Alliance

1.0

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Chapter 1

File Index

1.1 File List

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

Chapter 2

File Documentation

2.1 array.c File Reference

array manipulation module

```
#include "array.h"
#include "utils_fftw.h"
#include "space_config.h"
```

Macros

- #define **CHI_EM** 3
- #define **CHI_EL** 1
- #define **FFT_OFFSET** 2

Functions

- size_t get_flat_c (size_t is, size_t il, size_t im, size_t ix, size_t iy, size_t iz)

  returns flat index of the element of complex 6D array
- size_t getIndChiBufEM_c (size_t ix, size_t iy, size_t iz, size_t is, size_t ifield)

  returns flat index of an element of electromagnetic gyrokinetic potential in FOURIER SPACE
- size_t getIndChiBufEM_r (size_t ix, size_t iy, size_t iz, size_t is, size_t ifield)

  returns flat index of an element of electromagnetic gyrokinetic potential in POSITION SPACE
- size_t getIndChiBufEL_c (size_t ix, size_t iy, size_t iz, size_t is)

  returns returns flat index of an element of electrostatic gyrokinetic potential in FOURIER SPACE
- size_t getIndChiBufEL_r (size_t ix, size_t iy, size_t iz, size_t is)

  returns returns flat index of an element of electrostatic gyrokinetic potential in REAL SPACE
- size_t get_flat_r (size_t is, size_t il, size_t im, size_t ix, size_t iy, size_t iz)

  returns flat index of the element of real 6D array
- size_t get_flatIndexComplex3D (size_t ix, size_t iy, size_t iz)

  returns flat array of complex 3D array
- size_t getIndChi (size_t ix, size_t iy, size_t iz, size_t is)
- void multiply_ar_c (COMPLEX *ar1, COMPLEX *ar2, COMPLEX *ret)
- void multiply_ar_r (const double *ar1, const double *ar2, double *ret)

Variables

- struct array_size **array_local_size**
- struct array_size **array_global_size**
- struct offset_size **array_offset**
- struct offset_size **array_offset3D**

2.1.1 Detailed Description

array manipulation module

contains functions which are supposed to make array manipulation simpler

2.1.2 Function Documentation

2.1.2.1 get_flat_c()

```
size_t get_flat_c (
            size_t is,
            size_t il,
            size_t im,
            size_t ix,
            size_t iy,
            size_t iz )
```

returns flat index of the element of complex 6D array

Parameters

is	species type
il	Laguerre moment
im	Hermite moment
ix	kx index
iy	ky index
iz	kz index

returns flattened index of a complex array from its 6D index. Flattened index then can be passed to distribution function 6D array to get a required element at position (is,il,im,ix,iy,iz).

2.1.2.2 get_flat_r()

```
size_t get_flat_r (
            size_t is,
            size_t il,
            size_t im,
            size_t ix,
```

```
            size_t iy,
            size_t iz )
```

returns flat index of the element of real 6D array

Parameters

is	species type
il	Laguerre moment
im	Hermite moment
ix	x index
iy	y index
iz	z index

returns flattened index of a real array from its 6D index. Flattened index then can be passed to distribution function 6D array to get a required element at position (is,il,im,ix,iy,iz).

2.1.2.3 get_flatIndexComplex3D()

```
size_t get_flatIndexComplex3D (
            size_t ix,
            size_t iy,
            size_t iz )
```

returns flat array of complex 3D array

Parameters

ix	kx index
iy	ky index
iz	kz index

returns flattened index of a complex array from its 3D position index. Flattened index then can be passed to one of the fields ($\phi(\mathbf{k}), A_{||}(\mathbf{k}), B_{||}(\mathbf{k})$) 6D array to get a required element at position (ix,iy,iz).

2.1.2.4 getIndChi()

```
size_t getIndChi (
            size_t ix,
            size_t iy,
            size_t iz,
            size_t is )
```

getIndChi(size_t ix,size_t iy, size_t iz, size_t is)

2.1.2.5 getIndChiBufEL_c()

```
size_t getIndChiBufEL_c (
            size_t ix,
```

```
        size_t iy,
        size_t iz,
        size_t is )
```

returns returns flat index of an element of electrostatic gyrokinetic potential in FOURIER SPACE

Parameters

ix	kx index
iy	ky index
iz	kz index
is	particle species index

returns flattened index of a gyrokinetic potential $\chi^{\phi}(\mathbf{k})$ from its 4D index in FOURIER SPACE. flattened index is then can be used to access required value of the gyrokinetic potential at position (ix,iy,iz,is).

2.1.2.6 getIndChiBufEL_r()

```
size_t getIndChiBufEL_r (
             size_t ix,
             size_t iy,
             size_t iz,
             size_t is )
```

returns returns flat index of an element of electrostatic gyrokinetic potential in REAL SPACE

Parameters

ix	x index
iy	y index
iz	z index
is	particle species index

returns flattened index of a gyrokinetic potential $\chi^{\phi}(\mathbf{r})$ from its 4D index in REAL SPACE. flattened index is then can be used to access required value of the gyrokinetic potential at position (ix,iy,iz,is).

2.1.2.7 getIndChiBufEM_c()

```
size_t getIndChiBufEM_c (
             size_t ix,
             size_t iy,
             size_t iz,
             size_t is,
             size_t ifield )
```

returns flat index of an element of electromagnetic gyrokinetic potential in FOURIER SPACE

Parameters

ix	kx index
iy	ky index
iz	kz index
is	particle species index
ifield	field type

returns flattened index of a gyrokinetic potential $\chi^{\phi,A,B}$ from its 4D index in FOURIER SPACE. flattened index is then can be used to access required value of the gyrokinetic potential at position (ix,iy,iz,is). Type of gyrokinetic potential is specified by ifield parameter. Use 0 is to access $\chi^{\phi}(\mathbf{k})$, 1 to access $\chi^{A}(\mathbf{k})$ and 2 to access $\chi^{B}(\mathbf{k})$.

2.1.2.8 getIndChiBufEM_r()

```
size_t getIndChiBufEM_r (
            size_t ix,
            size_t iy,
            size_t iz,
            size_t is,
            size_t ifield )
```

returns flat index of an element of electromagnetic gyrokinetic potential in POSITION SPACE

Parameters

ix	x index
iy	y index
iz	z index
is	particle species index
ifield	field type

returns flattened index of a gyrokinetic potential $\chi^{\phi,A,B}(\mathbf{k})$ from its 4D index in POSITION SPACE. flattened index is then can be used to access required value of the gyrokinetic potential at position (ix,iy,iz,is). Type of gyrokinetic potential is specified by ifield parameter. Use 0 is to access $\chi^{\phi}(\mathbf{r})$, 1 to access $\chi^{A}(\mathbf{r})$ and 2 to access $\chi^{B}(\mathbf{r})$.

2.1.2.9 multiply_ar_c()

```
void multiply_ar_c (
            COMPLEX * ar1,
            COMPLEX * ar2,
            COMPLEX * ret )
```

multiply_ar_c(COMPLEX ∗ar1, COMPLEX ∗ar2, COMPLEX ∗ret)

2.1.2.10 multiply_ar_r()

```
void multiply_ar_r (
            const double * ar1,
            const double * ar2,
            double * ret )
```

multiply_ar_r(const double ∗ar1, const double ∗ar2, double ∗ret)

2.2 diagnostics.c File Reference

diagnostics module

```
#include "diagnostics.h"
#include "parameters_io.h"
```

Macros

- #define **TO_ROOT** 0
- #define **BUFFER_SIZE** 1

Functions

- void diag_computeSpectra (const COMPLEX *g, const COMPLEX *h, int timestep)
  general function to compute k or m spectra
- void diag_initSpec ()
  initialize spectra computation
- void diag_computeFreeEnergy (COMPLEX *g, COMPLEX *h)
  compute free energy
- void diag_computeKSpectrum (const COMPLEX *g, const COMPLEX *h, double *spec)
- void diag_computeMSpectrum (const COMPLEX *g, const COMPLEX *h, double *spec)
  computes free energy spectra in m space
- void diag_getShells ()
  computes shells from parameters
- double diag_computeFreeEnergyFields (COMPLEX *g, COMPLEX *fields)
  to be done later
- void diag_compute (COMPLEX *g, COMPLEX *h, int timestep)
  computes all diagnostics

Variables

- double * diag_kSpec = 0
  used to store free energy k spectra
- double * diag_mSpec = 0
  used to store free energy m spectra
- double * diag_shells = 0
  used to store positions of k shells required to compute k spectra
- double diag_freeEnergy
  free energy

2.2.1 Detailed Description

diagnostics module

different diagnostic tools are gathered in this module

2.2.2 Function Documentation

2.2.2.1 diag_compute()

```
void diag_compute (
            COMPLEX * g,
            COMPLEX * h,
            int timestep )
```

computes all diagnostics

Parameters

g	modified distribution function
h	distribution function
iter	current time step

2.2.2.2 diag_computeFreeEnergy()

```
void diag_computeFreeEnergy (
            COMPLEX * g,
            COMPLEX * h )
```

compute free energy

Parameters

g	modified gyrokinetic distribution function
h	gyrokintic distribution function

computes free energy as $W = 2.\Re(\sum_{k_x,k_y,k_z>0,m,l,s} g * \bar{h})$, taking into account reality condition.

2.2.2.3 diag_computeFreeEnergyFields()

```
diag_computeFreeEnergyFields (
            COMPLEX * g,
            COMPLEX * fields )
```

to be done later

Parameters

g	
fields	computes free energy from the fields and distribution function.

2.2.2.4 diag_computeKSpectrum()

```
void diag_computeKSpectrum (
            const COMPLEX * g,
            const COMPLEX * h,
            double * spec )
```

Parameters

g	modified gyrokinetic distribution function
h	gyrokinetic distribution function
spec	spectra array

computes free energy $k_\perp$ spectra $W(k_i^{shell}) = \frac{1}{N}\sum_{k_{i-1}^{shell}<|\mathbf{k}_\perp|<k_i^{shell}}\sum_{k_z,l,m,s} g\bar{h}$ where N is a number of wave vectors between shells k_{i-1}^{shell} and k_i^{shell}

2.2.2.5 diag_computeMSpectrum()

```
void diag_computeMSpectrum (
            const COMPLEX * g,
            const COMPLEX * h,
            double * spec )
```

computes free energy spectra in m space

Parameters

g	modified gyrokinetic distribution function
h	gyrokinetic distribution function
spec	spectra array

computes free energy m spectra as $W(m) = \sum_{k_x,k_y,k_z,l,s} g\bar{h}$

2.2.2.6 diag_computeSpectra()

```
void diag_computeSpectra (
            const COMPLEX * g,
            const COMPLEX * h,
            int timestep )
```

general function to compute k or m spectra

Parameters

g	gyrokinetic distribution function
h	distribution function
timestep	current time step

function computes spectra at timestep as given in parameter file. $k_\perp$ spectra is computed using diag_computeKSpectrum, and m spectra is computed using diag_computeMSpectrum

2.2.2.7 diag_getShells()

```
diag_getShells ( )
```

computes shells from parameters

computes positions of k_shells in between last_shell and first_shell as provided by user in parameter file. Position of i^{th} shell is computed as $k_i^{shell} = (last\_shell - first\_shell)/(k\_shells) \cdot i$

2.2.2.8 diag_initSpec()

```
void diag_initSpec ( )
```

initialize spectra computation

Prepares free energy spectra computation. For spectra in k: allocates diag_kSpec array used to store k spectra. Allocates diag_shells array and fills it with shell positions k^{shells}, used for binning of wave vectors when computing $k_\perp$ spectra. For spectra in m: allocates diag_mSpec array used to store m spectra. Called in init_start function

2.3 distrib.c File Reference

gyrokinetic distribution function module

```
#include "distrib.h"
```

Functions

- void distrib_getH (COMPLEX *h, const COMPLEX *g)
  computes h from g
- void distrib_getG (COMPLEX *g, const COMPLEX *h)
  computes g from h
- void distrib_getXGrad (const COMPLEX *in, COMPLEX *out)
  Computes gradient in kx direction.
- void distrib_getYGrad (const COMPLEX *in, COMPLEX *out)
  Computes gradient in ky direction.
- void distrib_getZGrad (const COMPLEX *in, COMPLEX *out)
  Computes gradient in kz direction.
- void distrib_enforceReality (COMPLEX *f)
  enforces reality condition on distribution function array
- void distrib_setZeroNHalf (COMPLEX *f)
  sets all Nk/2 modes to zero

2.3.1 Detailed Description

gyrokinetic distribution function module

everything required to perform different manipulations to distribution functions

2.3.2 Function Documentation

2.3.2.1 distrib_enforceReality()

```
void distrib_enforceReality (
            COMPLEX * f )
```

enforces reality condition on distribution function array

Parameters

f	complex array for which reality condition will be forced.

Enforces reality condition f(k) = conj(f(-k)) in plane kz = 0. For a given kx, it first checks where modes -kx are located using the #mpi_whereIsX function:
`where_neg = mpi_whereIsX[kxNeg * 2];`
If -kx is stored on a different processor, MPI_VECTOR with a 4D data slice f(kx,kz = 0) is sent to this processor, to the `buffer` array:
`mpi_sendVector(&f[ind6D],buffer,where_pos,where_neg);`
if the data stored on the same processor, no vector is being sent. Reality condition is fulfilled in a loop over all other coordinates:
`f[ind6D_neg] = conj(buffer[ind6D_pos]);`

2.3.2.2 distrib_getG()

```
distrib_getG (
            COMPLEX * g,
            const COMPLEX * h )
```

computes g from h

Parameters

g	complex array to store g
h	complex array with h

computes modified gyrokinetic distribution function g from gyrokinetic distribution function h. Please note that before calling this function gyrokinetic potentials must be computed

2.3.2.3 distrib_getH()

```
void distrib_getH (
            COMPLEX * h,
            const COMPLEX * g )
```

computes h from g

Parameters

h	complex array to store h
g	complex array with g

computes gyrokinetic distribution function h from modified gyrokinetic distribution function g. Please note that before calling this function gyrokinetic potentials must be computed

2.3.2.4 distrib_getXGrad()

```
void distrib_getXGrad (
```

```
            const COMPLEX * in,
            COMPLEX * out )
```

Computes gradient in kx direction.

Parameters

in	complex array. Distribution function of which gradient will be taken
out	complex array, where gradient is stored

Computes gradient in kx direction as following:
grad(f) = i ∗ kx ∗ f

2.3.2.5 distrib_getYGrad()

```
void distrib_getYGrad (
            const COMPLEX * in,
            COMPLEX * out )
```

Computes gradient in ky direction.

Parameters

in	complex array. Distribution function of which gradient will be taken
out	complex array, where gradient is stored

Computes gradient in ky direction as following:
grad(f) = i ∗ ky ∗ f

2.3.2.6 distrib_getZGrad()

```
void distrib_getZGrad (
            const COMPLEX * in,
            COMPLEX * out )
```

Computes gradient in kz direction.

Parameters

in	complex array. Distribution function of which gradient will be taken
out	complex array, where gradient is stored

Computes gradient in kz direction as following:
grad(f) = i ∗ kz ∗ f

2.3.2.7 distrib_setZeroNHalf()

```
void distrib_setZeroNHalf (
            COMPLEX * f )
```

sets all Nk/2 modes to zero

Parameters

f	complex array

sets Nkx/2, Nky/2 and Nz/2 modes of distribution function to zero. Due to reality condition, for kz yhe last mode should be set to zero.

2.4 equation.c File Reference

equation module

```
#include "equation.h"
#include "array.h"
#include "fields.h"
#include "distrib.h"
```

Macros

- #define **CHI_EM** 3
- #define **CHI_EL** 1
- #define **CHI_PHI** 0
- #define **CHI_A** 1
- #define **CHI_B** 2

Functions

- void equation_getLinearTerm (const COMPLEX ∗in, const COMPLEX ∗plus_boundary, const COMPLEX ∗minus_boundary, COMPLEX ∗out)

  computes linear term
- void equation_getNonlinearElectromagnetic (double ∗in, double ∗chiAr, double ∗out, double sign)

  returns nonlinear electromagnetic term
- void equation_getNonlinearElectrostatic (double ∗in, double ∗chiAr, double ∗out, double sign)

  returns nonlinear electrostatic term
- void equation_getNonlinearProduct (double ∗in, double ∗chiAr, double ∗out, double sign)

  chooses between computing electrostatic or electromagnetic term
- void equation_getNonlinearTerm (const COMPLEX ∗h, COMPLEX ∗out)

  computes nonlinear term
- void **equation_getRHS** (const COMPLEX ∗in_g, COMPLEX ∗in_h, COMPLEX ∗out)

2.4.1 Detailed Description

equation module

module required to compute RHS of the equation.

2.4.2 Function Documentation

2.4.2.1 equation_getLinearTerm()

```
void equation_getLinearTerm (
            const COMPLEX * in,
            const COMPLEX * plus_boundary,
            const COMPLEX * minus_boundary,
            COMPLEX * out )
```

computes linear term

Parameters

in	complex array
out	complex array
plus_boundary	complex array
minus_boundary	complex array

computes linear term `out` from distribution function `in` .

2.4.2.2 equation_getNonlinearElectromagnetic()

```
void equation_getNonlinearElectromagnetic (
            double * in,
            double * chiAr,
            double * out,
            double sign )
```

returns nonlinear electromagnetic term

Parameters

in	input double array
chiAr	input double array
out	output double array
sign	should be 1 or -1

performs multiplication between input 6D complex array `in` and gyrokinetic potential array `chiAr`, in such way that the structure of the product is the same as nonlinear term of drift-kinetic equations. Used by equation_getNonlinearProduct. `sign` is used to determine the sign of the resulting product. See equation_getNonlinearTerm for explanation.

2.4.2.3 equation_getNonlinearElectrostatic()

```
void equation_getNonlinearElectrostatic (
            double * in,
```

```
            double * chiAr,
            double * out,
            double sign )
```

returns nonlinear electrostatic term

Parameters

in	input double array
chiAr	input double array
out	output double array
sign	should be 1 or -1

see equation_getNonlinearElectromagnetic for explanation

2.4.2.4 equation_getNonlinearProduct()

```
equation_getNonlinearProduct (
            double * in,
            double * chiAr,
            double * out,
            double sign )
```

chooses between computing electrostatic or electromagnetic term

Parameters

in	input double array
chiAr	input double array
out	output double array
sign	should be 1 or -1

depending on flag `systemType` provided by user in parameter file, chooses between equation_getNonlinearElectrostatic and equation_getNonlinearElectromagnetic

2.4.2.5 equation_getNonlinearTerm()

```
void equation_getNonlinearTerm (
            const COMPLEX * h,
            COMPLEX * out )
```

computes nonlinear term

Parameters

h	input complex array
out	output complex array

function returns nonlinear term. First it takes y gradient of distribution function `h`, and x gradient of gyrokinetic

potentials chi, and transforms them to real space:
```
distrib_getYGrad(h, fftw_hBuf);
fields_getGradX(fftw_chiBuf);
fftw_c2r();
fftw_c2r_chi();
```
after that, it computes $\frac{\partial h}{\partial y}\frac{\partial \chi}{\partial x}$ part of the poisson brackets:
```
equation_getNonlinearProduct((double *)fftw_hBuf, (double *)fftw_chiBuf,
buffer, 1.);
```
with the result stored in `buffer` after that, it computes x gradient of `h` and y gradient of gyrokinetic potential chi, and transforms results to real space:
```
distrib_getXGrad(h, fftw_hBuf);
fields_getGradY(fftw_chiBuf);
fftw_c2r();
fftw_c2r_chi();
```
and computes second part of the poisson brackets $-\frac{\partial h}{\partial x}\frac{\partial \chi}{\partial y}$ and adds the result to `buffer`. `buffer` is then transformed back to Fourier space, and dealiasing is performed.

2.5 fields.c File Reference

field computation and manipulation module

```
#include "fields.h"
```

Macros

- #define **CHI_PHI** 0
- #define **CHI_A** 1
- #define **CHI_B** 2

Functions

- void fields_init ()
  intializes fields
- void fields_getA (const COMPLEX *g)
  compute A field
- void fields_getB (const COMPLEX *g0, const COMPLEX *g1)
  computes B potential
- void fields_getPhi (const COMPLEX *g0, const COMPLEX *g1)
  computes phi potential
- void fields_getFields (COMPLEX *g00, COMPLEX *g10, COMPLEX *g01)
  wrapper to get all the fields simultaneously
- void fields_getChi ()
  computes gyrokinetic potentials chi
- void fields_getChiPhi ()
  computes chiPhi gyrokinetic potential from phi potential
- void fields_getChiB ()
  computes chiB gyrokinetic potential from B potential
- void fields_getChiA ()
  computes chiA gyrokinetic potential from A potential

- void fields_sendG (COMPLEX *g)

  sends moments of gyrokinetic distribution function which are required to compute fields
- void fields_getFieldsFromH (COMPLEX *h00, COMPLEX *h10, COMPLEX *h01)

  wrapper to get all the fields simultaneously, computed from gyrokinetic distribution function
- void fields_getAFromH (const COMPLEX *h)

  compute A field
- void fields_getBFromH (const COMPLEX *h0, const COMPLEX *h1)

  computes B potential
- void fields_getPhiFromH (const COMPLEX *h)

  computes phi potential
- void fields_getGradX (COMPLEX *out)

  computes chi gradient in x direction
- void fields_getGradY (COMPLEX *out)

  computes chi gradient in y direction

Variables

- struct fields_fields **fields_fields**
- struct fields_chi **fields_chi**
- double * **A_denom**
- double * **qnvTsJ**
- double * **I_B**
- double * **I_phi**
- double * **a_pot**
- double * **b_pot**
- double * **c_pot**
- double * **phiB_denom**
- int * **global_nm_index**
- COMPLEX * **g00**
- COMPLEX * **g10**
- COMPLEX * **g01**

2.5.1 Detailed Description

field computation and manipulation module

Rerquired to compute $A_{||}(\mathbf{k}), B_{||}(\mathbf{k}), \phi(\mathbf{k})$ potentials, as well as gyrokinetic potentials $\chi_s^A(\mathbf{k}), \chi_s^B(\mathbf{k}), \chi_s^\phi(\mathbf{k})$

2.5.2 Function Documentation

2.5.2.1 fields_getA()

```
void fields_getA (
            const COMPLEX * g )
```

compute A field

Parameters

g	4D complex array (kx,ky,kz,s). Must be first Hermite and zeroth Laguerre moment of modified gyrokinetic distribution function g.

computes $A_{||}(\mathbf{k})$ potential from g^1_{s0} ($\mathtt{g}$ parameter)

2.5.2.2 fields_getAFromH()

```
void fields_getAFromH (
            const COMPLEX * h )
```

compute A field

Parameters

h	4D complex array (kx,ky,kz,s). Must be first Hermite and zeroth Laguerre moment of gyrokinetic distribution function h.

computes $A_{||}(\mathbf{k})$ potential from h^1_{s0} ($\mathtt{h}$ parameter)

2.5.2.3 fields_getB()

```
void fields_getB (
            const COMPLEX * g0,
            const COMPLEX * g1 )
```

computes B potential

Parameters

g0	4D complex array (kx,ky,kz,s). Zeroth Hermite and Laguerre moment of modified gyrokinetic distribution function.
g1	4D complex array (kx,ky,kz,s). Zeroth Hermite and first Laguerre moment of the modified distribution function.

Computes $B_{\perp}(\mathbf{k})$ from g^0_{s0} ($\mathtt{g0}$ parameter) and g^1_{s0} ($\mathtt{g1}$ parameter).

2.5.2.4 fields_getBFromH()

```
void fields_getBFromH (
            const COMPLEX * h0,
            const COMPLEX * h1 )
```

computes B potential

Parameters

h0	4D complex array (kx,ky,kz,s). Zeroth Hermite and Laguerre moment of gyrokinetic distribution function.
h1	4D complex array (kx,ky,kz,s). Zeroth Hermite and first Laguerre moment of distribution function.

Computes $B_\perp(\mathbf{k})$ from h^0_{s0} (h0 parameter) and h^1_{s0} (h1 parameter).

2.5.2.5 fields_getChi()

```
void fields_getChi ( )
```

computes gyrokinetic potentials chi

Wrapper for functions fields_getChiPhi, fields_getChiA, fields_getChiB

2.5.2.6 fields_getChiA()

```
void fields_getChiA ( )
```

computes chiA gyrokinetic potential from A potential

computes $chi^A_s(\mathbf{k})$

2.5.2.7 fields_getChiB()

```
void fields_getChiB ( )
```

computes chiB gyrokinetic potential from B potential

computes $\chi^B_s(\mathbf{k})$

2.5.2.8 fields_getChiPhi()

```
fields_getChiPhi ( )
```

computes chiPhi gyrokinetic potential from phi potential

computes $chi^\phi_s(\mathbf{k})$

2.5.2.9 fields_getFields()

```
void fields_getFields (
            COMPLEX * g00,
            COMPLEX * g10,
            COMPLEX * g01 )
```

wrapper to get all the fields simultaneously

Parameters

g00	4D complex array (kx,ky,kz,s). Zeroth Hermite and Laguerre moment of modified gyrokinetic distribution function.
g10	4D complex array (kx,ky,kz,s). Must be first Hermite and zeroth Laguerre moment of modified gyrokinetic distribution function g.
g01	4D complex array (kx,ky,kz,s). Zeroth Hermite and first Laguerre moment of the modified distribution function.

Wrapper for functions fields_getPhi, fields_getB, fields_getA.

2.5.2.10 fields_getFieldsFromH()

```
void fields_getFieldsFromH (
            COMPLEX * h00,
            COMPLEX * h10,
            COMPLEX * h01 )
```

wrapper to get all the fields simultaneously, computed from gyrokinetic distribution function

Parameters

h00	4D complex array (kx,ky,kz,s). Zeroth Hermite and Laguerre moment of gyrokinetic distribution function.
h10	4D complex array (kx,ky,kz,s). Must be first Hermite and zeroth Laguerre moment of gyrokinetic distribution function h.
h01	4D complex array (kx,ky,kz,s). Zeroth Hermite and first Laguerre moment of the distribution function.

Wrapper for functions fields_getPhiFromH, #fields_get_BFromH, fields_getAFromH.

2.5.2.11 fields_getGradX()

```
void fields_getGradX (
            COMPLEX * out )
```

computes chi gradient in x direction

Parameters

out	output complex array of size (kx,ky,kz,s,Nfields).

computes gradient in x direction for chi potentials. Nfields<\tt> can be 1 or 3, and chosen automatically at start of the simulation depending on the simulation type (electrostatic or electromagnetic)

2.5.2.12 fields_getGradY()

```
void fields_getGradY (
            COMPLEX * out )
```

computes chi gradient in y direction

Parameters

out	output complex array of size (kx,ky,kz,s,Nfields).

computes gradient in y direction for chi potentials. Nfields<\tt> can be 1 or 3, and chosen automatically at start of the simulation depending on the simulation type

(electrostatic or electromagnetic)

2.5.2.13 fields_getPhi()

```
void fields_getPhi (
            const COMPLEX * g0,
            const COMPLEX * g1 )
```

computes phi potential

Parameters

g0	4D complex array (kx,ky,kz,s). Zeroth Hermite and Laguerre moment of modified gyrokinetic distribution function.
g1	4D complex array (kx,ky,kz,s). Zeroth Hermite and first Laguerre moment of the modified distribution function.

Computes $\phi(\mathbf{k})$ from g^0_{s0} (g0 parameter) and g^1_{s0} (g1 parameter).

2.5.2.14 fields_getPhiFromH()

```
void fields_getPhiFromH (
            const COMPLEX * h )
```

computes phi potential

Parameters

h	4D complex array (kx,ky,kz,s). Zeroth Hermite and Laguerre moment of gyrokinetic distribution function.

Computes $\phi(\mathbf{k})$ from h^0_{s0} (h parameter)

2.5.2.15 fields_init()

```
void fields_init ( )
```

intializes fields

pre-computes some comstants required to compute fields. Called in init_start function

2.5.2.16 fields_sendG()

```
fields_sendG (
            COMPLEX * g )
```

sends moments of gyrokinetic distribution function which are required to compute fields

Parameters

g	complex array. Modified or non-modified gyrokinetic distribution function

sends $g^1_{s0}(\mathbf{k})f$, $g^0_{s1}(\mathbf{k})f$, $g^0_{s0}(\mathbf{k})f$

to all processes to compute potentials locally.

2.6 init.c File Reference

initialization module for alliance.

```
#include "init.h"
#include "distrib.h"
```

Macros

- #define RANK_IO 0

Functions

- void init_start (char *filename)
  initialization of ALLIANCE
- void init_printParameters ()
  parameter output
- void init_initEnums ()
  enumerator initialization
- void fill_rand (COMPLEX *ar1)
  fills the inital conditions randomly
- void fill_randM0 (COMPLEX *ar1)
  fill zeroth Hermite moment with random values
- void fill_randSingleKM (COMPLEX *ar1)
  fill single chosen wavevector and Hermite moment
- void init_conditions (COMPLEX *data)
  distribution function initialization
- double init_energySpec (double k, double m, double amp, double disp)
  returns energy spectrum

Variables

- enum adiabatic **kinetic**
- enum electromagnetic **systemType**
- enum initial **initialConditions**

2.6.1 Detailed Description

initialization module for alliance.

all the inititalization routines are here.

2.6.2 Macro Definition Documentation

2.6.2.1 RANK_IO

```
#define RANK_IO 0
```

defines rank of the processor used to output information to console

2.6.3 Function Documentation

2.6.3.1 fill_rand()

```
void fill_rand (
            COMPLEX * data )
```

fills the inital conditions randomly

Parameters

data	complex 6d array to fill initializes distribution with spectrum defined in init_energySpec This function is supposed to be used in-module only and should not be used elsewhere outside init.c file.

2.6.3.2 fill_randM0()

```
void fill_randM0 (
            COMPLEX * data )
```

fill zeroth Hermite moment with random values

Parameters

data	complex 6D array to fill

fills 0-th Hermite moment of a distribution function ar1 with random values This function is supposed to be used in-module only and should not be used elsewhere outside init.c file.

2.6.3.3 fill_randSingleKM()

```
void fill_randSingleKM (
            COMPLEX * ar1 )
```

fill single chosen wavevector and Hermite moment

Parameters

data	complex 6D array

initializes single wavevector and Hermite moment of a distribution function with random variable. This function is only for in-module use and should not be used elsewhere outside init.c file.

2.6.3.4 init_conditions()

```
void init_conditions (
            COMPLEX * data )
```

distribution function initialization

Parameters

data	complex 6D array

initializes distribution function with chosen method (see fill_rand, fill_randM0, fill_randSingleKM)

2.6.3.5 init_energySpec()

```
double init_energySpec (
            double k,
            double m,
            double amp,
            double disp )
```

returns energy spectrum

Parameters

k	a wavenumber at which spectrum is computed
m	Hermite moment at which amplitude is computed
amp	amplitude of the spectrum
disp	dispersion of the spectrum

computes spectrum of form $A \cdot k^2 exp(-2k^2/\sigma^2)$, where $\sigma = disp$, and $A = amp$ This function is supposed to be

used in-module only and should not be used elsewhere outside init.c file.

2.6.3.6 init_initEnums()

```
void init_initEnums ( )
```

enumerator initialization

initializes enumerators, which are then used to define if system is adiabatic or kinetic, electromagnetic or electrostatic, and type of initial conditions

2.6.3.7 init_printParameters()

```
void init_printParameters ( )
```

parameter output

prints parameters of the simulation

2.6.3.8 init_start()

```
void init_start (
            char * filename )
```

initialization of ALLIANCE

Parameters

filename	specifies parameter filename

initializes all the modules required for ALLIANCE to work.

2.7 parameters_io.c File Reference

reads inpuit parameters from parameter file provided by user

```
#include "parameters_io.h"
#include "utils_fftw.h"
```

Macros

- #define **VERBOSE** 0

Functions

- void init_global_size ()

  initializes global size of the 6D array
- void read_parameters (char ∗filename)

  reads parameters from user parameter file.
- void read_parametersFromFile (char ∗filename)

Variables

- struct system_param **parameters**

2.7.1 Detailed Description

reads inpuit parameters from parameter file provided by user

2.7.2 Function Documentation

2.7.2.1 init_global_size()

```
void init_global_size ( )
```

initializes global size of the 6D array

initializes `array_local_size` structure with global simulation size.

2.7.2.2 read_parameters()

```
read_parameters (
            char * filename )
```

reads parameters from user parameter file.

Reads parameters from user parameter file. All the parameters are stored in the `parameters` structure

2.7.2.3 read_parametersFromFile()

```
void read_parametersFromFile (
            char * filename )
```

read_parametersFromFile(char ∗filename):

2.8 solver.c File Reference

numerical solver

```
#include "solver.h"
```

Macros

- #define **SOLVERTYPE** RK4
- #define **IORANK** 0

Functions

- void solver_init ()
  initializes solver
- void solver_makeStep (COMPLEX **g, COMPLEX *h)
  iterate solver forward

Variables

- enum solverType **solverType**
- struct solver **solver**
- struct rk4 **rk4**

2.8.1 Detailed Description

numerical solver

2.8.2 Function Documentation

2.8.2.1 solver_init()

```
void solver_init ( )
```

initializes solver

initializes solver with the `solverType`.

2.8.2.2 solver_makeStep()

```
void solver_makeStep (
            COMPLEX ** g,
            COMPLEX * h )
```

iterate solver forward

Parameters

g	address of the 6D complex array. Modified gyrokinetic distribution function
h	6D complex array. Gyrokinetic distribution function

solves one simulation time step

2.9 space_config.c File Reference

space configuration module

```
#include "space_config.h"
#include <complex.h>
```

Macros

- #define **MINUS_I** -1.j

Functions

- void space_init ()

  initializes wave space. Called in init_start() function.
- void space_generateWaveSpace ()

  generates wave space
- void space_generateMSpace ()

  generates Hermite space
- void free_wavespace ()

  deallocates all the arrays

Variables

- double **space_Lx** = 100
- double **space_Ly** = 100
- double **space_Lz** = 100
- double * **space_kx**
- double * **space_ky**
- double * **space_kz**
- double * **space_kPerp**
- double * **space_kPerp2**
- double * **space_kSq**
- double * **space_sqrtM**
- size_t * **space_globalMIndex**
- COMPLEX * **space_iKx**
- COMPLEX * **space_iKy**
- COMPLEX * **space_iKz**

2.9.1 Detailed Description

space configuration module

creates k and m spaces

2.9.2 Function Documentation

2.9.2.1 free_wavespace()

```
free_wavespace ( )
```

deallocates all the arrays

to be added

2.9.2.2 space_generateMSpace()

```
space_generateMSpace ( )
```

generates Hermite space

to be added

2.9.2.3 space_generateWaveSpace()

```
void space_generateWaveSpace ( )
```

generates wave space

generates wave number arrays space_kx, space_ky, space_kz of lengths nkx,nky,nkz for a numerical box of size [lx, ly, lz] in kx,ky,kz directions as following:
`[0, pi / lx, 2 pi / lx, ... , (n / 2 + 1) pi / lx, - (n / 2) pi / lx, ... , - pi / lx]` generates arrays `space_iKx`, `space_iKy`, `space_iKz`, of lengths nkx,nky,nkz. These arrays are later used to compute gradients by fields_getGradX, fields_getGradY, distrib_getXGrad, distrib_getYGrad, distrib_getZGrad.

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