# Guacho 3D

V1.3

Generated by Doxygen 1.8.9.1

Tue Apr 26 2016 16:29:19

# Contents

# Chapter 1

# GUACHO-3D Documentation

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## 1.1 Introduction

Documentation of the Guacho code

## 1.2 release.notes



## 1.3 requirements

Fortran 90/95 compiler with C preprocessor, Message Passing Interface (optional), gmake.

# Chapter 2

# Modules Index

## 2.1 Modules List

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

# Chapter 3

# File Index

## 3.1 File List

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

# Chapter 4

# Module Documentation

## 4.1 boundaries Module Reference

Boundary conditions.

### Functions/Subroutines

- subroutine boundaryi ()

  *Boundary conditions for 1st order half timestep.*
- subroutine boundaryii ()

  *Boundary conditions for 2nd order half timestep.*

### 4.1.1 Detailed Description

Sets boundary conditions, the type of boundaries is set in the Makefile

### 4.1.2 Function/Subroutine Documentation

#### 4.1.2.1 subroutine boundaries::boundaryi ( )

Boundary conditions for 1st order half timestep
The conditions only are imposed at the innermost ghost cell, on the u (unstepped) variables

Definition at line 45 of file boundaries.f90.

#### 4.1.2.2 subroutine boundaries::boundaryii ( )

Boundary conditions for 2nd order half timestep
The conditions only are imposed in two ghost cells on the up (stepped) variables

Definition at line 257 of file boundaries.f90.

## 4.2 chemistry Module Reference

chemistry module

### Functions/Subroutines

- subroutine update_chem ()

  *Advances the chemistry network.*
- subroutine chemstep (y, y0, T, deltt)

  *Advances the chemistry network in one cell.*

## 4.2.1 Detailed Description

module to solve the chemical/ionic network.

## 4.2.2 Function/Subroutine Documentation

### 4.2.2.1 subroutine chemistry::chemstep ( real (kind=8), dimension(n_spec), intent(inout) *y,* real (kind=8), dimension(n_elem), intent(in) *y0,* real (kind=8), intent(in) *T,* real (kind=8), intent(in) *deltt* )

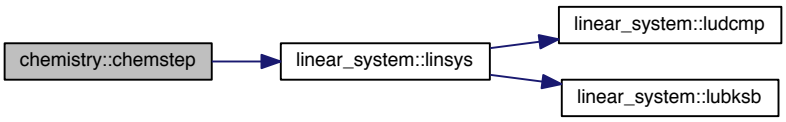
Advances the chemistry network on the in one cell

**Parameters**

| | |
|---|---|
| *real* | [inout] y(n_spec) : number densities of the species to be updated by the chemistry |
| *real* | [in] y[n_elem] : total number density of each of the elements involved in the reactions |
| *real* | [in] T : Temperature [K] |
| *real* | [in] deltt : time interval (from the hydro, in seconds) |

Definition at line 91 of file chemistry.f90.

Here is the call graph for this function:

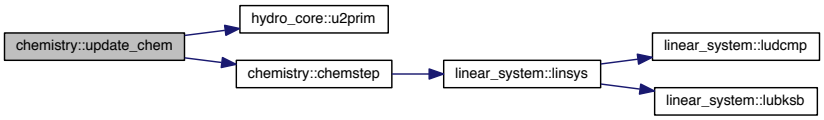



### 4.2.2.2 subroutine chemistry::update_chem ( )

Advances the chemistry network on the entire domain (except ghost cells), updates primitives and conserved variables in globals

Definition at line 43 of file chemistry.f90.

Here is the call graph for this function:



## 4.3 coldens_utilities Module Reference

Column density projection.

### Functions/Subroutines

- subroutine init_coldens ()

  *Initializes data.*
- subroutine read_data (u, itprint, filepath)

  *reads data from file*
- subroutine getxyz (i, j, k, x, y, z)

  *gets position of a cell*
- subroutine rotation_x (theta, x, y, z, xn, yn, zn)

  *Rotation around the X axis.*
- subroutine rotation_y (theta, x, y, z, xn, yn, zn)

  *Rotation around the Y axis.*
- subroutine rotation_z (theta, x, y, z, xn, yn, zn)

  *Rotation around the Z axis.*
- subroutine fill_map (nxmap, nymap, u, map, dxT, dyT, theta_x, theta_y, theta_z)

  *Fill target map.*
- subroutine write_header (unit, nx, ny)

  *Writes header.*
- subroutine write_map (fileout, nxmap, nymap, map)

  *Writes projection to file.*

### 4.3.1 Detailed Description

Utilities to compute a column density map

### 4.3.2 Function/Subroutine Documentation

#### 4.3.2.1 subroutine coldens_utilities::fill_map ( integer, intent(in) *nxmap,* integer, intent(in) *nymap,* real, dimension(neq,nxmin:nxmax,nymin:nymax, nzmin:nzmax), intent(in) *u,* real, dimension(nxmap,nymap), intent(out) *map,* real, intent(in) *dxT,* real, intent(in) *dyT,* real, intent(in) *theta_x,* real, intent(in) *theta_y,* real, intent(in) *theta_z* )

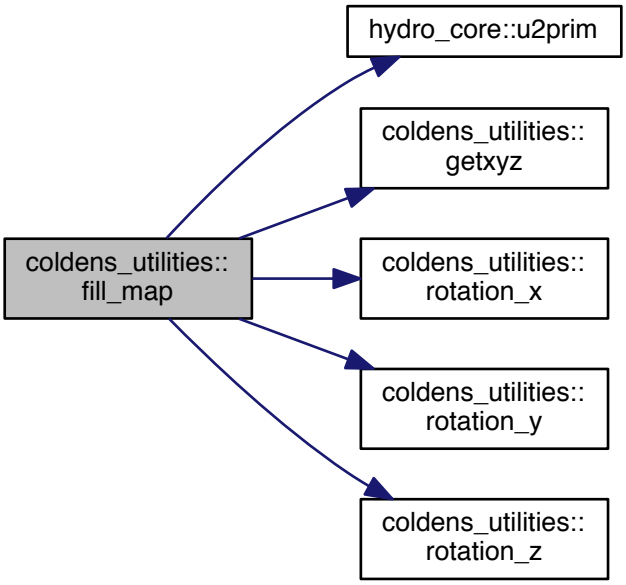
Fills the target map of one MPI block

**Parameters**

| | |
|---|---|
| *integer* | [in] nxmap : Number of X cells in target |
| *integer* | [in] nymap : Number of Y cells in target |
| *real* | [in] u(neq,nxmin:nxmax,nymin:nymax, nzmin:nzmax) : conserved variables |
| *real* | [out] map(nxmap,mymap) : Target map |
| *real* | [in] dxT : target pixel width |
| *real* | [in] dyT : target pixel height |
| *real* | [in] thetax : Rotation around X |
| *real* | [in] thetay : Rotation around Y |
| *real* | [in] thetaz : Rotation around Z |

Definition at line 307 of file coldens.f90.

Here is the call graph for this function:




#### 4.3.2.2 subroutine coldens_utilities::getxyz ( integer, intent(in) *i,* integer, intent(in) *j,* integer, intent(in) *k,* real, intent(out) *x,* real, intent(out) *y,* real, intent(out) *z* )

Returns the position and spherical radius calculated with respect to the center of the grid

**Parameters**

| | |
|---|---|
| *integer* | [in] i : cell index in the x direction |
| *integer* | [in] j : cell index in the y direction |
| *integer* | [in] k : cell index in the z direction |
| *real* | [in] x : x position in the grid |
| *real* | [in] y : y position in the grid |
| *real* | [in] z : z position in the grid |

Definition at line 209 of file coldens.f90.

#### 4.3.2.3 subroutine coldens_utilities::init_coldens ( )

Initializes data, MPI and other stuff

Definition at line 36 of file coldens.f90.

#### 4.3.2.4 subroutine coldens_utilities::read_data ( real, dimension(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax), intent(out) *u,* integer, intent(in) *itprint,* character (len=128), intent(in) *filepath* )

reads data from file

**Parameters**

| | |
|---|---|
| *real* | [out] u(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax) : conserved variables |
| *integer* | [in] itprint : number of output |
| *string* | [in] filepath : path where the output is |

Definition at line 135 of file coldens.f90.

#### 4.3.2.5 subroutine coldens_utilities::rotation_x ( real, intent(in) *theta,* real, intent(in) *x,* real, intent(in) *y,* real, intent(in) *z,* real, intent(out) *xn,* real, intent(out) *yn,* real, intent(out) *zn* )

Does a rotation around the x axis

**Parameters**

| | |
|---|---|
| *real* | [in], theta : Angle of rotation (in radians) |
| *real* | [in], x : original x position in the grid |
| *real* | [in], y : original y position in the grid |
| *real* | [in], x : original z position in the grid |
| *real* | [out], x : final x position in the grid |
| *real* | [out], y : final y position in the grid |
| *real* | [out], x : final z position in the grid |

Definition at line 235 of file coldens.f90.

#### 4.3.2.6 subroutine coldens_utilities::rotation_y ( real, intent(in) *theta,* real, intent(in) *x,* real, intent(in) *y,* real, intent(in) *z,* real, intent(out) *xn,* real, intent(out) *yn,* real, intent(out) *zn* )

Does a rotation around the x axis

**Parameters**

| | |
|---|---|
| *real* | [in], theta : Angle of rotation (in radians) |
| *real* | [in], x : original x position in the grid |
| *real* | [in], y : original y position in the grid |
| *real* | [in], x : original z position in the grid |
| *real* | [out], x : final x position in the grid |
| *real* | [out], y : final y position in the grid |
| *real* | [out], x : final z position in the grid |

Definition at line 259 of file coldens.f90.

#### 4.3.2.7 subroutine coldens_utilities::rotation_z ( real, intent(in) *theta,* real, intent(in) *x,* real, intent(in) *y,* real, intent(in) *z,* real, intent(out) *xn,* real, intent(out) *yn,* real, intent(out) *zn* )

Does a rotation around the x axis

**Parameters**

| | |
|---|---|
| *real* | [in], theta : Angle of rotation (in radians) |
| *real* | [in], x : original x position in the grid |
| *real* | [in], y : original y position in the grid |
| *real* | [in], x : original z position in the grid |
| *real* | [out], x : final x position in the grid |
| *real* | [out], y : final y position in the grid |

| | |
|---|---|
| *real* | [out], x : final z position in the grid |

Definition at line 281 of file coldens.f90.

#### 4.3.2.8 subroutine coldens_utilities::write_header ( integer, intent(in) *unit,* integer, intent(in) *nx,* integer, intent(in) *ny* )

Writes header for binary input

**Parameters**

| | |
|---|---|
| *integer* | [in] unit : number of logical unit |

Definition at line 359 of file coldens.f90.

#### 4.3.2.9 subroutine coldens_utilities::write_map ( character (len=128), intent(in) *fileout,* integer, intent(in) *nxmap,* integer, intent(in) *nymap,* real, dimension(nxmap,nymap), intent(in) *map* )

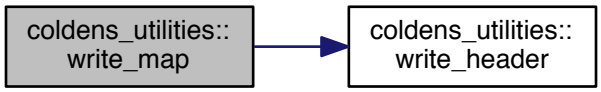
Writes projection to file

**Parameters**

| | |
|---|---|
| *integer* | [in] itprint : number of output |
| *string* | [in] fileout : file where to write |
| *integer* | [in] nxmap : Number of X cells in target |
| *integer* | [in] nymap : Number of Y cells in target |
| *real* | [in] map(nxmap,mymap) : Target map |

Definition at line 433 of file coldens.f90.

Here is the call graph for this function:




## 4.4 constants Module Reference

Module containing physical, asronomical constants, and other named constants.

### Variables

- real, parameter pi =acos(-1.)

  *π*
- real, parameter amh =1.66e-24

  *hydrogen mass*
- real, parameter kb =1.38e-16

  *Boltzmann constant (cgs)*
- real, parameter rg =8.3145e7

  *Gas constant (cgs)*

- real, parameter ggrav =6.67259e-8
  *Gravitational constant (cgs)*
- real, parameter clight =2.99E10
  *speed of light in vacuum (cgs)*
- real, parameter msun =1.99E33
  *solar radius (cgs)*
- real, parameter rsun =6.955e10
  *solar mass (cgs)*
- real, parameter mjup =1.898E30
  *Jupiter mass (cgs)*
- real, parameter rjup =7.1492E9
  *Jupiter radius (cgs)*
- real, parameter au =1.496e13
  *1AU in cm*
- real, parameter pc =3.0857E18
  *1pc in cm*
- real, parameter kpc =3.0857E21
  *1Kpc in cm*
- real, parameter hr =3600.
  *1hr in seconds*
- real, parameter day =86400.
  *1day in seconds*
- real, parameter yr =3.1536E7
  *1yr in seconds*
- real, parameter myr =3.1536E13
  *1Myr in seconds*
- integer, parameter **solver_hll** = 1
- integer, parameter **solver_hllc** = 2
- integer, parameter **solver_hlld** = 3
- integer, parameter **solver_hlle** = 4
- integer, parameter **eos_adiabatic** = 1
- integer, parameter **eos_single_specie** = 2
- integer, parameter **eos_h_rate** = 3
- integer, parameter **eos_chem** = 4
- integer, parameter **cool_none** = 0
- integer, parameter **cool_h** = 1
- integer, parameter **cool_bbc** = 2
- integer, parameter **cool_dmc** = 3
- integer, parameter **cool_chi** = 4
- integer, parameter **cool_chem** = 5
- integer, parameter **bc_outflow** = 1
- integer, parameter **bc_closed** = 2
- integer, parameter **bc_periodic** = 3
- integer, parameter **bc_inflow** = 4
- integer, parameter **limiter_no_average** = -1
- integer, parameter **limiter_no_limit** = 0
- integer, parameter **limiter_minmod** = 1
- integer, parameter **limiter_van_leer** = 2
- integer, parameter **limiter_van_albada** = 3
- integer, parameter **limiter_umist** = 4
- integer, parameter **limiter_woodward** = 5
- integer, parameter **limiter_superbee** = 6
- integer, parameter **tc_off** = 0
- integer, parameter **tc_isotropic** = 1
- integer, parameter **tc_anisotropic** = 2

## 4.5 cooling_chi Module Reference

Cooling module with CHIANTI generated cooling curves.

### Functions/Subroutines

- subroutine init_cooling_chianti ()
  *Initializes the DMC cooling.*
- subroutine read_table_chianti ()
  *Reads the cooling curve table.*
- real(kind=8) function coolchi (T)
  *Returns the cooling coefficient interpolating the table.*
- subroutine coolingchi ()
  *High level wrapper to apply cooling with CHIANTI tables.*

### Variables

- real(kind=8), dimension(:,:), allocatable **cooltab_chianti**

### 4.5.1 Detailed Description

Cooling module with CHIANTI generated cooling curves
The location of the tables is assumed to be in src/CHIANTIlib/coolingCHIANTI.tab

### 4.5.2 Function/Subroutine Documentation

#### 4.5.2.1 real (kind=8) function cooling_chi::coolchi ( real, intent(in) *T* )

**Parameters**

| | |
|---|---|
| *real* | [in] T : Temperature K |

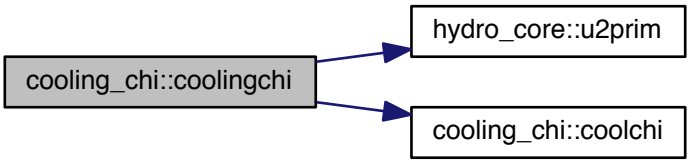
Definition at line 88 of file cooling_chi.f90.

#### 4.5.2.2 subroutine cooling_chi::coolingchi ( )

High level wrapper to apply cooling with CHIANTI tables
cooling is applied in the entire domain and updates both the conserved and primitive variables

Definition at line 115 of file cooling_chi.f90.

Here is the call graph for this function:

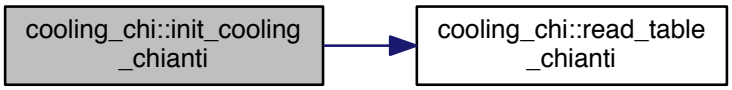


#### 4.5.2.3 subroutine cooling_chi::init_cooling_chianti ( )

Declares variables and reads table

Definition at line 42 of file cooling_chi.f90.

Here is the call graph for this function:




#### 4.5.2.4 subroutine cooling_chi::read_table_chianti ( )

Reads the cooling curve table generated by CHUANTI, the location is assumed in /src/CHIANTIlib/coolingCHIAN↩
TI.tab

Definition at line 57 of file cooling_chi.f90.

## 4.6 cooling_dmc Module Reference

Cooling module with Dalgarno McCray coronal cooling curve.

### Functions/Subroutines

- subroutine init_cooling_dmc ()

  *Initializes the DMC cooling.*
- subroutine read_table_dmc ()

  *Reads the cooling curve table.*
- real(kind=8) function cooldmc (T)

  *Returns the cooling coefficient interpolating the table.*
- subroutine coolingdmc ()

  *High level wrapper to apply cooling with DMC table.*

### Variables

- real(kind=8), dimension(:,:), allocatable **cooltab_dmc**

### 4.6.1 Detailed Description

Cooling module with Dalgarno McCray coronal cooling curve
The location of the tables is assumed to be in src/DMClib/coolingDMC.tab, it is read by init subroutine

### 4.6.2 Function/Subroutine Documentation

#### 4.6.2.1 real (kind=8) function cooling_dmc::cooldmc ( real, intent(in) *T* )

**Parameters**

| | |
|---|---|
| *real* | [in] T : Temperature K |

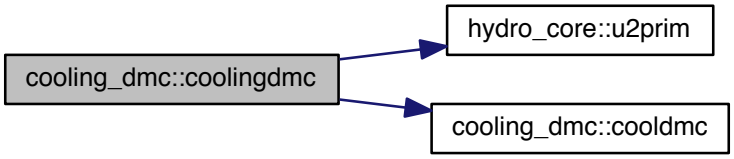
Definition at line 90 of file cooling_dmc.f90.

#### 4.6.2.2 subroutine cooling_dmc::coolingdmc ( )

High level wrapper to apply cooling with DMC table
cooling is applied in the entire domain and updates both the conserved and primitive variables

Definition at line 116 of file cooling_dmc.f90.

Here is the call graph for this function:




#### 4.6.2.3 subroutine cooling_dmc::init_cooling_dmc ( )

Declares variables and reads table

Definition at line 41 of file cooling_dmc.f90.

Here is the call graph for this function:


#### 4.6.2.4 subroutine cooling_dmc::read_table_dmc ( )

Reads the Dalgarno McCray cooling courve the location is assumed in src/DMClib/coolingDMC.tab, it is read by init subroutine

Definition at line 58 of file cooling_dmc.f90.

## 4.7 cooling_h Module Reference

Cooling with parametrized cooling and H rate equation.

### Functions/Subroutines

- subroutine coolingh ()

  *High level wrapper to apply cooling.*
- real(kind=8) function alpha (T)

  *calculates the recombination rate (case B)*
- real(kind=8) function alpha1 (T)

  *calculates the recombination rate to level 1*
- real(kind=8) function colf (T)

  *calculates the collisional ionization rate*
- real(kind=8) function betah (T)

  *betaH(T)*
- real(kind=8) function aloss (X1, X2, DT, DEN, DH0, TE0)

  *Non equilibrium cooling.*
- subroutine atomic (dt, uu, tau, radphi)

  *Updates the ionization fraction and applpies cooling.*

## 4.7.1 Detailed Description

Cooling with parametrized cooling and H rate equation

## 4.7.2 Function/Subroutine Documentation

### 4.7.2.1 real (kind=8) function cooling_h::aloss ( real (kind=8), intent(in) *X1,* real (kind=8), intent(in) *X2,* real, intent(in) *DT,* real (kind=8), intent(in) *DEN,* real (kind=8), intent(in) *DH0,* real (kind=8), intent(in) *TE0* )

Non-equilibrium energy loss for low temperatures considering the collisional excitation of [O I] and [O II] lines and radiative recombination of H. This cooling rate is multiplied by a factor of 7.033 so that it has the same value as the "coronal equilibrium" cooling rate at a temperature of 44770 K (at temperatures higher than this value, the equilibrium cooling rate is used). The collisional ionization of H and excitation of Lyman-alpha are computed separately, and added to the cooling rate.

**Parameters**

| | |
|---|---|
| *real8* | [in] x1 : initial H ionization fraction |
| *real8* | [in] x2 : final H ionization fraction |
| *real* | [in] dt : timestep |
| *real8* | [in] den : total density of hydrogen |
| *real8* | [in] dh0 : density of neutral hydrogen |
| *real8* | [in] Te0 : Temperature |

Definition at line 158 of file cooling_h.f90.

Here is the call graph for this function:

#### 4.7.2.2 real (kind=8) function cooling_h::alpha ( real (kind=8), intent(in) *T* )

calculates the recombination rate (case B)

**Parameters**

| | |
|---|---|
| *real8* | [in] T : Temperature K |

Definition at line 74 of file cooling_h.f90.

#### 4.7.2.3 real (kind=8) function cooling_h::alpha1 ( real (kind=8), intent(in) *T* )

calculates the recombination rate to level 1

**Parameters**

| | |
|---|---|
| *real8* | [in] T : Temperature K |

Definition at line 91 of file cooling_h.f90.

#### 4.7.2.4 subroutine cooling_h::atomic ( real, intent(in) *dt,* real, dimension(neq), intent(out) *uu,* real, intent(in) *tau,* real, intent(in) *radphi* )

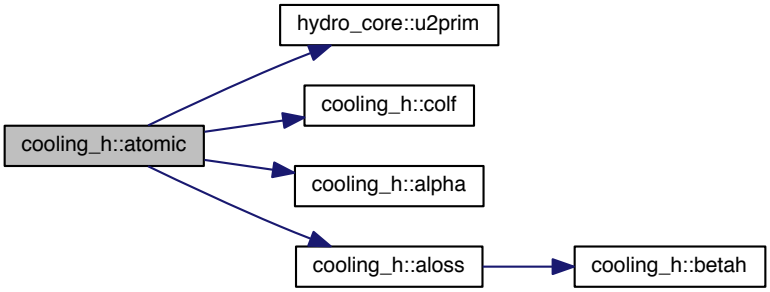
Calculates the new ionization state and energy density using a time dependent ionization calculation and an approximate time dependent cooling calculation

**Parameters**

| | |
|---|---|
| *real* | [in] dt : timestep (seconds) |
| *real* | [in] uu(neq) : conserved variablas in one cell |
| *real* | [in] tau : optical depth (not in use) |
| *real* | [in] radphi : photoionizing rate |

Definition at line 258 of file cooling_h.f90.

Here is the call graph for this function:




#### 4.7.2.5 real (kind=8) function cooling_h::betah ( real (kind=8), intent(in) *T* )

$\beta_H(T)$

**Parameters**

| | |
|---|---|
| *real* | 8[in] T : Temperature K |

Definition at line 124 of file cooling_h.f90.

#### 4.7.2.6 real (kind=8) function cooling_h::colf ( real (kind=8), intent(in) *T* )

calculates the collisional ionization rate

**Parameters**

| | |
|---|---|
| *real8[in]* | T : Temperature K |

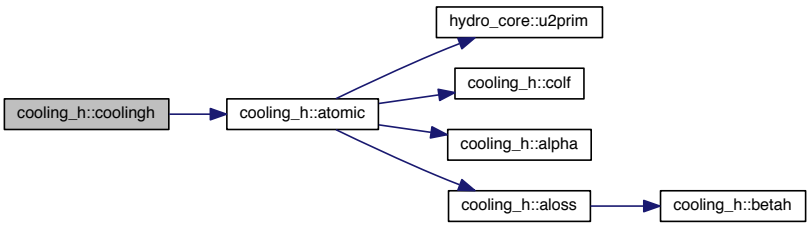
Definition at line 107 of file cooling_h.f90.

#### 4.7.2.7 subroutine cooling_h::coolingh ( )

High level wrapper to apply cooling
parametrized cooling curve, uses the ionization state of hydrogen and ties the O I and II to it

Definition at line 40 of file cooling_h.f90.

Here is the call graph for this function:




## 4.8 difrad Module Reference

Ray tracing Radiative Trasnport.

### Functions/Subroutines

- subroutine init_rand ()

  *initializes random number generation*
- subroutine emdiff (emax)

  *calculates the diffuse fotoionization emissivity*
- subroutine random_versor (xd, yd, zd)

  *returns the 3 components of a random versor*
- subroutine starsource (srad, x0, y0, z0, x, y, z, xd, yd, zd)

  *Place photon packets at a "star" surface.*
- subroutine photons (xl0, yl0, zl0, xd, yd, zd, f)

  *Photon trajectories.*
- subroutine radbounds ()

  *follows the rays across MPI boundaries*
- subroutine progress (j, tot)

*Progress bar.*

- subroutine diffuse_rad ()

  *Diffuse radiation driver.*

### Variables

- real, parameter a0 =6.3e-18

  *Fotoionization cross section.*

- integer, parameter nrays =1000000

  *Number of rays.*

- real, dimension(:,:,:), allocatable ph

  *Photoionizing rate.*

- real, dimension(:,:,:), allocatable em

  *Photoionizing emissivity.*

- real, dimension(:,:,:), allocatable photl

  *Auxiliary buffer for MPI.*

- real, dimension(:,:,:), allocatable photr

  *Auxiliary buffer for MPI.*

- real, dimension(:,:,:), allocatable photb

  *Auxiliary buffer for MPI.*

- real, dimension(:,:,:), allocatable phott

  *Auxiliary buffer for MPI.*

- real, dimension(:,:,:), allocatable photo

  *Auxiliary buffer for MPI.*

- real, dimension(:,:,:), allocatable photi

  *Auxiliary buffer for MPI.*

- integer, dimension(6) buffersize

  *Auxiliary buffer for MPI.*

## 4.8.1 Detailed Description

Ray tracing Radiative Trasnport

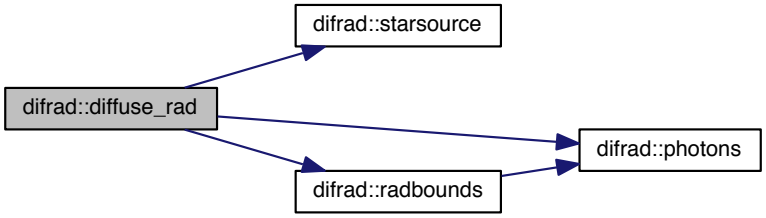
## 4.8.2 Function/Subroutine Documentation

### 4.8.2.1 subroutine difrad::diffuse_rad ( )

Upper level wrapper to compute the diffuse photoionization rate

Definition at line 655 of file difrad.f90.

Here is the call graph for this function:




#### 4.8.2.2 subroutine difrad::emdiff ( real, intent(out) *emax* )

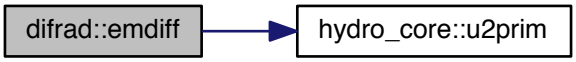
calculates the diffuse fotoionization emissivity in the entire domain

**Parameters**

| | |
|---|---|
| *real* | [out] emax : maximum emissivity in the entire grid |

Definition at line 96 of file difrad.f90.

Here is the call graph for this function:




#### 4.8.2.3 subroutine difrad::init_rand ( )

initializes random number generation

Definition at line 54 of file difrad.f90.

#### 4.8.2.4 subroutine difrad::photons ( real, intent(in) *xl0,* real, intent(in) *yl0,* real, intent(in) *zl0,* real, intent(in) *xd,* real, intent(in) *yd,* real, intent(in) *zd,* real, intent(inout) *f* )

Launches a photon from cell (xc,yc,zc) in the (xd,yd,zd) direction, with f and ionizing photons, and updates the photoionizing rate

**Parameters**

| | |
|---|---|
| *real* | [in] xl0 : Initial X position |
| *real* | [in] yl0 : Initial Y position |
| *real* | [in] zl0 : Initial Z position |
| *real* | [in] xd : Direction in X |
| *real* | [in] yd : Direction in Y |
| *real* | [in] zd : Direction in Z |
| *real* | [in] f : NUmber of photoionizong photons |

Definition at line 250 of file difrad.f90.

#### 4.8.2.5 subroutine difrad::progress ( integer(kind=4) *j,* integer(kind=4), intent(in) *tot* )

Progress bar (only tested with Fortran conmpiler) takes a number between 1 and tot

**Parameters**

| | |
|---|---|
| *integer* | [in] j : current iteration |
| *integer* | [in] tot : total number of iterartions |

Definition at line 633 of file difrad.f90.

#### 4.8.2.6 subroutine difrad::radbounds ( )

follows the rays across MPI boundaries

Definition at line 453 of file difrad.f90.

Here is the call graph for this function:


#### 4.8.2.7 subroutine difrad::random_versor ( real, intent(out) *xd,* real, intent(out) *yd,* real, intent(out) *zd* )

returns the 3 components of a random versor (unit magnitude)

**Parameters**

| | |
|---|---|
| *real* | [out] xd : x component |
| *real* | [out] yd : y component |
| *real* | [out] zd : z component |

Definition at line 147 of file difrad.f90.

#### 4.8.2.8 subroutine difrad::starsource ( real, intent(in) *srad,* real, intent(in) *x0,* real, intent(in) *y0,* real, intent(in) *z0,* real, intent(out) *x,* real, intent(out) *y,* real, intent(out) *z,* real, intent(out) *xd,* real, intent(out) *yd,* real, intent(out) *zd* )

returns the random location and direction at a star surface, if the direction goes into the star, the direction is inverted

**Parameters**

| | |
|---|---|
| *real* | [in] Srad : radius of the "star" |
| *real* | [in] x0 : X position of the center of the star |
| *real* | [in] y0 : Y position of the center of the star |
| *real* | [in] y0 : Z position of the center of the star |
| *real* | [out] x : random X position at the star surface |
| *real* | [out] y : random Y position at the star surface |
| *real* | [out] z : random Z position at the star surface |
| *real* | [out] xd : random X direction |
| *real* | [out] yd : random Y direction |
| *real* | [out] zd : random Z direction |

Definition at line 185 of file difrad.f90.

## 4.9 exoplanet Module Reference

Exoplanet module.

### Functions/Subroutines

- subroutine init_exo ()

  *Module initialization.*
- subroutine impose_exo (u, time)

  *Inject sources of wind.*

### Variables

- real rsw

  *Stellar wind radius.*
- real tsw

  *Stellar wind temperature.*
- real vsw

  *Stellar wind velocity.*
- real dsw

  *Stellar Wind Density.*
- real **rss**
- real bsw

  *Magnetic Field.*
- real bpw

  *Planetary Magnetic Field.*
- real rpw

  *Planetary radius.*
- real tpw

  *Planetary wind temperature.*
- real vpw

  *Planetary wind velocity.*
- real **dpw**
- real torb

  *planet: orbital period*
- real rorb

*orbital radius*

- real omegap

  *planet: angular velocity*

- real masss

  *Mass of the Star.*

- real massp

  *Mass of the Planet.*

- real xp

  *X position of the planet.*

- real yp

  *Y position of the planet.*

- real zp

  *Z position of the planet.*

### 4.9.1 Detailed Description

Problem Module for exoplanet

### 4.9.2 Function/Subroutine Documentation

#### 4.9.2.1 subroutine exoplanet::impose_exo ( real, dimension(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax), intent(out) *u,* real, intent(in) *time* )

Imposes the sources of wond from the star and planet

**Parameters**

| | |
|---|---|
| *real* | [out] u(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax) : conserver variables |
| *real* | [time] time : current integration timr |

Definition at line 126 of file exoplanet.f90.

#### 4.9.2.2 subroutine exoplanet::init_exo ( )

Here the parameters of the Star are initialized, and scaled to code units

Definition at line 60 of file exoplanet.f90.

## 4.10 field_cd_module Module Reference

Module to computes field CD div B correction.

### Functions/Subroutines

- subroutine boundaryi_ct ()

  *Boundary conditions (one cell) for field-CD.*

- subroutine get_current ()

  *Computes current.*

- subroutine field_cd_update (i, j, k, dt)

  *Upper level wrapper for field-CD update.*

### Variables

- real, dimension(:,:,:,:), allocatable e

  *electric current*

### 4.10.1 Detailed Description

This module corrects the div B with a field interpolated central difference scheme See. Sect. 4.5 of Toth 2000, Journal of Computational Physics 161, 605

### 4.10.2 Function/Subroutine Documentation

#### 4.10.2.1 subroutine field_cd_module::boundaryi_ct ( )

Boundary conditions applied to the current, used in the field-CD calculation

Definition at line 44 of file field_cd_module.f90.

#### 4.10.2.2 subroutine field_cd_module::field_cd_update ( integer, intent(in) *i*, integer, intent(in) *j*, integer, intent(in) *k*, real, intent(in) *dt* )

Upper level wrapper for field-CD, updates the hydro variables with upwind scheme and the field as field-CD

**Parameters**

| | |
|---|---|
| *integer* | [in] i : cell index in the X direction |
| *integer* | [in] j : cell index in the Y direction |
| *integer* | [in] k : cell index in the Z direction |
| *real* | [in] dt : timestep |

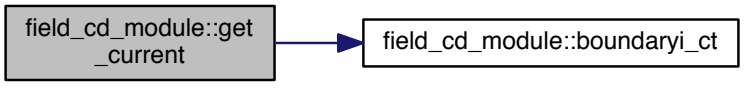
Definition at line 284 of file field_cd_module.f90.

#### 4.10.2.3 subroutine field_cd_module::get_current ( )

Obtains the current from the flixes (eq. 31 of Toth 2000)

Definition at line 243 of file field_cd_module.f90.

Here is the call graph for this function:




## 4.11 globals Module Reference

Module containing global variables.

### Variables

- real, dimension(:,:,:,:), allocatable u

  *conserved varibles*
- real, dimension(:,:,:,:), allocatable up

  *conserved varibles after 1/2 timestep*
- real, dimension(:,:,:,:), allocatable primit

  *primitive varibles*
- real, dimension(:,:,:,:), allocatable f

  *X fluxes.*
- real, dimension(:,:,:,:), allocatable g

  *Y fluxes.*
- real, dimension(:,:,:,:), allocatable h

  *Z fluxes.*
- real, dimension(:,:,:), allocatable temp

  *Temperature array [K].*
- real dx

  *grid spacing in X*
- real dy

  *grid spacing in Y*
- real dz

  *grid spacing in Z*
- integer, dimension(0:2) coords

  *position of neighboring MPI blocks*
- integer left

  *MPI neighbor in the -x direction.*
- integer right

  *MPI neighbor in the +x direction.*
- integer top

  *MPI neighbor in the -y direction.*
- integer bottom

  *MPI neighbor in the +y direction.*
- integer out

  *MPI neighbor in the -z direction.*
- integer in

  *MPI neighbor in the +z direction.*
- integer rank

  *MPI rank.*
- integer comm3d

  *Cartessian MPI comunicator.*
- real time

  *Current time.*
- real dt_cfl

  *Current CFL $ t$.*
- integer currentiteration

  *Current iteration.*

#### 4.11.1 Detailed Description

This module contains variables that are treated as global in the code

## 4.12 h_alpha_utilities Module Reference

H alpha projection.

### Functions/Subroutines

- subroutine init_ha ()

  *Initializes data.*
- subroutine read_data (u, itprint, filepath)

  *reads data from file*
- subroutine getxyz (i, j, k, x, y, z)

  *gets position of a cell*
- subroutine rotation_x (theta, x, y, z, xn, yn, zn)

  *Rotation around the X axis.*
- subroutine rotation_y (theta, x, y, z, xn, yn, zn)

  *Rotation around the Y axis.*
- subroutine rotation_z (theta, x, y, z, xn, yn, zn)

  *Rotation around the Z axis.*
- subroutine fill_map (nxmap, nymap, u, map, dxT, dyT, theta_x, theta_y, theta_z)

  *Fill target map.*
- subroutine write_ha (fileout, nxmap, nymap, map)

  *Writes projection to file.*
- subroutine write_rg (fileout, nxmap, nymap, map)

  *Writes projection to file in rg format.*

### 4.12.1 Detailed Description

Utilities to compute an H alpha map

### 4.12.2 Function/Subroutine Documentation

#### 4.12.2.1 subroutine h_alpha_utilities::fill_map ( integer, intent(in) *nxmap,* integer, intent(in) *nymap,* real, dimension(neq,nxmin:nxmax,nymin:nymax, nzmin:nzmax), intent(in) *u,* real, dimension(nxmap,nymap), intent(out) *map,* real, intent(in) *dxT,* real, intent(in) *dyT,* real, intent(in) *theta_x,* real, intent(in) *theta_y,* real, intent(in) *theta_z* )

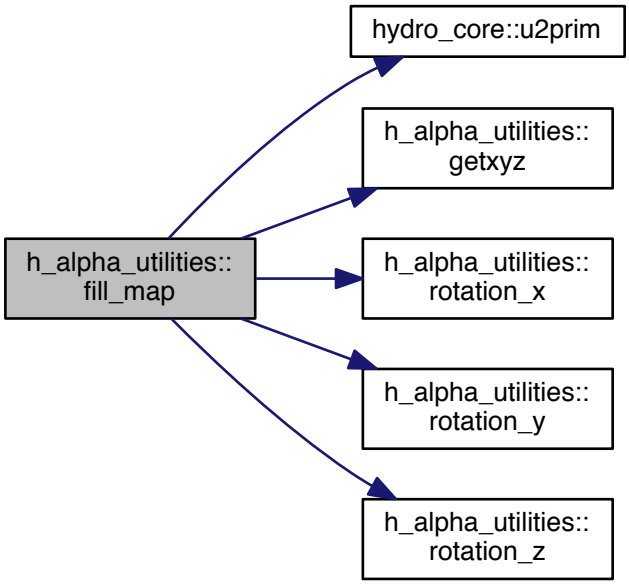
Fills the target map of one MPI block

**Parameters**

| | |
|---|---|
| *integer* | [in] nxmap : Number of X cells in target |
| *integer* | [in] nymap : Number of Y cells in target |
| *real* | [in] u(neq,nxmin:nxmax,nymin:nymax, nzmin:nzmax) : conserved variables |
| *real* | [out] map(nxmap,mymap) : Target map |
| *real* | [in] dxT : target pixel width |
| *real* | [in] dyT : target pixel height |
| *real* | [in] thetax : Rotation around X |
| *real* | [in] thetay : Rotation around Y |
| *real* | [in] thetaz : Rotation around Z |

Definition at line 285 of file h_alpha_proj.f90.

Here is the call graph for this function:




#### 4.12.2.2 subroutine h_alpha_utilities::getxyz ( integer, intent(in) *i,* integer, intent(in) *j,* integer, intent(in) *k,* real, intent(out) *x,* real, intent(out) *y,* real, intent(out) *z* )

Returns the position and spherical radius calculated with respect to the center of the grid

**Parameters**

| | |
|---|---|
| *integer* | [in] i : cell index in the x direction |
| *integer* | [in] j : cell index in the y direction |
| *integer* | [in] k : cell index in the z direction |
| *real* | [in] x : x position in the grid |
| *real* | [in] y : y position in the grid |
| *real* | [in] z : z position in the grid |

Definition at line 187 of file h_alpha_proj.f90.

#### 4.12.2.3 subroutine h_alpha_utilities::init_ha ( )

Initializes data, MPI and other stuff

Definition at line 35 of file h_alpha_proj.f90.

#### 4.12.2.4 subroutine h_alpha_utilities::read_data ( real, dimension(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax), intent(out) *u,* integer, intent(in) *itprint,* character (len=128), intent(in) *filepath* )

reads data from file

**Parameters**

| | |
|---|---|
| *real* | [out] u(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax) : conserved variables |
| *integer* | [in] itprint : number of output |
| *string* | [in] filepath : path where the output is |

Definition at line 134 of file h_alpha_proj.f90.

#### 4.12.2.5 subroutine h_alpha_utilities::rotation_x ( real, intent(in) *theta,* real, intent(in) *x,* real, intent(in) *y,* real, intent(in) *z,* real, intent(out) *xn,* real, intent(out) *yn,* real, intent(out) *zn* )

Does a rotation around the x axis

**Parameters**

| | |
|---|---|
| *real* | [in], theta : Angle of rotation (in radians) |
| *real* | [in], x : original x position in the grid |
| *real* | [in], y : original y position in the grid |
| *real* | [in], x : original z position in the grid |
| *real* | [out], x : final x position in the grid |
| *real* | [out], y : final y position in the grid |
| *real* | [out], x : final z position in the grid |

Definition at line 213 of file h_alpha_proj.f90.

#### 4.12.2.6 subroutine h_alpha_utilities::rotation_y ( real, intent(in) *theta,* real, intent(in) *x,* real, intent(in) *y,* real, intent(in) *z,* real, intent(out) *xn,* real, intent(out) *yn,* real, intent(out) *zn* )

Does a rotation around the x axis

**Parameters**

| | |
|---|---|
| *real* | [in], theta : Angle of rotation (in radians) |
| *real* | [in], x : original x position in the grid |
| *real* | [in], y : original y position in the grid |
| *real* | [in], x : original z position in the grid |
| *real* | [out], x : final x position in the grid |
| *real* | [out], y : final y position in the grid |
| *real* | [out], x : final z position in the grid |

Definition at line 237 of file h_alpha_proj.f90.

#### 4.12.2.7 subroutine h_alpha_utilities::rotation_z ( real, intent(in) *theta,* real, intent(in) *x,* real, intent(in) *y,* real, intent(in) *z,* real, intent(out) *xn,* real, intent(out) *yn,* real, intent(out) *zn* )

Does a rotation around the x axis

**Parameters**

| | |
|---|---|
| *real* | [in], theta : Angle of rotation (in radians) |
| *real* | [in], x : original x position in the grid |
| *real* | [in], y : original y position in the grid |
| *real* | [in], x : original z position in the grid |
| *real* | [out], x : final x position in the grid |
| *real* | [out], y : final y position in the grid |

| | |
|---|---|
| *real* | [out], x : final z position in the grid |

Definition at line 259 of file h_alpha_proj.f90.

#### 4.12.2.8 subroutine h_alpha_utilities::write_ha ( character (len=128), intent(in) *fileout,* integer, intent(in) *nxmap,* integer, intent(in) *nymap,* real, dimension(nxmap,nymap), intent(in) *map* )

Writes projection to file

**Parameters**

| | |
|---|---|
| *integer* | [in] itprint : number of output |
| *string* | [in] fileout : file where to write |
| *integer* | [in] nxmap : Number of X cells in target |
| *integer* | [in] nymap : Number of Y cells in target |
| *real* | [in] map(nxmap,mymap) : Target map |

Definition at line 362 of file h_alpha_proj.f90.

#### 4.12.2.9 subroutine h_alpha_utilities::write_rg ( character (len=128), intent(in) *fileout,* integer, intent(in) *nxmap,* integer, intent(in) *nymap,* real, dimension(nxmap,nymap), intent(in) *map* )

Writes projection to file

**Parameters**

| | |
|---|---|
| *integer* | [in] itprint : number of output |
| *string* | [in] fileout : file where to write |
| *integer* | [in] nxmap : Number of X cells in target |
| *integer* | [in] nymap : Number of Y cells in target |
| *real* | [in] map(nxmap,mymap) : Target map |

Definition at line 391 of file h_alpha_proj.f90.

## 4.13 hll Module Reference

HLL approximate Riemann solver module.

### Functions/Subroutines

- subroutine prim2fhll (priml, primr, ff)

  *Solves the Riemann problem at the interface PL,PR using the HLL solver.*
- subroutine hllfluxes (choice)

  *Calculates HLL fluxes from the primitive variables on all the domain.*

### 4.13.1 Detailed Description

The module contains the routines needed to Solve the Riemann problem in the entire domain and return the physical fluxes in x,y,z with the HLL solver

### 4.13.2 Function/Subroutine Documentation

#### 4.13.2.1 subroutine hll::hllfluxes ( integer, intent(in) *choice* )

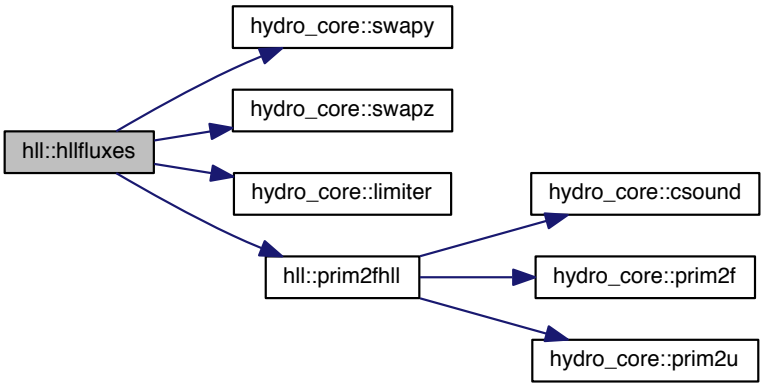
Calculates HLL fluxes from the primitive variables on all the domain

**Parameters**

| | |
|---|---|
| *integer* | [in] choice : 1, uses primit for the 1st half of timestep (first order)<br>2 uses primit for second order timestep |

Definition at line 91 of file hll.f90.

Here is the call graph for this function:




#### 4.13.2.2 subroutine hll::prim2fhll ( real, dimension(neq), intent(in) *priml,* real, dimension(neq), intent(in) *primr,* real, dimension(neq), intent(inout) *ff* )

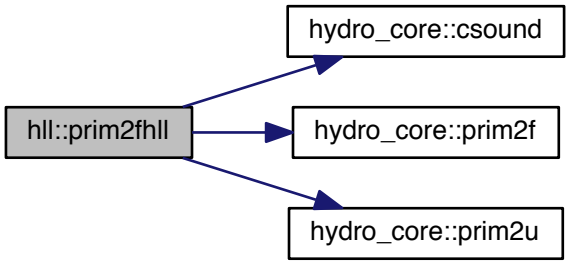
Solves the Riemann problem at the interface betweem PL and PR using the HLL solver
The fluxes are computed in the X direction, to obtain the y ans z directions a swap is performed

**Parameters**

| | |
|---|---|
| *real* | [in] primL : primitives at the Left state |
| *real* | [in] primR : primitives at the Right state |
| *real* | [out] ff : fluxes at the interface ( $F_{i+1/2}$) |

Definition at line 46 of file hll.f90.

Here is the call graph for this function:



## 4.14 hllc Module Reference

HLLC approximate Riemann solver module.

### Functions/Subroutines

- subroutine prim2fhllc (priml, primr, ff)

  *Solves the Riemann problem at the interface PL,PR using the HLLC solver.*
- subroutine hllcfluxes (choice)

  *Calculates HLLC fluxes from the primitive variables on all the domain.*

### 4.14.1 Detailed Description

The module contains the routines needed to Solve the Riemann problem in the entire domain and return the physical fluxes in x,y,z with the HLLC solver

### 4.14.2 Function/Subroutine Documentation

#### 4.14.2.1 subroutine hllc::hllcfluxes ( integer, intent(in) *choice* )

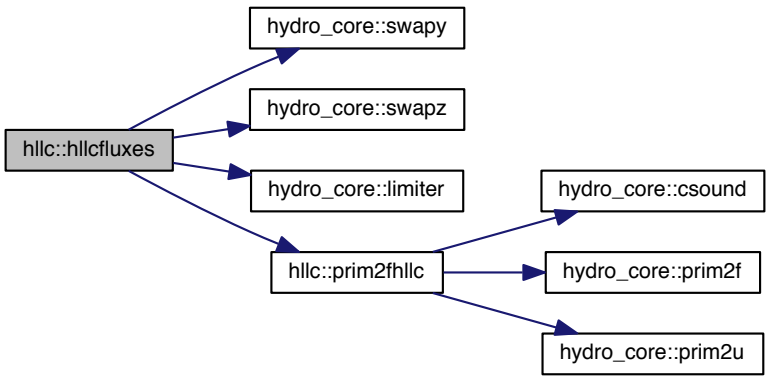
Calculates HLLC fluxes from the primitive variables on all the domain

**Parameters**

| | |
|---|---|
| *integer* | [in] choice : 1, uses primit for the 1st half of timestep (first order)<br>2 uses primit for second order timestep |

Definition at line 144 of file hllc.f90.

Here is the call graph for this function:




#### 4.14.2.2 subroutine hllc::prim2fhllc ( real, dimension(neq), intent(in) *priml,* real, dimension(neq), intent(in) *primr,* real, dimension(neq), intent(inout) *ff* )

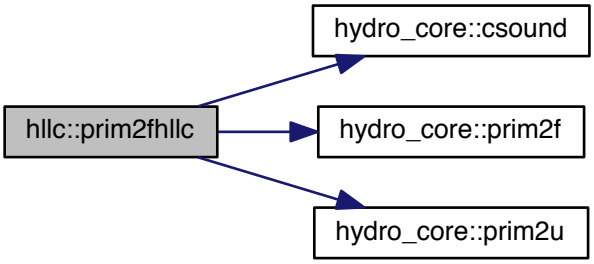
Solves the Riemann problem at the interface betweem PL and PR using the HLLC solver
The fluxes are computed in the X direction, to obtain the y ans z directions a swap is performed

**Parameters**

| | |
|---|---|
| *real* | [in] primL : primitives at the Left state |
| *real* | [in] primR : primitives at the Right state |
| *real* | [out] ff : fluxes at the interface ( $F_{i+1/2}$) |

Definition at line 45 of file hllc.f90.

Here is the call graph for this function:




## 4.15 hlld Module Reference

HLLD approximate Riemann solver module.

### Functions/Subroutines

- subroutine prim2fhlld (priml, primr, ff)

  *Solves the Riemann problem at the interface PL,PR using the HLLD solver.*
- subroutine hlldfluxes (choice)

  *Calculates HLLD fluxes from the primitive variables on all the domain.*

### 4.15.1 Detailed Description

The module contains the routines needed to Solve the Riemann problem in the entire domain and return the physical fluxes in x,y,z with the HLLD solver

### 4.15.2 Function/Subroutine Documentation

#### 4.15.2.1 subroutine hlld::hlldfluxes ( integer, intent(in) *choice* )

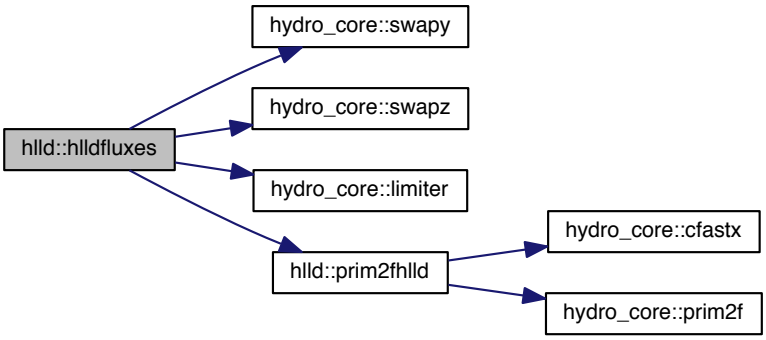
Calculates HLLD fluxes from the primitive variables on all the domain

**Parameters**

| | |
|---|---|
| *integer* | [in] choice : 1, uses primit for the 1st half of timestep (first order)<br>2 uses primit for second order timestep |

Definition at line 323 of file hlld.f90.

Here is the call graph for this function:




#### 4.15.2.2 subroutine hlld::prim2fhlld ( real, dimension(neq), intent(in) *priml,* real, dimension(neq), intent(in) *primr,* real, dimension(neq), intent(inout) *ff* )

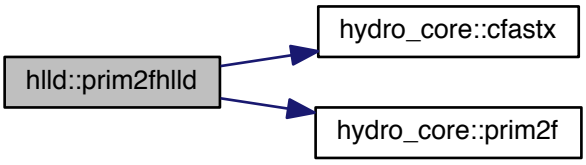
Solves the Riemann problem at the interface betweem PL and PR using the HLLD solver
The fluxes are computed in the X direction, to obtain the y ans z directions a swap is performed

**Parameters**

| | |
|---|---|
| *real* | [in] primL : primitives at the Left state |
| *real* | [in] primR : primitives at the Right state |
| *real* | [out] ff : fluxes at the interface ( $F_{i+1/2}$) |

Definition at line 47 of file hlld.f90.

Here is the call graph for this function:




## 4.16 hlle Module Reference

HLLE approximate Riemann solver module.

### Functions/Subroutines

- subroutine prim2fhlle (priml, primr, ff)

*Solves the Riemann problem at the interface PL,PR using the HLLE solver.*

- subroutine hllefluxes (choice)

  *Calculates HLLE fluxes from the primitive variables on all the domain.*

### 4.16.1 Detailed Description

The module contains the routines needed to Solve the Riemann problem in the entire domain and return the physical fluxes in x,y,z with the HLLE solver

### 4.16.2 Function/Subroutine Documentation

#### 4.16.2.1 subroutine hlle::hllefluxes ( integer, intent(in) *choice* )

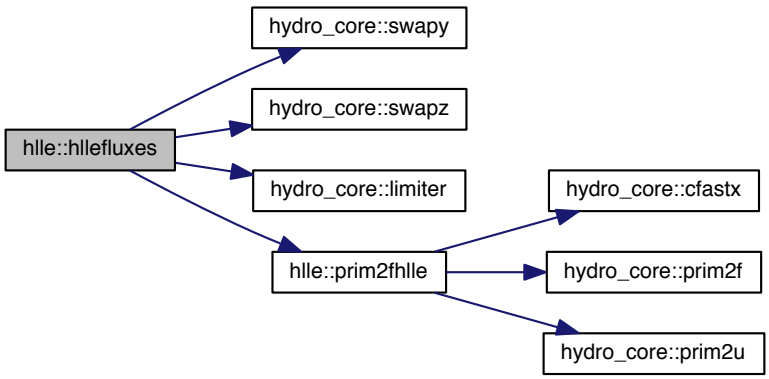
Calculates HLLE fluxes from the primitive variables on all the domain

**Parameters**

| | |
|---|---|
| *integer* | [in] choice : 1, uses primit for the 1st half of timestep (first order)<br>2 uses primit for second order timestep |

Definition at line 92 of file hlle.f90.

Here is the call graph for this function:




#### 4.16.2.2 subroutine hlle::prim2fhlle ( real, dimension(neq), intent(in) *priml,* real, dimension(neq), intent(in) *primr,* real, dimension(neq), intent(inout) *ff* )

Solves the Riemann problem at the interface betweem PL and PR using the HLLE solver
The fluxes are computed in the X direction, to obtain the y ans z directions a swap is performed

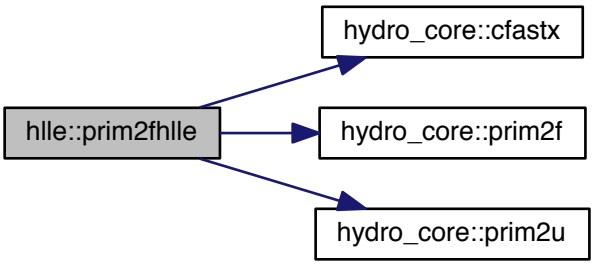
**Parameters**

| | |
|---|---|
| *real* | [in] primL : primitives at the Left state |
| *real* | [in] primR : primitives at the Right state |

| | |
|---|---|
| *real* | [out] ff : fluxes at the interface ( $F_{i+1/2}$) |

Definition at line 47 of file hlle.f90.

Here is the call graph for this function:




## 4.17 hydro_core Module Reference

Basic hydro (and MHD) subroutines utilities.

### Functions/Subroutines

- subroutine u2prim (uu, prim, T)

  *Computes the primitive variables and temperature from conserved variables on a single cell.*
- subroutine calcprim (u, primit, only_ghost)

  *Updated the primitives, using the conserved variables in the entire domain.*
- subroutine prim2u (prim, uu)

  *Computes the conserved conserved variables from the primitives in a single cell.*
- subroutine prim2f (prim, ff)

  *Computes the Euler Fluxes in one cell.*
- subroutine swapy (var, neq)

  *Swaps the x and y components in a cell.*
- subroutine swapz (var, neq)

  *Swaps the x and z components in a cell.*
- subroutine csound (p, d, cs)

  *Computes the sound speed.*
- subroutine cfast (p, d, bx, by, bz, cfx, cfy, cfz)

  *Computes the fast magnetosonic speeds in the 3 coordinates.*
- subroutine cfastx (prim, cfX)

  *Computes the fast magnetosonic speed in the x direction.*
- subroutine get_timestep (current_iter, n_iter, current_time, tprint, dt, dump_flag)

  *Otains the timestep allowed by the CFL condition in the entire.*
- subroutine limiter (PLL, PL, PR, PRR, neq)

  *Performs a linear reconstruction of the primitive variables.*

### 4.17.1 Detailed Description

This module contains subroutines and utilities that are the core of the hydro (and MHD) that are common to most implementations and will be used for the different specific solvers

### 4.17.2 Function/Subroutine Documentation

#### 4.17.2.1 subroutine hydro_core::calcprim ( real, dimension(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax), intent(in) *u,* real, dimension(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax), intent(out) *primit,* logical, intent(in), optional *only_ghost* )

Updated the primitives, using the conserved variables in the entire domain

**Parameters**

| | |
|---|---|
| *real* | [in] u(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax) : conserved variables |
| *real* | [out] prim(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax) : primitive variables |
| *logical* | [in] only_ghost : if set to true then updates the primitives only on the ghost cells, it defaults to false (the entire domain is updated) |

Definition at line 131 of file hydro_core.f90.

Here is the call graph for this function:


#### 4.17.2.2 subroutine hydro_core::cfast ( real, intent(in) *p,* real, intent(in) *d,* real, intent(in) *bx,* real, intent(in) *by,* real, intent(in) *bz,* real, intent(out) *cfx,* real, intent(out) *cfy,* real, intent(out) *cfz* )

Computes the fast magnetosonic speeds in the 3 coordinates

**Parameters**

| | |
|---|---|
| *real* | [in] p : value of pressure |
| *real* | [in] d : value of density |
| *real* | [in] Bx : value of the x component of the magnetic field |
| *real* | [in] By : value of the y component of the magnetic field |
| *real* | [in] Bz : value of the z component of the magnetic field |
| *real* | [out] csx : fast magnetosonic speed in x |
| *real* | [out] csy : fast magnetosonic speed in y |
| *real* | [out] csz : fast magnetosonic speed in z |

Definition at line 377 of file hydro_core.f90.

#### 4.17.2.3 subroutine hydro_core::cfastx ( real, dimension(neq), intent(in) *prim,* real, intent(out) *cfX* )

Computes the fast magnetosonic speed in the x direction

**Parameters**

| | |
|---|---|
| *real* | [in] prim(neq) : vector with the primitives in one cell |

Definition at line 398 of file hydro_core.f90.

#### 4.17.2.4 subroutine hydro_core::csound ( real, intent(in) *p,* real, intent(in) *d,* real, intent(out) *cs* )

Computes the sound speed

**Parameters**

| | |
|---|---|
| *real* | [in] p : value of pressure |
| *real* | [in] d : value of density |
| *real* | [out] cs : sound speed |

Definition at line 353 of file hydro_core.f90.

#### 4.17.2.5 subroutine hydro_core::get_timestep ( integer, intent(in) *current_iter,* integer, intent(in) *n_iter,* real, intent(in) *current_time,* real, intent(in) *tprint,* real, intent(out) *dt,* logical, intent(out) *dump_flag* )

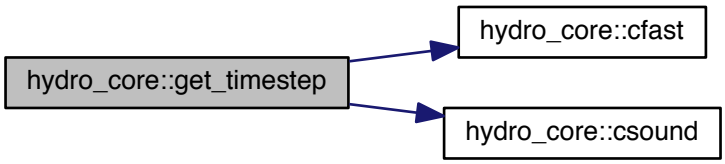
Otains the timestep allowed by the CFL condition in the entire domain using the global primitives, and sets logical variable to dump output

**Parameters**

| | |
|---|---|
| *integer* | [in] current_iter : Current iteration, it starts with a small but increasing CFL in the first N_trans iterarions |
| *integer* | [in] n_iter : Number of iterations to go from a small CFL to the final CFL (in parameters.f90) |
| *real* | [in] current_time : Current (global) simulation time |
| *real* | [in] tprint : time for the next programed disk dump |
| *real* | [out] : $\Delta t$ allowed by the CFL condition |
| *logical* | [out] dump_flag : Flag to write to disk |

Definition at line 428 of file hydro_core.f90.

Here is the call graph for this function:




#### 4.17.2.6 subroutine hydro_core::limiter ( real, dimension(neq), intent(in) *PLL,* real, dimension(neq), intent(inout) *PL,* real, dimension(neq), intent(inout) *PR,* real, dimension(neq), intent(in) *PRR,* integer, intent(in) *neq* )

returns a linear reconstruction of the variables at the interface beteen the primitives PLL, PL, PR, PRR
The reconstruction is made with a slope limiter chosen at compilation time (i.e. set on the Makefile)

**Parameters**

| | |
|---|---|
| *real* | [in] : primitives at the left of the left state |
| *real* | [inout] : primitives at the left state |
| *real* | [inout] : primitives at the right state |
| *real* | [in] : primitives at the right of the right state |
| *real* | [in] : number of equations |

Definition at line 503 of file hydro_core.f90.

#### 4.17.2.7 subroutine hydro_core::prim2f ( real, dimension(neq), intent(in) *prim,* real, dimension(neq), intent(out) *ff* )

Computes the Euler Fluxes in one cell, using the primitices
It returns the flux in the x direction (i.e. F), the y and z fluxes can be obtained swaping the respective entries (see swapy and swapz subroutines)

**Parameters**

| | |
|---|---|
| *real* | [in] prim(neq) : primitives in one cell |
| *real* | [out] ff(neq) : Euler Fluxes (x direction) |

Definition at line 248 of file hydro_core.f90.

#### 4.17.2.8 subroutine hydro_core::prim2u ( real, dimension(neq), intent(in) *prim,* real, dimension(neq), intent(out) *uu* )

Computes the conserved conserved variables from the primitives in a single cell

**Parameters**

| | |
|---|---|
| *real* | [in] prim(neq) : primitives in one cell |
| *real* | [out] uu(neq) : conserved varibles in one cell |

Definition at line 206 of file hydro_core.f90.

#### 4.17.2.9 subroutine hydro_core::swapy ( real, dimension(neq), intent(inout) *var,* integer, intent(in) *neq* )

Swaps the x and y components in a cell.

**Parameters**

| | |
|---|---|
| *real* | [inout] var(neq) : variable to be swapped |
| *real* | [in] neq : number of equations in the code |

Definition at line 298 of file hydro_core.f90.

#### 4.17.2.10 subroutine hydro_core::swapz ( real, dimension(neq), intent(inout) *var,* integer, intent(in) *neq* )

Swaps the x and z components in a cell.

**Parameters**

| | |
|---|---|
| *real* | [inout] var(neq) : variable to be swapped |
| *real* | [in] neq : number of equations in the code |

Definition at line 325 of file hydro_core.f90.

#### 4.17.2.11 subroutine hydro_core::u2prim ( real, dimension(neq), intent(in) *uu,* real, dimension(neq), intent(out) *prim,* real, intent(out) *T* )

Computes the primitive variables and temperature from conserved variables on a single cell

**Parameters**

| | |
|---|---|
| *real* | [in] uu(neq) : conserved variables in one cell |
| *real* | [out] prim(neq) : primitives in one cell |
| *real* | [out] T : Temperature [K] |

Definition at line 45 of file hydro_core.f90.

## 4.18 hydro_solver Module Reference

Advances the simulation one timestep.

### Functions/Subroutines

- subroutine viscosity ()

  *Adds artificial viscosity to the conserved variables.*
- subroutine step (dt)

  *Upwind timestep.*
- subroutine tstep ()

  *High level wrapper to advancce the simulation.*

### 4.18.1 Detailed Description

Advances the solution from $t$ to $t + \Delta t$

### 4.18.2 Function/Subroutine Documentation

#### 4.18.2.1 subroutine hydro_solver::step ( real, intent(in) *dt* )

Performs the upwind timestep according to

$$U_i^{n+1} = U_i^n - \frac{\Delta t}{\Delta x}\left[F_{i+1/2}^{n+1/2} - F_{i-1/2}^{n+1/2}\right]$$

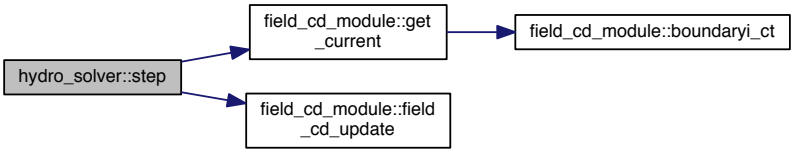
(in 3D), it takes $U^{n+1}$=up from the global variables and $U^n$=u

**Parameters**

| | |
|---|---|
| *real* | [in] dt : timestep |

Definition at line 75 of file hydro_solver.f90.

Here is the call graph for this function:

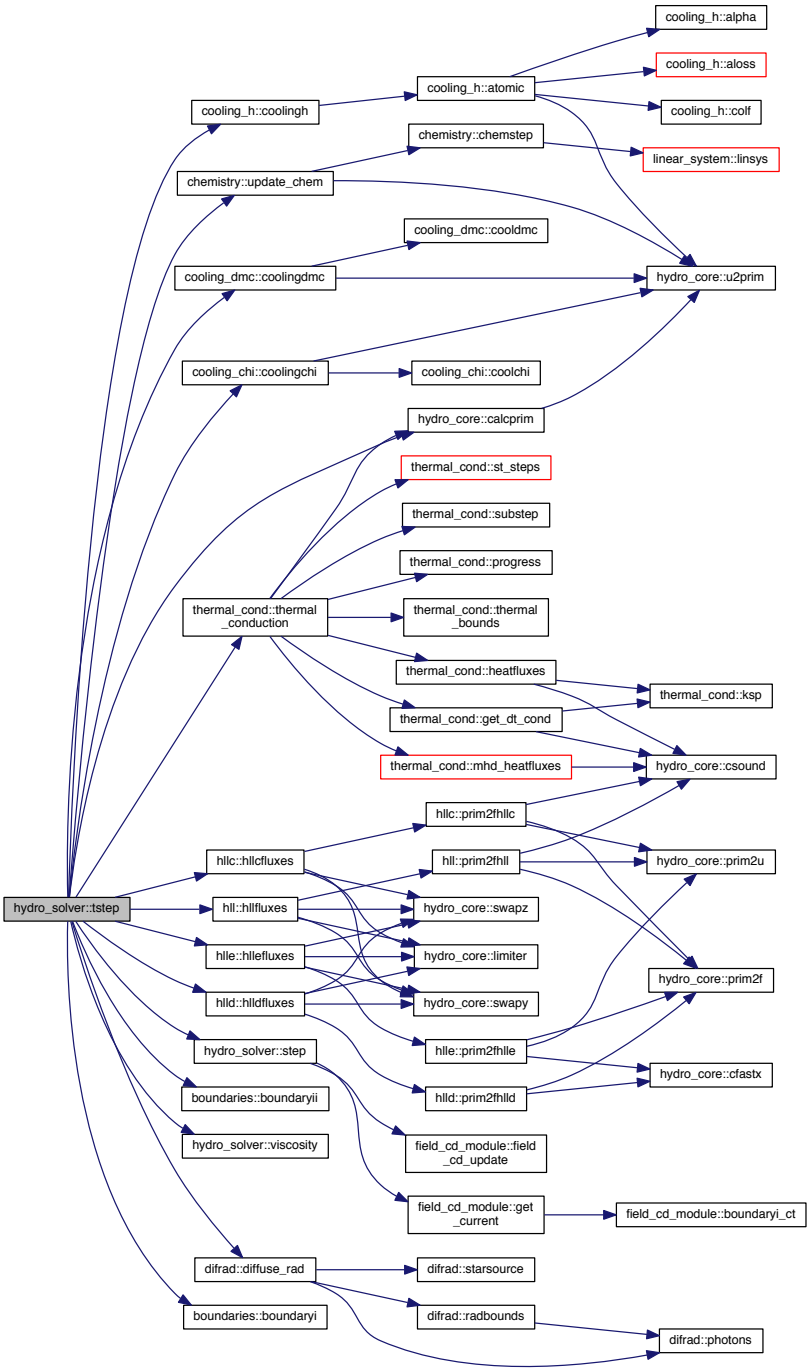


#### 4.18.2.2 subroutine hydro_solver::tstep ( )

High level wrapper to advancce the simulation
The variables are taken from the globals module.

Definition at line 127 of file hydro_solver.f90.

Here is the call graph for this function:



#### 4.18.2.3 subroutine hydro_solver::viscosity ( )

Adds artificial viscosity to the conserved variables
Takes the variables from the globals module and it assumes that the up are the stepped variables, while u are unstepped

Definition at line 45 of file hydro_solver.f90.

## 4.19 init Module Reference

Guacho-3D initialization.

### Functions/Subroutines

- subroutine initmain (tprint, itprint)

  *Main initialization routine.*

- subroutine initflow (itprint)

  *Initializes the conserved variables, in the globals module.*

### 4.19.1 Detailed Description

This module contains the routines needed to initializa the code, it also initiaizes all the modules set by the user.

### 4.19.2 Function/Subroutine Documentation

#### 4.19.2.1 subroutine init::initflow ( integer, intent(inout) *itprint* )

Initializes the conserved variables, in the globals module

**Parameters**

| | |
|---|---|
| *real* | [inout] itprint : number of current output |

Definition at line 388 of file init.f90.

#### 4.19.2.2 subroutine init::initmain ( real, intent(out) *tprint,* integer, intent(out) *itprint* )

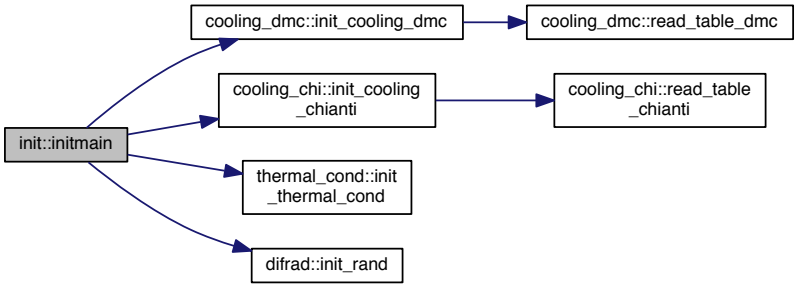
This subsroutine initializes all the variables in the globals module, MPI, cooling and user_mod routines; and outputs to screen the main parameters used in the run

**Parameters**

| | |
|---|---|
| *real* | [out] tprint : time of next output |
| *integer* | [out] itprint : number of next output |

Definition at line 41 of file init.f90.

Here is the call graph for this function:




## 4.20 jet Module Reference

jet module

### Functions/Subroutines

- subroutine **init_jet** ()
- subroutine **impose_jet** (u, time)

### Variables

- real, save **rj**
- real, save **lj**
- real, save **denj**
- real, save **tempj**
- real, save **vj0**
- real, save **dvj**
- real, save **tau**
- real, save **omega**
- real, dimension(3), save **posj**
- real, save **alpha**
- real, save **omegap**

#### 4.20.1 Detailed Description

Module to impose a jet with precesion and variability

## 4.21 linear_system Module Reference

linear system inversion module

### Functions/Subroutines

- subroutine ludcmp (a, n, indx, d)

  *LU decomposition.*
- subroutine lubksb (a, n, indx, b)

  *Solves a set of linear equations.*
- subroutine linsys (a, b, n)

  *Driver to solves a set of linear equations.*

## 4.21.1 Detailed Description

Inversion of a system of linear equations with an LU decomposition method (these routines are from Numerical Methods by Press et al.)

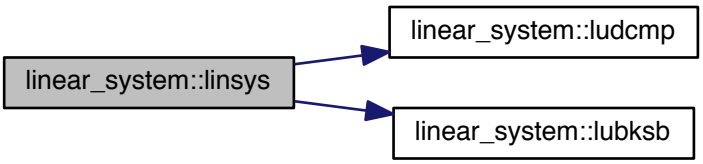
## 4.21.2 Function/Subroutine Documentation

#### 4.21.2.1 subroutine linear_system::linsys ( real (kind=8), dimension(n,n) *a,* real (kind=8), dimension(n) *b,* integer, intent(in) *n* )

Solves a linear set of equations

Definition at line 178 of file linear_system.f90.

Here is the call graph for this function:




#### 4.21.2.2 subroutine linear_system::lubksb ( real (kind=8), dimension(n,n), intent(in) *a,* integer, intent(in) *n,* integer, dimension(n), intent(in) *indx,* real (kind=8), dimension(n), intent(inout) *b* )

Solves a linear set of equations of the form

Definition at line 129 of file linear_system.f90.

#### 4.21.2.3 subroutine linear_system::ludcmp ( real (kind=8), dimension(n,n), intent(inout) *a,* integer, intent(in) *n,* integer, dimension(n), intent(out) *indx,* real (kind=8), intent(inout) *d* )

LU decomposition of a row-wise permutation

**Parameters**

| | |
|---|---|
| *real* | [inout] a(n,n) : matrix to be decomposed result is done in place |
| *integer* | [in] n : size of the matrix |
| *real* | [out] index(n) : vector that contains the row permutation affected by the partial pivoting |
| *integer* | [inout] d : +/- 1 depending if the row intergarches is even or odd |

Definition at line 46 of file linear_system.f90.

## 4.22 lyman_alpha_utilities Module Reference

Lyman_alpha_utilities.

### Functions/Subroutines

- subroutine init_la ()

  *Initializes data.*
- subroutine read_data (u, itprint, filepath)

  *reads data from file*
- subroutine getxyz (i, j, k, x, y, z)

  *gets position of a cell*
- subroutine rotation_x (theta, x, y, z, xn, yn, zn)

  *Rotation around the X axis.*
- subroutine rotation_y (theta, x, y, z, xn, yn, zn)

  *Rotation around the Y axis.*
- subroutine rotation_z (theta, x, y, z, xn, yn, zn)

  *Rotation around the Z axis.*
- subroutine fill_map (nxmap, nymap, nvmap, vmin, vmax, u, map, dxT, dyT, theta_x, theta_y, theta_z)

  *Fill target map.*
- subroutine write_la (itprint, filepath, nxmap, nymap, nvmap, map)

  *Writes projection to file.*
- subroutine phigauss (T, vzn, vmin, vmax, nvmap, profile)

  *This routine computes a gaussian line profile.*

### 4.22.1 Detailed Description

Utilities to compute the Lyman-

### 4.22.2 Function/Subroutine Documentation

#### 4.22.2.1 subroutine lyman_alpha_utilities::fill_map ( integer, intent(in) *nxmap,* integer, intent(in) *nymap,* integer, intent(in) *nvmap,* real, intent(in) *vmin,* real, intent(in) *vmax,* real, dimension(neq,nxmin:nxmax,nymin:nymax, nzmin:nzmax), intent(in) *u,* real, dimension(nxmap,nymap,nvmap), intent(out) *map,* real, intent(in) *dxT,* real, intent(in) *dyT,* real, intent(in) *theta_x,* real, intent(in) *theta_y,* real, intent(in) *theta_z* )

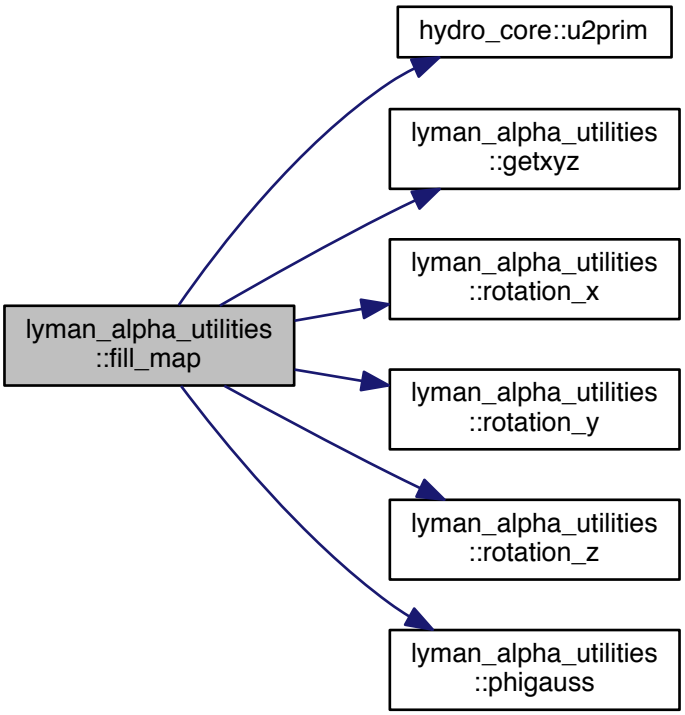
Fills the target map of one MPI block

**Parameters**

| | |
|---|---|
| *integer* | [in] nxmap : Number of X cells in target |
| *integer* | [in] nymap : Number of Y cells in target |
| *real* | [in] u(neq,nxmin:nxmax,nymin:nymax, nzmin:nzmax) : conserved variables |
| *real* | [out] map(nxmap,mymap) : Target map |
| *real* | [in] dxT : target pixel width |
| *real* | [in] dyT : target pixel height |
| *real* | [in] thetax : Rotation around X |
| *real* | [in] thetay : Rotation around Y |
| *real* | [in] thetaz : Rotation around Z |

Definition at line 285 of file lyman_alpha_tau.f90.

Here is the call graph for this function:




#### 4.22.2.2 subroutine lyman_alpha_utilities::getxyz ( integer, intent(in) *i,* integer, intent(in) *j,* integer, intent(in) *k,* real, intent(out) *x,* real, intent(out) *y,* real, intent(out) *z* )

Returns the position and spherical radius calculated with respect to the center of the grid

**Parameters**

| | |
|---|---|
| *integer* | [in] i : cell index in the x direction |
| *integer* | [in] j : cell index in the y direction |
| *integer* | [in] k : cell index in the z direction |
| *real* | [in] x : x position in the grid |
| *real* | [in] y : y position in the grid |
| *real* | [in] z : z position in the grid |

Definition at line 186 of file lyman_alpha_tau.f90.

#### 4.22.2.3 subroutine lyman_alpha_utilities::init_la ( )

Initializes data, MPI and other stuff

Definition at line 36 of file lyman_alpha_tau.f90.

#### 4.22.2.4 subroutine lyman_alpha_utilities::phigauss ( real, intent(in) *T,* real, intent(in) *vzn,* real, intent(in) *vmin,* real, intent(in) *vmax,* integer, intent(in) *nvmap,* real, dimension(nvmap), intent(out) *profile* )

This routine computes a gaussian line profile

Definition at line 386 of file lyman_alpha_tau.f90.

#### 4.22.2.5 subroutine lyman_alpha_utilities::read_data ( real, dimension(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax), intent(out) *u,* integer, intent(in) *itprint,* character (len=128), intent(in) *filepath* )

reads data from file

**Parameters**

| | |
|---|---|
| *real* | [out] u(neq,nxmin:nxmax,nymin:nymax,nzmin:nzmax) : conserved variables |
| *integer* | [in] itprint : number of output |
| *string* | [in] filepath : path where the output is |

Definition at line 136 of file lyman_alpha_tau.f90.

#### 4.22.2.6 subroutine lyman_alpha_utilities::rotation_x ( real, intent(in) *theta,* real, intent(in) *x,* real, intent(in) *y,* real, intent(in) *z,* real, intent(out) *xn,* real, intent(out) *yn,* real, intent(out) *zn* )

Does a rotation around the x axis

**Parameters**

| | |
|---|---|
| *real* | [in], theta : Angle of rotation (in radians) |
| *real* | [in], x : original x position in the grid |
| *real* | [in], y : original y position in the grid |
| *real* | [in], x : original z position in the grid |
| *real* | [out], x : final x position in the grid |
| *real* | [out], y : final y position in the grid |
| *real* | [out], x : final z position in the grid |

Definition at line 212 of file lyman_alpha_tau.f90.

#### 4.22.2.7 subroutine lyman_alpha_utilities::rotation_y ( real, intent(in) *theta,* real, intent(in) *x,* real, intent(in) *y,* real, intent(in) *z,* real, intent(out) *xn,* real, intent(out) *yn,* real, intent(out) *zn* )

Does a rotation around the x axis

**Parameters**

| | |
|---|---|
| *real* | [in], theta : Angle of rotation (in radians) |
| *real* | [in], x : original x position in the grid |
| *real* | [in], y : original y position in the grid |
| *real* | [in], x : original z position in the grid |
| *real* | [out], x : final x position in the grid |
| *real* | [out], y : final y position in the grid |
| *real* | [out], x : final z position in the grid |

Definition at line 236 of file lyman_alpha_tau.f90.

#### 4.22.2.8 subroutine lyman_alpha_utilities::rotation_z ( real, intent(in) *theta,* real, intent(in) *x,* real, intent(in) *y,* real, intent(in) *z,* real, intent(out) *xn,* real, intent(out) *yn,* real, intent(out) *zn* )

Does a rotation around the x axis

**Parameters**

| | |
|---|---|
| *real* | [in], theta : Angle of rotation (in radians) |
| *real* | [in], x : original x position in the grid |
| *real* | [in], y : original y position in the grid |
| *real* | [in], x : original z position in the grid |
| *real* | [out], x : final x position in the grid |
| *real* | [out], y : final y position in the grid |
| *real* | [out], x : final z position in the grid |

Definition at line 258 of file lyman_alpha_tau.f90.

#### 4.22.2.9 subroutine lyman_alpha_utilities::write_la ( integer, intent(in) *itprint,* character (len=128), intent(in) *filepath,* integer, intent(in) *nxmap,* integer, intent(in) *nymap,* integer, intent(in) *nvmap,* real, dimension(nxmap,nymap,nvmap), intent(in) *map* )

Writes projection to file

**Parameters**

| | |
|---|---|
| *integer* | [in] itprint : number of output |
| *string* | [in] filepath : path where to write |
| *integer* | [in] nxmap : Number of X cells in target |
| *integer* | [in] nymap : Number of Y cells in target |
| *integer* | [in] nvmap : Number of velocity channels |
| *real* | [in] map(nxmap,mymap) : Target map |

Definition at line 361 of file lyman_alpha_tau.f90.

## 4.23 network Module Reference

Chemical/atomic network module.

### Functions/Subroutines

- subroutine **derv** (y, rate, dydt, y0)
- subroutine **get_jacobian** (y, jacobian, rate)
- subroutine **get_reaction_rates** (rate, T)
- subroutine **nr_init** (y, y0)
- logical function **check_no_conservation** (y, y0_in)

### Variables

- integer, parameter **n_spec** = 4
- integer, parameter **nequil** = 2
- integer, parameter **n_elem** = 1
- integer, parameter **n_nequ** = n_spec - nequil
- integer, parameter **h** = 1
- integer, parameter **hp** = 2
- integer, parameter **h2** = 3
- integer, parameter **ie** = 4
- integer, parameter **iht** = 1
- integer, parameter **ihn** = 3
- integer, parameter **n_reac** = 8
- integer, parameter **ir1** = 1

- integer, parameter **ir2** = 2
- integer, parameter **ir3** = 3
- integer, parameter **ir4** = 4
- integer, parameter **ir5** = 5
- integer, parameter **ir6** = 6
- integer, parameter **ir7** = 7
- integer, parameter **ir8** = 8

### 4.23.1 Detailed Description

this module should be generated by an interface code.

## 4.24 out_bin_module Module Reference

Output in BIN format.

### Functions/Subroutines

- subroutine write_header (unit, neq_out, nghost_out)

  *Writes header.*
- subroutine write_bin (itprint)

  *Writes Data, one file per processor.*

### 4.24.1 Detailed Description

This module writes the ouput in BIN format

### 4.24.2 Function/Subroutine Documentation

#### 4.24.2.1 subroutine out_bin_module::write_bin ( integer, intent(in) *itprint* )

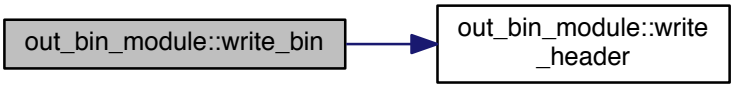
Writes Data in BIN format one file per processor

**Parameters**

| | |
|---|---|
| *integer* | [in] itprint : number of output |

Definition at line 109 of file Out_BIN_Module.f90.

Here is the call graph for this function:



#### 4.24.2.2 subroutine out_bin_module::write_header ( integer, intent(in) *unit,* integer, intent(in) *neq_out,* integer, intent(in) *nghost_out* )

Writes header for binary input

**Parameters**

| | |
|---|---|
| *integer* | [in] unit : number of logical unit |

Definition at line 41 of file Out_BIN_Module.f90.

## 4.25 out_silo_module Module Reference

Output in Silo (+HDF5) Format.

### Functions/Subroutines

- subroutine writeblocks (itprint)

  *Writes Data, one file per processor.*
- subroutine writemaster (itprint)

  *Writes the Master File.*
- subroutine write_utsilo (itprint)

  *Upper level wrapper.*

### 4.25.1 Detailed Description

This module writes the ouput in SILO (HDF5) format

### 4.25.2 Function/Subroutine Documentation

#### 4.25.2.1 subroutine out_silo_module::write_utsilo ( integer, intent(in) *itprint* )

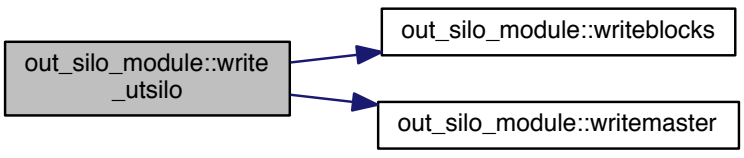
Upper level wrapper for the SILO output

**Parameters**

| | |
|---|---|
| *integer* | [in] itprint : number of output |

Definition at line 348 of file Out_Silo_Module.f90.

Here is the call graph for this function:




#### 4.25.2.2 subroutine out_silo_module::writeblocks ( integer, intent(in) *itprint* )

Writes Data in silo format one file per processor

**Parameters**

| | |
|---|---|
| *integer* | [in] itprint : number of output |

Definition at line 45 of file Out_Silo_Module.f90.

#### 4.25.2.3 subroutine out_silo_module::writemaster ( integer, intent(in) *itprint* )

Writes the master file with the metadata and multivars

**Parameters**

| | |
|---|---|
| *integer* | [in] itprint : number of output |

Definition at line 199 of file Out_Silo_Module.f90.

## 4.26 out_vtk_module Module Reference

Output in VTK format.

### Functions/Subroutines

- subroutine write_vtk (itprint)

  *Writes Data, one file per processor.*

### 4.26.1 Detailed Description

This module writes the ouput in VTK format

### 4.26.2 Function/Subroutine Documentation

#### 4.26.2.1 subroutine out_vtk_module::write_vtk ( integer, intent(in) *itprint* )

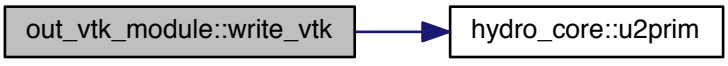
Writes Data in VTK format one file per processor

**Parameters**

| | |
|---|---|
| *integer* | [in] itprint : number of output |

Definition at line 42 of file Out_VTK_Module.f90.

Here is the call graph for this function:



## 4.27 output Module Reference

Writes output.

### Functions/Subroutines

- subroutine write_output (itprint)

  *Writes output.*

### 4.27.1 Detailed Description

This module writes the ouput in the formats specified in the makefile

### 4.27.2 Function/Subroutine Documentation

#### 4.27.2.1 subroutine output::write_output ( integer, intent(in) *itprint* )

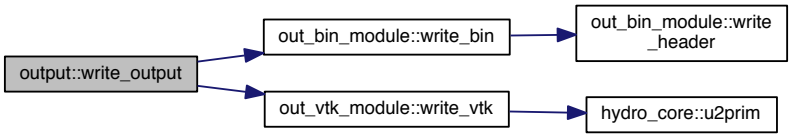
Writes output, the format is chosen in makefile
Supported formats are ∗.bin and VTK (both BINARY), Silo (+hdf5)

**Parameters**

| | |
|---|---|
| *integer* | [in] itprint : number of output |

Definition at line 41 of file output.f90.

Here is the call graph for this function:




## 4.28 sources Module Reference

Adds source terms.

### Functions/Subroutines

- subroutine getpos (i, j, k, x, y, z, r)

  *Gets position in the grid.*
- subroutine grav_source (xc, yc, zc, pp, s)

  *Gravity due to point sources.*
- subroutine radpress_source (i, j, k, xc, yc, zc, rc, pp, s)

  *Radiation pressure force.*
- subroutine divergence_b (i, j, k, d)

  *Computes div(B)*

- subroutine divbcorr_8w_source (i, j, k, pp, s)

  *8 Wave source terms for div(B) correction*

- subroutine source (i, j, k, prim, s)

  *Upper level wrapper for sources.*

### 4.28.1 Detailed Description

This module adds the source terms from gravity, radiation pressure (not fully tested), and div(B) cleaning if the 8 wave scheme is used

### 4.28.2 Function/Subroutine Documentation

#### 4.28.2.1 subroutine sources::divbcorr_8w_source ( integer, intent(in) *i,* integer, intent(in) *j,* integer, intent(in) *k,* real, dimension(neq), intent(in) *pp,* real, dimension(neq), intent(inout) *s* )

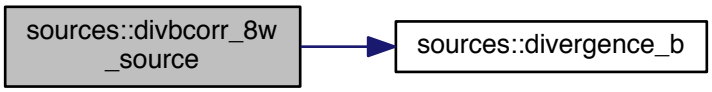
Adds terms proportional to div B in Faraday's Law, momentum equation and energy equation as propoes in Powell et al. 1999

**Parameters**

| | |
|---|---|
| *integer* | [in] i : cell index in the X direction |
| *integer* | [in] j : cell index in the Y direction |
| *integer* | [in] k : cell index in the Z direction |
| *real* | [in] pp(neq) : vector of primitive variables |
| *real* | [out] s(neq) : vector with source terms |

Definition at line 196 of file sources.f90.

Here is the call graph for this function:




#### 4.28.2.2 subroutine sources::divergence_b ( integer, intent(in) *i,* integer, intent(in) *j,* integer, intent(in) *k,* real, intent(out) *d* )

Computes div(B)

**Parameters**

| | |
|---|---|
| *integer* | [in] i : cell index in the X direction |
| *integer* | [in] j : cell index in the Y direction |
| *integer* | [in] k : cell index in the Z direction |
| *real* | [out] d :: div(B) |

Definition at line 173 of file sources.f90.

#### 4.28.2.3 subroutine sources::getpos ( integer, intent(in) *i,* integer, intent(in) *j,* integer, intent(in) *k,* real, intent(out) *x,* real, intent(out) *y,* real, intent(out) *z,* real, intent(out) *r* )

Gets the position and spherical radius calculated with respect to the center of the grid

**Parameters**

| | |
|---|---|
| *integer* | [in] i : index in the X direction |
| *integer* | [in] j : index in the Y direction |
| *integer* | [in] k : index in the Z direction |
| *real* | [out] x : X position form the center of the grid (code units) |
| *real* | [out] y : Y position form the center of the grid (code units) |
| *real* | [out] z : Z position form the center of the grid (code units) |
| *real* | [out] r : Spherical radius form the center of the grid (code units) |

Definition at line 58 of file sources.f90.

#### 4.28.2.4 subroutine sources::grav_source ( real, intent(in) *xc,* real, intent(in) *yc,* real, intent(in) *zc,* real, dimension(neq), intent(in) *pp,* real, dimension(neq), intent(inout) *s* )

Adds the gravitational force due to point particles, at this moment is fixed to two point sources (exoplanet)

**Parameters**

| | |
|---|---|
| *real* | [in] xc : X position of the cell |
| *real* | [in] yc : Y position of the cell |
| *real* | [in] zc : Z position of the cell |
| *real* | [in] pp(neq) : vector of primitive variables |
| *real* | [out] s(neq) : vector with source terms |

Definition at line 83 of file sources.f90.

#### 4.28.2.5 subroutine sources::radpress_source ( integer, intent(in) *i,* integer, intent(in) *j,* integer, intent(in) *k,* real, intent(in) *xc,* real, intent(in) *yc,* real, intent(in) *zc,* real, intent(in) *rc,* real, dimension(neq), intent(in) *pp,* real, dimension(neq), intent(inout) *s* )

Adds the radiaiton pressure force due to photo-ionization

**Parameters**

| | |
|---|---|
| *integer* | [in] i : cell index in the X direction |
| *integer* | [in] j : cell index in the Y direction |
| *integer* | [in] k : cell index in the Z direction |
| *real* | [in] xc : X position of the cell |
| *real* | [in] yc : Y position of the cell |
| *real* | [in] zc : Z position of the cell |
| *reak* | [in] rc : $\sqrt{x^2 + y^2 + z^2}$ |
| *real* | [in] pp(neq) : vector of primitive variables |
| *real* | [out] s(neq) : vector with source terms |

Definition at line 140 of file sources.f90.

#### 4.28.2.6 subroutine sources::source ( integer, intent(in) *i,* integer, intent(in) *j,* integer, intent(in) *k,* real, dimension(neq), intent(in) *prim,* real, dimension(neq), intent(out) *s* )

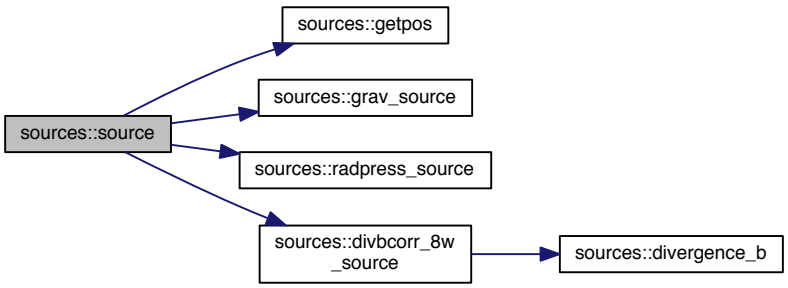
Upper level wrapper for sources
Main driver, this is called from the upwind stepping

**Parameters**

| | |
|---|---|
| *integer* | [in] i : cell index in the X direction |
| *integer* | [in] j : cell index in the Y direction |
| *integer* | [in] k : cell index in the Z direction |
| *real* | [in] prim(neq) : vector of primitive variables |
| *real* | [out] s(neq) : vector with source terms |

Definition at line 233 of file sources.f90.

Here is the call graph for this function:




## 4.29 thermal_cond Module Reference

Adds thermal conducion.

### Functions/Subroutines

- subroutine init_thermal_cond ()

  *Intializes Temperature array.*
- subroutine get_dt_cond (dt)

  *computes conduction timescale*
- subroutine progress (j, tot)

  *Progress bar.*
- real function ksp (T)

  *Spitzer conductivity.*
- real function ksp_parl (xtemp)

  *Spitzer parallel conductivity.*
- real function ksp_perp (xtemp, xdens, B2)

  *Spitzer perpendicular conductivity.*
- subroutine heatfluxes ()

  *Returns Heat Fluxes.*
- subroutine mhd_heatfluxes ()

  *Returns Heat Fluxes with anisotropic thermal conduction.*
- subroutine thermal_bounds ()

  *Exchanges ghost cells for energy only.*
- real function superstep (N, snu)

  *Length of superstep.*
- real function substep (j, N, nu)

*Size of substep j.*

- subroutine st_steps (fs, Ns, fstep)

  *Returns the number of Supersteps.*

- subroutine thermal_conduction ()

  *Upper level wrapper for thermal conduction.*

## Variables

- real, parameter ph =0.4

  *Parameter for the sturated regime in McKee.*

- real, parameter nu =0.01

  *Super-stepping daMPI_NBg factor.*

- real, parameter snu =sqrt(nu)

  *Sqrt of damping factor.*

- integer, parameter max_iter = 100

  *Maximum number of iterations.*

- real, parameter tstep_red_factor =0.25

  *timestep reduction factor for the conduction*

- real dt_cond

  *conduction timestep*

- integer tc_log

  *loical unit to write TC log*

### 4.29.1 Detailed Description

Adds a thermal conduction term, affects both the primitive and conserved variables

### 4.29.2 Function/Subroutine Documentation

#### 4.29.2.1 subroutine thermal_cond::get_dt_cond ( real, intent(out) *dt* )

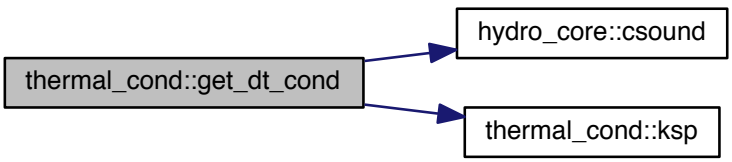
computes conduction timescale (in seconds)

**Parameters**

| | |
|---|---|
| *real* | [out] dt :: conduction timescale |

Definition at line 79 of file thermal_cond.f90.

Here is the call graph for this function:

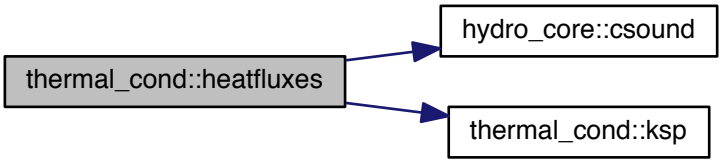


#### 4.29.2.2 subroutine thermal_cond::heatfluxes ( )

Heat flux, if saturation enabled it takes minimum of the Spitzer and the saturated value
The result is stored in the 5th component of global the F,G,H fluxes (in cgs, conversion is done in dt product)

Definition at line 190 of file thermal_cond.f90.

Here is the call graph for this function:




#### 4.29.2.3 subroutine thermal_cond::init_thermal_cond ( )

Intializes Temperature array (to resolve dependencies it was moved to the globals module)

Definition at line 53 of file thermal_cond.f90.

#### 4.29.2.4 real function thermal_cond::ksp ( real, intent(in) *T* )

Computes the Spitzer conductivity

**Parameters**

| | |
|---|---|
| *real* | [in] T : temperature [K] |

Definition at line 143 of file thermal_cond.f90.

#### 4.29.2.5 real function thermal_cond::ksp_parl ( real, intent(in) *xtemp* )

Computes the Spitzer conductivity parallel to B

**Parameters**

| | |
|---|---|
| *real* | [in] T : temperature [K] |

Definition at line 158 of file thermal_cond.f90.

#### 4.29.2.6 real function thermal_cond::ksp_perp ( real, intent(in) *xtemp,* real, intent(in) *xdens,* real, intent(in) *B2* )

Computes the Spitzer conductivity perpendicular to B

**Parameters**

| | |
|---|---|
| *real* | [in] T : temperature [K] |

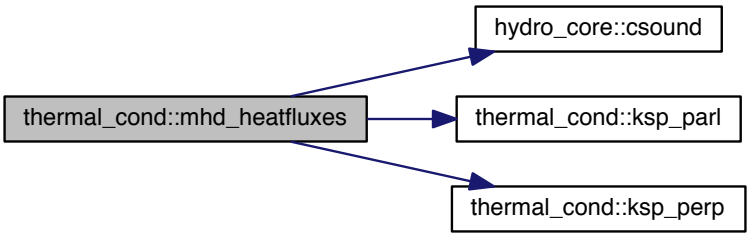
Definition at line 173 of file thermal_cond.f90.

#### 4.29.2.7 subroutine thermal_cond::mhd_heatfluxes ( )

Heat flux, if sturation enabled takes minimum of the Spitzer and the saturated value
The result is stored in the 5th component of global the F,G,H fluxes (in cgs, conversion is done in dt product)

Definition at line 278 of file thermal_cond.f90.

Here is the call graph for this function:




#### 4.29.2.8 subroutine thermal_cond::progress ( integer(kind=4) *j,* integer(kind=4), intent(in) *tot* )

Progress bar takes a number between 1 and tot

**Parameters**

| | |
|---|---|
| *integer* | [in] j : current iteration |
| *integer* | [in] tot : total number of iterartions |

Definition at line 121 of file thermal_cond.f90.

#### 4.29.2.9 subroutine thermal_cond::st_steps ( real, intent(in) *fs,* integer, intent(out) *Ns,* real, intent(out) *fstep* )

Returns the number of Supersteps

**Parameters**

| | |
|---|---|
| *real* | fs : ratio of dtcond/dthydro |
| *integer* | Ns : Number of Supersteps |
| *real* | fstep : Number of supersteps (float) |

Definition at line 665 of file thermal_cond.f90.

Here is the call graph for this function:


#### 4.29.2.10 real function thermal_cond::substep ( integer, intent(in) *j,* integer, intent(in) *N,* real, intent(in) *nu* )

Returns the size of substep j of N

**Parameters**

| | |
|---|---|
| *integer* | [in] j : index of current step |
| *integer* | [in] N : Total number of substeps |
| *real* | [in] nu : daMPI_NBg factor |

Definition at line 647 of file thermal_cond.f90.

#### 4.29.2.11 real function thermal_cond::superstep ( integer *N,* real, intent(in) *snu* )

Returns the length of the superstep with N inner substeps

**Parameters**

| | |
|---|---|
| *integer* | [in] N : Nunber of inner substeps |
| *real* | [in] snu : sqrt of daMPI_NBg factor |

Definition at line 626 of file thermal_cond.f90.

#### 4.29.2.12 subroutine thermal_cond::thermal_bounds ( )

Exchanges one layer of boundaries, only the equation that corresponds to the energy

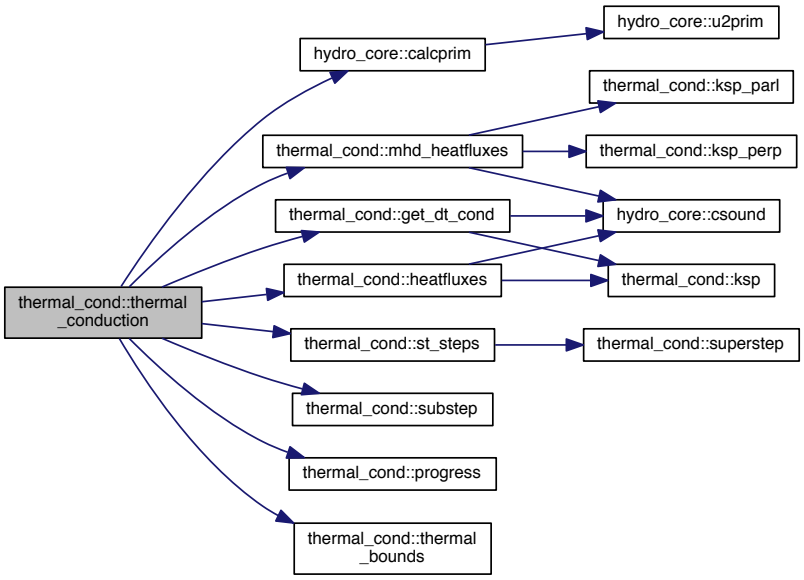
Definition at line 497 of file thermal_cond.f90.

#### 4.29.2.13 subroutine thermal_cond::thermal_conduction ( )

This routine adds the heat conduction, receives the hydro timestep in seconds, and assumes the primitives and Temp(i,j,k) arrays are updated

Definition at line 691 of file thermal_cond.f90.

Here is the call graph for this function:



# Chapter 5

# File Documentation

## 5.1 doc/mainpage.h File Reference

Webpage frontend.

## 5.2 src/boundaries.f90 File Reference

Boundary conditions.

### Modules

- module boundaries

  *Boundary conditions.*

### Functions/Subroutines

- subroutine boundaries::boundaryi ()

  *Boundary conditions for 1st order half timestep.*
- subroutine boundaries::boundaryii ()

  *Boundary conditions for 2nd order half timestep.*

### 5.2.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.3 src/chemistry.f90 File Reference

chemistry module

### Modules

- module chemistry

  *chemistry module*

### Functions/Subroutines

- subroutine chemistry::update_chem ()

  *Advances the chemistry network.*
- subroutine chemistry::chemstep (y, y0, T, deltt)

  *Advances the chemistry network in one cell.*

#### 5.3.1 Detailed Description

**Author**

A. Castellanos, A. Rodriguez, A. Raga and A. Esquivel

**Date**

10/Mar/2016

## 5.4 src/coldens.f90 File Reference

Column density projection.

### Modules

- module coldens_utilities

  *Column density projection.*

### Functions/Subroutines

- subroutine coldens_utilities::init_coldens ()

  *Initializes data.*
- subroutine coldens_utilities::read_data (u, itprint, filepath)

  *reads data from file*
- subroutine coldens_utilities::getxyz (i, j, k, x, y, z)

  *gets position of a cell*
- subroutine coldens_utilities::rotation_x (theta, x, y, z, xn, yn, zn)

  *Rotation around the X axis.*
- subroutine coldens_utilities::rotation_y (theta, x, y, z, xn, yn, zn)

  *Rotation around the Y axis.*
- subroutine coldens_utilities::rotation_z (theta, x, y, z, xn, yn, zn)

  *Rotation around the Z axis.*
- subroutine coldens_utilities::fill_map (nxmap, nymap, u, map, dxT, dyT, theta_x, theta_y, theta_z)

  *Fill target map.*
- subroutine coldens_utilities::write_header (unit, nx, ny)

  *Writes header.*
- subroutine coldens_utilities::write_map (fileout, nxmap, nymap, map)

*Writes projection to file.*

- program coldens

  *Computes the H-alpha emission.*

### 5.4.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

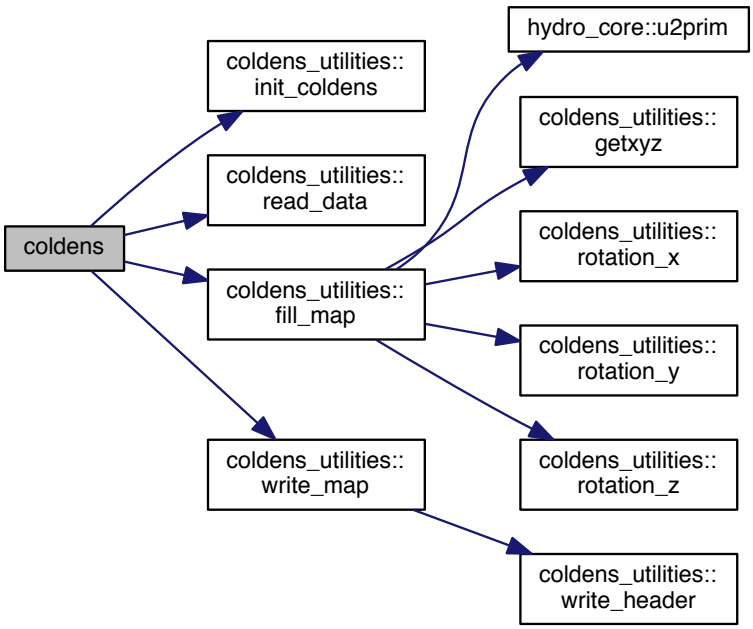
### 5.4.2 Function/Subroutine Documentation

#### 5.4.2.1 program coldens ( )

Computes the H-alpha apbsorption
It rotates the data along each of the coordinates axis by an amount $\theta_x, \theta_y, \theta_z$, and projectcs the map along the the LOS, which is taken to be the Z axis

Definition at line 465 of file coldens.f90.

Here is the call graph for this function:




## 5.5 src/constants.f90 File Reference

Constants module.

## Modules

- module constants

  *Module containing physical, asronomical constants, and other named constants.*

## Variables

- real, parameter constants::pi =acos(-1.)

  $\pi$
- real, parameter constants::amh =1.66e-24

  *hydrogen mass*
- real, parameter constants::kb =1.38e-16

  *Boltzmann constant (cgs)*
- real, parameter constants::rg =8.3145e7

  *Gas constant (cgs)*
- real, parameter constants::ggrav =6.67259e-8

  *Gravitational constant (cgs)*
- real, parameter constants::clight =2.99E10

  *speed of light in vacuum (cgs)*
- real, parameter constants::msun =1.99E33

  *solar radius (cgs)*
- real, parameter constants::rsun =6.955e10

  *solar mass (cgs)*
- real, parameter constants::mjup =1.898E30

  *Jupiter mass (cgs)*
- real, parameter constants::rjup =7.1492E9

  *Jupiter radius (cgs)*
- real, parameter constants::au =1.496e13

  *1AU in cm*
- real, parameter constants::pc =3.0857E18

  *1pc in cm*
- real, parameter constants::kpc =3.0857E21

  *1Kpc in cm*
- real, parameter constants::hr =3600.

  *1hr in seconds*
- real, parameter constants::day =86400.

  *1day in seconds*
- real, parameter constants::yr =3.1536E7

  *1yr in seconds*
- real, parameter constants::myr =3.1536E13

  *1Myr in seconds*
- integer, parameter **constants::solver_hll** = 1
- integer, parameter **constants::solver_hllc** = 2
- integer, parameter **constants::solver_hlld** = 3
- integer, parameter **constants::solver_hlle** = 4
- integer, parameter **constants::eos_adiabatic** = 1
- integer, parameter **constants::eos_single_specie** = 2
- integer, parameter **constants::eos_h_rate** = 3
- integer, parameter **constants::eos_chem** = 4
- integer, parameter **constants::cool_none** = 0
- integer, parameter **constants::cool_h** = 1

- integer, parameter **constants::cool_bbc** = 2
- integer, parameter **constants::cool_dmc** = 3
- integer, parameter **constants::cool_chi** = 4
- integer, parameter **constants::cool_chem** = 5
- integer, parameter **constants::bc_outflow** = 1
- integer, parameter **constants::bc_closed** = 2
- integer, parameter **constants::bc_periodic** = 3
- integer, parameter **constants::bc_inflow** = 4
- integer, parameter **constants::limiter_no_average** = -1
- integer, parameter **constants::limiter_no_limit** = 0
- integer, parameter **constants::limiter_minmod** = 1
- integer, parameter **constants::limiter_van_leer** = 2
- integer, parameter **constants::limiter_van_albada** = 3
- integer, parameter **constants::limiter_umist** = 4
- integer, parameter **constants::limiter_woodward** = 5
- integer, parameter **constants::limiter_superbee** = 6
- integer, parameter **constants::tc_off** = 0
- integer, parameter **constants::tc_isotropic** = 1
- integer, parameter **constants::tc_anisotropic** = 2

### 5.5.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.6 src/cooling_chi.f90 File Reference

Cooling module with CHIANTI generated cooling curves.

### Modules

- module cooling_chi

  *Cooling module with CHIANTI generated cooling curves.*

### Functions/Subroutines

- subroutine cooling_chi::init_cooling_chianti ()

  *Initializes the DMC cooling.*
- subroutine cooling_chi::read_table_chianti ()

  *Reads the cooling curve table.*
- real(kind=8) function cooling_chi::coolchi (T)

  *Returns the cooling coefficient interpolating the table.*
- subroutine cooling_chi::coolingchi ()

  *High level wrapper to apply cooling with CHIANTI tables.*

### Variables

- real(kind=8), dimension(:,:), allocatable **cooling_chi::cooltab_chianti**

#### 5.6.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.7 src/cooling_dmc.f90 File Reference

Cooling module with Dlgarno Mac Cray coronal cooling curve.

### Modules

- module cooling_dmc

  *Cooling module with Dalgarno McCray coronal cooling curve.*

### Functions/Subroutines

- subroutine cooling_dmc::init_cooling_dmc ()

  *Initializes the DMC cooling.*
- subroutine cooling_dmc::read_table_dmc ()

  *Reads the cooling curve table.*
- real(kind=8) function cooling_dmc::cooldmc (T)

  *Returns the cooling coefficient interpolating the table.*
- subroutine cooling_dmc::coolingdmc ()

  *High level wrapper to apply cooling with DMC table.*

### Variables

- real(kind=8), dimension(:,:), allocatable **cooling_dmc::cooltab_dmc**

#### 5.7.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.8 src/cooling_h.f90 File Reference

Cooling with hydrogen rate parametrized cooling.

### Modules

- module cooling_h

  *Cooling with parametrized cooling and H rate equation.*

### Functions/Subroutines

- subroutine cooling_h::coolingh ()

  *High level wrapper to apply cooling.*
- real(kind=8) function cooling_h::alpha (T)

  *calculates the recombination rate (case B)*
- real(kind=8) function cooling_h::alpha1 (T)

  *calculates the recombination rate to level 1*
- real(kind=8) function cooling_h::colf (T)

  *calculates the collisional ionization rate*
- real(kind=8) function cooling_h::betah (T)

  *betaH(T)*
- real(kind=8) function cooling_h::aloss (X1, X2, DT, DEN, DH0, TE0)

  *Non equilibrium cooling.*
- subroutine cooling_h::atomic (dt, uu, tau, radphi)

  *Updates the ionization fraction and applpies cooling.*

#### 5.8.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.9 src/difrad.f90 File Reference

Diffuse radiation module.

### Modules

- module difrad

  *Ray tracing Radiative Trasnport.*

### Functions/Subroutines

- subroutine difrad::init_rand ()

  *initializes random number generation*
- subroutine difrad::emdiff (emax)

  *calculates the diffuse fotoionization emissivity*
- subroutine difrad::random_versor (xd, yd, zd)

  *returns the 3 components of a random versor*
- subroutine difrad::starsource (srad, x0, y0, z0, x, y, z, xd, yd, zd)

*Place photon packets at a "star" surface.*

- subroutine difrad::photons (xl0, yl0, zl0, xd, yd, zd, f)

  *Photon trajectories.*

- subroutine difrad::radbounds ()

  *follows the rays across MPI boundaries*

- subroutine difrad::progress (j, tot)

  *Progress bar.*

- subroutine difrad::diffuse_rad ()

  *Diffuse radiation driver.*

### Variables

- real, parameter difrad::a0 =6.3e-18

  *Fotoionization cross section.*

- integer, parameter difrad::nrays =1000000

  *Number of rays.*

- real, dimension(:,:,:), allocatable difrad::ph

  *Photoionizing rate.*

- real, dimension(:,:,:), allocatable difrad::em

  *Photoionizing emissivity.*

- real, dimension(:,:,:), allocatable difrad::photl

  *Auxiliary buffer for MPI.*

- real, dimension(:,:,:), allocatable difrad::photr

  *Auxiliary buffer for MPI.*

- real, dimension(:,:,:), allocatable difrad::photb

  *Auxiliary buffer for MPI.*

- real, dimension(:,:,:), allocatable difrad::phott

  *Auxiliary buffer for MPI.*

- real, dimension(:,:,:), allocatable difrad::photo

  *Auxiliary buffer for MPI.*

- real, dimension(:,:,:), allocatable difrad::photi

  *Auxiliary buffer for MPI.*

- integer, dimension(6) difrad::buffersize

  *Auxiliary buffer for MPI.*

#### 5.9.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.10 src/exoplanet.f90 File Reference

Exoplanet problem module.

## Modules

- module exoplanet

  *Exoplanet module.*

## Functions/Subroutines

- subroutine exoplanet::init_exo ()

  *Module initialization.*
- subroutine exoplanet::impose_exo (u, time)

  *Inject sources of wind.*

## Variables

- real exoplanet::rsw

  *Stellar wind radius.*
- real exoplanet::tsw

  *Stellar wind temperature.*
- real exoplanet::vsw

  *Stellar wind velocity.*
- real exoplanet::dsw

  *Stellar Wind Density.*
- real **exoplanet::rss**
- real exoplanet::bsw

  *Magnetic Field.*
- real exoplanet::bpw

  *Planetary Magnetic Field.*
- real exoplanet::rpw

  *Planetary radius.*
- real exoplanet::tpw

  *Planetary wind temperature.*
- real exoplanet::vpw

  *Planetary wind velocity.*
- real **exoplanet::dpw**
- real exoplanet::torb

  *planet: orbital period*
- real exoplanet::rorb

  *orbital radius*
- real exoplanet::omegap

  *planet: angular velocity*
- real exoplanet::masss

  *Mass of the Star.*
- real exoplanet::massp

  *Mass of the Planet.*
- real exoplanet::xp

  *X position of the planet.*
- real exoplanet::yp

  *Y position of the planet.*
- real exoplanet::zp

  *Z position of the planet.*

### 5.10.1 Detailed Description

**Author**

M. Schneiter, C. Villarreal D'Angelo, A. Esquivel

**Date**

2/Nov/2014

## 5.11 src/field_cd_module.f90 File Reference

Constrained Transport module.

### Modules

- module field_cd_module

  *Module to computes field CD div B correction.*

### Functions/Subroutines

- subroutine field_cd_module::boundaryi_ct ()

  *Boundary conditions (one cell) for field-CD.*
- subroutine field_cd_module::get_current ()

  *Computes current.*
- subroutine field_cd_module::field_cd_update (i, j, k, dt)

  *Upper level wrapper for field-CD update.*

### Variables

- real, dimension(:,:,:,:), allocatable field_cd_module::e

  *electric current*

### 5.11.1 Detailed Description

**Author**

C. Villareal D'Angelo, M. Schneiter, A. Esquivel

**Date**

26/Apr/2016

## 5.12 src/globals.f90 File Reference

Global variables.

### Modules

- module globals

  *Module containing global variables.*

## Variables

- real, dimension(:,:,:,:), allocatable globals::u

  *conserved varibles*
- real, dimension(:,:,:,:), allocatable globals::up

  *conserved varibles after 1/2 timestep*
- real, dimension(:,:,:,:), allocatable globals::primit

  *primitive varibles*
- real, dimension(:,:,:,:), allocatable globals::f

  *X fluxes.*
- real, dimension(:,:,:,:), allocatable globals::g

  *Y fluxes.*
- real, dimension(:,:,:,:), allocatable globals::h

  *Z fluxes.*
- real, dimension(:,:,:), allocatable globals::temp

  *Temperature array [K].*
- real globals::dx

  *grid spacing in X*
- real globals::dy

  *grid spacing in Y*
- real globals::dz

  *grid spacing in Z*
- integer, dimension(0:2) globals::coords

  *position of neighboring MPI blocks*
- integer globals::left

  *MPI neighbor in the -x direction.*
- integer globals::right

  *MPI neighbor in the +x direction.*
- integer globals::top

  *MPI neighbor in the -y direction.*
- integer globals::bottom

  *MPI neighbor in the +y direction.*
- integer globals::out

  *MPI neighbor in the -z direction.*
- integer globals::in

  *MPI neighbor in the +z direction.*
- integer globals::rank

  *MPI rank.*
- integer globals::comm3d

  *Cartessian MPI comunicator.*
- real globals::time

  *Current time.*
- real globals::dt_cfl

  *Current CFL $ t$.*
- integer globals::currentiteration

  *Current iteration.*

### 5.12.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.13 src/h_alpha_proj.f90 File Reference

H alpha projection.

### Modules

- module h_alpha_utilities

  *H alpha projection.*

### Functions/Subroutines

- subroutine h_alpha_utilities::init_ha ()

  *Initializes data.*
- subroutine h_alpha_utilities::read_data (u, itprint, filepath)

  *reads data from file*
- subroutine h_alpha_utilities::getxyz (i, j, k, x, y, z)

  *gets position of a cell*
- subroutine h_alpha_utilities::rotation_x (theta, x, y, z, xn, yn, zn)

  *Rotation around the X axis.*
- subroutine h_alpha_utilities::rotation_y (theta, x, y, z, xn, yn, zn)

  *Rotation around the Y axis.*
- subroutine h_alpha_utilities::rotation_z (theta, x, y, z, xn, yn, zn)

  *Rotation around the Z axis.*
- subroutine h_alpha_utilities::fill_map (nxmap, nymap, u, map, dxT, dyT, theta_x, theta_y, theta_z)

  *Fill target map.*
- subroutine h_alpha_utilities::write_ha (fileout, nxmap, nymap, map)

  *Writes projection to file.*
- subroutine h_alpha_utilities::write_rg (fileout, nxmap, nymap, map)

  *Writes projection to file in rg format.*
- program h_alpha_proj

  *Computes the H-alpha emission.*

### 5.13.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

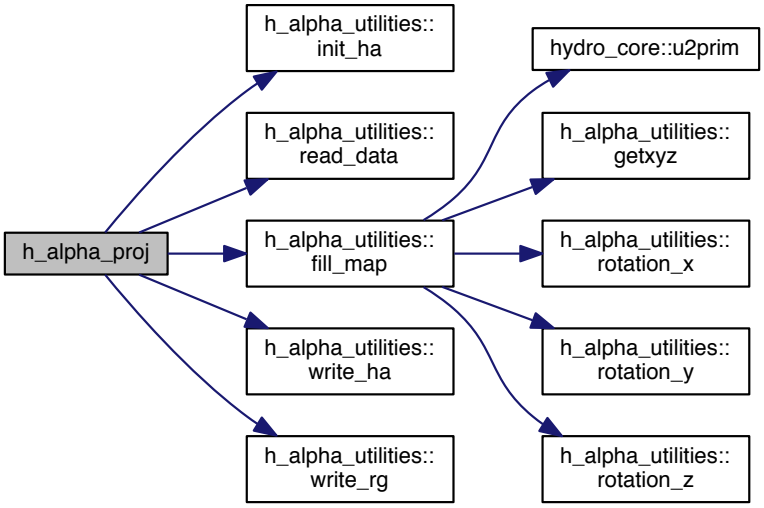
### 5.13.2 Function/Subroutine Documentation

#### 5.13.2.1 program h_alpha_proj ( )

Computes the H-alpha apbsorption
It rotates the data along each of the coordinates axis by an amount $\theta_x, \theta_y, \theta_z$, and projectcs the map along the the LOS, which is taken to be the Z axis

Definition at line 428 of file h_alpha_proj.f90.

Here is the call graph for this function:




## 5.14 src/hll.f90 File Reference

HLL approximate Riemann solver module.

### Modules

- module hll

  *HLL approximate Riemann solver module.*

### Functions/Subroutines

- subroutine hll::prim2fhll (priml, primr, ff)

  *Solves the Riemann problem at the interface PL,PR using the HLL solver.*
- subroutine hll::hllfluxes (choice)

  *Calculates HLL fluxes from the primitive variables on all the domain.*

### 5.14.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.15 src/hllc.f90 File Reference

HLLC approximate Riemann solver module.

### Modules

- module hllc

  *HLLC approximate Riemann solver module.*

### Functions/Subroutines

- subroutine hllc::prim2fhllc (priml, primr, ff)

  *Solves the Riemann problem at the interface PL,PR using the HLLC solver.*
- subroutine hllc::hllcfluxes (choice)

  *Calculates HLLC fluxes from the primitive variables on all the domain.*

### 5.15.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.16 src/hlld.f90 File Reference

HLLD approximate Riemann solver module.

### Modules

- module hlld

  *HLLD approximate Riemann solver module.*

### Functions/Subroutines

- subroutine hlld::prim2fhlld (priml, primr, ff)

  *Solves the Riemann problem at the interface PL,PR using the HLLD solver.*
- subroutine hlld::hlldfluxes (choice)

  *Calculates HLLD fluxes from the primitive variables on all the domain.*

### 5.16.1 Detailed Description

**Author**

C. Villarreal D'Angelo, A. Esquivel, M. Schneiter

**Date**

2/Nov/2014

## 5.17 src/hlle.f90 File Reference

HLLE approximate Riemann solver module.

### Modules

- module hlle

  *HLLE approximate Riemann solver module.*

### Functions/Subroutines

- subroutine hlle::prim2fhlle (priml, primr, ff)

  *Solves the Riemann problem at the interface PL,PR using the HLLE solver.*
- subroutine hlle::hllefluxes (choice)

  *Calculates HLLE fluxes from the primitive variables on all the domain.*

### 5.17.1 Detailed Description

**Author**

C. Villarreal D'Angelo, A. Esquivel, M. Schneiter

**Date**

2/Nov/2014

## 5.18 src/hydro_core.f90 File Reference

Hydrodynamical and Magnetohidrodynamocal bacic module.

### Modules

- module hydro_core

  *Basic hydro (and MHD) subroutines utilities.*

### Functions/Subroutines

- subroutine hydro_core::u2prim (uu, prim, T)

  *Computes the primitive variables and temperature from conserved variables on a single cell.*
- subroutine hydro_core::calcprim (u, primit, only_ghost)

*Updated the primitives, using the conserved variables in the entire domain.*

- subroutine hydro_core::prim2u (prim, uu)

  *Computes the conserved conserved variables from the primitives in a single cell.*
- subroutine hydro_core::prim2f (prim, ff)

  *Computes the Euler Fluxes in one cell.*
- subroutine hydro_core::swapy (var, neq)

  *Swaps the x and y components in a cell.*
- subroutine hydro_core::swapz (var, neq)

  *Swaps the x and z components in a cell.*
- subroutine hydro_core::csound (p, d, cs)

  *Computes the sound speed.*
- subroutine hydro_core::cfast (p, d, bx, by, bz, cfx, cfy, cfz)

  *Computes the fast magnetosonic speeds in the 3 coordinates.*
- subroutine hydro_core::cfastx (prim, cfX)

  *Computes the fast magnetosonic speed in the x direction.*
- subroutine hydro_core::get_timestep (current_iter, n_iter, current_time, tprint, dt, dump_flag)

  *Otains the timestep allowed by the CFL condition in the entire.*
- subroutine hydro_core::limiter (PLL, PL, PR, PRR, neq)

  *Performs a linear reconstruction of the primitive variables.*
- real function **average** (a, b)

### 5.18.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.19 src/hydro_solver.f90 File Reference

Hydrodynamical and Magnetohidrodynamocal solver module.

### Modules

- module hydro_solver

  *Advances the simulation one timestep.*

### Functions/Subroutines

- subroutine hydro_solver::viscosity ()

  *Adds artificial viscosity to the conserved variables.*
- subroutine hydro_solver::step (dt)

  *Upwind timestep.*
- subroutine hydro_solver::tstep ()

  *High level wrapper to advancce the simulation.*

### 5.19.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.20 src/init.f90 File Reference

Guacho-3D initialization module.

### Modules

- module init

  *Guacho-3D initialization.*

### Functions/Subroutines

- subroutine init::initmain (tprint, itprint)

  *Main initialization routine.*
- subroutine init::initflow (itprint)

  *Initializes the conserved variables, in the globals module.*

### 5.20.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.21 src/jet.f90 File Reference

jet module

### Modules

- module jet

  *jet module*

### Functions/Subroutines

- subroutine **jet::init_jet** ()
- subroutine **jet::impose_jet** (u, time)

### Variables

- real, save **jet::rj**
- real, save **jet::lj**
- real, save **jet::denj**
- real, save **jet::tempj**
- real, save **jet::vj0**
- real, save **jet::dvj**
- real, save **jet::tau**
- real, save **jet::omega**
- real, dimension(3), save **jet::posj**
- real, save **jet::alpha**
- real, save **jet::omegap**

#### 5.21.1 Detailed Description

**Author**

A. Esquivel

**Date**

24/Nov/2014

## 5.22 src/linear_system.f90 File Reference

linear system inversion module

### Modules

- module linear_system

  *linear system inversion module*

### Functions/Subroutines

- subroutine linear_system::ludcmp (a, n, indx, d)

  *LU decomposition.*
- subroutine linear_system::lubksb (a, n, indx, b)

  *Solves a set of linear equations.*
- subroutine linear_system::linsys (a, b, n)

  *Driver to solves a set of linear equations.*

#### 5.22.1 Detailed Description

**Author**

A. Castellanos, A. Rodriguez, A. Raga and A. Esquivel

**Date**

10/Mar/2016

## 5.23 src/lyman_alpha_tau.f90 File Reference

Lyman_alpha_utilities.

### Modules

- module lyman_alpha_utilities

  *Lyman_alpha_utilities.*

### Functions/Subroutines

- subroutine lyman_alpha_utilities::init_la ()

  *Initializes data.*
- subroutine lyman_alpha_utilities::read_data (u, itprint, filepath)

  *reads data from file*
- subroutine lyman_alpha_utilities::getxyz (i, j, k, x, y, z)

  *gets position of a cell*
- subroutine lyman_alpha_utilities::rotation_x (theta, x, y, z, xn, yn, zn)

  *Rotation around the X axis.*
- subroutine lyman_alpha_utilities::rotation_y (theta, x, y, z, xn, yn, zn)

  *Rotation around the Y axis.*
- subroutine lyman_alpha_utilities::rotation_z (theta, x, y, z, xn, yn, zn)

  *Rotation around the Z axis.*
- subroutine lyman_alpha_utilities::fill_map (nxmap, nymap, nvmap, vmin, vmax, u, map, dxT, dyT, theta_x, theta_y, theta_z)

  *Fill target map.*
- subroutine lyman_alpha_utilities::write_la (itprint, filepath, nxmap, nymap, nvmap, map)

  *Writes projection to file.*
- subroutine lyman_alpha_utilities::phigauss (T, vzn, vmin, vmax, nvmap, profile)

  *This routine computes a gaussian line profile.*
- program lyman_alpha_tau

  *Computes the Ly-alpha apbsorption.*

### 5.23.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

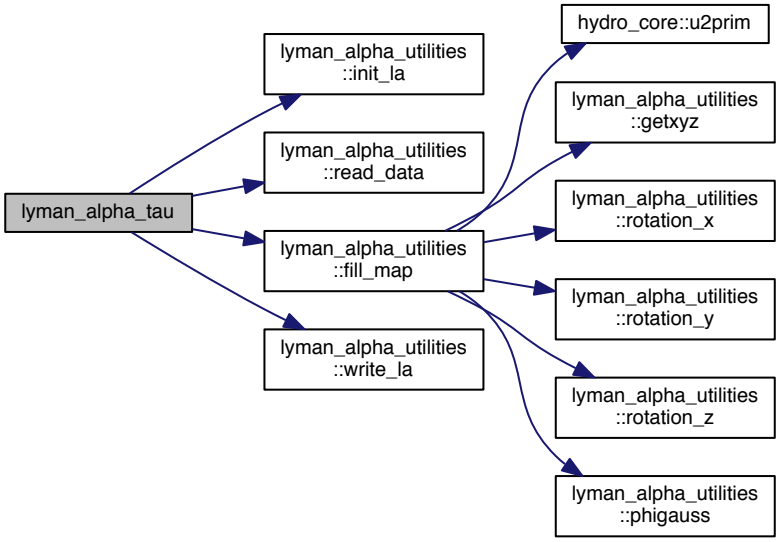
### 5.23.2 Function/Subroutine Documentation

#### 5.23.2.1 program lyman_alpha_tau ( )

Computes the Ly-alpha apbsorption
It rotates the data along each of the coordinates axis by an amount $\theta_x, \theta_y, \theta_z$, and the LOS is along the Z axis

Definition at line 419 of file lyman_alpha_tau.f90.

Here is the call graph for this function:




## 5.24 src/main.f90 File Reference

Guacho-3D main program.

### Functions/Subroutines

- program guacho

  *Guacho-3D Main Program This is the main program unit of the Guacho-3D code.*
  *The code itegrates Euler equations in three dimensions, the choice of the integration method is set in the makefile.*
  *The flow (conserved) variables are taken to be:*
  *ieq=*
  *1 : rho (total)*
  *2 : rho u*
  *3 : rho v*
  *4 : rho w*
  *5 : Internal energy (thermal+kinetic)*
  *6 : bx (optional, if MHD or PMHD)*
  *7 : by (optional, if MHD or PMHD)*
  *8 : bz (optional, if MHD or PMHD)*
  *additional variables advected into the flow, e.g.:*
  *9 (6): n_HI*
  *10 (7): n_HII*
  *11 (8): n_HeI*
  *12 (9): n_HeII*
  *13 (10): n_HeIII*
  *14 (11): rho∗zbar*
  *15 (12): ne*
  *This can be changed bu the user according to cooling function for instance.*

### 5.24.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.25 src/network.f90 File Reference

chemical network module

### Modules

- module network

  *Chemical/atomic network module.*

### Functions/Subroutines

- subroutine **network::derv** (y, rate, dydt, y0)
- subroutine **network::get_jacobian** (y, jacobian, rate)
- subroutine **network::get_reaction_rates** (rate, T)
- subroutine **network::nr_init** (y, y0)
- logical function **network::check_no_conservation** (y, y0_in)

### Variables

- integer, parameter **network::n_spec** = 4
- integer, parameter **network::nequil** = 2
- integer, parameter **network::n_elem** = 1
- integer, parameter **network::n_nequ** = n_spec - nequil
- integer, parameter **network::h** = 1
- integer, parameter **network::hp** = 2
- integer, parameter **network::h2** = 3
- integer, parameter **network::ie** = 4
- integer, parameter **network::iht** = 1
- integer, parameter **network::ihn** = 3
- integer, parameter **network::n_reac** = 8
- integer, parameter **network::ir1** = 1
- integer, parameter **network::ir2** = 2
- integer, parameter **network::ir3** = 3
- integer, parameter **network::ir4** = 4
- integer, parameter **network::ir5** = 5
- integer, parameter **network::ir6** = 6
- integer, parameter **network::ir7** = 7
- integer, parameter **network::ir8** = 8

### 5.25.1 Detailed Description

**Author**

A. Rodriguez, A. Castellanos, A. Raga and A. Esquivel

**Date**

1/Feb/2015

## 5.26 src/Out_BIN_Module.f90 File Reference

Output in BIN Format.

### Modules

- module out_bin_module

  *Output in BIN format.*

### Functions/Subroutines

- subroutine out_bin_module::write_header (unit, neq_out, nghost_out)

  *Writes header.*
- subroutine out_bin_module::write_bin (itprint)

  *Writes Data, one file per processor.*

### 5.26.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.27 src/Out_Silo_Module.f90 File Reference

Output in Silo Format.

### Modules

- module out_silo_module

  *Output in Silo (+HDF5) Format.*

### Functions/Subroutines

- subroutine out_silo_module::writeblocks (itprint)

  *Writes Data, one file per processor.*
- subroutine out_silo_module::writemaster (itprint)

*Writes the Master File.*

- subroutine out_silo_module::write_utsilo (itprint)

  *Upper level wrapper.*

### 5.27.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.28 src/Out_VTK_Module.f90 File Reference

Output in VTK Format.

### Modules

- module out_vtk_module

  *Output in VTK format.*

### Functions/Subroutines

- subroutine out_vtk_module::write_vtk (itprint)

  *Writes Data, one file per processor.*

### 5.28.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.29 src/output.f90 File Reference

Writes Output.

### Modules

- module output

  *Writes output.*

### Functions/Subroutines

- subroutine output::write_output (itprint)

  *Writes output.*

### 5.29.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.30 src/sources.f90 File Reference

Adds source terms.

### Modules

- module sources
  *Adds source terms.*

### Functions/Subroutines

- subroutine sources::getpos (i, j, k, x, y, z, r)
  *Gets position in the grid.*
- subroutine sources::grav_source (xc, yc, zc, pp, s)
  *Gravity due to point sources.*
- subroutine sources::radpress_source (i, j, k, xc, yc, zc, rc, pp, s)
  *Radiation pressure force.*
- subroutine sources::divergence_b (i, j, k, d)
  *Computes div(B)*
- subroutine sources::divbcorr_8w_source (i, j, k, pp, s)
  *8 Wave source terms for div(B) correction*
- subroutine sources::source (i, j, k, prim, s)
  *Upper level wrapper for sources.*

### 5.30.1 Detailed Description

**Author**

Alejandro Esquivel

**Date**

2/Nov/2014

## 5.31 src/thermal_cond.f90 File Reference

Thermal conduction module.

### Modules

- module thermal_cond
  *Adds thermal conducion.*

## Functions/Subroutines

- subroutine thermal_cond::init_thermal_cond ()

  *Intializes Temperature array.*
- subroutine thermal_cond::get_dt_cond (dt)

  *computes conduction timescale*
- subroutine thermal_cond::progress (j, tot)

  *Progress bar.*
- real function thermal_cond::ksp (T)

  *Spitzer conductivity.*
- real function thermal_cond::ksp_parl (xtemp)

  *Spitzer parallel conductivity.*
- real function thermal_cond::ksp_perp (xtemp, xdens, B2)

  *Spitzer perpendicular conductivity.*
- subroutine thermal_cond::heatfluxes ()

  *Returns Heat Fluxes.*
- subroutine thermal_cond::mhd_heatfluxes ()

  *Returns Heat Fluxes with anisotropic thermal conduction.*
- subroutine thermal_cond::thermal_bounds ()

  *Exchanges ghost cells for energy only.*
- real function thermal_cond::superstep (N, snu)

  *Length of superstep.*
- real function thermal_cond::substep (j, N, nu)

  *Size of substep j.*
- subroutine thermal_cond::st_steps (fs, Ns, fstep)

  *Returns the number of Supersteps.*
- subroutine thermal_cond::thermal_conduction ()

  *Upper level wrapper for thermal conduction.*

## Variables

- real, parameter thermal_cond::ph =0.4

  *Parameter for the sturated regime in McKee.*
- real, parameter thermal_cond::nu =0.01

  *Super-stepping daMPI_NBg factor.*
- real, parameter thermal_cond::snu =sqrt(nu)

  *Sqrt of damping factor.*
- integer, parameter thermal_cond::max_iter = 100

  *Maximum number of iterations.*
- real, parameter thermal_cond::tstep_red_factor =0.25

  *timestep reduction factor for the conduction*
- real thermal_cond::dt_cond

  *conduction timestep*
- integer thermal_cond::tc_log

  *loical unit to write TC log*

### 5.31.1 Detailed Description

**Author**

Alejandro Esquivel & Ernesto Zurbiggen

**Date**

07/Sep/2015

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