- class PlanFFT$<$ compType $>$

  Class which handle fourier transforms of fields on 3d cubic lattices.

Variables

- const int **FFT_FORWARD**
- const int **FFT_BACKWARD**
- const int **FFT_IN_PLACE**
- const int **FFT_OUT_OF_PLACE**
- temporaryMemFFT **tempMemory**

6.7.1 Detailed Description

FFT wrapper. LATfield2_PlanFFT.hpp contain the class PlanFFT definition.

6.8 LATfield2_SettingsFile.hpp File Reference

Settings file reader.

Classes

- class SettingsFile

  A class desinged to make reading in runtime settings easier.

6.8.1 Detailed Description

Settings file reader.

6.9 LATfield2_Site.hpp File Reference

Site class definition.

Classes

- class Site

  A small class which aim to point to given lattice site.
- class cKSite

  A child of Site, built to work with the fourier space lattices for complex to complex transforms.
- class rKSite

  A child of Site, built to work with the fourier space lattices for real to complex transforms.

6.9.1 Detailed Description

Site class definition. LATfield2_Site.hpp contain the class Site definition.

Chapter 7

Example Documentation

7.1 FFTs

A simple example of the usage of the FFT wrapper of LATfield2. The wrapper use FFTW library to perform 1d serial FFTs. Therefor FFTW 2 (or higher) need to be installed on the cluster. (So do not forget to load the module fftw of your cluster. . .)

```
#include <iostream>
#include "LATfield2.hpp"

using namespace LATfield2;


int main(int argc, char **argv)
{
    int n,m;
    int BoxSize = 64;
    int halo = 1;
    int khalo =0;
    int dim = 3;
    int comp = 1;
    double sigma2=0.5;
    double res =0.5;


    for (int i=1 ; i < argc ; i++ ){
        if ( argv[i][0] != '-' )
            continue;
        switch(argv[i][1]) {
            case 'n':
                n = atoi(argv[++i]);
                break;
            case 'm':
                m =  atoi(argv[++i]);
                break;
            case 'b':
                BoxSize = atoi(argv[++i]);
                break;
        }
    }

    parallel.initialize(n,m);


    Lattice lat(dim,BoxSize,halo);


    //Real to complex fourier transform

    Lattice latKreal;
    latKreal.initializeRealFFT(lat, khalo);

    Site x(lat);
    rKSite kReal(latKreal);

    Field<Real> phi;
    phi.initialize(lat,comp);
    Field<Imag> phiK;
    phiK.initialize(latK,comp);

    PlanFFT<Imag> planReal(&phi,&phiK);

    planReal.execute(FFT_FORWARD);

    planReal.execute(FFT_BACKWARD);

    //complex to complex fourier transform

    Lattice latKcomplex;
    latKcomplex.initializeComplexFFT(lat, khalo);

    Site x(lat);
    cKSite kComplex(latKreal);

    Field<Imag> rho;
    rho.initialize(lat,comp);

    Field<Imag> rhoK;
    rhoK.initialize(latK,comp);

    PlanFFT<Imag> planComplex(&rho,&rhoK);

    planComplex.execute(FFT_FORWARD);

    planComplex.execute(FFT_BACKWARD);


}
```

7.1.1 Compile and Run

Travel to the LATfield2/examples folder. Then you can compile this example with (using mpic++, verify which compiler you want to use):

Double precision:

```
mpic++ -o fft_exec fft.cpp -I../ -DFFT3D -lfftw
```

Single precision:

```
mpic++ -o fft_exec fft.cpp -I../ -DFFT3D -DSINGLE -lfftwf
```

It can be executed using (here using "mpirun -np 4" to run with 4 process):

```
mpirun -np 4 ./ioserver_exec -n 2 -m 2
```

The executable will not return anything, and the FFT are perform on fields which have not be assigned. Therefor it is not so useful to run this example, maybe just to see if it does not crash on your cluster. In that case, please report the crash to `david.daverio@gmail.com`. The FFT wrapper of LATfield2 is continuously under development, therefor your report will be extremely useful (for you as for other users).

7.1.2 Going through the code

7.1.2.1 Declaration of the lattice in real space.

The lattice in real space is declared as usual.

```
    Lattice lat(dim,BoxSize,halo);
```

7.1.2.2 Real to Complex (r2c) Fourier transform

First thing to do is to declare the lattice in fourier space. For a r2c FFT it is done using the initializeRealFFT method of the Lattice class.

```
Lattice latKreal;
latKreal.initializeRealFFT(lat, khalo);
```

At that point, one should be aware that the lattice in fourier space have not the same data distribution in a single process and not the same distribution in the cluster. Therefor one should use different site objet for both lattice. For r2c transform, the fourier space site is the rKSite class.

```
Site x(lat);
rKSite kReal(latKreal);
```

Once both lattice (real and Fourier one) are initialized, one can declare the fields. The PlanFFT class will allocate the needed memory both field and some temporary memory. Therefor the field need to be initialized but not allocated.

For the real field one should use the Real datatype (which is a redefinition of float or double, depending the precision requirement)

```
Field<Real> phi;
phi.initialize(lat,comp);
```

For the fourier field one should use the Imag datatype (which is a redefinition of fftwf_complex or fftw_complex, depending the precision requirement)

```
Field<Imag> phiK;
phiK.initialize(latK,comp);
```

Once both field are initialized, the planer can be declared and initialized:

```
PlanFFT<Imag> planReal(&phi,&phiK);
```

One should notice that the reference of the field have to be pass as the initialization of the planer will allocate the field.

Then you can perform the fourier transform using the execute method of the PlanFFT class.

```
planReal.execute(FFT_FORWARD);
planReal.execute(FFT_BACKWARD);
```

7.1.2.3 Complex to Complex (c2c) Fourier transform

First thing to do is to declare the lattice in fourier space. For a c2c FFT it is done using the initializeComplexFFT method of the Lattice class.

```
Lattice latKcomplex;
latKcomplex.initializeComplexFFT(lat, khalo);
```

At that point, one should be aware that the lattice in fourier space have not the same data distribution in a single process and not the same distribution in the cluster. Therefor one should use different site objet for both lattice. For r2c transform, the fourier space site is the cKSite class.

```
Site x(lat);
cKSite kComplex(latKreal);
```

Once both lattice (real and Fourier one) are initialized, one can declare the fields. The PlanFFT class will allocate the needed memory both field and some temporary memory. Therefor the field need to be initialized but not allocated.

For both the real and the fourier fields one should use the Imag datatype (which is a redefinition of fftwf_complex or fftw_complex, depending the precision requirement)

```
    Field<Imag> rho;
    rho.initialize(lat,comp);


    Field<Imag> rhoK;
    rhoK.initialize(latK,comp);
```

Once both field are initialized, the planer can be declared and initialized:

```
    PlanFFT<Imag> planComplex(&rho,&rhoK);
```

One should notice that the reference of the field have to be pass as the initialization of the planer will allocate the field.

Then you can perform the fourier transform using the execute method of the PlanFFT class.

```
    planComplex.execute(FFT_FORWARD);
    planComplex.execute(FFT_BACKWARD);
```

7.1.2.4 important points

One should notice that the wrapper is based on the FFTW library, more precisely the 1d serial transform of FFTW. Therefore to know exactly what is computed the best is to refer to the FFTW documentation and look at the 1d version of FFTW.

http://www.fftw.org/doc/What-FFTW-Really-Computes.html

Secondly, one should notice that FFTW forward methods will return a result which have been multiply by the size of the array. Therefor, to have the correct result once should divide by Lattice.sites() the result given by the wrapper. This is not done within the wrapper to return the same result than FFTW.

7.2 gettingStarted

A very simple example which aims to describe the main features of LATfield2. This example is composed by 5 blocks of code. First the parallel object is initialized, and this must be the first operation within a code which use LATfield2 as it initialize MPI. Secondly a Lattice object is declared. Thirdly Field objects are declared on the Lattice. Forth the some operation are performed on the fields, then finally the field are written on disk.

```
#include "LATfield2.hpp"
using namespace LATfield2;


int main(int argc, char **argv)
{

    //-------- Initilization of the parallel object ---------
    int n,m;

    for (int i=1 ; i < argc ; i++ ){
        if ( argv[i][0] != '-' )
            continue;
        switch(argv[i][1]) {
            case 'n':
                n = atoi(argv[++i]);
                break;
            case 'm':
                m =  atoi(argv[++i]);
                break;
        }
    }

    parallel.initialize(n,m);
    COUT << "Parallel grid size: ("<<parallel.grid_size()[0]<<","<<parallel.
      grid_size()[1]<<"). "<<endl;
    //-----------------------   end   ------------------------


    //------------   Declaration of a Lattice   --------------
    int dim = 3;
    int latSize[dim] = {25,57,32};
    int halo = 1;
    Lattice lat(dim,latSize,halo);

    COUT << "Lattice size: ("<< lat.size(0)<<","<< lat.size(1)<<","<< lat.
      size(2)<<");"<<endl;
    cout << "Process ranks: "<< parallel.rank()<<",("<< parallel.grid_rank()[0]<<","<<parallel
      .grid_rank()[1]<< "); ";
    cout << "Local lattice size: ("<< lat.sizeLocal(0)<<","<< lat.
      sizeLocal(1)<<","<< lat.sizeLocal(2)<<"); ";
    cout << "Coordinate of the first local point: (0,"<< lat.coordSkip()[1] <<","<< lat.
      coordSkip()[0] <<")."<<endl;
    //-----------------------   end   ------------------------


    //-----------   Declaration of the Fields   --------------
    Field<Real> rho(lat);
    Field<Real> gradPhi(lat,3);

    Field<Real> phi;
    phi.initialize(lat);
    phi.alloc();
    //-----------------------   end   ------------------------

    //--------------   Operations on Fields   ----------------
    Site x(lat);

    double x2;
    for(x.first();x.test();x.next())
    {
        x2  = pow(0.5 + x.coord(0) - lat.size(0)/2.,2.);
        x2 += pow(0.5 + x.coord(1) - lat.size(1)/2.,2.);
        x2 += pow(0.5 + x.coord(2) - lat.size(2)/2.,2.);
        phi(x) = exp(-x2 * 2.);
    }

    phi.updateHalo();

    for(x.first();x.test();x.next())
    {

        gradPhi(x,0) = (phi(x+0)-phi(x-0));
        gradPhi(x,1) = (phi(x+1)-phi(x-1));
        gradPhi(x,2) = (phi(x+2)-phi(x-2));

        rho(x)=0;
        for(int i=0;i<3;i++)rho(x) += phi(x+i) - 2 * phi(x) + phi(x-i);

    }
    //-----------------------   end   ------------------------

    //------------------   writing fields   ------------------
    string str_filename = "./test_phi";

#ifdef HDF5
    str_filename += ".h5";
    phi.saveHDF5(str_filename);
    str_filename = "test_phi_slice.h5";
    phi.saveSliceHDF5(str_filename,0,3);
#else
    str_filename += ".txt";
    phi.write(str_filename);
#endif


    //--------------------------------------------------------
}
```

7.2.1 Compile and Run

Travel to the LATfield2/examples folder. Then you can compile this example with (using mpic++, verify which compiler you want to use):

```
mpic++ -o getStart gettingStarted.cpp -I../ -DHDF5 -lhdf5
```

Wich will compile using HDF5 for the Field I/O. If you have not HDF5 installed then you should compile with:

```
mpic++ -o getStart gettingStarted.cpp -I../
```

It can be executed using (here using "mpirun -np 4" to run with 4 process):

```
mpirun -np 4 ./getStart -n 2 -m 2
```

The executable will prompt the following text:

```
Parallel grid size: (2,2).
Lattice size: (25,57,32);
Process ranks: 0,(0,0); Local lattice size: (25,28,16); First local point coordinate: (0,0,0).
Process ranks: 1,(1,0); Local lattice size: (25,28,16); First local point coordinate: (0,0,16).
Process ranks: 2,(0,1); Local lattice size: (25,29,16); First local point coordinate: (0,28,0).
Process ranks: 3,(1,1); Local lattice size: (25,29,16); First local point coordinate: (0,28,16).
```

First line give the size of the 2 dimension of the parallel grid. Second line give the size of a Lattice. Then each process output its ranks and the description of the local part of the lattice (the part of the lattice which is stored on the given process).

7.2.2 Going through the code

7.2.2.1 Parallel initialization

The first operation to perform within any code which use LATfield2 is to initialize the parallel object by giving the size of the 2 dimensions of the parallel grid. This numbers depend on the number of process used to run, therefor it is advised to read this numbers from the executable arguments. Here this 2 integer are given using "-n XX -m YY":

```
#include "LATfield2.hpp"
using namespace LATfield2;


int main(int argc, char **argv)
{

    //-------- Initilization of the parallel object ---------
    int n,m;

    for (int i=1 ; i < argc ; i++ ){
        if ( argv[i][0] != '-' )
            continue;
        switch(argv[i][1]) {
            case 'n':
                n = atoi(argv[++i]);
                break;
            case 'm':
                m =  atoi(argv[++i]);
                break;
        }
    }
```

Then the parallel object is initialized passing the two integer n and m:

```
    parallel.initialize(n,m);
```

This will initialize the parallel grid by calling MPI_initialize and will also construct all MPI communicators needed by the library.

After this, one can output the size of the parallel grid:

```
    COUT << "Parallel grid size: ("<<parallel.grid_size()[0]<<","<<parallel.
      grid_size()[1]<<"). "<<endl;
```

The command COUT is a definition of

```
if(parallel.isRoot())cout
```

and therefor only the root process (the one with rank 0) will perform the output.

7.2.2.2 Lattice declaration

```
    //------------   Declaration of a Lattice   --------------
```

LATfield2 can work with lattice of N-dimension, with N larger or equal to 2. In this example we will declare a lattice with 3 dimension.

```
    int dim = 3;
    int latSize[dim] = {25,57,32};
    int halo = 1;
    Lattice lat(dim,latSize,halo);
```

Note that the halo (number of ghost cells) is a single integer, as each dimension of the lattice have the same halo within LATfield2. Also note that if boxSize is an integer (instead of a pointer) this will initialize the lattice with each dimension with the same size.

Let output the description of the Lattice:

First lets output the size of the 3 dimension using COUT to avoid that every process output the same information.

```
    COUT << "Lattice size: ("<< lat.size(0)<<","<< lat.size(1)<<","<< lat.size(2)<<");"<<endl;
```

Then lets output on a single line the local description of the lattice. So first lets output the MPI ranks of each process, first the world rank then the 2d ranks (the position with the parallel grid). Then lets output the size of the part of the lattice which is stored in this given process. And finally the offset to this local part in respect to the global lattice.

```
    cout << "Process ranks: "<< parallel.rank()<<",("<< parallel.grid_rank()[0]<<","<<parallel
      .grid_rank()[1]<< "); ";
    cout << "Local lattice size: ("<< lat.sizeLocal(0)<<","<< lat.sizeLocal(1)<<","<< lat.sizeLocal(2)<<");
       ";
    cout << "Coordinate of the first local point: (0,"<< lat.coordSkip()[1] <<","<< lat.coordSkip()[0] <<"
      )."<<endl;
```

7.2.2.3 Field declaration

```
    //-----------   Declaration of the Fields   --------------
```

In this simple example we want to work with 3 fields, ϕ, ρ and $\nabla\phi$ who are named in the code phi, rho and gradphi. One can declare, initialize and allocate field using:

```
    Field<Real> rho(lat);
    Field<Real> gradPhi(lat,3);
```

In the case that declaration should be separately performed (as within a class declaration, or when several fields point to the same array and therefor should not be allocated), one can use the following 3 command:

```
    Field<Real> phi;
    phi.initialize(lat);
    phi.alloc();
```

7.2.2.4 Field opperations

```
    //--------------   Operations on Fields   ----------------
```

First, we would like to initialize the value of ϕ to be a gaussian defined as $\phi = e^{-2(x-x_0)^2}$. To do so we have to declare a Site object on the lattice of ϕ. This object will allow to work with coordinate.

```
    Site x(lat);
```

Then it is possible to loop over all site using the usual for loop:

```
    double x2;
    for(x.first();x.test();x.next())
    {
        x2  = pow(0.5 + x.coord(0) - lat.size(0)/2.,2.);
        x2 += pow(0.5 + x.coord(1) - lat.size(1)/2.,2.);
        x2 += pow(0.5 + x.coord(2) - lat.size(2)/2.,2.);
        phi(x) = exp(-x2 * 2.);
    }
```

In that loop the exponential is built with $x_0 = latticeSize/2 + 0.5$ this mean that the gaussian is centered at the center of the lattice center cell. The coord method return the coordinate of the site object in lattice unite (integer).

Then some spacial derivative are computed to build $gradPhi = \vec{\nabla}\phi$ and $\rho = \Delta\phi$. To do so, first thing to do is to update the ghost cells (halo) of ϕ.

```
    phi.updateHalo();
```

Then the derivation can be performed. Here for simplicity we have set dx to one.

```
    for(x.first();x.test();x.next())
    {

        gradPhi(x,0) = (phi(x+0)-phi(x-0));
        gradPhi(x,1) = (phi(x+1)-phi(x-1));
        gradPhi(x,2) = (phi(x+2)-phi(x-2));

        rho(x)=0;
        for(int i=0;i<3;i++)rho(x) += phi(x+i) - 2 * phi(x) + phi(x-i);

    }
```

This shows how to work with file with multiple components (gradPhi). And exhibit the usage of the Site object for displacement in the Lattice. The operator + and - are overloaded to provide an extremely easy way to travel on the lattice. Both operator will return the neighbor site in the direction specified after the operator.

7.2.2.5 Field I/O

```
    //------------------   writing fields   ------------------
```

This method allow to write a file with different file format. Using HDF5 or using ASCII format.

```
    string str_filename = "./test_phi";

#ifdef HDF5
    str_filename += ".h5";
    phi.saveHDF5(str_filename);
    str_filename = "test_phi_slice.h5";
    phi.saveSliceHDF5(str_filename,0,3);
#else
    str_filename += ".txt";
    phi.write(str_filename);
#endif
```

7.3 IOserver

A very simple example to exhibit the usage of the I/O server. It will write two very simple file in ASCII, in which each compute core will write a single line. Such usage are clearly unrealistic, as a usual I/O will perform it faster due to the extremely small amount of data per message.

The server work as follow. It need to be started only on the I/O cores. Then the compute core will process their usual computation. Once some I/O have to be performed. The compute cores have to open an "ostream" to the I/O cores. The files can be created and opened. Only one file can be open simultaneously currently, and there is no method to reopen a file which have been closed. This feature will be added, in the next update of the server. Once all data have been transferred to the I/O cores, one can close the "ostream". This operation will launch the writing to disks procedure and the server will be in a busy state until all data have been written on disks.

```
#include <iostream>
#include "LATfield2.hpp"

using namespace LATfield2;



int main(int argc, char **argv)
{
    int n,m;
    int io_size;
    int io_groupe_size;


    for (int i=1 ; i < argc ; i++ ){
        if ( argv[i][0] != '-' )
            continue;
        switch(argv[i][1]) {
            case 'n':
                n = atoi(argv[++i]);
                break;
            case 'm':
                m =  atoi(argv[++i]);
                break;
            case 'i':
                io_size =  atoi(argv[++i]);
                break;
            case 'g':
                io_groupe_size = atoi(argv[++i]);
                break;
        }
    }

    parallel.initialize(n,m,io_size,io_groupe_size);

    if(parallel.isIO()) IO_Server.start();
    else
    {
        string filename = "./testfile";
        ioserver_file file;

        string sentence;
        sentence = "I am the " + int2string(parallel.world_rank(),99999) + " MPI process. My rank
       is ";
        sentence += int2string(parallel.rank(),99999) + " in the compute group. I have the position (";
        sentence += int2string(parallel.grid_rank()[0],99999) + "," + int2string(parallel.
      grid_rank()[1],99999);
        sentence += ") in the processes grid." ;

        char * sendbuffer;
        sendbuffer = (char*)malloc(sentence.size()+1);
        for(int i=0;i<sentence.size();i++)sendbuffer[i]=sentence[i];
        sendbuffer[sentence.size()]='\n';



        while(IO_Server.openOstream()==OSTREAM_FAIL)usleep(50);

        file = IO_Server.createFile(filename);
        IO_Server.writeBuffer(file,sendbuffer,sentence.size()+1);
        IO_Server.closeFile(file);

        IO_Server.closeOstream();

        IO_Server.stop();
    }
}
```

7.3.1 Compile and Run

Travel to the LATfield2/examples folder. Then you can compile this example with (using mpic++, verify which compiler you want to use):

```
mpic++ -o ioserver_exec IOserver.cpp -I../ -DEXTERNAL_IO
```

It can be executed using (here using "mpirun -np 4" to run with 4 process):

```
mpirun -np 24 ./ioserver_exec -n 4 -m 4 -i 8 -g 4
```

The n and m parameter are as usual parameters to initialize the parallel object. Then 2 additional parameters are passed. First -i which is the total number of MPI processes of the IO server, then -g is the number of IO process which write data in a single file. Therefor n∗m+i need to be equal to the total number of MPI processes used by the job and i/g must be an integer.

7.3.2 Going through the code

7.3.2.1 Parallel initialization and server launch

The initialization of the parallel object is performed as without the IO server, the only difference is that two addition parameter are passed to the parallel object. The number of process of the IO server, and the size of one group of the server, which is the number of process which write in the same disk. It is advised to set the group size to be an integer multiple of the number of core on a node.

```
#include <iostream>
#include "LATfield2.hpp"

using namespace LATfield2;


int main(int argc, char **argv)
{
    int n,m;
    int io_size;
    int io_groupe_size;


    for (int i=1 ; i < argc ; i++ ){
        if ( argv[i][0] != '-' )
            continue;
        switch(argv[i][1]) {
            case 'n':
                n = atoi(argv[++i]);
                break;
            case 'm':
                m =  atoi(argv[++i]);
                break;
            case 'i':
                io_size =  atoi(argv[++i]);
                break;
            case 'g':
                io_groupe_size = atoi(argv[++i]);
                break;
        }
    }

    parallel.initialize(n,m,io_size,io_groupe_size);
```

Once the parallel object is initialized, the parallel object contain a list of compute and IO core. The method isIO() return true for IO process and false for compute ones. Basicaly, a IO process have to perform only one operation, launching the server. This is perform using the start() method.

```
    if(parallel.isIO()) IO_Server.start();
```

7.3.2.2 Compute processes

Then the part of the code executed by the compute process need to be in the else of the previous if, or in a block within

```
if(!parallel.isIO()){...}.
```

In this simple example, each processes will write a simple sentence which contain his position in the processes grid.

```
    else
    {

        string filename = "./testfile";
        ioserver_file file;

        string sentence;
        sentence = "I am the " + int2string(parallel.world_rank(),99999) + " MPI process. My rank
       is ";
        sentence += int2string(parallel.rank(),99999) + " in the compute group. I have the position (";
        sentence += int2string(parallel.grid_rank()[0],99999) + "," + int2string(parallel.
      grid_rank()[1],99999);
        sentence += ") in the processes grid." ;

        char * sendbuffer;
        sendbuffer = (char*)malloc(sentence.size()+1);
        for(int i=0;i<sentence.size();i++)sendbuffer[i]=sentence[i];
        sendbuffer[sentence.size()]='\n';
```

In real application the construction of the data which need to be send should be done only when the file is open, and send to the server by several message (order 5 is the most efficient). This allow a much better usage of the IOserver.

First step to start a transfer from to the IOserver is to open an ostream to the server on the computes processes. The server have no method to wait until it is ready. And a ostream can be open only if the server is in the ready state. The server can be in busy state for to reason. First it has not finish to launch, and secondly the server is currently writing a file. This busy state will desapear from the next version of the server, but still need lot of development.

```
        while(IO_Server.openOstream()==OSTREAM_FAIL)usleep(50);
```

Once a stream is open one can open a file. Currently it is possible to open 5 file within one ostream, but not simultaneously (next version of the server will be able to deal with multiple file simultaneously). Currently, there is no method to open an existing file. The only method which open a file is createFile, which will create a file or trunk it if existing.

```
        file = IO_Server.createFile(filename);
```

Once a file is open, data can be transferred to the IOserver using the write method. In this method the size of the sendBuffer is given in bytes, and the buffer is expected to be a pointer to a char array. (so if not a char array, typecast it: (char∗))

```
        IO_Server.writeBuffer(file,sendbuffer,sentence.size()+1);
```

When all data have been send to the file, one can close the file. Which is very important, as when a file is open, the server will continuously look for data send by the compute process to this file.

```
        IO_Server.closeFile(file);
```

Once every data have been send to the file where it should be written, and to launch the transfer from the server to the disks, the ostream must be closed. At that moment the server will start to write data on disks and will turn his state as busy. Once the data are written on the disk a new ostream can be open.

```
        IO_Server.closeOstream();
```

One need to be aware that to correctly terminate MPI, the server have to shut down. Otherwise the process of the IOserver will never stop to listen the sync line to look for an instruction to open a ostream. And therefor the IO server cores will never reach the end of the executable. . .

The call to stop the server is performed by the compute process for obvious reason:

```
        IO_Server.stop();
```

7.4 poissonSolver

A simple poisson solver which verify the result. The code will be documented in a close future, but even without documentation it is a useful example

```
#include <iostream>
#include "LATfield2.hpp"

using namespace LATfield2;


int main(int argc, char **argv)
{
    int n,m;
    int BoxSize = 64;
    int halo = 1;
    int khalo =0;
    int dim = 3;
    int comp = 1;
    double sigma2=0.5;
    double res =0.5;


    for (int i=1 ; i < argc ; i++ ){
        if ( argv[i][0] != '-' )
            continue;
        switch(argv[i][1]) {
            case 'n':
                n = atoi(argv[++i]);
                break;
            case 'm':
                m =  atoi(argv[++i]);
                break;
            case 'b':
                BoxSize = atoi(argv[++i]);
                break;
        }
    }

    parallel.initialize(n,m);


    double res2 =res*res;
    double renormFFT;



    Lattice lat(dim,BoxSize,halo);
    Lattice latK;
    latK.initializeRealFFT(lat, khalo);

    Site x(lat);
    rKSite k(latK);

    Field<Real> phi;
    phi.initialize(lat,comp);
    Field<Imag> phiK;
    phiK.initialize(latK,comp);
    PlanFFT<Imag> planPhi(&phi,&phiK);


    Field<Real> rhoVerif(lat,comp);
    Field<Real> rho;
    rho.initialize(lat,comp);
    Field<Imag> rhoK;
    rhoK.initialize(latK,comp);
    PlanFFT<Imag> planRho(&rho,&rhoK);


    renormFFT=(double)lat.sites();

    //fill rho with a gaussian:


    for(x.first();x.test();x.next())
    {
        double x2 = pow(0.5l + x.coord(0) - lat.size(0)/2,2);
        x2 += pow(0.5l + x.coord(1) - lat.size(1)/2,2);
        x2 += pow(0.5l + x.coord(2) - lat.size(2)/2,2);
        rho(x)= 1.0 * exp(-x2/sigma2);
    }
    phi.updateHalo();


    planRho.execute(FFT_FORWARD);


    k.first();
    if(parallel.isRoot())
    {
        phiK(k)=0.0;
        k.next();
    }
    for(;k.test();k.next())
    {
        phiK(k)= rhoK(k) /
        ( 2.0 *(cos(2.0*M_PI*k.coord(0)/BoxSize)
                + cos(2.0*M_PI*k.coord(1)/BoxSize)
                + cos(2.0*M_PI*k.coord(2)/BoxSize)-3.0)/res2 );
    }

    planPhi.execute(FFT_BACKWARD);

    for(x.first();x.test();x.next())
    {
        rhoVerif(x) =  (phi(x+0) - 2 * phi(x) + phi(x-0))/res2;
        rhoVerif(x) += (phi(x+1) - 2 * phi(x) + phi(x-1))/res2;
        rhoVerif(x) += (phi(x+2) - 2 * phi(x) + phi(x-2))/res2;
    }





    double error;

    double maxError=0;
    double minError=20;
    double averageError=0;

    for(x.first();x.test();x.next())
    {
        error =  (abs( rho(x)- ( rhoVerif(x)/renormFFT) ) ) / abs(rhoVerif(x));
        averageError+=error;
        if(minError>error)minError=error;
        if(maxError<error)maxError=error;

    }

    parallel.max(maxError);
    parallel.min(minError);
    parallel.sum(averageError);

    averageError/=renormFFT;

    parallel.barrier();

    COUT<<"Min error: "<<minError<<", Max error: "<<maxError<<" , Average error: "<<averageError<<endl;


}
```