Phase-field Solver for Eutectic Transformation

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Chapter 1

Code-guide for solver eutectic

The solver has been successfully tested using OpenFOAM v6.

1.1 Compiling the solver

- Following commands should create the executable of the solver

  cd $FOAM_RUN/PhaseFieldSolverEutectic/eutectic

  wclean

  wmake

- The solver can be run by following the instructions in *userGuide*.

1.2 Further details

The implementation, client and header files of the solver have been written following OpenFOAM conventions. These are explained next with flow charts generated from the source code using Doxygen. It must be noted that the solver is based on `laplacianFoam` solver within OpenFOAM. Hence, it may be helpful for the user to become familiar with `OpenFOAM Programmer's Guide` and `laplacianFoam` beforehand.

Chapter 2

File Index

2.1 File List

Here is a list of all files with brief descriptions:

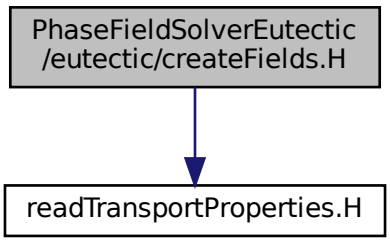
Chapter 3

File Documentation

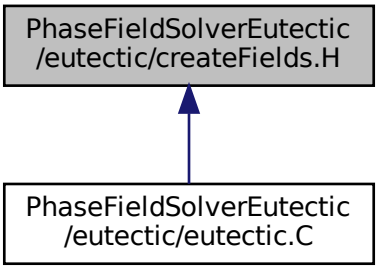
3.1 PhaseFieldSolverEutectic/eutectic/createFields.H File Reference

```
#include "readTransportProperties.H"
```

Include dependency graph for createFields.H:



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



Functions

- volScalarField phi_alpha (IOobject("phi_alpha", runTime.timeName(), mesh, IOobject::MUST_READ, IOobject::AUTO_WRITE), mesh)

  Creating phase-fields with the option to write.
- volScalarField phi_beta (IOobject("phi_beta", runTime.timeName(), mesh, IOobject::MUST_READ, IOobject::AUTO_WRITE), mesh)
- volScalarField phi_liq (IOobject("phi_liq", runTime.timeName(), mesh, IOobject::MUST_READ, IOobject::↩ AUTO_WRITE), mesh)
- volScalarField T (IOobject("T", runTime.timeName(), mesh, IOobject::MUST_READ, IOobject::AUTO_↩ WRITE), mesh)

  Creating temperature field with the option to write.
- volScalarField mu (IOobject("mu", runTime.timeName(), mesh, IOobject::MUST_READ, IOobject::AUTO_↩ WRITE), mesh)

  Creating chemical potential field with the option to write.

3.1.1 Function Documentation

3.1.1.1 phi_alpha()

```
volScalarField phi_alpha (
            IOobject("phi_alpha", runTime.timeName(), mesh, IOobject::MUST_READ, IOobject::↩
AUTO_WRITE) ,
            mesh  )
```

Creating phase-fields with the option to write.

3.1.1.2 phi_beta()

```
volScalarField phi_beta (
            IOobject("phi_beta", runTime.timeName(), mesh, IOobject::MUST_READ, IOobject::↩
AUTO_WRITE) ,
            mesh  )
```

3.1.1.3 phi_liq()

```
volScalarField phi_liq (
            IOobject("phi_liq", runTime.timeName(), mesh, IOobject::MUST_READ, IOobject::↩
AUTO_WRITE) ,
            mesh  )
```

3.1.1.4 T()

```
volScalarField T (
            IOobject("T", runTime.timeName(), mesh, IOobject::MUST_READ, IOobject::AUTO_↩
WRITE) ,
            mesh  )
```

Creating temperature field with the option to write.

Referenced by main().

Here is the caller graph for this function:

3.1.1.5 mu()

```
volScalarField mu (
            IOobject("mu", runTime.timeName(), mesh, IOobject::MUST_READ, IOobject::AUTO_↩
WRITE) ,
            mesh  )
```

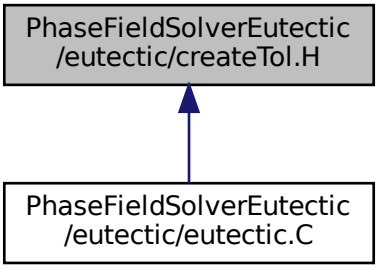
Creating chemical potential field with the option to write.

Referenced by main().

Here is the caller graph for this function:

3.2 PhaseFieldSolverEutectic/eutectic/createTol.H File Reference

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



Functions

- scalar Tol (readScalar(get_Tol_from_this.lookup("Tol")))

  Initial tolerance "Tol" within subDict "Tol_is_defined_here" in fvSolution.

Variables

- const dictionary & get_Tol_from_this = mesh.solutionDict().subDict("Tol_is_defined_here")

3.2.1 Function Documentation

3.2.1.1 Tol()

```
scalar Tol (
            readScalar(get_Tol_from_this.lookup("Tol"))  )
```

Initial tolerance "Tol" within subDict "Tol_is_defined_here" in fvSolution.

3.2.2 Variable Documentation

3.2.2.1 get_Tol_from_this

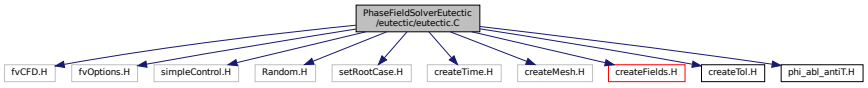
```
const dictionary& get_Tol_from_this = mesh.solutionDict().subDict("Tol_is_defined_here")
```

Definition at line 1 of file createTol.H.

3.3 PhaseFieldSolverEutectic/eutectic/eutectic.C File Reference

```
#include "fvCFD.H"
#include "fvOptions.H"
#include "simpleControl.H"
#include "Random.H"
#include "setRootCase.H"
#include "createTime.H"
#include "createMesh.H"
#include "createFields.H"
#include "createTol.H"
#include "phi_abl_antiT.H"
```

Include dependency graph for eutectic.C:



Functions

- int main (int argc, char ∗argv[ ])

3.3.1 Function Documentation

3.3.1.1 main()

```
int main (
            int argc,
            char * argv[] )
```

The imposed temperature field as a function of thermal gradient in the x direction, G

Initial tolerance to check convergence

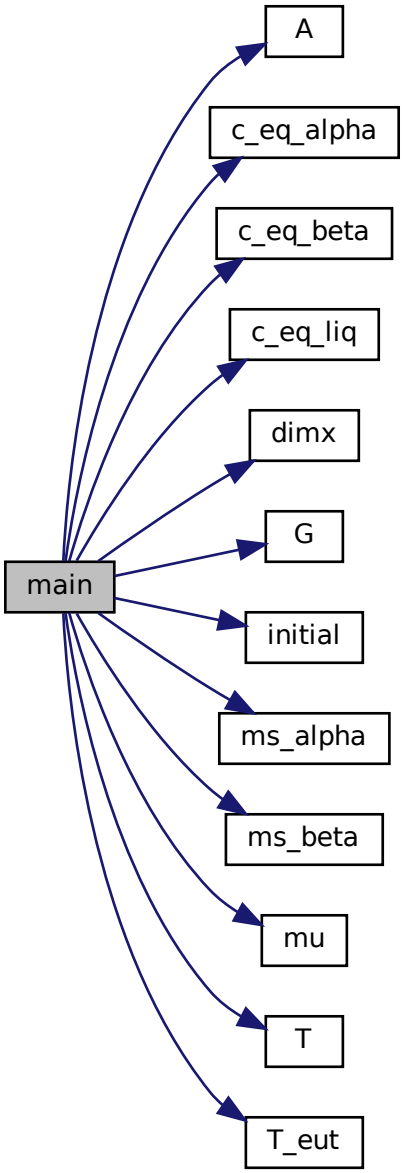
Solving the phase-field and chemical potential equations

Writing the results according to keywords in controlDict

Definition at line 39 of file eutectic.C.

References A(), c_eq_alpha(), c_eq_beta(), c_eq_liq(), dimx(), G(), initial(), ms_alpha(), ms_beta(), mu(), T(), and T_eut().

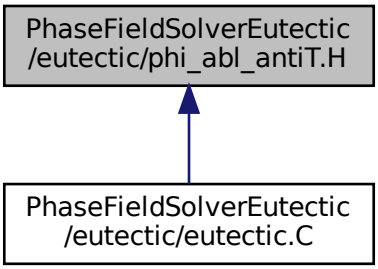
Here is the call graph for this function:



3.4 PhaseFieldSolverEutectic/eutectic/info.md File Reference

3.5 PhaseFieldSolverEutectic/eutectic/phi_abl_antiT.H File Reference

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



Functions

- fvScalarMatrix phi_alphaEqn (tau ∗epsilon ∗dimt ∗fvm::ddt(phi_alpha) - v ∗grad_alpha.component(vector↩ ::X)==(-2.0/3.0) ∗(-2.0 ∗gamma ∗epsilon ∗dimx ∗dimx ∗fvm::laplacian(phi_alpha)+9.0 ∗gamma/epsilon ∗2.↩ 0 ∗(phi_alpha) ∗(1.0-phi_alpha) ∗(1.0-2.0 ∗phi_alpha)+(-1.0/4.0 ∗(mu - B_alpha) ∗(mu - B_alpha)/A+D_↩ alpha) ∗0.25 ∗15 ∗(3.0 ∗phi_alpha ∗phi_alpha ∗phi_alpha ∗phi_alpha - 4.0 ∗phi_alpha ∗phi_alpha ∗phi_alpha - phi_alpha ∗phi_alpha+2.0 ∗phi_alpha -(phi_beta - phi_liq) ∗(phi_beta - phi_liq) ∗(2.0 ∗phi_alpha - 3.0 ∗phi_alpha ∗phi_alpha))+(-1.0/4.0 ∗(mu - B_beta) ∗(mu - B_beta)/A+D_beta) ∗-0.5 ∗15 ∗((phi_beta ∗phi_beta - phi_beta ∗phi_beta ∗phi_beta) ∗(phi_alpha - phi_liq))+(-1.0/4.0 ∗(mu - B_liq) ∗(mu - B_liq)/A+D_liq) ∗-0.5 ∗15 ∗((phi_liq ∗phi_liq - phi_liq ∗phi_liq ∗phi_liq) ∗(phi_alpha - phi_beta)))+(1.0/3.0) ∗(-2.0 ∗gamma ∗epsilon ∗dimx ∗dimx ∗fvc::laplacian(phi_liq)+9.0 ∗gamma/epsilon ∗2.0 ∗(phi_liq) ∗(1.0-phi_liq) ∗(1.0-2.↩ 0 ∗phi_liq)+(-1.0/4.0 ∗(mu - B_alpha) ∗(mu - B_alpha)/A+D_alpha) ∗-0.5 ∗15 ∗((phi_alpha ∗phi_alpha - phi_alpha ∗phi_alpha ∗phi_alpha) ∗(phi_liq - phi_beta))+(-1.0/4.0 ∗(mu - B_beta) ∗(mu - B_beta)/A+D_beta) ∗-0.5 ∗15 ∗((phi_beta ∗phi_beta - phi_beta ∗phi_beta ∗phi_beta) ∗(phi_liq - phi_alpha))+(-1.0/4.0 ∗(mu - B↩ _liq) ∗(mu - B_liq)/A+D_liq) ∗0.25 ∗15 ∗(3.0 ∗phi_liq ∗phi_liq ∗phi_liq ∗phi_liq - 4.0 ∗phi_liq ∗phi_liq ∗phi_liq - phi_liq ∗phi_liq+2.0 ∗phi_liq -(phi_alpha - phi_beta) ∗(phi_alpha - phi_beta) ∗(2.0 ∗phi_liq - 3.0 ∗phi_liq ∗phi_liq)))+(1.0/3.0) ∗(-2.0 ∗gamma ∗epsilon ∗dimx ∗dimx ∗fvc::laplacian(phi_beta)+9.0 ∗gamma/epsilon ∗2.0 ∗(phi_beta) ∗(1.0-phi_beta) ∗(1.0-2.0 ∗phi_beta)+(-1.0/4.0 ∗(mu - B_alpha) ∗(mu - B_alpha)/A+D_alpha) ∗-0.5 ∗15 ∗((phi_alpha ∗phi_alpha - phi_alpha ∗phi_alpha ∗phi_alpha) ∗(phi_beta - phi_liq))+(-1.0/4.0 ∗(mu - B_beta) ∗(mu - B_beta)/A+D_beta) ∗0.25 ∗15 ∗(3.0 ∗phi_beta ∗phi_beta ∗phi_beta ∗phi_beta - 4.0 ∗phi_beta ∗phi_beta ∗phi_beta - phi_beta ∗phi_beta+2.0 ∗phi_beta -(phi_liq - phi_alpha) ∗(phi_liq - phi_alpha) ∗(2.↩ 0 ∗phi_beta - 3.0 ∗phi_beta ∗phi_beta))+(-1.0/4.0 ∗(mu - B_liq) ∗(mu - B_liq)/A+D_liq) ∗-0.5 ∗15 ∗((phi_liq ∗phi_liq - phi_liq ∗phi_liq ∗phi_liq) ∗(phi_beta - phi_alpha))))
- fvScalarMatrix phi_betaEqn (tau ∗epsilon ∗dimt ∗fvm::ddt(phi_beta) - v ∗grad_beta.component(vector↩ ::X)==(-2.0/3.0) ∗(-2.0 ∗gamma ∗epsilon ∗dimx ∗dimx ∗fvm::laplacian(phi_beta)+9.0 ∗gamma/epsilon ∗2.0 ∗(phi_beta) ∗(1.0-phi_beta) ∗(1.0-2.0 ∗phi_beta)+(-1.0/4.0 ∗(mu - B_alpha) ∗(mu - B_alpha)/A+D_alpha) ∗-0.5 ∗15 ∗((phi_alpha ∗phi_alpha - phi_alpha ∗phi_alpha ∗phi_alpha) ∗(phi_beta - phi_liq))+(-1.0/4.0 ∗(mu - B_beta) ∗(mu - B_beta)/A+D_beta) ∗0.25 ∗15 ∗(3.0 ∗phi_beta ∗phi_beta ∗phi_beta ∗phi_beta - 4.0 ∗phi_beta ∗phi_beta ∗phi_beta - phi_beta ∗phi_beta+2.0 ∗phi_beta -(phi_liq - phi_alpha) ∗(phi_liq - phi_alpha) ∗(2.↩ 0 ∗phi_beta - 3.0 ∗phi_beta ∗phi_beta))+(-1.0/4.0 ∗(mu - B_liq) ∗(mu - B_liq)/A+D_liq) ∗-0.5 ∗15 ∗((phi_liq ∗phi_liq - phi_liq ∗phi_liq ∗phi_liq) ∗(phi_beta - phi_alpha)))+(1.0/3.0) ∗(-2.0 ∗gamma ∗epsilon ∗dimx ∗dimx ∗fvc::laplacian(phi_liq)+9.0 ∗gamma/epsilon ∗2.0 ∗(phi_liq) ∗(1.0-phi_liq) ∗(1.0-2.0 ∗phi_liq)+(-1.0/4.0 ∗(mu -

B_alpha) ∗(mu - B_alpha)/A+D_alpha) ∗-0.5 ∗15 ∗((phi_alpha ∗phi_alpha - phi_alpha ∗phi_alpha ∗phi_alpha) ∗(phi_liq - phi_beta))+(-1.0/4.0 ∗(mu - B_beta) ∗(mu - B_beta)/A+D_beta) ∗-0.5 ∗15 ∗((phi_beta ∗phi_beta - phi_beta ∗phi_beta ∗phi_beta) ∗(phi_liq - phi_alpha))+(-1.0/4.0 ∗(mu - B_liq) ∗(mu - B_liq)/A+D_liq) ∗0.25 ∗15 ∗(3.0 ∗phi_liq ∗phi_liq ∗phi_liq ∗phi_liq - 4.0 ∗phi_liq ∗phi_liq ∗phi_liq - phi_liq ∗phi_liq+2.0 ∗phi_liq - (phi_alpha - phi_beta) ∗(phi_alpha - phi_beta) ∗(2.0 ∗phi_liq - 3.0 ∗phi_liq ∗phi_liq)))+(1.0/3.0) ∗(-2.0 ∗gamma ∗epsilon ∗dimx ∗dimx ∗fvc::laplacian(phi_alpha)+9.0 ∗gamma/epsilon ∗2.0 ∗(phi_alpha) ∗(1.0-phi_alpha) ∗(1.0-2.0 ∗phi_alpha)+(-1.0/4.0 ∗(mu - B_alpha) ∗(mu - B_alpha)/A+D_alpha) ∗0.25 ∗15 ∗(3.0 ∗phi_alpha ∗phi_alpha ∗phi_alpha ∗phi_alpha - 4.0 ∗phi_alpha ∗phi_alpha ∗phi_alpha - phi_alpha ∗phi_alpha+2.0 ∗phi_alpha -(phi_beta - phi_liq) ∗(phi_beta - phi_liq) ∗(2.0 ∗phi_alpha - 3.0 ∗phi_alpha ∗phi_alpha))+(-1.0/4.0 ∗(mu - B_beta) ∗(mu - B_beta)/A+D_beta) ∗-0.5 ∗15 ∗((phi_beta ∗phi_beta - phi_beta ∗phi_beta ∗phi_beta) ∗(phi_alpha - phi_liq))+(-1.0/4.0 ∗(mu - B_liq) ∗(mu - B_liq)/A+D_liq) ∗-0.5 ∗15 ∗((phi_liq ∗phi_liq - phi_liq ∗phi_liq ∗phi_liq) ∗(phi_alpha - phi_beta))))

- fvScalarMatrix phi_liqEqn (tau ∗epsilon ∗dimt ∗fvm::ddt(phi_liq) - v ∗grad_liq.component(vector::X)==(-2.0/3.0) ∗(-2.0 ∗gamma ∗epsilon ∗dimx ∗dimx ∗fvm::laplacian(phi_liq)+9.0 ∗gamma/epsilon ∗2.0 ∗(phi_liq) ∗(1.0-phi_liq) ∗(1.0-2.0 ∗phi_liq)+(-1.0/4.0 ∗(mu - B_alpha) ∗(mu - B_alpha)/A+D_alpha) ∗-0.5 ∗15 ∗((phi_alpha ∗phi_alpha - phi_alpha ∗phi_alpha ∗phi_alpha) ∗(phi_liq - phi_beta))+(-1.0/4.0 ∗(mu - B_beta) ∗(mu - B_beta)/A+D_beta) ∗-0.5 ∗15 ∗((phi_beta ∗phi_beta - phi_beta ∗phi_beta ∗phi_beta) ∗(phi_liq - phi_alpha))+(-1.0/4.0 ∗(mu - B_liq) ∗(mu - B_liq)/A+D_liq) ∗0.25 ∗15 ∗(3.0 ∗phi_liq ∗phi_liq ∗phi_liq ∗phi_liq - 4.0 ∗phi_liq ∗phi_liq ∗phi_liq - phi_liq ∗phi_liq+2.0 ∗phi_liq -(phi_alpha - phi_beta) ∗(phi_alpha - phi_beta) ∗(2.0 ∗phi_liq - 3.0 ∗phi_liq ∗phi_liq)))+(1.0/3.0) ∗(-2.0 ∗gamma ∗epsilon ∗dimx ∗dimx ∗fvc::laplacian(phi_alpha)+9.0 ∗gamma/epsilon ∗2.0 ∗(phi_alpha) ∗(1.0-phi_alpha) ∗(1.0-2.0 ∗phi_alpha)+(-1.0/4.0 ∗(mu - B_alpha) ∗(mu - B_alpha)/A+D_alpha) ∗0.25 ∗15 ∗(3.0 ∗phi_alpha ∗phi_alpha ∗phi_alpha ∗phi_alpha - 4.0 ∗phi_alpha ∗phi_alpha ∗phi_alpha - phi_alpha ∗phi_alpha+2.0 ∗phi_alpha -(phi_beta - phi_liq) ∗(phi_beta - phi_liq) ∗(2.0 ∗phi_alpha - 3.0 ∗phi_alpha ∗phi_alpha))+(-1.0/4.0 ∗(mu - B_beta) ∗(mu - B_beta)/A+D_beta) ∗-0.5 ∗15 ∗((phi_beta ∗phi_beta - phi_beta ∗phi_beta ∗phi_beta) ∗(phi_alpha - phi_liq))+(-1.0/4.0 ∗(mu - B_liq) ∗(mu - B_liq)/A+D_liq) ∗-0.5 ∗15 ∗((phi_liq ∗phi_liq - phi_liq ∗phi_liq ∗phi_liq) ∗(phi_alpha - phi_beta)))+(1.0/3.0) ∗(-2.0 ∗gamma ∗epsilon ∗dimx ∗dimx ∗fvc::laplacian(phi_beta)+9.0 ∗gamma/epsilon ∗2.0 ∗(phi_beta) ∗(1.0-phi_beta) ∗(1.0-2.0 ∗phi_beta)+(-1.0/4.0 ∗(mu - B_alpha) ∗(mu - B_alpha)/A+D_alpha) ∗-0.5 ∗15 ∗((phi_alpha ∗phi_alpha - phi_alpha ∗phi_alpha ∗phi_alpha) ∗(phi_beta - phi_liq))+(-1.0/4.0 ∗(mu - B_beta) ∗(mu - B_beta)/A+D_beta) ∗0.25 ∗15 ∗(3.0 ∗phi_beta ∗phi_beta ∗phi_beta ∗phi_beta - 4.0 ∗phi_beta ∗phi_beta ∗phi_beta - phi_beta ∗phi_beta+2.0 ∗phi_beta -(phi_liq - phi_alpha) ∗(phi_liq - phi_alpha) ∗(2.0 ∗phi_beta - 3.0 ∗phi_beta ∗phi_beta))+(-1.0/4.0 ∗(mu - B_liq) ∗(mu - B_liq)/A+D_liq) ∗-0.5 ∗15 ∗((phi_liq ∗phi_liq - phi_liq ∗phi_liq ∗phi_liq) ∗(phi_beta - phi_alpha))))
- while ((initial_residual_alpha.value() > Tol||initial_residual_beta.value() > Tol||initial_residual_liq.value() > Tol) &&counter< 100)

Variables

- dimensionedScalar initial_residual_alpha = phi_alphaEqn.solve().max().initialResidual()
- dimensionedScalar initial_residual_beta = phi_betaEqn.solve().max().initialResidual()
- dimensionedScalar initial_residual_liq = phi_liqEqn.solve().max().initialResidual()
- scalar counter = 0
- do
- volVectorField grad_beta =dimx∗fvc::grad(phi_beta)
- volVectorField grad_liq =dimx∗fvc::grad(phi_liq)

3.5.1 Function Documentation

3.5.1.1 phi_alphaEqn()

```
fvScalarMatrix phi_alphaEqn (
            tau *epsilon *dimt * fvm::ddtphi_alpha) - v *grad_alpha.component(vector::X =
=(-2.0/3.0) *(-2.0 *gamma *epsilon *dimx *dimx *fvm::laplacian(phi_alpha)+9.0 *gamma/epsilon *2.0 *(phi_alpha)
_alpha) *(mu - B_alpha)/A+D_alpha) *0.25 *15 *(3.0 *phi_alpha *phi_alpha *phi_alpha *phi_alpha - 4.0 *phi_alpha
_beta) *(mu - B_beta)/A+D_beta) *-0.5 *15 *((phi_beta *phi_beta - phi_beta *phi_beta *phi_beta) *(phi_alpha - p
_liq) *(mu - B_liq)/A+D_liq) *-0.5 *15 *((phi_liq *phi_liq - phi_liq *phi_liq *phi_liq) *(phi_alpha - phi_beta)
::laplacian(phi_liq)+9.0 *gamma/epsilon *2.0 *(phi_liq) *(1.0-phi_liq) *(1.0-2.0 *phi_liq)+(-1.0/4.0 *(mu - B←
_alpha) *(mu - B_alpha)/A+D_alpha) *-0.5 *15 *((phi_alpha *phi_alpha - phi_alpha *phi_alpha *phi_alpha) *(phi_l
_beta) *(mu - B_beta)/A+D_beta) *-0.5 *15 *((phi_beta *phi_beta - phi_beta *phi_beta *phi_beta) *(phi_liq - phi
_liq) *(mu - B_liq)/A+D_liq) *0.25 *15 *(3.0 *phi_liq *phi_liq *phi_liq *phi_liq - 4.0 *phi_liq *phi_liq *phi_l
::laplacian(phi_beta)+9.0 *gamma/epsilon *2.0 *(phi_beta) *(1.0-phi_beta) *(1.0-2.0 *phi_beta)+(-1.0/4.0 *(mu
_alpha) *(mu - B_alpha)/A+D_alpha) *-0.5 *15 *((phi_alpha *phi_alpha - phi_alpha *phi_alpha *phi_alpha) *(phi_b
_beta) *(mu - B_beta)/A+D_beta) *0.25 *15 *(3.0 *phi_beta *phi_beta *phi_beta *phi_beta - 4.0 *phi_beta *phi_be
_liq) *(mu - B_liq)/A+D_liq) *-0.5 *15 *((phi_liq *phi_liq - phi_liq *phi_liq *phi_liq) *(phi_beta - phi_alpha)
)
```

3.5.1.2 phi_betaEqn()

```
fvScalarMatrix phi_betaEqn (
            tau *epsilon *dimt * fvm::ddtphi_beta) - v *grad_beta.component(vector::X = =(-2.0/3.0) *(-2.0 *ga
::laplacian(phi_beta)+9.0 *gamma/epsilon *2.0 *(phi_beta) *(1.0-phi_beta) *(1.0-2.0 *phi_beta)+(-1.0/4.0 *(mu
_alpha) *(mu - B_alpha)/A+D_alpha) *-0.5 *15 *((phi_alpha *phi_alpha - phi_alpha *phi_alpha *phi_alpha) *(phi_b
_beta) *(mu - B_beta)/A+D_beta) *0.25 *15 *(3.0 *phi_beta *phi_beta *phi_beta *phi_beta - 4.0 *phi_beta *phi_be
_liq) *(mu - B_liq)/A+D_liq) *-0.5 *15 *((phi_liq *phi_liq - phi_liq *phi_liq *phi_liq) *(phi_beta - phi_alpha)
::laplacian(phi_liq)+9.0 *gamma/epsilon *2.0 *(phi_liq) *(1.0-phi_liq) *(1.0-2.0 *phi_liq)+(-1.0/4.0 *(mu - B←
_alpha) *(mu - B_alpha)/A+D_alpha) *-0.5 *15 *((phi_alpha *phi_alpha - phi_alpha *phi_alpha *phi_alpha) *(phi_l
_beta) *(mu - B_beta)/A+D_beta) *-0.5 *15 *((phi_beta *phi_beta - phi_beta *phi_beta *phi_beta) *(phi_liq - phi
_liq) *(mu - B_liq)/A+D_liq) *0.25 *15 *(3.0 *phi_liq *phi_liq *phi_liq *phi_liq - 4.0 *phi_liq *phi_liq *phi_l
::laplacian(phi_alpha)+9.0 *gamma/epsilon *2.0 *(phi_alpha) *(1.0-phi_alpha) *(1.0-2.0 *phi_alpha)+(-1.0/4.0 *
_alpha) *(mu - B_alpha)/A+D_alpha) *0.25 *15 *(3.0 *phi_alpha *phi_alpha *phi_alpha *phi_alpha - 4.0 *phi_alpha
_beta) *(mu - B_beta)/A+D_beta) *-0.5 *15 *((phi_beta *phi_beta - phi_beta *phi_beta *phi_beta) *(phi_alpha - p
_liq) *(mu - B_liq)/A+D_liq) *-0.5 *15 *((phi_liq *phi_liq - phi_liq *phi_liq *phi_liq) *(phi_alpha - phi_beta)
)
```

3.5.1.3 phi_liqEqn()

```
fvScalarMatrix phi_liqEqn (
            tau *epsilon *dimt * fvm::ddtphi_liq) - v *grad_liq.component(vector::X = =(-2.0/3.0) *(-2.0 *gamm
::laplacian(phi_liq)+9.0 *gamma/epsilon *2.0 *(phi_liq) *(1.0-phi_liq) *(1.0-2.0 *phi_liq)+(-1.0/4.0 *(mu - B←
_alpha) *(mu - B_alpha)/A+D_alpha) *-0.5 *15 *((phi_alpha *phi_alpha - phi_alpha *phi_alpha *phi_alpha) *(phi_l
_beta) *(mu - B_beta)/A+D_beta) *-0.5 *15 *((phi_beta *phi_beta - phi_beta *phi_beta *phi_beta) *(phi_liq - phi
_liq) *(mu - B_liq)/A+D_liq) *0.25 *15 *(3.0 *phi_liq *phi_liq *phi_liq *phi_liq - 4.0 *phi_liq *phi_liq *phi_l
::laplacian(phi_alpha)+9.0 *gamma/epsilon *2.0 *(phi_alpha) *(1.0-phi_alpha) *(1.0-2.0 *phi_alpha)+(-1.0/4.0 *
_alpha) *(mu - B_alpha)/A+D_alpha) *0.25 *15 *(3.0 *phi_alpha *phi_alpha *phi_alpha *phi_alpha - 4.0 *phi_alpha
_beta) *(mu - B_beta)/A+D_beta) *-0.5 *15 *((phi_beta *phi_beta - phi_beta *phi_beta *phi_beta) *(phi_alpha - p
_liq) *(mu - B_liq)/A+D_liq) *-0.5 *15 *((phi_liq *phi_liq - phi_liq *phi_liq *phi_liq) *(phi_alpha - phi_beta)
::laplacian(phi_beta)+9.0 *gamma/epsilon *2.0 *(phi_beta) *(1.0-phi_beta) *(1.0-2.0 *phi_beta)+(-1.0/4.0 *(mu
_alpha) *(mu - B_alpha)/A+D_alpha) *-0.5 *15 *((phi_alpha *phi_alpha - phi_alpha *phi_alpha *phi_alpha) *(phi_b
_beta) *(mu - B_beta)/A+D_beta) *0.25 *15 *(3.0 *phi_beta *phi_beta *phi_beta *phi_beta - 4.0 *phi_beta *phi_be
_liq) *(mu - B_liq)/A+D_liq) *-0.5 *15 *((phi_liq *phi_liq - phi_liq *phi_liq *phi_liq) *(phi_beta - phi_alpha)
)
```

3.5.1.4 while()

```
while ( )
```

3.5.2 Variable Documentation

3.5.2.1 initial_residual_alpha

```
initial_residual_alpha = phi_alphaEqn.solve().max().initialResidual()
```

Definition at line 2 of file phi_abl_antiT.H.

3.5.2.2 initial_residual_beta

```
initial_residual_beta = phi_betaEqn.solve().max().initialResidual()
```

Definition at line 3 of file phi_abl_antiT.H.

3.5.2.3 initial_residual_liq

```
initial_residual_liq = phi_liqEqn.solve().max().initialResidual()
```

Definition at line 4 of file phi_abl_antiT.H.

3.5.2.4 counter

```
counter = 0
```

Definition at line 5 of file phi_abl_antiT.H.

3.5.2.5 do

```
do
```

Initial value:

```
{
    volVectorField grad_alpha =dimx*fvc::grad(phi_alpha)
```

Implicit discretization using fvm class for time derivative and laplacian. Explicit discretization using fvc class for gradient and divergence. Phase-field equations with approximate relation between c, mu and T according to the parabolic approximation for free energy

Definition at line 9 of file phi_abl_antiT.H.

3.5.2.6 grad_beta

```
volVectorField grad_beta =dimx*fvc::grad(phi_beta)
```

Definition at line 11 of file phi_abl_antiT.H.

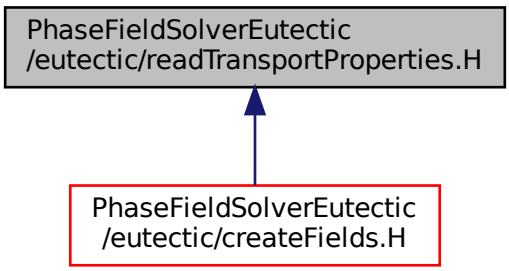
3.5.2.7 grad_liq

```
volVectorField grad_liq =dimx*fvc::grad(phi_liq)
```

Definition at line 12 of file phi_abl_antiT.H.

3.6 PhaseFieldSolverEutectic/eutectic/readTransportProperties.H File Reference

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



Functions

- IOdictionary transportProperties (IOobject("transportProperties", runTime.constant(), mesh, IOobject::↩ MUST_READ, IOobject::NO_WRITE))

  The input properties to be exported to createFields.
- dimensionedScalar dimt (transportProperties.lookup("dimt"))

  The input properties are read from constant/transportProperties dictionary.
- dimensionedScalar dimx (transportProperties.lookup("dimx"))

  Dimension of position.
- dimensionedScalar ms_alpha (transportProperties.lookup("ms_alpha"))

  Slope liq-alpha and alpha-liq.
- dimensionedScalar ms_beta (transportProperties.lookup("ms_beta"))

  Slope liq-beta and beta-liq.
- dimensionedScalar c_eq_liq (transportProperties.lookup("c_eq_liq"))

Eutectic composition of liquid phase.

- dimensionedScalar c_eq_alpha (transportProperties.lookup("c_eq_alpha"))

  Eutectic composition of alpha phase.
- dimensionedScalar c_eq_beta (transportProperties.lookup("c_eq_beta"))

  Eutectic composition of beta phase.
- dimensionedScalar G (transportProperties.lookup("G"))

  Thermal gradient.
- dimensionedScalar v (transportProperties.lookup("v"))

  Velocity.
- dimensionedScalar A (transportProperties.lookup("A"))
- dimensionedScalar D (transportProperties.lookup("D"))

  Diffusivity in liquid.
- dimensionedScalar T_eut (transportProperties.lookup("T_eut"))

  Eutectic temperature.
- dimensionedScalar initial (transportProperties.lookup("initial"))

  Constant value from temperature profile.
- dimensionedScalar tau (transportProperties.lookup("tau"))

  Relaxation coefficient.
- dimensionedScalar gamma (transportProperties.lookup("gamma"))

  Interface energy parameter.
- dimensionedScalar epsilon (transportProperties.lookup("epsilon"))

  Interface width parameter.

3.6.1 Function Documentation

3.6.1.1 transportProperties()

```
IOdictionary transportProperties (
            IOobject("transportProperties", runTime.constant(), mesh, IOobject::MUST_READ,
IOobject::NO_WRITE)  )
```

The input properties to be exported to createFields.

3.6.1.2 dimt()

```
dimensionedScalar dimt (
            transportProperties.  lookup"dimt" )
```

The input properties are read from constant/transportProperties dictionary.

Dimension of time

3.6.1.3 dimx()

```
dimensionedScalar dimx (
            transportProperties.  lookup"dimx" )
```

Dimension of position.

Referenced by main().

Here is the caller graph for this function:

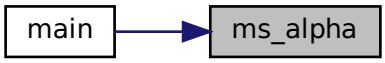
3.6.1.4 ms_alpha()

```
dimensionedScalar ms_alpha (
            transportProperties.  lookup"ms_alpha" )
```

Slope liq-alpha and alpha-liq.

Referenced by main().

Here is the caller graph for this function:



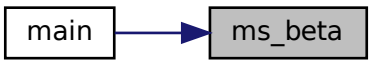
3.6.1.5 ms_beta()

```
dimensionedScalar ms_beta (
            transportProperties.  lookup"ms_beta" )
```

Slope liq-beta and beta-liq.

Referenced by main().

Here is the caller graph for this function:



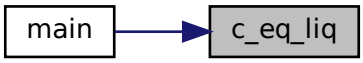
3.6.1.6 c_eq_liq()

```
dimensionedScalar c_eq_liq (
            transportProperties.  lookup"c_eq_liq" )
```

Eutectic composition of liquid phase.

Referenced by main().

Here is the caller graph for this function:



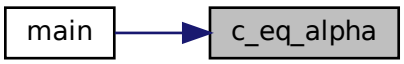
3.6.1.7 c_eq_alpha()

```
dimensionedScalar c_eq_alpha (
            transportProperties.  lookup"c_eq_alpha" )
```

Eutectic composition of alpha phase.

Referenced by main().

Here is the caller graph for this function:



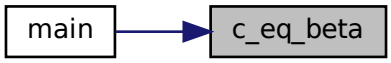
3.6.1.8 c_eq_beta()

```
dimensionedScalar c_eq_beta (
            transportProperties.  lookup"c_eq_beta" )
```

Eutectic composition of beta phase.

Referenced by main().

Here is the caller graph for this function:



3.6.1.9 G()

```
dimensionedScalar G (
            transportProperties.  lookup"G" )
```

Thermal gradient.

Referenced by main().

Here is the caller graph for this function:

3.6.1.10 v()

```
dimensionedScalar v (
            transportProperties.  lookup"v" )
```

Velocity.

3.6.1.11 A()

```
dimensionedScalar A (
            transportProperties.  lookup"A" )
```

Referenced by main().

Here is the caller graph for this function:

3.6.1.12 D()

```
dimensionedScalar D (
            transportProperties.  lookup"D" )
```

Diffusivity in liquid.

3.6.1.13 T_eut()

```
dimensionedScalar T_eut (
            transportProperties.  lookup"T_eut" )
```

Eutectic temperature.

Referenced by main().

Here is the caller graph for this function:

3.6.1.14 initial()

```
dimensionedScalar initial (
            transportProperties.  lookup"initial" )
```

Constant value from temperature profile.

Referenced by main().

Here is the caller graph for this function:

3.6.1.15 tau()

```
dimensionedScalar tau (
            transportProperties.  lookup"tau" )
```

Relaxation coefficient.

3.6.1.16 gamma()

```
dimensionedScalar gamma (
            transportProperties.  lookup"gamma" )
```

Interface energy parameter.

3.6.1.17 epsilon()

```
dimensionedScalar epsilon (
            transportProperties.  lookup"epsilon" )
```

Interface width parameter.

3.7 PhaseFieldSolverEutectic/eutectic/set_delta_t.H File Reference

Functions

- runTime setDeltaT (min(deltaTFactor ∗runTime.deltaTValue(), maxDeltaT))

Variables

- dimensionedScalar maxResidual = 1e-7

  Timestep reduction for improving convergence.
- dimensionedScalar maxDeltaT = 1
- dimensionedScalar maxDeltaTFactor = maxResidual/(initial_residual_liq)
- dimensionedScalar deltaTFactor = min(min(maxDeltaTFactor, 1.0 + 0.1∗maxDeltaTFactor), 1.↩ 2∗(maxDeltaTFactor/maxDeltaTFactor))

3.7.1 Function Documentation

3.7.1.1 setDeltaT()

```
runTime setDeltaT (
            min(deltaTFactor *runTime.deltaTValue(), maxDeltaT)  )
```

3.7.2 Variable Documentation

3.7.2.1 maxResidual

```
dimensionedScalar maxResidual = 1e-7
```

Timestep reduction for improving convergence.

Definition at line 36 of file set_delta_t.H.

3.7.2.2 maxDeltaT

```
dimensionedScalar maxDeltaT = 1
```

Definition at line 37 of file set_delta_t.H.

3.7.2.3 maxDeltaTFactor

```
dimensionedScalar maxDeltaTFactor = maxResidual/( initial_residual_liq)
```

Definition at line 38 of file set_delta_t.H.

3.7.2.4 deltaTFactor

```
dimensionedScalar deltaTFactor = min(min(maxDeltaTFactor, 1.0 + 0.1*maxDeltaTFactor), 1.↩
2*(maxDeltaTFactor/maxDeltaTFactor) )
```

Definition at line 39 of file set_delta_t.H.

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