spacex

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5.1 File List

Here is a list of all files with brief descriptions:

6 Namespace Documentation

6.1 chain Namespace Reference

Classes

- struct Node

  Struture to store the relative distance and index of two particles.

Typedefs

- template<typename Scalar , size_t N>
  using VectorArray = std::array< vec3< Scalar >, N >
- template<size_t N>
  using IndexArray = std::array< size_t, N >
- template<typename Scalar , size_t N>
  using NodeArray = std::array< Node< Scalar >, N >

Functions

- template<typename Scalar , size_t N>
  void getChainIndex (const VectorArray< Scalar, N > &pos, IndexArray< N > &chainIndex)

  Calculate the mapping index from Cartesian coordinate to chain coordinate.
- template<typename Scalar , size_t N>
  void createAdjMartix (const VectorArray< Scalar, N > &pos, NodeArray< Scalar, N $*$(N - 1)/2 > &Adj↩ Matrix)

  Create the adjoint matrix for particle pairs.
- template<typename Scalar , size_t N>
  void createChainIndex (NodeArray< Scalar, N $*$(N - 1)/2 > &AdjMatrix, IndexArray< N > &chainIndex)

  Create mapping index from adjoint matrix.
- template<size_t N>
  bool IsDiff (const IndexArray< N > &Index1, const IndexArray< N > &Index2)

  Check if two mapping indexes are the same.
- template<typename Scalar , size_t N>
  void updateChain (VectorArray< Scalar, N > &pos, IndexArray< N > &chainIndex, IndexArray< N > &newIndex)

  Update the position chain.
- template<typename Scalar , size_t N>
  void synChain (VectorArray< Scalar, N > &data, VectorArray< Scalar, N > &chainData, IndexArray< N > &chainIndex)

  Calulate the chain data from Cartesian data and chain index mapping.
- template<typename Scalar , size_t N>
  void synCartesian (VectorArray< Scalar, N > &chainData, VectorArray< Scalar, N > &data, IndexArray< N > &chainIndex)

  Calulate the Cartesian data from chain data and chain index mapping.

6.1.1 Typedef Documentation

6.1.1.1 IndexArray

```
template<size_t N>
using chain::IndexArray = typedef std::array<size_t, N>
```

6.1.1.2 NodeArray

```
template<typename Scalar , size_t N>
using chain::NodeArray = typedef std::array<Node<Scalar>, N>
```

6.1.1.3 VectorArray

```
template<typename Scalar , size_t N>
using chain::VectorArray = typedef std::array<vec3<Scalar>, N>
```

6.1.2 Function Documentation

6.1.2.1 createAdjMartix()

```
template<typename Scalar , size_t N>
void chain::createAdjMartix (
             const VectorArray< Scalar, N > & pos,
             NodeArray< Scalar, N *(N - 1)/2 > & AdjMatrix )
```

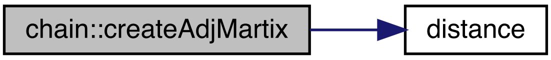
Create the adjoint matrix for particle pairs.

Create the adjoint matrix(distance of particle pairs organized by index-index matrix).

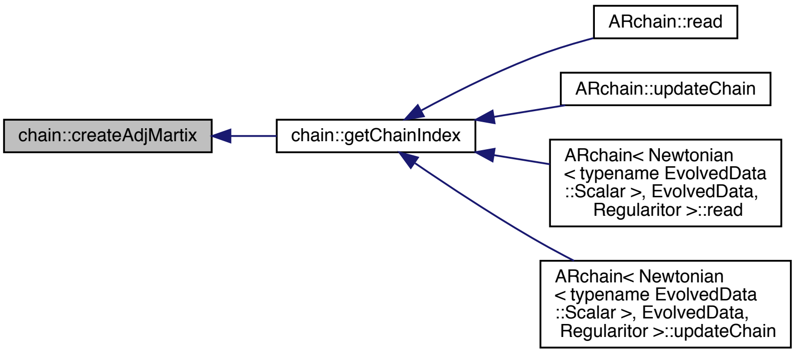
Parameters

pos	The array of particle position, used to calculate the distance of particle pairs.
AdjMatrix	The adjoint matrix needs to be calculated as a return value.

Here is the call graph for this function:



Here is the caller graph for this function:


chain::createAdjMartix
chain::getChainIndex
ARchain::read
ARchain::updateChain
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::read
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::updateChain

6.1.2.2 createChainIndex()

```
template<typename Scalar , size_t N>
void chain::createChainIndex (
             NodeArray< Scalar, N *(N - 1)/2 > & AdjMatrix,
             IndexArray< N > & chainIndex )
```

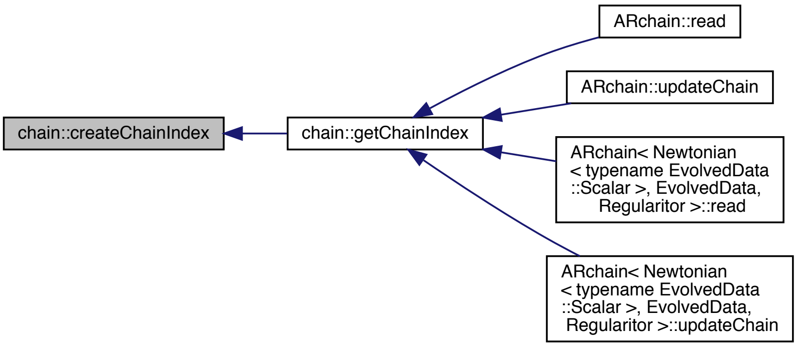
Create mapping index from adjoint matrix.

Create mapping index from sorted elements of adjoint matrix and connect them to a chain consequently.

Parameters

AdjMatrix	The adjoint matrix.
chainIndex	The maping index needs to be calculated as a return value.

Here is the caller graph for this function:


chain::createChainIndex
chain::getChainIndex
ARchain::read
ARchain::updateChain
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::read
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::updateChain

6.1.2.3 getChainIndex()

```
template<typename Scalar , size_t N>
void chain::getChainIndex (
             const VectorArray< Scalar, N > & pos,
             IndexArray< N > & chainIndex )
```

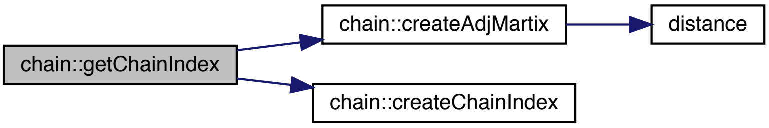
Calculate the mapping index from Cartesian coordinate to chain coordinate.

Find the mapping index from Cartesian coordinate to chain coordinate. The chain is formed by connecting the nearest particle pairs consequently.

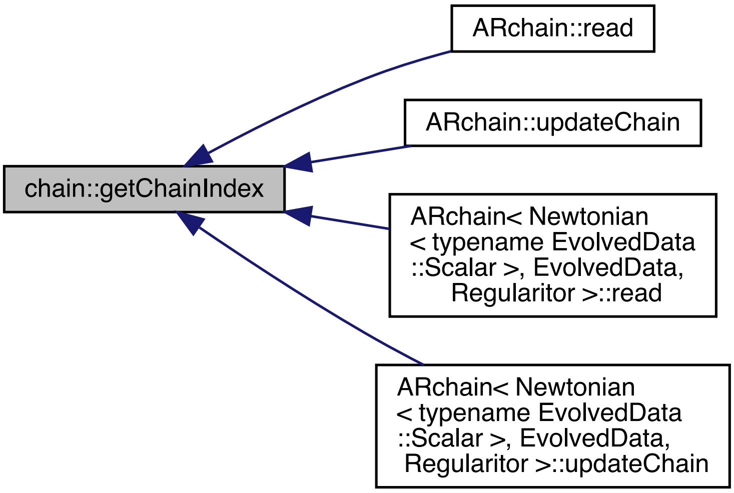
Parameters

pos	The array of particle position, used to calculate the distance of particle pairs.
chainIndex	The maping index needs to be calculated as a return value.

Here is the call graph for this function:



Here is the caller graph for this function:


ARchain::read
ARchain::updateChain
chain::getChainIndex
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::read
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::updateChain

6.1.2.4 IsDiff()

```
template<size_t N>
bool chain::IsDiff (
            const IndexArray< N > & Index1,
            const IndexArray< N > & Index2 )
```

Check if two mapping indexes are the same.

Checking the identity of two chain index mappings.

Parameters

Index1	The first index array.
Index2	The second index array.

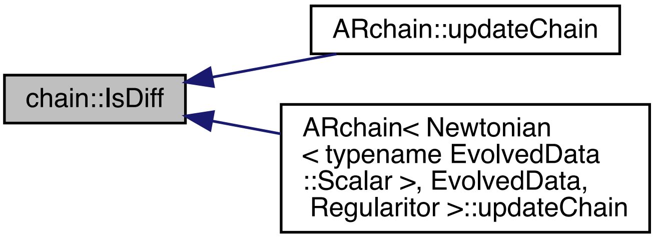
Returns

boolean

Note

[2,4,5,3,1] is identical to [1,3,5,4,2]

Here is the caller graph for this function:



6.1.2.5 synCartesian()

```
template<typename Scalar , size_t N>
void chain::synCartesian (
            VectorArray< Scalar, N > & chainData,
            VectorArray< Scalar, N > & data,
            IndexArray< N > & chainIndex )
```

Calulate the Cartesian data from chain data and chain index mapping.

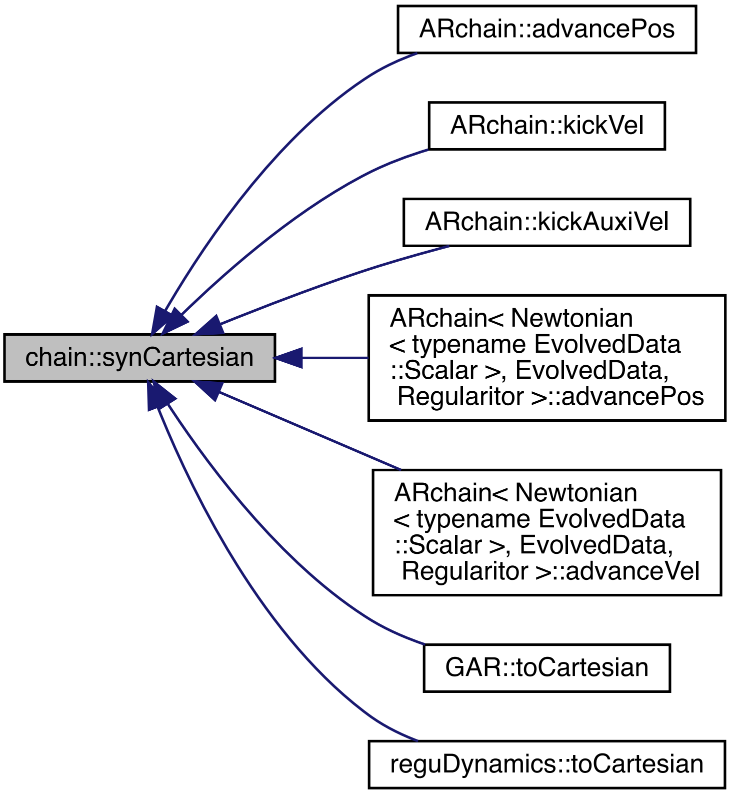
Parameters

chainData	Data in chain coordinates.
data	Data need to be calculated in Cartesian coordinates.
chainIndex	Chain index mapping.

Note

> This function should be a inverse transformation of synChain().

Here is the caller graph for this function:


chain::synCartesian
ARchain::advancePos
ARchain::kickVel
ARchain::kickAuxiVel
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advancePos
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advanceVel
GAR::toCartesian
reguDynamics::toCartesian

6.1.2.6 synChain()

```
template<typename Scalar , size_t N>
void chain::synChain (
             VectorArray< Scalar, N > & data,
             VectorArray< Scalar, N > & chainData,
             IndexArray< N > & chainIndex )
```

Calulate the chain data from Cartesian data and chain index mapping.

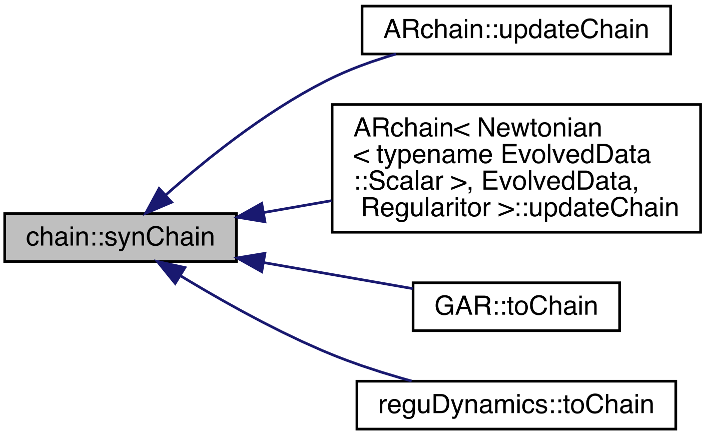
Parameters

data	Data in Cartesian coordinates.
chainData	Data need to be calculated in chain coordinates.
chainIndex	Chain index mapping.

Note

This function should be a inverse transformation of synCartesian().

Here is the caller graph for this function:


ARchain::updateChain
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::updateChain
chain::synChain
GAR::toChain
reguDynamics::toChain

6.1.2.7 updateChain()

```
template<typename Scalar , size_t N>
void chain::updateChain (
             VectorArray< Scalar, N > & pos,
             IndexArray< N > & chainIndex,
             IndexArray< N > & newIndex )
```

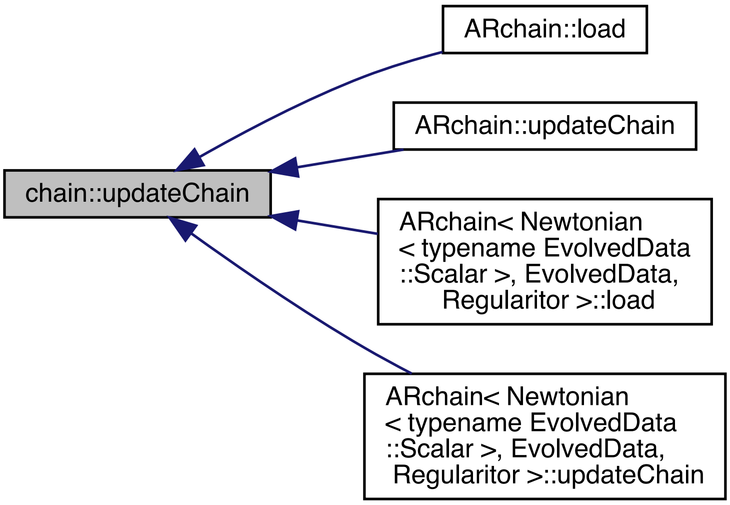
Update the position chain.

Update the position chain. Due to the evolution, the chain index mapping could change with time, this function is used to update the position chain with old chain data.

Parameters

pos	The old chain position array needs update.
chainIndex	The old chain index mapping.
newIndex	The new chain index mapping.

Here is the caller graph for this function:


chain::updateChain
ARchain::load
ARchain::updateChain
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::load
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::updateChain

6.2 NOTICE Namespace Reference

Functions

- void Telegram (const char ∗host, const char ∗msg)
- void Title (const char ∗T)
- void SubTitle (const char ∗T)
- void EraseLine ()
- void Line ()
- void SubLine ()
- void RunInfo (double timeLimit, double outputsize_terval, double tolerance)

Variables

- constexpr size_t WIDTH = 80
- bool Message = true

6.2.1 Function Documentation

6.2.1.1 EraseLine()

```
void NOTICE::EraseLine ( )  [inline]
```

6.2.1.2 Line()

```
void NOTICE::Line ( )  [inline]
```

6.2.1.3 RunInfo()

```
void NOTICE::RunInfo (
             double timeLimit,
             double outputsize_terval,
             double tolerance )  [inline]
```

6.2.1.4 SubLine()

```
void NOTICE::SubLine ( )  [inline]
```

6.2.1.5 SubTitle()

```
void NOTICE::SubTitle (
             const char * T )  [inline]
```

6.2.1.6 Telegram()

```
void NOTICE::Telegram (
             const char * host,
             const char * msg )  [inline]
```

6.2.1.7 Title()

```
void NOTICE::Title (
             const char * T )  [inline]
```

6.2.2 Variable Documentation

6.2.2.1 Message

```
bool NOTICE::Message = true
```

6.2.2.2 WIDTH

```
constexpr size_t NOTICE::WIDTH = 80
```

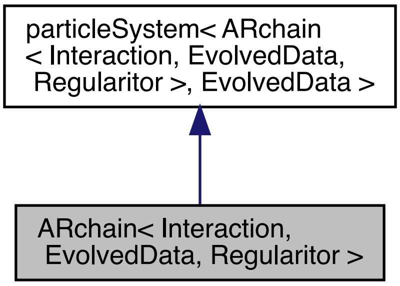
7 Class Documentation

7.1 ARchain< Interaction, EvolvedData, Regularitor > Class Template Reference

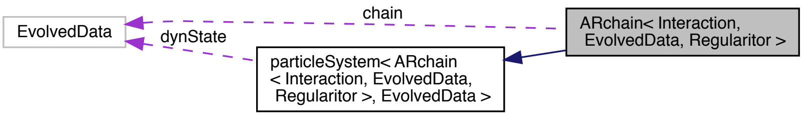
Algorithmatic Regularization chain System.

```
#include <ARchain.h>
```

Inheritance diagram for ARchain< Interaction, EvolvedData, Regularitor >:


particleSystem< ARchain < Interaction, EvolvedData, Regularitor >, EvolvedData >
ARchain< Interaction, EvolvedData, Regularitor >

Collaboration diagram for ARchain< Interaction, EvolvedData, Regularitor >:


EvolvedData
chain
dynState
ARchain< Interaction, EvolvedData, Regularitor >
particleSystem< ARchain < Interaction, EvolvedData, Regularitor >, EvolvedData >

Public Types

- typedef EvolvedData::Scalar Scalar
- typedef EvolvedData::Vector Vector
- typedef EvolvedData::VectorArray VectorArray
- typedef EvolvedData::ScalarArray ScalarArray
- typedef std::array< size_t, EvolvedData::size()> IndexArray
- typedef std::array< Scalar, EvolvedData::volume()> PlainArray

Public Member Functions

- void advancePos (Scalar timeStepSize)

  Advance position one step with current velocity.
- void advanceVel (Scalar timeStepSize)

  Advance velocity one step with current acceleration.
- const ARchain & operator= (const ARchain &other)

  Overload operator =.
- std::istream & read (std::istream &)

  Input data from standard c++ istream.
- void load (PlainArray &data)

  Load data from a plain array.
- Scalar timeScale (Scalar scale)

  Interface to rescale the time.
- PlainArray & array ()

  Transfer the evolved data to a plain scalar array.

Static Public Member Functions

- static constexpr size_t size ()

  Get the number of the particles.

Private Member Functions

- void advanceOmega (Scalar stepSize)

  Advance regularization variable omega.
- void advanceB (Scalar stepSize)

  Advance regularization variable bindE.
- void kickVel (Scalar stepSize)

  Advance velocity with current acceleration.
- void kickAuxiVel (Scalar stepSize)

  Advance auxiliary velocity with current acceleration.
- void updateAccWith (VectorArray &vel, VectorArray &chainVel)

  Update velocity dependent acceleration with given velocity. Then update the total acceleration.
- void updateVelIndepAcc ()

  Update velocity independent acceleration.
- void updateChain ()

  Update the chain data based on current Cartesian coordinates.

Private Attributes

- EvolvedData chain

  Evolved variables in chain coordinates.
- IndexArray chainIndex

  Mapping index from Cartesian coordinates to chain coordinates.
- VectorArray velIndepAcc

  Velocity independent acceleration array in Cartesian coordiantes.
- VectorArray chainVelIndepAcc

  Velocity independent acceleration array in chain coordiantes.

- VectorArray velDepAcc

  Velocity dependent acceleration array in Cartesian coordiantes.
- VectorArray chainVelDepAcc

  Velocity dependent acceleration array in chain coordiantes.
- Interaction velDepForce

  Velocity dependent pair force functor.
- Regularitor regular

  Regularization interface.

Additional Inherited Members

7.1.1 Detailed Description

template<typename Interaction, typename EvolvedData, typename Regularitor>
class ARchain< Interaction, EvolvedData, Regularitor >

Algorithmatic Regularization chain System.

See details in `https://arxiv.org/abs/0709.3367` .

7.1.2 Member Typedef Documentation

7.1.2.1 IndexArray

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
typedef std::array<size_t, EvolvedData::size()> ARchain< Interaction, EvolvedData, Regularitor
>::IndexArray
```

7.1.2.2 PlainArray

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
typedef std::array<Scalar, EvolvedData::volume()> ARchain< Interaction, EvolvedData, Regularitor
>::PlainArray
```

7.1.2.3 Scalar

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
typedef EvolvedData::Scalar ARchain< Interaction, EvolvedData, Regularitor >::Scalar
```

7.1.2.4 ScalarArray

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
typedef EvolvedData::ScalarArray ARchain< Interaction, EvolvedData, Regularitor >::ScalarArray
```

7.1.2.5 Vector

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
typedef EvolvedData::Vector ARchain< Interaction, EvolvedData, Regularitor >::Vector
```

7.1.2.6 VectorArray

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
typedef EvolvedData::VectorArray ARchain< Interaction, EvolvedData, Regularitor >::VectorArray
```

7.1.3 Member Function Documentation

7.1.3.1 advanceB()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void ARchain< Interaction, EvolvedData, Regularitor >::advanceB (
            Scalar stepSize )  [private]
```

Advance regularization variable bindE.

Advance bindE with velocity dependent acceleration and auxiliar velocity with physical time step size.

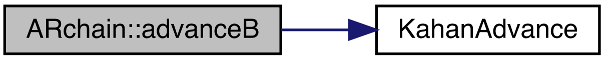
Parameters

stepSize	Physical time step.

Note

Update the bindE in chain, which will be processed by the integrator.

Here is the call graph for this function:



7.1.3.2 advanceOmega()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void ARchain< Interaction, EvolvedData, Regularitor >::advanceOmega (
            Scalar stepSize )  [private]
```

Advance regularization variable omega.

Advance omega with velocity independent acceleration and auxiliar velocity with physical time step size.

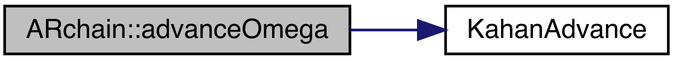
Parameters

stepSize	Physical time step.

Note

Update the omega in chain, which will be processed by the integrator.

Here is the call graph for this function:



7.1.3.3 advancePos()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void ARchain< Interaction, EvolvedData, Regularitor >::advancePos (
            Scalar timeStepSize )
```

Advance position one step with current velocity.

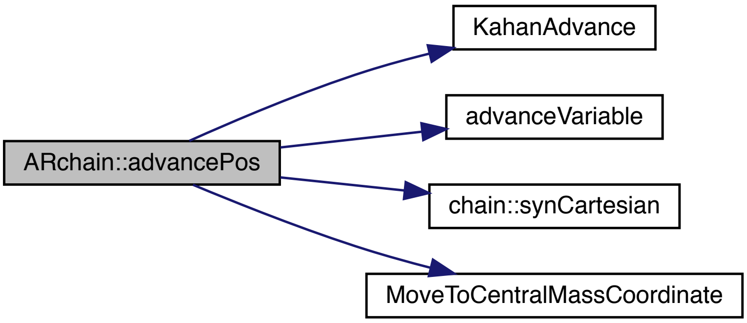
Advance chain position one step with current velocity.

Advance chain position array and physical time one step with current integration step size and velocity.

Parameters

timeStepSize	Integration step size, will be transfered to physical time in the function.

Here is the call graph for this function:



7.1.3.4 advanceVel()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void ARchain< Interaction, EvolvedData, Regularitor >::advanceVel (
             Scalar timeStepSize )
```

Advance velocity one step with current acceleration.

Advance chain velocity one step with current acceleration.

Advance chain velocity and chian auxiliary velocity array one step with current integration step size and accelerations.

Parameters

timeStepSize	Integration step size, will be transfered to physical time in the function.

7.1.3.5 array()

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
PlainArray& ARchain< Interaction, EvolvedData, Regularitor >::array ( )  [inline]
```

Transfer the evolved data to a plain scalar array.

Note

> Overload base class array().

7.1.3.6 kickAuxiVel()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void ARchain< Interaction, EvolvedData, Regularitor >::kickAuxiVel (
            Scalar stepSize )  [private]
```

Advance auxiliary velocity with current acceleration.

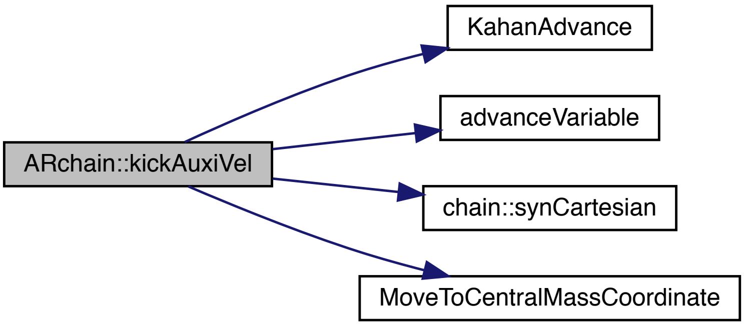
Advance chain auxiliary velocity with current acceleration.

Advance the chain auxiliary velocity with current total acceleration variable 'acc' and synchronize the Cartesian data.

Parameters

stepSize	Integration step size.

Here is the call graph for this function:



7.1.3.7 kickVel()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void ARchain< Interaction, EvolvedData, Regularitor >::kickVel (
            Scalar stepSize )  [private]
```

Advance velocity with current acceleration.

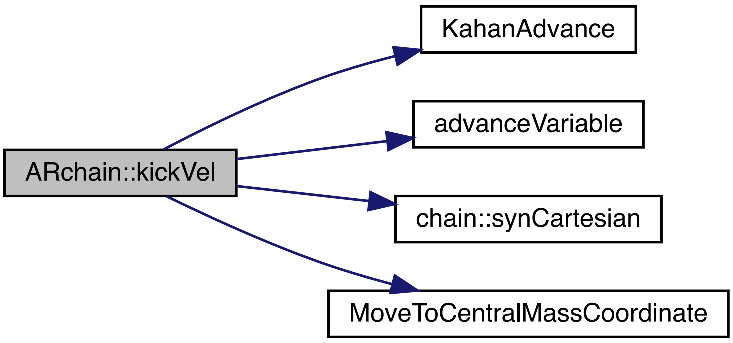
Advance chain velocity with current acceleration.

Advance the chain velocity with current total acceleration variable 'acc' and synchronize the Cartesian data.

Parameters

stepSize	Integration step size.

Here is the call graph for this function:



7.1.3.8 load()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void ARchain< Interaction, EvolvedData, Regularitor >::load (
             PlainArray & data )
```

Load data from a plain array.

Note

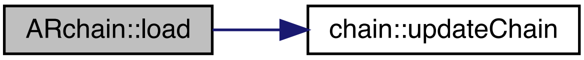
Overload base class load().

Interface usded by integrator and ODE iterator. Load data from a plain array processed by itegrator and iterator to chain data. Then synchrosize Cartesian data and update the chain. Derived class could overload this function to additional process.

Parameters

data	Plain scalar array.

Here is the call graph for this function:



7.1.3.9 operator=()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
const ARchain< Interaction, EvolvedData, Regularitor > & ARchain< Interaction, EvolvedData,
Regularitor >::operator= (
            const ARchain< Interaction, EvolvedData, Regularitor > & other )
```

Overload operator =.

7.1.3.10 read()

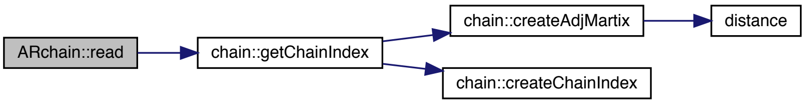
```
template<typename Interaction , typename EvolvedData , typename Regularitor >
std::istream & ARchain< Interaction, EvolvedData, Regularitor >::read (
            std::istream & input )
```

Input data from standard c++ istream.

Note

Overload base class read().

Implement of CRTP '>>' method. Here is the call graph for this function:



7.1.3.11 size()

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
static constexpr size_t ARchain< Interaction, EvolvedData, Regularitor >::size ( )  [inline],
[static]
```

Get the number of the particles.

Returns

The particle number.

Note

Overload base class size().

7.1.3.12 timeScale()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
EvolvedData::Scalar ARchain< Interaction, EvolvedData, Regularitor >::timeScale (
            Scalar scale )
```

Interface to rescale the time.

Note

Overload base class timeScale().

Interace used by dynamic system. Transfer integration time to physical time.

Returns

The phsyical time.

7.1.3.13 updateAccWith()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void ARchain< Interaction, EvolvedData, Regularitor >::updateAccWith (
            VectorArray & velocity,
            VectorArray & chainVel )  [private]
```

Update velocity dependent acceleration with given velocity. Then update the total acceleration.

Update the velocity dependent accelaration variable 'velDepAcc' with given velocity and velocity dependent pair force 'velDepForce'. Then update the total acceleration 'acc' by adding 'velIndepAcc' and 'velDepAcc'.

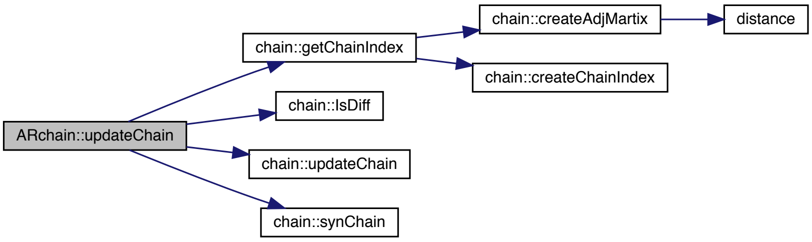
7.1.3.14 updateChain()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void ARchain< Interaction, EvolvedData, Regularitor >::updateChain ( )  [private]
```

Update the chain data based on current Cartesian coordinates.

Update chain index and chain.

Due to the evolution, the relative position of particles may vary with time. This function update the chain index and chain if needed. Here is the call graph for this function:



7.1.3.15 updateVelIndepAcc()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void ARchain< Interaction, EvolvedData, Regularitor >::updateVelIndepAcc ( )  [private]
```

Update velocity independent acceleration.

Update velocity independent acceleration 'velIndepAcc' based on Newtonian interaction with chain data.

7.1.4 Member Data Documentation

7.1.4.1 chain

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
EvolvedData ARchain< Interaction, EvolvedData, Regularitor >::chain  [private]
```

Evolved variables in chain coordinates.

7.1.4.2 chainIndex

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
IndexArray ARchain< Interaction, EvolvedData, Regularitor >::chainIndex  [private]
```

Mapping index from Cartesian coordinates to chain coordinates.

7.1.4.3 chainVelDepAcc

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
VectorArray ARchain< Interaction, EvolvedData, Regularitor >::chainVelDepAcc  [private]
```

Velocity dependent acceleration array in chain coordiantes.

7.1.4.4 chainVelIndepAcc

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
VectorArray ARchain< Interaction, EvolvedData, Regularitor >::chainVelIndepAcc  [private]
```

Velocity independent acceleration array in chain coordiantes.

7.1.4.5 regular

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
Regularitor ARchain< Interaction, EvolvedData, Regularitor >::regular  [private]
```

Regularization interface.

7.1.4.6 velDepAcc

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
VectorArray ARchain< Interaction, EvolvedData, Regularitor >::velDepAcc  [private]
```

Velocity dependent acceleration array in Cartesian coordiantes.

7.1.4.7 velDepForce

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
Interaction ARchain< Interaction, EvolvedData, Regularitor >::velDepForce  [private]
```

Velocity dependent pair force functor.

7.1.4.8 velIndepAcc

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
VectorArray ARchain< Interaction, EvolvedData, Regularitor >::velIndepAcc  [private]
```

Velocity independent acceleration array in Cartesian coordiantes.

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

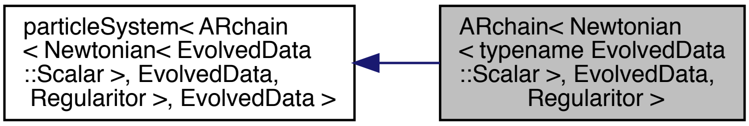
- particleSystem/ARchain.h

7.2 ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor > Class Template Reference

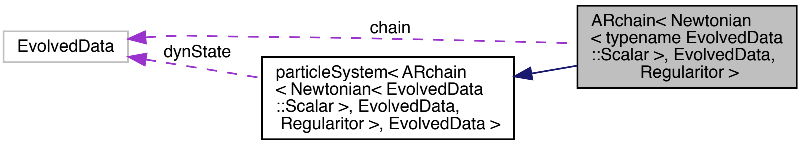
Partial specilization of template ARchain.

```
#include <ARchain.h>
```

Inheritance diagram for ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >:


particleSystem< ARchain < Newtonian< EvolvedData ::Scalar >, EvolvedData, Regularitor >, EvolvedData >
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >

Collaboration diagram for ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >:


EvolvedData
chain
dynState
particleSystem< ARchain < Newtonian< EvolvedData ::Scalar >, EvolvedData, Regularitor >, EvolvedData >
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >

Public Types

- typedef EvolvedData::Scalar Scalar
- typedef EvolvedData::Vector Vector
- typedef EvolvedData::VectorArray VectorArray
- typedef EvolvedData::ScalarArray ScalarArray
- typedef std::array< size_t, EvolvedData::size()> IndexArray
- typedef std::array< Scalar, EvolvedData::volume()> PlainArray

Public Member Functions

- void advancePos (Scalar timeStepSize)

  Advance position one step with current velocity.
- void advanceVel (Scalar timeStepSize)

  Advance velocity one step with current acceleration.
- const ARchain & operator= (const ARchain &other)

  Overload operator =.
- std::istream & read (std::istream &)

  Input data from standard c++ istream.
- void load (PlainArray &data)

  Load data from a plain array.
- Scalar timeScale (Scalar scale)

  Interface to rescale the time.
- PlainArray & array ()

  Transfer the evolved data to a plain scalar array.

Static Public Member Functions

- static constexpr size_t size ()

  Get the number of the particles.

Private Member Functions

- void advanceOmega (Scalar stepSize)

  Advance regularization variable omega.
- void updateVelIndepAcc ()

  Update velocity independent acceleration.
- void updateChain ()

  Update the chain data based on current Cartesian coordinates.

Private Attributes

- EvolvedData chain

  Evolved variables in chain coordinates.
- IndexArray chainIndex

  Mapping index from Cartesian coordinates to chain coordinates.
- VectorArray velIndepAcc

  Velocity independent acceleration array in Cartesian coordiantes.
- Regularitor regular

  Regularization interface.

Additional Inherited Members

7.2.1 Detailed Description

template<typename EvolvedData, typename Regularitor> class ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >

Partial specilization of template ARchain.

7.2.2 Member Typedef Documentation

7.2.2.1 IndexArray

```
template<typename EvolvedData , typename Regularitor >
typedef std::array<size_t, EvolvedData::size()> ARchain< Newtonian< typename EvolvedData::Scalar
>, EvolvedData, Regularitor >::IndexArray
```

7.2.2.2 PlainArray

```
template<typename EvolvedData , typename Regularitor >
typedef std::array<Scalar, EvolvedData::volume()> ARchain< Newtonian< typename EvolvedData::Scalar
>, EvolvedData, Regularitor >::PlainArray
```

7.2.2.3 Scalar

```
template<typename EvolvedData , typename Regularitor >
typedef EvolvedData::Scalar ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData,
Regularitor >::Scalar
```

7.2.2.4 ScalarArray

```
template<typename EvolvedData , typename Regularitor >
typedef EvolvedData::ScalarArray ARchain< Newtonian< typename EvolvedData::Scalar >, Evolved↩
Data, Regularitor >::ScalarArray
```

7.2.2.5 Vector

```
template<typename EvolvedData , typename Regularitor >
typedef EvolvedData::Vector ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData,
Regularitor >::Vector
```

7.2.2.6 VectorArray

```
template<typename EvolvedData , typename Regularitor >
typedef EvolvedData::VectorArray ARchain< Newtonian< typename EvolvedData::Scalar >, Evolved↩
Data, Regularitor >::VectorArray
```

7.2.3 Member Function Documentation

7.2.3.1 advanceOmega()

```
template<typename EvolvedData , typename Regularitor >
void ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >::advance↩
Omega (
             Scalar stepSize )  [private]
```

Advance regularization variable omega.

Advance omega with velocity independent acceleration and velocity with physical time step size.

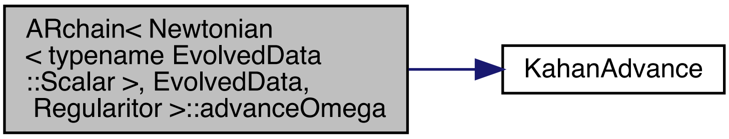
Parameters

stepSize	Physical time step.

Note

Update the omega in chain, which will be processed by the integrator.

Here is the call graph for this function:



7.2.3.2 advancePos()

```
template<typename EvolvedData , typename Regularitor >
void ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >::advance←
Pos (
            Scalar timeStepSize )
```

Advance position one step with current velocity.

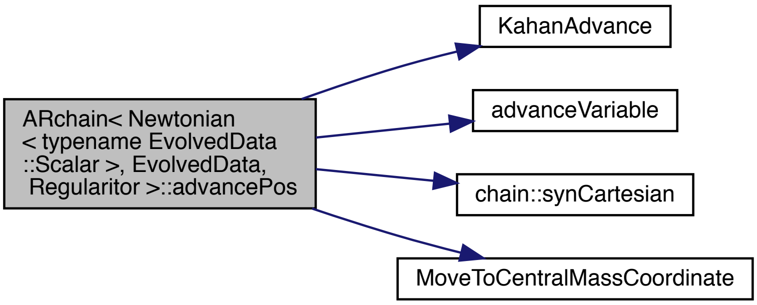
Advance chain position one step with current velocity.

Advance chain position array and physical time one step with current integration step size and velocity.

Parameters

timeStepSize	Integration step size, will be transfered to physical time in the function.

Here is the call graph for this function:



7.2.3.3 advanceVel()

```
template<typename EvolvedData , typename Regularitor >
void ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >::advance↩
Vel (
            Scalar timeStepSize )
```

Advance velocity one step with current acceleration.

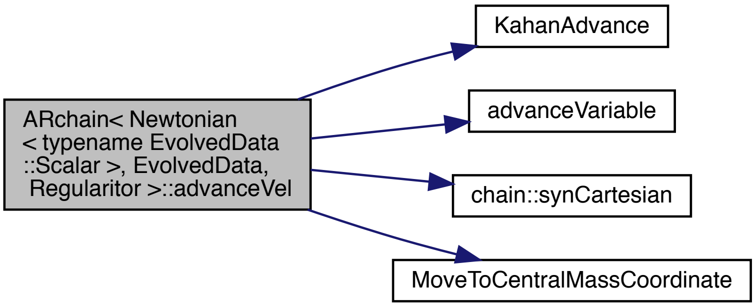
Advance chain velocity one step with current acceleration.

Advance chain velocity one step with current integration step size and accelerations.

Parameters

timeStepSize	Integration step size, will be transfered to physical time in the function.

Here is the call graph for this function:


ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advanceVel
KahanAdvance
advanceVariable
chain::synCartesian
MoveToCentralMassCoordinate

7.2.3.4 array()

```
template<typename EvolvedData , typename Regularitor >
PlainArray& ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >↩
::array ( )  [inline]
```

Transfer the evolved data to a plain scalar array.

Note

Overload base class array().

7.2.3.5 load()

```
template<typename EvolvedData , typename Regularitor >
void ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >::load (
            PlainArray & data )
```

Load data from a plain array.

Note

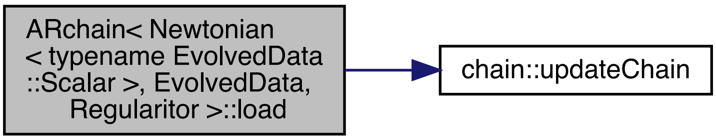
Overload base class load().

Interface usded by integrator and ODE iterator. Load data from a plain array processed by itegrator and iterator to chain data. Then synchrosize Cartesian data and update the chain. Derived class could overload this function to additional process.

Parameters

data	Plain scalar array.

Here is the call graph for this function:



7.2.3.6 operator=()

```
template<typename EvolvedData , typename Regularitor >
const ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor > & ARchain<
Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >::operator= (
            const ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor
> & other )
```

Overload operator =.

7.2.3.7 read()

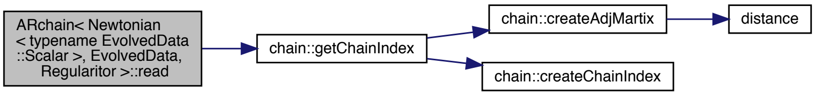
```
template<typename EvolvedData , typename Regularitor >
std::istream & ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor
>::read (
             std::istream & input )
```

Input data from standard c++ istream.

Note

Overload base class read().

Implement of CRTP '>>' method. Here is the call graph for this function:


ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::read
chain::getChainIndex
chain::createAdjMartix
distance
chain::createChainIndex

7.2.3.8 size()

```
template<typename EvolvedData , typename Regularitor >
static constexpr size_t ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData,
Regularitor >::size ( )  [inline], [static]
```

Get the number of the particles.

Returns

The particle number.

Note

Overload base class size().

7.2.3.9 timeScale()

```
template<typename EvolvedData , typename Regularitor >
EvolvedData::Scalar ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor
>::timeScale (
             Scalar scale )
```

Interface to rescale the time.

Note

Overload base class timeScale().

Interace used by dynamic system. Transfer integration time to physical time.

Returns

The phsyical time.

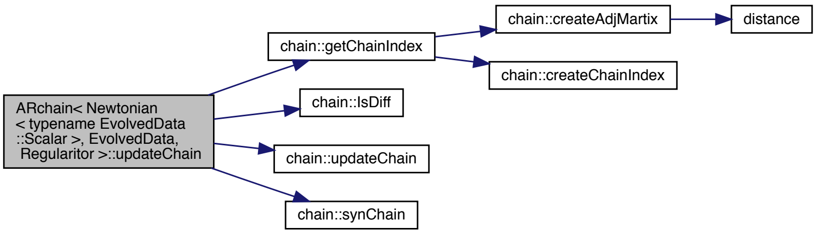
7.2.3.10 updateChain()

```
template<typename EvolvedData , typename Regularitor >
void ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >::update←-
Chain ( ) [private]
```

Update the chain data based on current Cartesian coordinates.

Update chain index and chain.

Due to the evolution, the relative position of particles may vary with time. This function update the chain index and chain if needed. Here is the call graph for this function:



7.2.3.11 updateVelIndepAcc()

```
template<typename EvolvedData , typename Regularitor >
void ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >::update←-
VelIndepAcc ( ) [private]
```

Update velocity independent acceleration.

Update velocity independent acceleration 'velIndepAcc' based on Newtonian interaction with chain data. Then calculate the corresponding chain acceleration.

7.2.4 Member Data Documentation

7.2.4.1 chain

```
template<typename EvolvedData , typename Regularitor >
EvolvedData ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >←-
::chain [private]
```

Evolved variables in chain coordinates.

7.2.4.2 chainIndex

```
template<typename EvolvedData , typename Regularitor >
IndexArray ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >↩
::chainIndex  [private]
```

Mapping index from Cartesian coordinates to chain coordinates.

7.2.4.3 regular

```
template<typename EvolvedData , typename Regularitor >
Regularitor ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >↩
::regular  [private]
```

Regularization interface.

7.2.4.4 velIndepAcc

```
template<typename EvolvedData , typename Regularitor >
VectorArray ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >↩
::velIndepAcc  [private]
```

Velocity independent acceleration array in Cartesian coordiantes.

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

- particleSystem/ARchain.h

7.3 BSIterator< ParticSys, Integrator > Class Template Reference

Bulirsch-Stoer extrapolation algorithm.

```
#include <BSIterator.h>
```

Public Types

- typedef ParticSys::Scalar Scalar
- template<typename Scalar , size_t N>
using scalarArray = std::array< Scalar, N >

Public Member Functions

- BSIterator ()

  Constructor for initializing cost, nSteps, fmin and CC.
- Scalar iterate (ParticSys &particles, Integrator &integrator, Scalar stepLength)

  Interface of ODE iterator.
- void setRelativeError (Scalar relError)

  Set the local relative error.
- void setAbsoluteError (Scalar absError)

  Set the local absolute error.

Private Member Functions

- void copyDataToExtrapTab (size_t k)

  Copy the current results of localsystem as a plain array to the first column of extrapolation talbe.
- bool checkRejection (Scalar error, size_t k) const

  Check the rejection criteria for current iteration.
- void extrapolate (size_t k)

  Extrapolate the kth row to the right end.
- Scalar getError (size_t k) const

  Calculate the error of the k row of the extrapolation table.
- Scalar getTimeStepCoef (Scalar error, size_t order)

  Calculate the new iteration integration step coefficient.
- Scalar prepareForNewIteration (size_t k, bool lastRejection)

  Calculate the new iteration integration step and new iteration depth for next iteration.

Private Attributes

- ParticSys localSystem

  The local partical system used to iterate.
- scalarArray< scalarArray< Scalar, ParticSys::volume()>,(MaxDepth+1) ∗(MaxDepth+2)/2 > extrapTab

  Extrapolation table.
- scalarArray< Scalar,(MaxDepth+1) ∗(MaxDepth+2)/2 > CC

  Extrapolation coefficient.
- scalarArray< Scalar, MaxDepth+1 > macroStepLength

  Macro step length for different iteration depth.
- scalarArray< Scalar, MaxDepth+1 > work

  The work(calculation quantities) per integration length of each iteration depth.
- scalarArray< Scalar, MaxDepth+1 > fmin

  The minimal coeffient of integration step estimation.
- scalarArray< size_t, MaxDepth+1 > cost

  The work(calculation quantities) of each iteration depth.
- scalarArray< size_t, MaxDepth+1 > nSteps

  Steps of integration of each iteration depth.
- Scalar absoluteError {1e-15}

  Local absolute error.
- Scalar relativeError {1e-15}

  Local relative error.
- Scalar s1 {0.94}

  Coefficient of new step length estimation. See "Numerical recipes" on page 926.
- Scalar s2 {0.95}

  Coefficient of new step length estimation.
- Scalar s3 {0.02}

  Coefficient of new step length estimation.
- Scalar s4 {4.0}

  Coefficient of new step length estimation.
- size_t iterDepth {7}

  Current iteraation depth.

Static Private Attributes

- static const size_t MaxDepth {8}

  The Maximum iteration depth.

7.3.1 Detailed Description

template<typename ParticSys, typename Integrator>
class BSIterator< ParticSys, Integrator >

Bulirsch-Stoer extrapolation algorithm.

7.3.2 Member Typedef Documentation

7.3.2.1 Scalar

```
template<typename ParticSys , typename Integrator >
typedef ParticSys::Scalar BSIterator< ParticSys, Integrator >::Scalar
```

7.3.2.2 scalarArray

```
template<typename ParticSys , typename Integrator >
template<typename Scalar , size_t N>
using BSIterator< ParticSys, Integrator >::scalarArray = std::array<Scalar, N>
```

7.3.3 Constructor & Destructor Documentation

7.3.3.1 BSIterator()

```
template<typename ParticSys , typename Integrator >
BSIterator< ParticSys, Integrator >::BSIterator ( )
```

Constructor for initializing cost, nSteps, fmin and CC.

7.3.4 Member Function Documentation

7.3.4.1 checkRejection()

```
template<typename ParticSys , typename Integrator >
bool BSIterator< ParticSys, Integrator >::checkRejection (
             Scalar error,
             size_t k ) const  [private]
```

Check the rejection criteria for current iteration.

Parameters

k	The kth iteration depth.

Returns

If current iteration is rejected.

7.3.4.2 copyDataToExtrapTab()

```
template<typename ParticSys , typename Integrator >
void BSIterator< ParticSys, Integrator >::copyDataToExtrapTab (
             size_t k )  [private]
```

Copy the current results of localsystem as a plain array to the first column of extrapolation talbe.

Parameters

k	The kth row of extrapolation table.

7.3.4.3 extrapolate()

```
template<typename ParticSys , typename Integrator >
void BSIterator< ParticSys, Integrator >::extrapolate (
             size_t k )  [private]
```

Extrapolate the kth row to the right end.

Extrapolate the k-th row to the right end.

Parameters

k	The kth row of extrapolation table.

7.3.4.4 getError()

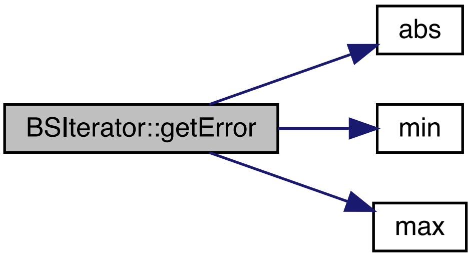
```
template<typename ParticSys , typename Integrator >
ParticSys::Scalar BSIterator< ParticSys, Integrator >::getError (
             size_t k ) const  [private]
```

Calculate the error of the k row of the extrapolation table.

Parameters

k	The kth row of extrapolation table.

Here is the call graph for this function:



7.3.4.5 getTimeStepCoef()

```
template<typename ParticSys , typename Integrator >
ParticSys::Scalar BSIterator< ParticSys, Integrator >::getTimeStepCoef (
              Scalar error,
              size_t order )  [private]
```

Calculate the new iteration integration step coefficient.

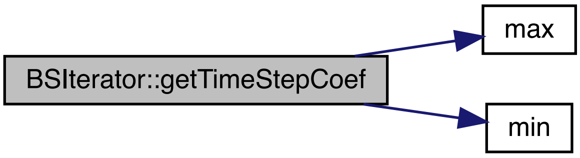
Parameters

error	The error of the k-th row of extrapolation table.
order	The order of the error in k-th row of extrapolation table.

Returns

The new iteration integration step length coefficient.

Here is the call graph for this function:



7.3.4.6 iterate()

```
template<typename ParticSys , typename Integrator >
ParticSys::Scalar BSIterator< ParticSys, Integrator >::iterate (
             ParticSys & particles,
             Integrator & integrator,
             Scalar stepLength )
```

Interface of ODE iterator.

Note

BSiterator will force use the internal mid-point integrator as the basic integrator.

Parameters

particles	Particle system need iteration.
integrator	Basica integrator used to evolve, but here BS iterator will force use internal mid-point integrator.
stepLength	Macro integration step length.

Returns

The next macro integration step length.

7.3.4.7 prepareForNewIteration()

```
template<typename ParticSys , typename Integrator >
ParticSys::Scalar BSIterator< ParticSys, Integrator >::prepareForNewIteration (
             size_t k,
             bool lastRejection )  [private]
```

Calculate the new iteration integration step and new iteration depth for next iteration.

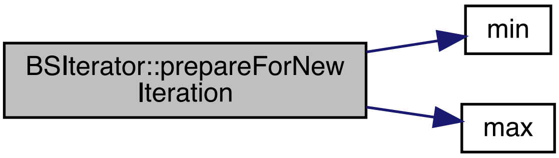
Parameters

k	The k-th iteration depth.
lastRejection	The rejection status of last trail of iteration.

Returns

The new iteration step length.

Here is the call graph for this function:



7.3.4.8 setAbsoluteError()

```
template<typename ParticSys , typename Integrator >
void BSIterator< ParticSys, Integrator >::setAbsoluteError (
            Scalar absError )  [inline]
```

Set the local absolute error.

7.3.4.9 setRelativeError()

```
template<typename ParticSys , typename Integrator >
void BSIterator< ParticSys, Integrator >::setRelativeError (
            Scalar relError )  [inline]
```

Set the local relative error.

7.3.5 Member Data Documentation

7.3.5.1 absoluteError

```
template<typename ParticSys , typename Integrator >
Scalar BSIterator< ParticSys, Integrator >::absoluteError {1e-15}  [private]
```

Local absolute error.

7.3.5.2 CC

```
template<typename ParticSys , typename Integrator >
scalarArray< Scalar, (MaxDepth + 1)∗ (MaxDepth + 2) / 2 > BSIterator< ParticSys, Integrator
>::CC  [private]
```

Extrapolation coefficient.

7.3.5.3 cost

```
template<typename ParticSys , typename Integrator >
scalarArray< size_t, MaxDepth + 1 > BSIterator< ParticSys, Integrator >::cost  [private]
```

The work(calculation quantities) of each iteration depth.

7.3.5.4 extrapTab

```
template<typename ParticSys , typename Integrator >
scalarArray< scalarArray<Scalar, ParticSys::volume()>, (MaxDepth + 1)∗ (MaxDepth + 2) / 2 >
BSIterator< ParticSys, Integrator >::extrapTab  [private]
```

Extrapolation table.

7.3.5.5 fmin

```
template<typename ParticSys , typename Integrator >
scalarArray< Scalar, MaxDepth + 1 > BSIterator< ParticSys, Integrator >::fmin  [private]
```

The minimal coeffient of integration step estimation.

7.3.5.6 iterDepth

```
template<typename ParticSys , typename Integrator >
size_t BSIterator< ParticSys, Integrator >::iterDepth {7}  [private]
```

Current iteraation depth.

7.3.5.7 localSystem

```
template<typename ParticSys , typename Integrator >
ParticSys BSIterator< ParticSys, Integrator >::localSystem  [private]
```

The local partical system used to iterate.

7.3.5.8 macroStepLength

```
template<typename ParticSys , typename Integrator >
scalarArray< Scalar, MaxDepth + 1 > BSIterator< ParticSys, Integrator >::macroStepLength
[private]
```

Macro step length for different iteration depth.

7.3.5.9 MaxDepth

```
template<typename ParticSys , typename Integrator >
const size_t BSIterator< ParticSys, Integrator >::MaxDepth {8}  [static], [private]
```

The Maximum iteration depth.

7.3.5.10 nSteps

```
template<typename ParticSys , typename Integrator >
scalarArray< size_t, MaxDepth + 1 > BSIterator< ParticSys, Integrator >::nSteps  [private]
```

Steps of integration of each iteration depth.

7.3.5.11 relativeError

```
template<typename ParticSys , typename Integrator >
Scalar BSIterator< ParticSys, Integrator >::relativeError {1e-15}  [private]
```

Local relative error.

7.3.5.12 s1

```
template<typename ParticSys , typename Integrator >
Scalar BSIterator< ParticSys, Integrator >::s1 {0.94}  [private]
```

Coefficient of new step length estimation. See "Numerical recipes" on page 926.

7.3.5.13 s2

```
template<typename ParticSys , typename Integrator >
Scalar BSIterator< ParticSys, Integrator >::s2 {0.95}  [private]
```

Coefficient of new step length estimation.

7.3.5.14 s3

```
template<typename ParticSys , typename Integrator >
Scalar BSIterator< ParticSys, Integrator >::s3 {0.02}  [private]
```

Coefficient of new step length estimation.

7.3.5.15 s4

```
template<typename ParticSys , typename Integrator >
Scalar BSIterator< ParticSys, Integrator >::s4 {4.0}  [private]
```

Coefficient of new step length estimation.

7.3.5.16 work

```
template<typename ParticSys , typename Integrator >
scalarArray< Scalar, MaxDepth + 1 > BSIterator< ParticSys, Integrator >::work  [private]
```

The work(calculation quantities) per integration length of each iteration depth.

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

- ODEiterator/BSIterator.h

7.4 constIterator< ParticSys, Integrator > Class Template Reference

Most common iterator.

```
#include <constIterator.h>
```

Public Types

- typedef ParticSys::Scalar Scalar

  interface to iterate particle system for one step

Public Member Functions

- Scalar iterate (ParticSys &particles, Integrator &integrator, Scalar stepLength)

7.4.1 Detailed Description

template<typename ParticSys, typename Integrator>
class constIterator< ParticSys, Integrator >

Most common iterator.

Constant iterator keep the step length constant and integrate the particle system for one step.

7.4.2 Member Typedef Documentation

7.4.2.1 Scalar

```
template<typename ParticSys , typename Integrator >
typedef ParticSys::Scalar constIterator< ParticSys, Integrator >::Scalar
```

interface to iterate particle system for one step

Parameters

particles	Particle system needs evolution.
integrator	Integrator to integrate the particle system.
stepLength	Macro step length for iteration(Here, the step length of the integrator).

Returns

step length for next iteration.

7.4.3 Member Function Documentation

7.4.3.1 iterate()

```
template<typename ParticSys , typename Integrator >
Scalar constIterator< ParticSys, Integrator >::iterate (
             ParticSys & particles,
             Integrator & integrator,
             Scalar stepLength )  [inline]
```

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

- ODEiterator/constIterator.h

7.5 dynamics< DataType, N > Class Template Reference

Class of dynamical variable.

```
#include <dynamicState.h>
```

Public Types

- typedef DataType Scalar
- typedef vec3< Scalar > Vector
- typedef std::array< vec3< Scalar >, N > VectorArray
- typedef std::array< Scalar, N > ScalarArray

Public Member Functions

- std::array< Scalar, volume()> & array ()

  Transfer this class to a plain array.
- void initAddiVariable (ScalarArray &mass)

  Initialize extra user defined variables. Interface required for other class.
- void setZero ()

  Set all data to be zero.

Static Public Member Functions

- static constexpr size_t size ()

  Get the number of the particles.
- static constexpr size_t volume ()

  Get the total data number.

Public Attributes

- VectorArray pos

  Array of position of the particles. Element is 3D vector.
- VectorArray vel

  Array of velocity of the particles. Element is 3D vector.
- Scalar time {0.0}

  The physical time of the dynamic system.

7.5.1 Detailed Description

template<typename DataType, size_t N>
class dynamics< DataType, N >

Class of dynamical variable.

All variables in this class are physical quantities need to be evolved. If you want to create you own dynamic state, make sure remove constant quantities away from the class. The interface array() can be used to operate the data in the class as a plain array(for evolution). Extra constant physical quantities waste the calculation.

7.5.2 Member Typedef Documentation

7.5.2.1 Scalar

```
template<typename DataType , size_t N>
typedef DataType dynamics< DataType, N >::Scalar
```

7.5.2.2 ScalarArray

```
template<typename DataType , size_t N>
typedef std::array<Scalar, N> dynamics< DataType, N >::ScalarArray
```

7.5.2.3 Vector

```
template<typename DataType , size_t N>
typedef vec3<Scalar> dynamics< DataType, N >::Vector
```

7.5.2.4 VectorArray

```
template<typename DataType , size_t N>
typedef std::array<vec3<Scalar>, N> dynamics< DataType, N >::VectorArray
```

7.5.3 Member Function Documentation

7.5.3.1 array()

```
template<typename DataType , size_t N>
std::array<Scalar, volume()>& dynamics< DataType, N >::array ( )  [inline]
```

Transfer this class to a plain array.

Returns

The reference of head of this class, reinterpret as a plain array.

7.5.3.2 initAddiVariable()

```
template<typename DataType , size_t N>
void dynamics< DataType, N >::initAddiVariable (
             ScalarArray & mass )  [inline]
```

Initialize extra user defined variables. Interface required for other class.

Parameters

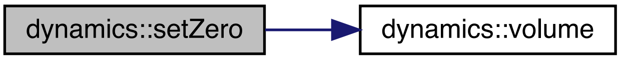
mass	The mass of particles, might be required for initialization.

7.5.3.3 setZero()

```
template<typename DataType , size_t N>
void dynamics< DataType, N >::setZero ( )  [inline]
```

Set all data to be zero.

Here is the call graph for this function:



7.5.3.4 size()

```
template<typename DataType , size_t N>
static constexpr size_t dynamics< DataType, N >::size ( )  [inline], [static]
```

Get the number of the particles.

Returns

The particle number.

7.5.3.5 volume()

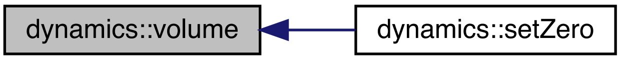
```
template<typename DataType , size_t N>
static constexpr size_t dynamics< DataType, N >::volume ( )  [inline], [static]
```

Get the total data number.

Returns

The data number.

Here is the caller graph for this function:



7.5.4 Member Data Documentation

7.5.4.1 pos

```
template<typename DataType , size_t N>
VectorArray dynamics< DataType, N >::pos
```

Array of position of the particles. Element is 3D vector.

7.5.4.2 time

```
template<typename DataType , size_t N>
Scalar dynamics< DataType, N >::time {0.0}
```

The physical time of the dynamic system.

7.5.4.3 vel

```
template<typename DataType , size_t N>
VectorArray dynamics< DataType, N >::vel
```

Array of velocity of the particles. Element is 3D vector.

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

- dynamicState.h

7.6 dynamicSystem< ParticSys, Integrator, ODEiterator > Class Template Reference

A wrapper to make particle system, integrator and ODE iterator work together.

```
#include <dynamicSystem.h>
```

Public Member Functions

- void advanceOneStep ()

  Advance the particle system for one step.
- void loadText (char const ∗initFilePath)

  Load particle system initial condition from file.
- void setStepLength (double)

  Set the step length.
- virtual ∼dynamicSystem ()

  Default destructor, virtualize for inherent class.

Public Attributes

- double stepLength {0.0}

  Macro step size for ODE iterator.
- ParticSys particles

  Particle system.
- Integrator integrator

  Integrator.
- ODEiterator iterator

  ODE Iterator.

Private Member Functions

- void getInitStepLength ()

  Calculate the initial step length of the particle system.

7.6.1 Detailed Description

template<typename ParticSys, typename Integrator, typename ODEiterator>
class dynamicSystem< ParticSys, Integrator, ODEiterator >

A wrapper to make particle system, integrator and ODE iterator work together.

7.6.2 Constructor & Destructor Documentation

7.6.2.1 ~dynamicSystem()

```
template<typename ParticSys, typename Integrator, typename ODEiterator>
virtual dynamicSystem< ParticSys, Integrator, ODEiterator >::~dynamicSystem ( )  [inline],
[virtual]
```

Default destructor, virtualize for inherent class.

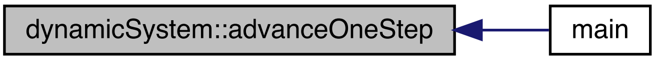
7.6.3 Member Function Documentation

7.6.3.1 advanceOneStep()

```
template<typename ParticSys , typename Integrator , typename ODEiterator >
void dynamicSystem< ParticSys, Integrator, ODEiterator >::advanceOneStep ( )  [inline]
```

Advance the particle system for one step.

Advance the particle system with current steplength stepLength. The ODE iterator iterate the integrator to convergence by its own implement. The step length will also be updated by its own implement. Here is the caller graph for this function:



7.6.3.2 getInitStepLength()

```
template<typename ParticSys , typename Integrator , typename ODEiterator >
void dynamicSystem< ParticSys, Integrator, ODEiterator >::getInitStepLength ( )  [private]
```

Calculate the initial step length of the particle system.

If the user didn't set the step length with setStepLength(), calculate the proper initial step length automatically.

7.6.3.3 loadText()

```
template<typename ParticSys , typename Integrator , typename ODEiterator >
void dynamicSystem< ParticSys, Integrator, ODEiterator >::loadText (
             char const * initFilePath )
```

Load particle system initial condition from file.

This function will read and check the initial file header (begin with '#') and the particle number after the '#'. Pass the rest information to particles by operator '>>'. The way to load the initial condition depend on the implemet of the particles. If the initial condition read successfully. This function will call getInitStepLength() to set the initial step length.

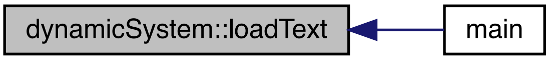
Parameters

initFilePath	The relative path of initial conditions file

Exceptions

If	the partcile number in the header is inconsisitent with the size of particles, this function will throw an exception.

Here is the caller graph for this function:

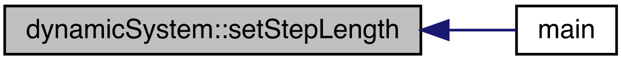


7.6.3.4 setStepLength()

```
template<typename ParticSys , typename Integrator , typename ODEiterator >
void dynamicSystem< ParticSys, Integrator, ODEiterator >::setStepLength (
             double stepSize )
```

Set the step length.

Here is the caller graph for this function:



7.6.4 Member Data Documentation

7.6.4.1 integrator

```
template<typename ParticSys, typename Integrator, typename ODEiterator>
Integrator dynamicSystem< ParticSys, Integrator, ODEiterator >::integrator
```

Integrator.

7.6.4.2 iterator

```
template<typename ParticSys, typename Integrator, typename ODEiterator>
ODEiterator dynamicSystem< ParticSys, Integrator, ODEiterator >::iterator
```

ODE Iterator.

7.6.4.3 particles

```
template<typename ParticSys, typename Integrator, typename ODEiterator>
ParticSys dynamicSystem< ParticSys, Integrator, ODEiterator >::particles
```

Particle system.

7.6.4.4 stepLength

```
template<typename ParticSys, typename Integrator, typename ODEiterator>
double dynamicSystem< ParticSys, Integrator, ODEiterator >::stepLength {0.0}
```

Macro step size for ODE iterator.

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

- dynamicSystem.h

7.7 errhand Class Reference

```
#include <errhand.h>
```

Public Member Functions

- errhand (std::string err_msg_input, const char ∗file_input, size_t line_input)
- std::string get_msg () const
- std::string get_file () const
- size_t get_line () const
- std::string to_string_loc (const char ∗obj)
- void invoke_telegram_bot ()
- void print_to_stdout ()

Private Attributes

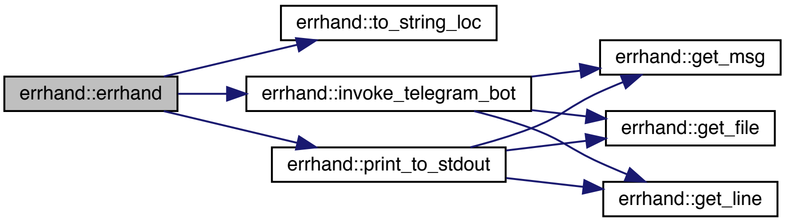
- std::string err_msg
- std::string file
- size_t line

7.7.1 Constructor & Destructor Documentation

7.7.1.1 errhand()

```
errhand::errhand (
            std::string err_msg_input,
            const char ∗ file_input,
            size_t line_input )  [inline]
```

Here is the call graph for this function:

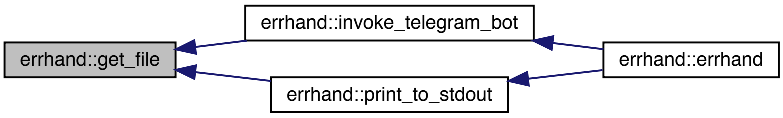


7.7.2 Member Function Documentation

7.7.2.1 get_file()

```
std::string errhand::get_file ( ) const  [inline]
```

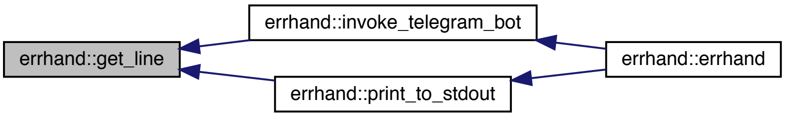
Here is the caller graph for this function:



7.7.2.2 get_line()

```
size_t errhand::get_line ( ) const  [inline]
```

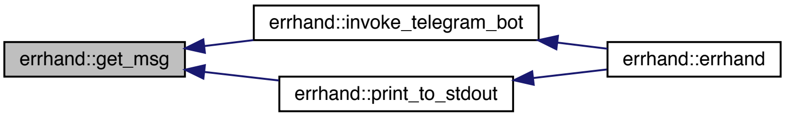
Here is the caller graph for this function:



7.7.2.3 get_msg()

```
std::string errhand::get_msg ( ) const  [inline]
```

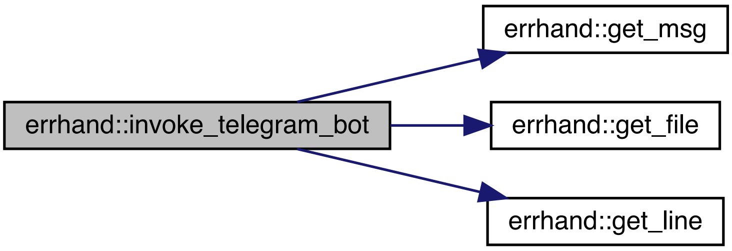
Here is the caller graph for this function:



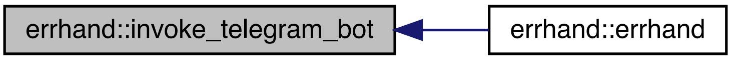
7.7.2.4 invoke_telegram_bot()

```
void errhand::invoke_telegram_bot ( )  [inline]
```

Here is the call graph for this function:



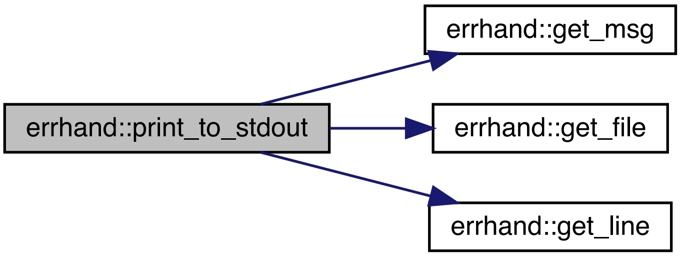
Here is the caller graph for this function:



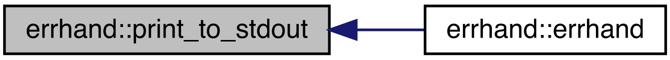
7.7.2.5 print_to_stdout()

```
void errhand::print_to_stdout ( )  [inline]
```

Here is the call graph for this function:



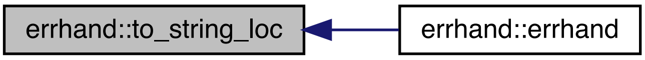
Here is the caller graph for this function:



7.7.2.6 to_string_loc()

```
std::string errhand::to_string_loc (
             const char * obj )  [inline]
```

Here is the caller graph for this function:



7.7.3 Member Data Documentation

7.7.3.1 err_msg

```
std::string errhand::err_msg  [private]
```

7.7.3.2 file

```
std::string errhand::file  [private]
```

7.7.3.3 line

```
size_t errhand::line  [private]
```

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

- errhand.h

7.8 GAR< DataType, N > Class Template Reference

Class of velocity dependent dynamical system with regularization variables.

```
#include <GAR.h>
```

Public Types

- typedef DataType Scalar
- typedef vec3< Scalar > Vector
- typedef std::array< vec3< Scalar >, N > VectorArray
- typedef std::array< Scalar, N > ScalarArray
- typedef std::array< size_t, N > IndexArray

Public Member Functions

- std::array< Scalar, volume()> & array ()

  Transfer this class to a plain array.
- void setZero ()

  Set all data to be zero.
- Scalar getOmega (const ScalarArray &mass)

  Calculate the regularization variable omega.
- void initAddiVariable (ScalarArray &mass)

  Initialize extra user defined variables. Interface required for other class.
- void toChain (GAR &chainData, IndexArray &index)

  Transfer Cartesian coordinate regularization system to chain regularization system.
- void toCartesian (GAR &cartesian, IndexArray &index)

  Transfer chain coordinate regularization system to Cartesian regularization system.
- void moveToCentralMassCoords (ScalarArray &mass)

  Move particles to central mass coordinates.

Static Public Member Functions

- static constexpr size_t size ()

  Get the number of the particles.
- static constexpr size_t volume ()

  Get the total data number.

Public Attributes

- VectorArray pos

  Array of position of the particles. Element is 3D vector.
- VectorArray vel

  Array of velocity of the particles. Element is 3D vector.
- VectorArray auxiVel

  Array of auxiliary velocity of the particles. Element is 3D vector.
- Scalar time {0.0}

  The physical time of the dynamic system.
- Scalar bindE {0.0}

  The binding energy(for regularization) of the dynamic system.
- Scalar omega {0.0}

  The regularization variable of the dynamic system.

7.8.1 Detailed Description

template<typename DataType, size_t N>
class GAR< DataType, N >

Class of velocity dependent dynamical system with regularization variables.

A simple extension of class dynamics in dynamicState.h. Used for regularization system. See detail in https://academic.oup.com/mnras/article/372/1/219/974304 .

7.8.2 Member Typedef Documentation

7.8.2.1 IndexArray

```
template<typename DataType , size_t N>
typedef std::array<size_t, N> GAR< DataType, N >::IndexArray
```

7.8.2.2 Scalar

```
template<typename DataType , size_t N>
typedef DataType GAR< DataType, N >::Scalar
```

7.8.2.3 ScalarArray

```
template<typename DataType , size_t N>
typedef std::array<Scalar, N> GAR< DataType, N >::ScalarArray
```

7.8.2.4 Vector

```
template<typename DataType , size_t N>
typedef vec3<Scalar> GAR< DataType, N >::Vector
```

7.8.2.5 VectorArray

```
template<typename DataType , size_t N>
typedef std::array<vec3<Scalar>, N> GAR< DataType, N >::VectorArray
```

7.8.3 Member Function Documentation

7.8.3.1 array()

```
template<typename DataType , size_t N>
std::array<Scalar, volume()>& GAR< DataType, N >::array ( )  [inline]
```

Transfer this class to a plain array.

Returns

The reference of head of this class, reinterpret as a plain array.

7.8.3.2 getOmega()

```
template<typename DataType , size_t N>
Scalar GAR< DataType, N >::getOmega (
             const ScalarArray & mass )  [inline]
```

Calculate the regularization variable omega.

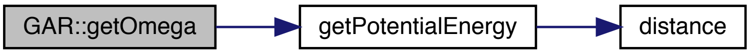
Parameters

mass	The mass of particles, might be required for calculation.

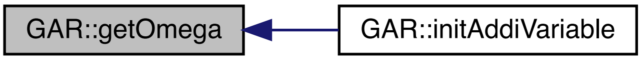
Returns

The calculated value of omega.

Here is the call graph for this function:



Here is the caller graph for this function:



7.8.3.3 initAddiVariable()

```
template<typename DataType , size_t N>
void GAR< DataType, N >::initAddiVariable (
             ScalarArray & mass )  [inline]
```

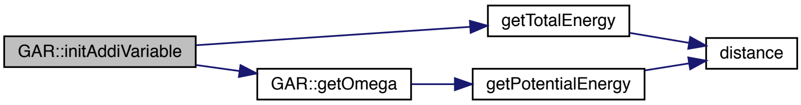
Initialize extra user defined variables. Interface required for other class.

Initialize regularizaiton variable bindE and omega.

Parameters

mass	The mass of particles, might be required for initialization.

Here is the call graph for this function:



7.8.3.4 moveToCentralMassCoords()

```
template<typename DataType , size_t N>
void GAR< DataType, N >::moveToCentralMassCoords (
             ScalarArray & mass )  [inline]
```

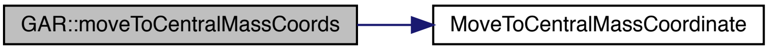
Move particles to central mass coordinates.

Move position, velocity and auxiliary velocity to central mass coordinates.

Parameters

mass	Mass of the particles required for moving.

Here is the call graph for this function:

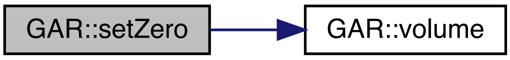


7.8.3.5 setZero()

```
template<typename DataType , size_t N>
void GAR< DataType, N >::setZero ( )  [inline]
```

Set all data to be zero.

Here is the call graph for this function:



7.8.3.6 size()

```
template<typename DataType , size_t N>
static constexpr size_t GAR< DataType, N >::size ( )  [inline], [static]
```

Get the number of the particles.

Returns

The particle number.

7.8.3.7 toCartesian()

```
template<typename DataType , size_t N>
void GAR< DataType, N >::toCartesian (
            GAR< DataType, N > & cartesian,
            IndexArray & index )  [inline]
```

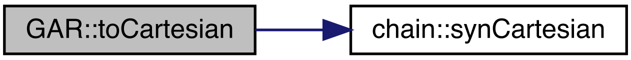
Transfer chain coordinate regularization system to Cartesian regularization system.

Coordinate transformation. From chain to Cartesian. See details in https://link.springer.com/article/10.1007%2FBF00695714 .

Parameters

cartesian	The destination regularization system in Cartesian coordinates.
index	The maping index between Cartesian coordinates and chain coordinates.

Here is the call graph for this function:



7.8.3.8 toChain()

```
template<typename DataType , size_t N>
void GAR< DataType, N >::toChain (
             GAR< DataType, N > & chainData,
             IndexArray & index )  [inline]
```

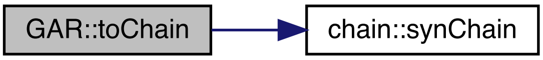
Transfer Cartesian coordinate regularization system to chain regularization system.

Coordinate transformation. From Cartesian to chain. See details in https://link.springer.com/article/10.1007%2FBF00695714 .

Parameters

chainData	The destination regularization system in chain coordinates.
index	The maping index between Cartesian coordinates and chain coordinates.

Here is the call graph for this function:



7.8.3.9 volume()

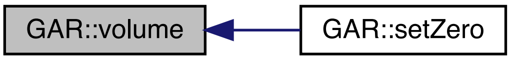
```
template<typename DataType , size_t N>
static constexpr size_t GAR< DataType, N >::volume ( )  [inline], [static]
```

Get the total data number.

Returns

The data number.

Here is the caller graph for this function:



7.8.4 Member Data Documentation

7.8.4.1 auxiVel

```
template<typename DataType , size_t N>
VectorArray GAR< DataType, N >::auxiVel
```

Array of auxiliary velocity of the particles. Element is 3D vector.

7.8.4.2 bindE

```
template<typename DataType , size_t N>
Scalar GAR< DataType, N >::bindE {0.0}
```

The binding energy(for regularization) of the dynamic system.

7.8.4.3 omega

```
template<typename DataType , size_t N>
Scalar GAR< DataType, N >::omega {0.0}
```

The regularization variable of the dynamic system.

7.8.4.4 pos

```
template<typename DataType , size_t N>
VectorArray GAR< DataType, N >::pos
```

Array of position of the particles. Element is 3D vector.

7.8.4.5 time

```
template<typename DataType , size_t N>
Scalar GAR< DataType, N >::time {0.0}
```

The physical time of the dynamic system.

7.8.4.6 vel

```
template<typename DataType , size_t N>
VectorArray GAR< DataType, N >::vel
```

Array of velocity of the particles. Element is 3D vector.

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

- particleSystem/GAR.h

7.9 logH< DynamicState > Class Template Reference

logH extention algorithmatic regularization interface

```
#include <regularization.h>
```

Public Types

- typedef DynamicState::Scalar Scalar

Public Member Functions

- Scalar getPhysicalPosTime (std::array< Scalar, size()> &mass, DynamicState &dyn, Scalar stepSize)
  Calculate the physical time for position advance from integration step size.
- Scalar getPhysicalVelTime (std::array< Scalar, size()> &mass, DynamicState &dyn, Scalar stepSize)
  Calculate the physical time for velocity advance from integration step size.

Static Public Member Functions

- static constexpr size_t size ()

7.9.1 Detailed Description

template<typename DynamicState>
class logH< DynamicState >

logH extention algorithmatic regularization interface

See detials in `https://link.springer.com/article/10.1023%2FA%3A1008368322547` and `http://iopscience.iop.org/article/10.1086/301102/meta`.

7.9.2 Member Typedef Documentation

7.9.2.1 Scalar

```
template<typename DynamicState >
typedef DynamicState::Scalar logH< DynamicState >::Scalar
```

7.9.3 Member Function Documentation

7.9.3.1 getPhysicalPosTime()

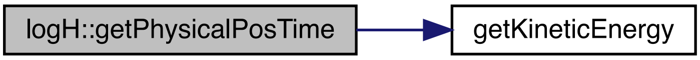
```
template<typename DynamicState >
Scalar logH< DynamicState >::getPhysicalPosTime (
            std::array< Scalar, size()> & mass,
            DynamicState & dyn,
            Scalar stepSize )  [inline]
```

Calculate the physical time for position advance from integration step size.

Parameters

mass	Array of particle mass.
dyn	Dynamic system contains position, velocity and regularization variables. See example class in dynamicState.h.
stepSize	Integration step size. This could not be the physical time. Look references for details in class despriction.

Here is the call graph for this function:



7.9.3.2 getPhysicalVelTime()

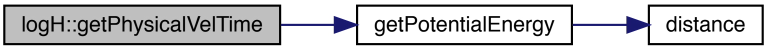
```
template<typename DynamicState >
Scalar logH< DynamicState >::getPhysicalVelTime (
            std::array< Scalar, size()> & mass,
            DynamicState & dyn,
            Scalar stepSize )  [inline]
```

Calculate the physical time for velocity advance from integration step size.

Parameters

mass	Array of particle mass.
dyn	Dynamic system contains position, velocity and regularization variables. See example class in dynamicState.h.
stepSize	Integration step size. This could not be the physical time. Look references for details in class despriction.

Here is the call graph for this function:



7.9.3.3 size()

```
template<typename DynamicState >
static constexpr size_t logH< DynamicState >::size ( )  [inline], [static]
```

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

- particleSystem/regularization.h

7.10 Newtonian< Scalar > Class Template Reference

Marker of None velocity dependent force functor(c++ std11)

```
#include <interaction.h>
```

Public Member Functions

- void operator() ()

7.10.1 Detailed Description

template<typename Scalar>
class Newtonian< Scalar >

Marker of None velocity dependent force functor(c++ std11)

7.10.2 Member Function Documentation

7.10.2.1 operator()()

```
template<typename Scalar >
void Newtonian< Scalar >::operator() ( ) [inline]
```

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

- interaction/interaction.h

7.11 chain::Node< Scalar > Struct Template Reference

Struture to store the relative distance and index of two particles.

```
#include <chain.h>
```

Public Attributes

- Scalar Rij
- size_t i
- size_t j
- bool available

7.11.1 Detailed Description

template<typename Scalar>
struct chain::Node< Scalar >

Struture to store the relative distance and index of two particles.

7.11.2 Member Data Documentation

7.11.2.1 available

```
template<typename Scalar>
bool chain::Node< Scalar >::available
```

State of node. If this node can be chained.

7.11.2.2 i

```
template<typename Scalar>
size_t chain::Node< Scalar >::i
```

Particle index.

7.11.2.3 j

```
template<typename Scalar>
size_t chain::Node< Scalar >::j
```

Particle index.

7.11.2.4 Rij

```
template<typename Scalar>
Scalar chain::Node< Scalar >::Rij
```

Relative distance of two particles.

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

- particleSystem/chain.h

7.12 NoRegu< DynamicState > Class Template Reference

Ordinary algorithmatic regularization interface.

```
#include <regularization.h>
```

Public Types

- typedef DynamicState::Scalar Scalar

Public Member Functions

- Scalar getPhysicalPosTime (std::array< Scalar, size()> &mass, DynamicState &dyn, Scalar stepSize)

  Calculate the physical time for position advance from integration step size.
- Scalar getPhysicalVelTime (std::array< Scalar, size()> &mass, DynamicState &dyn, Scalar stepSize)

  Calculate the physical time for velocity advance from integration step size.

Static Public Member Functions

- static constexpr size_t size ()

7.12.1 Detailed Description

template<typename DynamicState>
class NoRegu< DynamicState >

Ordinary algorithmatic regularization interface.

No regularization.

7.12.2 Member Typedef Documentation

7.12.2.1 Scalar

```
template<typename DynamicState >
typedef DynamicState::Scalar NoRegu< DynamicState >::Scalar
```

7.12.3 Member Function Documentation

7.12.3.1 getPhysicalPosTime()

```
template<typename DynamicState >
Scalar NoRegu< DynamicState >::getPhysicalPosTime (
            std::array< Scalar, size()> & mass,
            DynamicState & dyn,
            Scalar stepSize ) [inline]
```

Calculate the physical time for position advance from integration step size.

Parameters

mass	Array of particle mass.
dyn	Dynamic system contains position, velocity and regularization variables. See example class in dynamicState.h.
stepSize	Integration step size.

7.12.3.2 getPhysicalVelTime()

```
template<typename DynamicState >
Scalar NoRegu< DynamicState >::getPhysicalVelTime (
            std::array< Scalar, size()> & mass,
            DynamicState & dyn,
            Scalar stepSize ) [inline]
```

Calculate the physical time for velocity advance from integration step size.

Parameters

mass	Array of particle mass.
dyn	Dynamic system contains position, velocity and regularization variables. See example class in dynamicState.h.
stepSize	Integration step size.

7.12.3.3 size()

```
template<typename DynamicState >
static constexpr size_t NoRegu< DynamicState >::size ( )  [inline], [static]
```

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

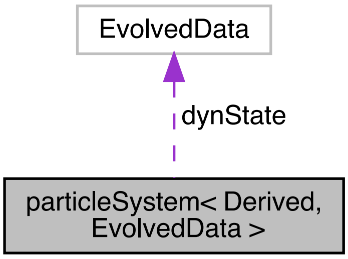
- particleSystem/regularization.h

7.13 particleSystem< Derived, EvolvedData > Class Template Reference

Base class of particle System.

```
#include <particleSystem.h>
```

Collaboration diagram for particleSystem< Derived, EvolvedData >:



Public Types

- typedef EvolvedData::Scalar Scalar
- typedef EvolvedData::Vector Vector
- typedef EvolvedData::VectorArray VectorArray
- typedef EvolvedData::ScalarArray ScalarArray
- typedef std::array< size_t, EvolvedData::size()> IntArray
- typedef std::array< Scalar, EvolvedData::volume()> PlainArray

Public Member Functions

- particleSystem ()

  Default construction.
- virtual ~particleSystem ()

  Virtualize default destructor.
- PlainArray & array ()

  Transfer evolved data to a plain array.
- Scalar timeScale (Scalar scale)

Interface to rescale the time.
- void load (PlainArray &data)

  Load data from a plain array.
- std::ostream & write (std::ostream &) const

  Output data to standard c++ ostream.
- std::istream & read (std::istream &)

  Input data from standard c++ istream.
- const particleSystem & operator= (const particleSystem &other)

  Overload operator =.

Static Public Member Functions

- static constexpr size_t size ()

  Get the number of the particles.
- static constexpr size_t volume ()

  Get the total dynamic scalar number.

Public Attributes

- EvolvedData dynState

  Evolved variables class.
- VectorArray & pos

  Position array interface. Reference to dynState.pos.
- VectorArray & vel

  Velocity array interface. Reference to dynState.vel.
- Scalar & time

  Physical time scalar interface. Reference to dynState.time.
- ScalarArray mass

  Mass array.
- ScalarArray radius

  Radius array.
- IntArray type

  Particle type array.

Protected Attributes

- VectorArray acc

  Acceleration array used to update velocity.

7.13.1 Detailed Description

template<typename Derived, typename EvolvedData>
class particleSystem< Derived, EvolvedData >

Base class of particle System.

Base particles system class. Other particle system can inherit this class. Considering the performance, we don't set virtual function. Here we use CRTP technique to bind derived class method. See more details in `https://en.wikipedia.org/wiki/Curiously_recurring_template_pattern`.

7.13.2 Member Typedef Documentation

7.13.2.1 IntArray

```
template<typename Derived, typename EvolvedData>
typedef std::array<size_t, EvolvedData::size()> particleSystem< Derived, EvolvedData >↩
::IntArray
```

7.13.2.2 PlainArray

```
template<typename Derived, typename EvolvedData>
typedef std::array<Scalar, EvolvedData::volume()> particleSystem< Derived, EvolvedData >↩
::PlainArray
```

7.13.2.3 Scalar

```
template<typename Derived, typename EvolvedData>
typedef EvolvedData::Scalar particleSystem< Derived, EvolvedData >::Scalar
```

7.13.2.4 ScalarArray

```
template<typename Derived, typename EvolvedData>
typedef EvolvedData::ScalarArray particleSystem< Derived, EvolvedData >::ScalarArray
```

7.13.2.5 Vector

```
template<typename Derived, typename EvolvedData>
typedef EvolvedData::Vector particleSystem< Derived, EvolvedData >::Vector
```

7.13.2.6 VectorArray

```
template<typename Derived, typename EvolvedData>
typedef EvolvedData::VectorArray particleSystem< Derived, EvolvedData >::VectorArray
```

7.13.3 Constructor & Destructor Documentation

7.13.3.1 particleSystem()

```
template<typename Derived, typename EvolvedData>
particleSystem< Derived, EvolvedData >::particleSystem ( )  [inline]
```

Default construction.

Default constructor. Bind position, velocity and time interface reference to dynState.pos, dynState.vel and dyn.↩ time.

7.13.3.2 ∼particleSystem()

```
template<typename Derived, typename EvolvedData>
virtual particleSystem< Derived, EvolvedData >::∼particleSystem ( )  [inline], [virtual]
```

Virtualize default destructor.

7.13.4 Member Function Documentation

7.13.4.1 array()

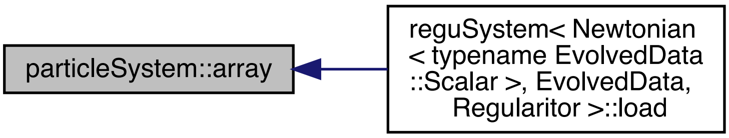
```
template<typename Derived, typename EvolvedData>
PlainArray& particleSystem< Derived, EvolvedData >::array ( )  [inline]
```

Transfer evolved data to a plain array.

Returns

The reference of a plain array.

Here is the caller graph for this function:


particleSystem::array
reguSystem< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::load

7.13.4.2 load()

```
template<typename Derived , typename EvolvedData >
void particleSystem< Derived, EvolvedData >::load (
            PlainArray & data )
```

Load data from a plain array.

Interface usded by integrator and ODE iterator. Load data from a plain array processed by itegrator and iterator. Derived class could overload this function to additional process.

Parameters

data	Plain scalar array.

7.13.4.3 operator=()

```
template<typename Derived , typename EvolvedData >
const particleSystem< Derived, EvolvedData > & particleSystem< Derived, EvolvedData >::operator=
(
             const particleSystem< Derived, EvolvedData > & other )
```

Overload operator =.

7.13.4.4 read()

```
template<typename Derived , typename EvolvedData >
std::istream & particleSystem< Derived, EvolvedData >::read (
             std::istream & input )
```

Input data from standard c++ istream.

Implement of CRTP '>>' method.

7.13.4.5 size()

```
template<typename Derived, typename EvolvedData>
static constexpr size_t particleSystem< Derived, EvolvedData >::size ( )  [inline], [static]
```

Get the number of the particles.

Returns

The particle number.

7.13.4.6 timeScale()

```
template<typename Derived, typename EvolvedData>
Scalar particleSystem< Derived, EvolvedData >::timeScale (
             Scalar scale )  [inline]
```

Interface to rescale the time.

Interace used by dynamic system. Transfer integration time(For some system, integration time is different from physical time) to physical time.

Returns

The phsyical time.

7.13.4.7 volume()

```
template<typename Derived, typename EvolvedData>
static constexpr size_t particleSystem< Derived, EvolvedData >::volume ( )  [inline], [static]
```

Get the total dynamic scalar number.

Returns

The dynamic scalar number.

7.13.4.8 write()

```
template<typename Derived , typename EvolvedData >
std::ostream & particleSystem< Derived, EvolvedData >::write (
            std::ostream & output ) const
```

Output data to standard c++ ostream.

Implement of CRTP '<<' method.

7.13.5 Member Data Documentation

7.13.5.1 acc

```
template<typename Derived, typename EvolvedData>
VectorArray particleSystem< Derived, EvolvedData >::acc  [protected]
```

Acceleration array used to update velocity.

7.13.5.2 dynState

```
template<typename Derived, typename EvolvedData>
EvolvedData particleSystem< Derived, EvolvedData >::dynState
```

Evolved variables class.

7.13.5.3 mass

```
template<typename Derived, typename EvolvedData>
ScalarArray particleSystem< Derived, EvolvedData >::mass
```

Mass array.

7.13.5.4 pos

```
template<typename Derived, typename EvolvedData>
VectorArray& particleSystem< Derived, EvolvedData >::pos
```

Position array interface. Reference to dynState.pos.

7.13.5.5 radius

```
template<typename Derived, typename EvolvedData>
ScalarArray particleSystem< Derived, EvolvedData >::radius
```

Radius array.

7.13.5.6 time

```
template<typename Derived, typename EvolvedData>
Scalar& particleSystem< Derived, EvolvedData >::time
```

Physical time scalar interface. Reference to dynState.time.

7.13.5.7 type

```
template<typename Derived, typename EvolvedData>
IntArray particleSystem< Derived, EvolvedData >::type
```

Particle type array.

7.13.5.8 vel

```
template<typename Derived, typename EvolvedData>
VectorArray& particleSystem< Derived, EvolvedData >::vel
```

Velocity array interface. Reference to dynState.vel.

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

- particleSystem.h

7.14 PN1th< Scalar > Class Template Reference

Post newtonian pair interaction functor(c++ std11)

```
#include <interaction.h>
```

Public Member Functions

- void operator() (Scalar m1, Scalar m2, Vector &dr, Vector &dv, Vector &v1, Vector &v2, Vector &acc1, Vector &acc2)

  Update the velocity dependent acceleration of particle 1 and 2.

Private Types

- typedef vec3< Scalar > Vector

7.14.1 Detailed Description

template<typename Scalar>
class PN1th< Scalar >

Post newtonian pair interaction functor(c++ std11)

7.14.2 Member Typedef Documentation

7.14.2.1 Vector

```
template<typename Scalar >
typedef vec3<Scalar> PN1th< Scalar >::Vector  [private]
```

7.14.3 Member Function Documentation

7.14.3.1 operator()()

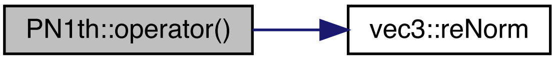
```
template<typename Scalar >
void PN1th< Scalar >::operator() (
             Scalar m1,
             Scalar m2,
             Vector & dr,
             Vector & dv,
             Vector & v1,
             Vector & v2,
             Vector & acc1,
             Vector & acc2 )  [inline]
```

Update the velocity dependent acceleration of particle 1 and 2.

Parameters

m1	Mass of particle 1.
m2	Mass of particle 2.
dr	Relative position pos1 - pos2.
dv	Relative velocity vel1 - vel2.
v1	Velocity of particle 1.
v2	Velocity of particle 2.
acc1	Velocity dependent acceleration of particle 1 as return value.

Here is the call graph for this function:



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

- interaction/interaction.h

7.15 reguDynamics< DataType, N > Class Template Reference

Class of dynamical system with regularization variables.

```
#include <regularState.h>
```

Public Types

- typedef DataType Scalar
- typedef vec3< Scalar > Vector
- typedef std::array< vec3< Scalar >, N > VectorArray
- typedef std::array< Scalar, N > ScalarArray
- typedef std::array< size_t, N > IndexArray

Public Member Functions

- std::array< Scalar, volume()> & array ()

  Transfer this class to a plain array.
- void setZero ()

  Set all data to be zero.
- Scalar getOmega (ScalarArray &mass)

  Calculate the regularization variable omega.
- void initAddiVariable (ScalarArray &mass)

  Initialize extra user defined variables. Interface required for other class.
- void toChain (reguDynamics &chainData, IndexArray &index)

  Transfer Cartesian coordinate regularization system to chain regularization system.
- void toCartesian (reguDynamics &cartesian, IndexArray &index)

  Transfer chain coordinate regularization system to Cartesian regularization system.
- void moveToCentralMassCoords (ScalarArray &mass)

  Move particles to central mass coordinates.

Static Public Member Functions

- static constexpr size_t size ()

  Get the number of the particles.
- static constexpr size_t volume ()

  Get the total data number.

Public Attributes

- VectorArray pos

  Array of position of the particles. Element is 3D vector.
- VectorArray vel

  Array of velocity of the particles. Element is 3D vector.
- Scalar time {0.0}

  The physical time of the dynamic system.
- Scalar bindE {0.0}

  The binding energy(for regularization) of the dynamic system.
- Scalar omega {0.0}

  The regularization variable of the dynamic system.

7.15.1 Detailed Description

template<typename DataType, size_t N>
class reguDynamics< DataType, N >

Class of dynamical system with regularization variables.

A simple extension of class dynamics in dynamicState.h. Used for regularization system. See detail in `https://academic.oup.com/mnras/article/372/1/219/974304`.

7.15.2 Member Typedef Documentation

7.15.2.1 IndexArray

```
template<typename DataType , size_t N>
typedef std::array<size_t, N> reguDynamics< DataType, N >::IndexArray
```

7.15.2.2 Scalar

```
template<typename DataType , size_t N>
typedef DataType reguDynamics< DataType, N >::Scalar
```

7.15.2.3 ScalarArray

```
template<typename DataType , size_t N>
typedef std::array<Scalar, N> reguDynamics< DataType, N >::ScalarArray
```

7.15.2.4 Vector

```
template<typename DataType , size_t N>
typedef vec3<Scalar> reguDynamics< DataType, N >::Vector
```

7.15.2.5 VectorArray

```
template<typename DataType , size_t N>
typedef std::array<vec3<Scalar>, N> reguDynamics< DataType, N >::VectorArray
```

7.15.3 Member Function Documentation

7.15.3.1 array()

```
template<typename DataType , size_t N>
std::array<Scalar, volume()>& reguDynamics< DataType, N >::array ( )  [inline]
```

Transfer this class to a plain array.

Returns

The reference of head of this class, reinterpret as a plain array.

7.15.3.2 getOmega()

```
template<typename DataType , size_t N>
Scalar reguDynamics< DataType, N >::getOmega (
            ScalarArray & mass )  [inline]
```

Calculate the regularization variable omega.

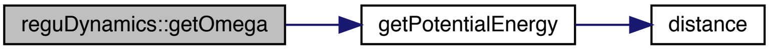
Parameters

mass	The mass of particles, might be required for calculation.

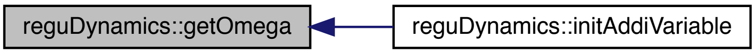
Returns

The calculated value of omega.

Here is the call graph for this function:



Here is the caller graph for this function:



7.15.3.3 initAddiVariable()

```
template<typename DataType , size_t N>
void reguDynamics< DataType, N >::initAddiVariable (
             ScalarArray & mass )  [inline]
```

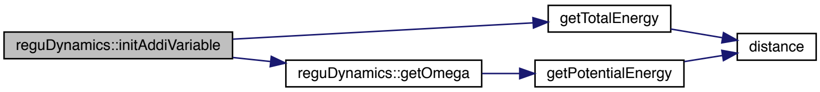
Initialize extra user defined variables. Interface required for other class.

Initialize regularizaiton variable bindE and omega.

Parameters

mass	The mass of particles, might be required for initialization.

Here is the call graph for this function:



7.15.3.4 moveToCentralMassCoords()

```
template<typename DataType , size_t N>
void reguDynamics< DataType, N >::moveToCentralMassCoords (
            ScalarArray & mass )  [inline]
```

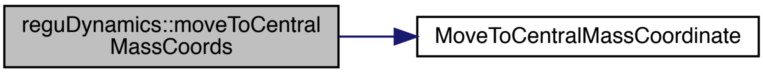
Move particles to central mass coordinates.

Move position and velocity to central mass coordinates.

Parameters

mass	Mass of the particles required for moving.

Here is the call graph for this function:

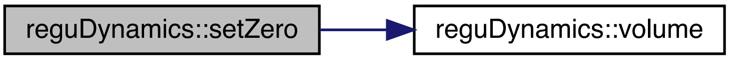

reguDynamics::moveToCentral MassCoords
MoveToCentralMassCoordinate

7.15.3.5 setZero()

```
template<typename DataType , size_t N>
void reguDynamics< DataType, N >::setZero ( )  [inline]
```

Set all data to be zero.

Here is the call graph for this function:



7.15.3.6 size()

```
template<typename DataType , size_t N>
static constexpr size_t reguDynamics< DataType, N >::size ( )  [inline], [static]
```

Get the number of the particles.

Returns

The particle number.

7.15.3.7 toCartesian()

```
template<typename DataType , size_t N>
void reguDynamics< DataType, N >::toCartesian (
             reguDynamics< DataType, N > & cartesian,
             IndexArray & index )  [inline]
```

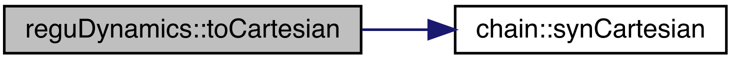
Transfer chain coordinate regularization system to Cartesian regularization system.

Coordinate transformation. From chain to Cartesian. See details in https://link.springer.↩ com/article/10.1007%2FBF00695714 .

Parameters

cartesian	The destination regularization system in Cartesian coordinates.
index	The maping index between Cartesian coordinates and chain coordinates.

Here is the call graph for this function:



7.15.3.8 toChain()

```
template<typename DataType , size_t N>
void reguDynamics< DataType, N >::toChain (
             reguDynamics< DataType, N > & chainData,
             IndexArray & index )  [inline]
```

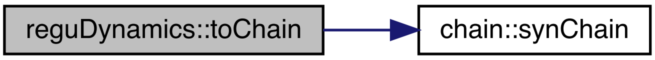
Transfer Cartesian coordinate regularization system to chain regularization system.

Coordinate transformation. From Cartesian to chain. See details in https://link.springer.↩ com/article/10.1007%2FBF00695714 .

Parameters

chainData	The destination regularization system in chain coordinates.
index	The maping index between Cartesian coordinates and chain coordinates.

Here is the call graph for this function:



7.15.3.9 volume()

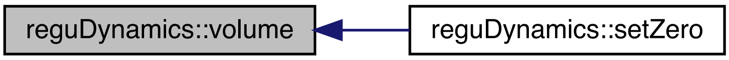
```
template<typename DataType , size_t N>
static constexpr size_t reguDynamics< DataType, N >::volume ( )  [inline], [static]
```

Get the total data number.

Returns

The data number.

Here is the caller graph for this function:



7.15.4 Member Data Documentation

7.15.4.1 bindE

```
template<typename DataType , size_t N>
Scalar reguDynamics< DataType, N >::bindE {0.0}
```

The binding energy(for regularization) of the dynamic system.

7.15.4.2 omega

```
template<typename DataType , size_t N>
Scalar reguDynamics< DataType, N >::omega {0.0}
```

The regularization variable of the dynamic system.

7.15.4.3 pos

```
template<typename DataType , size_t N>
VectorArray reguDynamics< DataType, N >::pos
```

Array of position of the particles. Element is 3D vector.

7.15.4.4 time

```
template<typename DataType , size_t N>
Scalar reguDynamics< DataType, N >::time {0.0}
```

The physical time of the dynamic system.

7.15.4.5 vel

```
template<typename DataType , size_t N>
VectorArray reguDynamics< DataType, N >::vel
```

Array of velocity of the particles. Element is 3D vector.

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

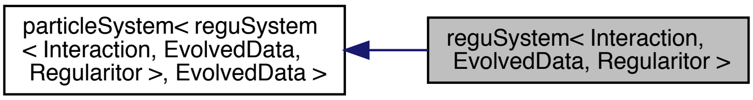
- particleSystem/regularState.h

7.16 reguSystem< Interaction, EvolvedData, Regularitor > Class Template Reference

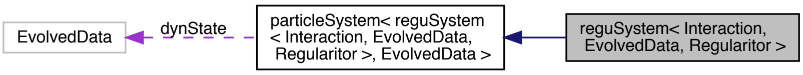
Regularized particle System.

`#include <reguSystem.h>`

Inheritance diagram for reguSystem< Interaction, EvolvedData, Regularitor >:


particleSystem< reguSystem < Interaction, EvolvedData, Regularitor >, EvolvedData >
reguSystem< Interaction, EvolvedData, Regularitor >

Collaboration diagram for reguSystem< Interaction, EvolvedData, Regularitor >:


EvolvedData
dynState
particleSystem< reguSystem < Interaction, EvolvedData, Regularitor >, EvolvedData >
reguSystem< Interaction, EvolvedData, Regularitor >

Public Types

- typedef EvolvedData::Scalar Scalar
- typedef EvolvedData::Vector Vector
- typedef EvolvedData::VectorArray VectorArray
- typedef EvolvedData::ScalarArray ScalarArray
- typedef std::array< Scalar, EvolvedData::volume()> PlainArray

Public Member Functions

- void advancePos (Scalar timeStepSize)

    Advance position one step with current velocity.
- void advanceVel (Scalar timeStepSize)

    Advance velocity one step with current acceleration.
- const reguSystem & operator= (const reguSystem &other)

    Overload operator =.
- std::istream & read (std::istream &)

    Input data from standard c++ istream.
- void load (PlainArray &data)

    Load data from a plain array.
- Scalar timeScale (Scalar scale)

    Interface to rescale the time.

Static Public Member Functions

- static constexpr size_t size ()

    Get the number of the particles.
- static constexpr size_t volume ()

    Get the total dynamic scalar number.

Private Member Functions

- void advanceOmega (Scalar stepSize)

    Advance regularization variable omega.
- void advanceB (Scalar stepSize)

    Advance regularization variable bindE.
- void kickVel (Scalar stepSize)

    Advance velocity with current acceleration.
- void kickAuxiVel (Scalar stepSize)

    Advance auxiliar velocity with current acceleration.
- void updateAccWith (VectorArray &vel)

    Update velocity dependent acceleration with given velocity. Then update the total acceleration.
- void updateVelIndepAcc ()

    Update velocity independent acceleration.

Private Attributes

- VectorArray velIndepAcc

  Velocity independent acceleration array.
- VectorArray velDepAcc

  Velocity dependent acceleration array.
- Interaction velDepForce

  Velocity dependent pair force functor.
- Regularitor regular

  Regularization interface.

Additional Inherited Members

7.16.1 Detailed Description

template<typename Interaction, typename EvolvedData, typename Regularitor>
class reguSystem< Interaction, EvolvedData, Regularitor >

Regularized particle System.

Regularied particle system. See details in `https://link.springer.com/article/10.1023%2FA%3A1008368322547`, `http://iopscience.iop.org/article/10.1086/301102/meta` and `https://link.springer.com/article/10.1023%2FA%3A1021149313347`.

7.16.2 Member Typedef Documentation

7.16.2.1 PlainArray

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
typedef std::array<Scalar, EvolvedData::volume()> reguSystem< Interaction, EvolvedData, Regularitor
>::PlainArray
```

7.16.2.2 Scalar

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
typedef EvolvedData::Scalar reguSystem< Interaction, EvolvedData, Regularitor >::Scalar
```

7.16.2.3 ScalarArray

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
typedef EvolvedData::ScalarArray reguSystem< Interaction, EvolvedData, Regularitor >::ScalarArray
```

7.16.2.4 Vector

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
typedef EvolvedData::Vector reguSystem< Interaction, EvolvedData, Regularitor >::Vector
```

7.16.2.5 VectorArray

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
typedef EvolvedData::VectorArray reguSystem< Interaction, EvolvedData, Regularitor >::VectorArray
```

7.16.3 Member Function Documentation

7.16.3.1 advanceB()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void reguSystem< Interaction, EvolvedData, Regularitor >::advanceB (
             Scalar stepSize )  [private]
```

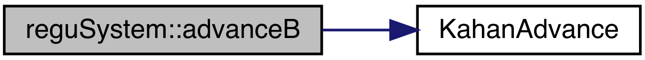
Advance regularization variable bindE.

Advance bindE with velocity dependent acceleration and auxiliar velocity with physical time step size.

Parameters

stepSize	Physical time step.

Here is the call graph for this function:



7.16.3.2 advanceOmega()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void reguSystem< Interaction, EvolvedData, Regularitor >::advanceOmega (
             Scalar stepSize )  [private]
```

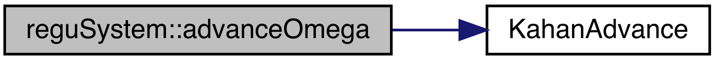
Advance regularization variable omega.

Advance omega with velocity independent acceleration and auxiliar velocity with physical time step size.

Parameters

stepSize	Physical time step.

Here is the call graph for this function:



7.16.3.3 advancePos()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void reguSystem< Interaction, EvolvedData, Regularitor >::advancePos (
            Scalar timeStepSize )
```

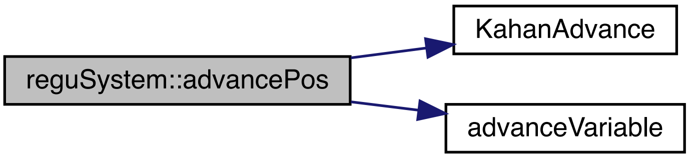
Advance position one step with current velocity.

Advance position array and physical time one step with current integration step size and velocity.

Parameters

timeStepSize	Integration step size, will be transfered to physical time in the function.

Here is the call graph for this function:



7.16.3.4 advanceVel()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void reguSystem< Interaction, EvolvedData, Regularitor >::advanceVel (
            Scalar timeStepSize )
```

Advance velocity one step with current acceleration.

Advance velocity and auxiliary velocity array one step with current integration step size and accelerations.

Parameters

timeStepSize	Integration step size, will be transfered to physical time in the function.

7.16.3.5 kickAuxiVel()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void reguSystem< Interaction, EvolvedData, Regularitor >::kickAuxiVel (
            Scalar stepSize )  [private]
```

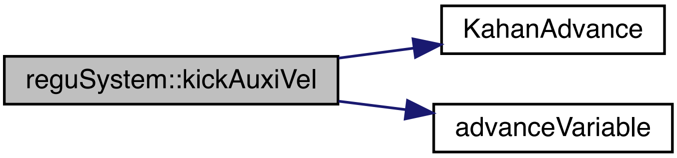
Advance auxiliar velocity with current acceleration.

Advance the auxiliar velocity with current total acceleration variable 'acc'.

Parameters

stepSize	Integration step size.

Here is the call graph for this function:



7.16.3.6 kickVel()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void reguSystem< Interaction, EvolvedData, Regularitor >::kickVel (
            Scalar stepSize )  [private]
```

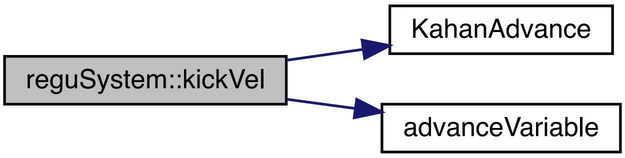
Advance velocity with current acceleration.

Advance the velocity with current total acceleration variable 'acc'.

Parameters

stepSize	Integration step size.

Here is the call graph for this function:



7.16.3.7 load()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void reguSystem< Interaction, EvolvedData, Regularitor >::load (
             PlainArray & data )
```

Load data from a plain array.

Note

Overload base class load().

Interface usded by integrator and ODE iterator. Load data from a plain array processed by itegrator and iterator. Derived class could overload this function to additional process.

Parameters

data	Plain scalar array.

7.16.3.8 operator=()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
const reguSystem< Interaction, EvolvedData, Regularitor > & reguSystem< Interaction, Evolved↩
Data, Regularitor >::operator= (
             const reguSystem< Interaction, EvolvedData, Regularitor > & other )
```

Overload operator =.

7.16.3.9 read()

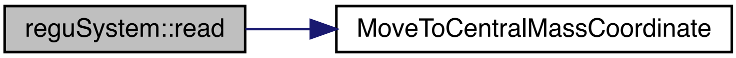
```
template<typename Interaction , typename EvolvedData , typename Regularitor >
std::istream & reguSystem< Interaction, EvolvedData, Regularitor >::read (
             std::istream & input )
```

Input data from standard c++ istream.

Note

Overload base class read().

Implement of CRTP '>>' method. Here is the call graph for this function:



7.16.3.10 size()

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
static constexpr size_t reguSystem< Interaction, EvolvedData, Regularitor >::size ( )  [inline],
[static]
```

Get the number of the particles.

Returns

The particle number.

Note

Overload base class size().

7.16.3.11 timeScale()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
EvolvedData::Scalar reguSystem< Interaction, EvolvedData, Regularitor >::timeScale (
             Scalar scale )
```

Interface to rescale the time.

Note

Overload base class timeScale().

Interace used by dynamic system. Transfer integration time to physical time.

Returns

The phsyical time.

7.16.3.12 updateAccWith()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void reguSystem< Interaction, EvolvedData, Regularitor >::updateAccWith (
            VectorArray & velocity )  [private]
```

Update velocity dependent acceleration with given velocity. Then update the total acceleration.

Update the velocity dependent accelaration variable 'velDepAcc' with given velocity and velocity dependent pair force 'velDepForce'. Then update the total acceleration 'acc' by adding 'velIndepAcc' and 'velDepAcc'.

7.16.3.13 updateVelIndepAcc()

```
template<typename Interaction , typename EvolvedData , typename Regularitor >
void reguSystem< Interaction, EvolvedData, Regularitor >::updateVelIndepAcc ( )  [private]
```

Update velocity independent acceleration.

Update velocity independent acceleration 'velIndepAcc' with Newtonian interaction.

7.16.3.14 volume()

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
static constexpr size_t reguSystem< Interaction, EvolvedData, Regularitor >::volume ( )  [inline],
[static]
```

Get the total dynamic scalar number.

Returns

The dynamic scalar number.

Note

Overload base class volume().

7.16.4 Member Data Documentation

7.16.4.1 regular

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
Regularitor reguSystem< Interaction, EvolvedData, Regularitor >::regular  [private]
```

Regularization interface.

7.16.4.2 velDepAcc

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
VectorArray reguSystem< Interaction, EvolvedData, Regularitor >::velDepAcc  [private]
```

Velocity dependent acceleration array.

7.16.4.3 velDepForce

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
Interaction reguSystem< Interaction, EvolvedData, Regularitor >::velDepForce  [private]
```

Velocity dependent pair force functor.

7.16.4.4 velIndepAcc

```
template<typename Interaction, typename EvolvedData, typename Regularitor>
VectorArray reguSystem< Interaction, EvolvedData, Regularitor >::velIndepAcc  [private]
```

Velocity independent acceleration array.

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

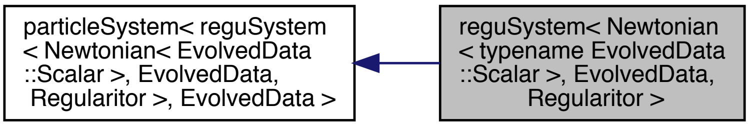
- particleSystem/reguSystem.h

7.17 reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor > Class Template Reference

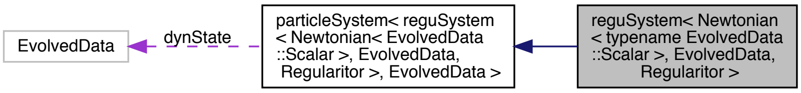
Partial specialization of reguSystem for velocity independent system.

```
#include <reguSystem.h>
```

Inheritance diagram for reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >:


particleSystem< reguSystem < Newtonian< EvolvedData ::Scalar >, EvolvedData, Regularitor >, EvolvedData >
reguSystem< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >

Collaboration diagram for reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >:


EvolvedData
dynState
particleSystem< reguSystem < Newtonian< EvolvedData ::Scalar >, EvolvedData, Regularitor >, EvolvedData >
reguSystem< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >

Public Types

- typedef EvolvedData::Scalar Scalar
- typedef EvolvedData::Vector Vector
- typedef EvolvedData::VectorArray VectorArray
- typedef EvolvedData::ScalarArray ScalarArray
- typedef std::array< Scalar, EvolvedData::volume()> PlainArray

Public Member Functions

- void advancePos (Scalar timeStepSize)

  Advance position one step with current velocity.
- void advanceVel (Scalar timeStepSize)

  Advance velocity one step with current acceleration.
- std::istream & read (std::istream &)

  Input data from standard c++ istream.
- void load (PlainArray &data)

  Load data from a plain array.
- Scalar timeScale (Scalar scale)

  Interface to rescale the time.

Static Public Member Functions

- static constexpr size_t size ()

  Get the number of the particles.
- static constexpr size_t volume ()

  Get the total dynamic scalar number.

Private Member Functions

- void advanceOmega (Scalar stepSize)

  Advance regularization variable omega.
- void updateVelIndepAcc ()

  Update velocity independent acceleration.

Private Attributes

- Regularitor regular

  Regularization interface.

Additional Inherited Members

7.17.1 Detailed Description

template<typename EvolvedData, typename Regularitor>
class reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >

Partial specialization of reguSystem for velocity independent system.

7.17.2 Member Typedef Documentation

7.17.2.1 PlainArray

```
template<typename EvolvedData , typename Regularitor >
typedef std::array<Scalar, EvolvedData::volume()> reguSystem< Newtonian< typename EvolvedData::Scalar
>, EvolvedData, Regularitor >::PlainArray
```

7.17.2.2 Scalar

```
template<typename EvolvedData , typename Regularitor >
typedef EvolvedData::Scalar reguSystem< Newtonian< typename EvolvedData::Scalar >, Evolved↩
Data, Regularitor >::Scalar
```

7.17.2.3 ScalarArray

```
template<typename EvolvedData , typename Regularitor >
typedef EvolvedData::ScalarArray reguSystem< Newtonian< typename EvolvedData::Scalar >, Evolved↩
Data, Regularitor >::ScalarArray
```

7.17.2.4 Vector

```
template<typename EvolvedData , typename Regularitor >
typedef EvolvedData::Vector reguSystem< Newtonian< typename EvolvedData::Scalar >, Evolved↩
Data, Regularitor >::Vector
```

7.17.2.5 VectorArray

```
template<typename EvolvedData , typename Regularitor >
typedef EvolvedData::VectorArray reguSystem< Newtonian< typename EvolvedData::Scalar >, Evolved↩
Data, Regularitor >::VectorArray
```

7.17.3 Member Function Documentation

7.17.3.1 advanceOmega()

```
template<typename EvolvedData , typename Regularitor >
void reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >↩
::advanceOmega (
            Scalar stepSize )  [private]
```

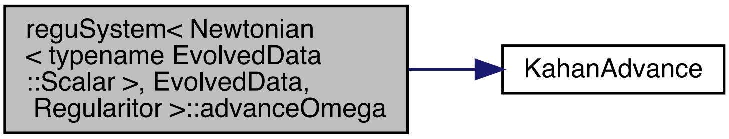
Advance regularization variable omega.

Advance omega with velocity independent acceleration and auxiliar velocity with physical time step size.

Parameters

stepSize	Physical time step.

Here is the call graph for this function:



7.17.3.2 advancePos()

```
template<typename EvolvedData , typename Regularitor >
void reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >↩
::advancePos (
             Scalar timeStepSize )
```

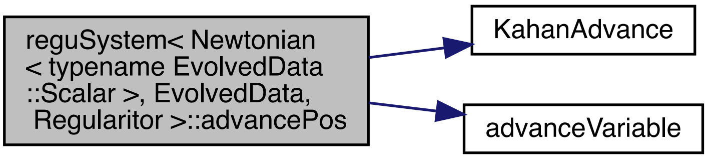
Advance position one step with current velocity.

Advance position array and physical time one step with current integration step size and velocity.

Parameters

timeStepSize	Integration step size, will be transfered to physical time in the function.

Here is the call graph for this function:



7.17.3.3 advanceVel()

```
template<typename EvolvedData , typename Regularitor >
void reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >↩
::advanceVel (
            Scalar timeStepSize )
```

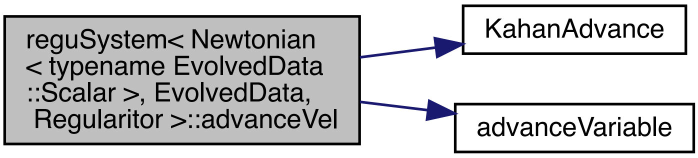
Advance velocity one step with current acceleration.

Advance velocity array one step with current integration step size and accelerations.

Parameters

timeStepSize	Integration step size, will be transfered to physical time in the function.

Here is the call graph for this function:


reguSystem< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advanceVel
KahanAdvance
advanceVariable

7.17.3.4 load()

```
template<typename EvolvedData , typename Regularitor >
void reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >::load
(
            PlainArray & data )
```

Load data from a plain array.

Note

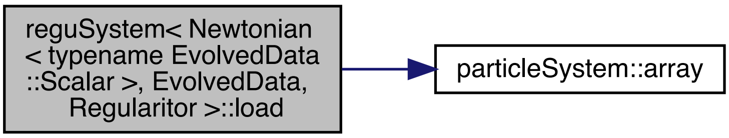
Overload base class load().

Interface usded by integrator and ODE iterator. Load data from a plain array processed by itegrator and iterator. Derived class could overload this function to additional process.

Parameters

data	Plain scalar array.

Here is the call graph for this function:


reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >::load
particleSystem::array

7.17.3.5 read()

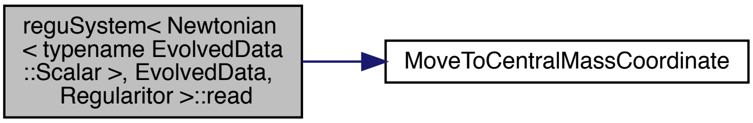
```
template<typename EvolvedData , typename Regularitor >
std::istream & reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor
>::read (
            std::istream & input )
```

Input data from standard c++ istream.

Note

> Overload base class read().

Implement of CRTP '>>' method. Here is the call graph for this function:


reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >::read
MoveToCentralMassCoordinate

7.17.3.6 size()

```
template<typename EvolvedData , typename Regularitor >
static constexpr size_t reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData,
Regularitor >::size ( ) [inline], [static]
```

Get the number of the particles.

Returns

> The particle number.

Note

> Overload base class size().

7.17.3.7 timeScale()

```
template<typename EvolvedData , typename Regularitor >
EvolvedData::Scalar reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor
>::timeScale (
             Scalar scale )
```

Interface to rescale the time.

Note

Overload base class timeScale().

Interace used by dynamic system. Transfer integration time to physical time.

Returns

The phsyical time.

7.17.3.8 updateVelIndepAcc()

```
template<typename EvolvedData , typename Regularitor >
void reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >↩
::updateVelIndepAcc ( )  [private]
```

Update velocity independent acceleration.

Update velocity independent acceleration 'acc' with Newtonian interaction.

7.17.3.9 volume()

```
template<typename EvolvedData , typename Regularitor >
static constexpr size_t reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData,
Regularitor >::volume ( )  [inline], [static]
```

Get the total dynamic scalar number.

Returns

The dynamic scalar number.

Note

Overload base class volume().

7.17.4 Member Data Documentation

7.17.4.1 regular

```
template<typename EvolvedData , typename Regularitor >
Regularitor reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor
>::regular  [private]
```

Regularization interface.

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

- particleSystem/reguSystem.h

7.18 symplectic10th< ParticSys > Class Template Reference

Tenth order symplectic integrator.

```
#include <symplectic10th.h>
```

Public Member Functions

- void integrate (ParticSys &particles, double stepLength)

  Interface to integrate particle system.

Static Public Attributes

- static const int order {10}

  Order of the integrator.

7.18.1 Detailed Description

template<typename ParticSys>
class symplectic10th< ParticSys >

Tenth order symplectic integrator.

7.18.2 Member Function Documentation

7.18.2.1 integrate()

```
template<typename ParticSys >
void symplectic10th< ParticSys >::integrate (
            ParticSys & particles,
            double stepLength )
```

Interface to integrate particle system.

This function integrate the particle system for one step with DKD leapfrog second order symplectic algorithm.

Parameters

particles	Particle system need to be integrated.
stepLength	Step size for integration.

7.18.3 Member Data Documentation

7.18.3.1 order

```
template<typename ParticSys >
const int symplectic10th< ParticSys >::order {10}  [static]
```

Order of the integrator.

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

- integrator/symplectic/symplectic10th.h

7.19 symplectic2th< ParticSys > Class Template Reference

Second order symplectic integrator.

```
#include <symplectic2th.h>
```

Public Member Functions

- void integrate (ParticSys &particles, Scalar stepLength)
  Interface to integrate particle system.

Static Public Attributes

- static const int order {2}
  Order of the integrator.

Private Types

- typedef ParticSys::Scalar Scalar

7.19.1 Detailed Description

template<typename ParticSys>
class symplectic2th< ParticSys >

Second order symplectic integrator.

7.19.2 Member Typedef Documentation

7.19.2.1 Scalar

```
template<typename ParticSys >
typedef ParticSys::Scalar symplectic2th< ParticSys >::Scalar  [private]
```

7.19.3 Member Function Documentation

7.19.3.1 integrate()

```
template<typename ParticSys >
void symplectic2th< ParticSys >::integrate (
            ParticSys & particles,
            Scalar stepLength )
```

Interface to integrate particle system.

This function integrate the particle system for one step with DKD leapfrog second order symplectic algorithm.

Parameters

particles	Particle system need to be integrated.
stepLength	Step size for integration.

7.19.4 Member Data Documentation

7.19.4.1 order

```
template<typename ParticSys >
const int symplectic2th< ParticSys >::order {2}  [static]
```

Order of the integrator.

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

- integrator/symplectic/symplectic2th.h

7.20 symplectic4th< ParticSys > Class Template Reference

Fourth order symplectic integrator.

```
#include <symplectic4th.h>
```

Public Member Functions

- void integrate (ParticSys &particles, double stepLength)

  Interface to integrate particle system.

Static Public Attributes

- static const int order {4}

  Order of the integrator.

7.20.1 Detailed Description

template<typename ParticSys>
class symplectic4th< ParticSys >

Fourth order symplectic integrator.

7.20.2 Member Function Documentation

7.20.2.1 integrate()

```
template<typename ParticSys >
void symplectic4th< ParticSys >::integrate (
            ParticSys & particles,
            double stepLength )
```

Interface to integrate particle system.

This function integrate the particle system for one step with DKD leapfrog second order symplectic algorithm.

Parameters

particles	Particle system need to be integrated.
stepLength	Step size for integration.

7.20.3 Member Data Documentation

7.20.3.1 order

```
template<typename ParticSys >
const int symplectic4th< ParticSys >::order {4}  [static]
```

Order of the integrator.

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

- integrator/symplectic/symplectic4th.h

7.21 symplectic6th< ParticSys > Class Template Reference

Sixth order symplectic integrator.

```
#include <symplectic6th.h>
```

Static Public Attributes

- static const int order {6}

  Order of the integrator.

Private Member Functions

- void integrate (ParticSys &particles, double stepLength)

  Interface to integrate particle system.

7.21.1 Detailed Description

template<typename ParticSys>
class symplectic6th< ParticSys >

Sixth order symplectic integrator.

7.21.2 Member Function Documentation

7.21.2.1 integrate()

```
template<typename ParticSys >
void symplectic6th< ParticSys >::integrate (
            ParticSys & particles,
            double stepLength )  [private]
```

Interface to integrate particle system.

This function integrate the particle system for one step with DKD leapfrog second order symplectic algorithm.

Parameters

particles	Particle system need to be integrated.
stepLength	Step size for integration.

7.21.3 Member Data Documentation

7.21.3.1 order

```
template<typename ParticSys >
const int symplectic6th< ParticSys >::order {6}  [static]
```

Order of the integrator.

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

- integrator/symplectic/symplectic6th.h

7.22 symplectic8th< ParticSys > Class Template Reference

Eighth order symplectic integrator.

```
#include <symplectic8th.h>
```

Public Member Functions

- void integrate (ParticSys &particles, double stepLength)

  Interface to integrate particle system.

Static Public Attributes

- static const int order {8}

  Order of the integrator.

7.22.1 Detailed Description

template<typename ParticSys>
class symplectic8th< ParticSys >

Eighth order symplectic integrator.

7.22.2 Member Function Documentation

7.22.2.1 integrate()

```
template<typename ParticSys >
void symplectic8th< ParticSys >::integrate (
             ParticSys & particles,
             double stepLength )
```

Interface to integrate particle system.

This function integrate the particle system for one step with DKD leapfrog second order symplectic algorithm.

Parameters

particles	Particle system need to be integrated.
stepLength	Step size for integration.

7.22.3 Member Data Documentation

7.22.3.1 order

```
template<typename ParticSys >
const int symplectic8th< ParticSys >::order {8}  [static]
```

Order of the integrator.

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

- integrator/symplectic/symplectic8th.h

7.23 TTL< DynamicState > Class Template Reference

Time Transform Leapfrog algorithmatic regularization interface.

```
#include <regularization.h>
```

Public Types

- typedef DynamicState::Scalar Scalar

Public Member Functions

- Scalar getPhysicalPosTime (std::array< Scalar, size()> &mass, DynamicState &dyn, Scalar stepSize)

  Calculate the physical time for position advance from integration step size.
- Scalar getPhysicalVelTime (std::array< Scalar, size()> &mass, DynamicState &dyn, Scalar stepSize)

  Calculate the physical time for velocity advance from integration step size.

Static Public Member Functions

- static constexpr size_t size ()

7.23.1 Detailed Description

template<typename DynamicState>
class TTL< DynamicState >

Time Transform Leapfrog algorithmatic regularization interface.

See detials in `https://link.springer.com/article/10.1023%2FA%3A1021149313347` .

7.23.2 Member Typedef Documentation

7.23.2.1 Scalar

```
template<typename DynamicState >
typedef DynamicState::Scalar TTL< DynamicState >::Scalar
```

7.23.3 Member Function Documentation

7.23.3.1 getPhysicalPosTime()

```
template<typename DynamicState >
Scalar TTL< DynamicState >::getPhysicalPosTime (
             std::array< Scalar, size()> & mass,
             DynamicState & dyn,
             Scalar stepSize )  [inline]
```

Calculate the physical time for position advance from integration step size.

Parameters

mass	Array of particle mass.
dyn	Dynamic system contains position, velocity and regularization variables. See example class in dynamicState.h.
stepSize	Integration step size. This could not be the physical time. Look references for details in class despriction.

7.23.3.2 getPhysicalVelTime()

```
template<typename DynamicState >
Scalar TTL< DynamicState >::getPhysicalVelTime (
             std::array< Scalar, size()> & mass,
             DynamicState & dyn,
             Scalar stepSize )  [inline]
```

Calculate the physical time for velocity advance from integration step size.

Parameters

mass	Array of particle mass.
dyn	Dynamic system contains position, velocity and regularization variables. See example class in dynamicState.h.
stepSize	Integration step size. This could not be the physical time. Look references for details in class despriction.

7.23.3.3 size()

```
template<typename DynamicState >
static constexpr size_t TTL< DynamicState >::size ( )  [inline], [static]
```

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

- particleSystem/regularization.h

7.24 vec3< T > Struct Template Reference

Self 3D vector class.

```
#include <vector3.h>
```

Public Member Functions

- vec3 ()
- vec3 (T vx, T vy, T vz)
- vec3 (const vec3 &v)
- vec3 operator+ (const vec3 &v) const

  Addition by wise.
- vec3 operator- (const vec3 &v) const

  Subtraction by wise.
- vec3 operator/ (const vec3 &v) const

  Divition by wise.
- vec3 operator+ (const double c) const

  Add scalar by wise.
- vec3 operator- (const double c) const

  Subtract scalar by wise.
- vec3 operator* (const double c) const

  Multiply scalar by wise.
- vec3 operator/ (const double c) const

  Divide scalar by wise.
- vec3 operator- () const

  Opposite vector.
- vec3 operator^ (const vec3 &v) const

  Cross product.
- vec3 abs () const

  Absolute value by wise.
- const vec3 & operator+= (const vec3 &v)
- const vec3 & operator-= (const vec3 &v)
- const vec3 & operator/= (const vec3 &v)
- const vec3 & operator+= (const double c)
- const vec3 & operator-= (const double c)
- const vec3 & operator*= (const double c)
- const vec3 & operator/= (const double c)
- const vec3 & operator= (const vec3 &v)

- double operator∗ (const vec3 &v) const

  Inner product.
- double norm () const

  Calculate the norm.
- double normSquare () const

  Calcualte the square of the norm.
- double reNorm () const

  Calculate the inverse of the norm.
- void setZero ()

Public Attributes

- T x
- T y
- T z

Friends

- vec3 operator+ (const double c, const vec3 &v)
- vec3 operator- (const double c, const vec3 &v)
- vec3 operator∗ (const double c, const vec3 &v)
- std::ostream & operator<< (std::ostream &output, const vec3 &v)

  Output to ostream.
- std::istream & operator>> (std::istream &input, vec3 &v)

  Input from istream.

7.24.1 Detailed Description

template<typename T>
struct vec3< T >

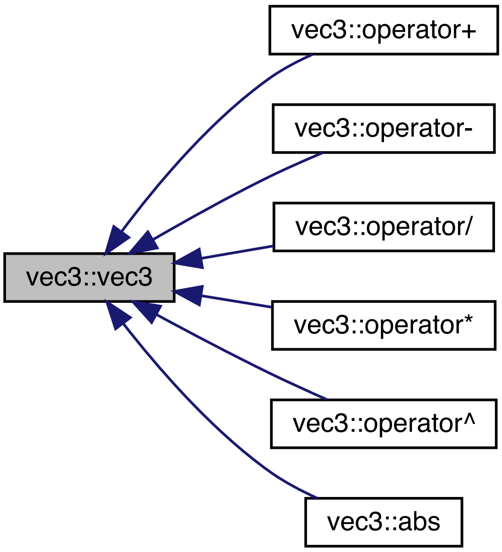
Self 3D vector class.

7.24.2 Constructor & Destructor Documentation

7.24.2.1 vec3() [1/3]

```
template<typename T>
vec3< T >::vec3 ( )  [inline]
```

Here is the caller graph for this function:



7.24.2.2 vec3() [2/3]

```
template<typename T>
vec3< T >::vec3 (
            T vx,
            T vy,
            T vz )  [inline]
```

7.24.2.3 vec3() [3/3]

```
template<typename T>
vec3< T >::vec3 (
            const vec3< T > & v )  [inline]
```

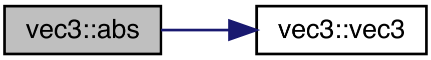
7.24.3 Member Function Documentation

7.24.3.1 abs()

```
template<typename T>
vec3 vec3< T >::abs ( ) const  [inline]
```

Absolute value by wise.

Here is the call graph for this function:



7.24.3.2 norm()

```
template<typename T>
double vec3< T >::norm ( ) const  [inline]
```

Calculate the norm.

7.24.3.3 normSquare()

```
template<typename T>
double vec3< T >::normSquare ( ) const  [inline]
```

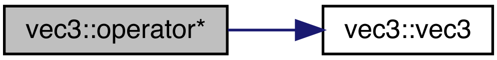
Calcualte the square of the norm.

7.24.3.4 operator*() [1/2]

```
template<typename T>
vec3 vec3< T >::operator* (
             const double c ) const  [inline]
```

Multiply scalar by wise.

Here is the call graph for this function:



7.24.3.5 operator*() [2/2]

```
template<typename T>
double vec3< T >::operator* (
            const vec3< T > & v ) const  [inline]
```

Inner product.

7.24.3.6 operator*=()

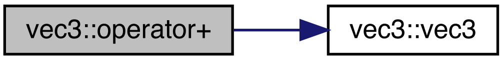
```
template<typename T>
const vec3& vec3< T >::operator*= (
            const double c )  [inline]
```

7.24.3.7 operator+() [1/2]

```
template<typename T>
vec3 vec3< T >::operator+ (
            const vec3< T > & v ) const  [inline]
```

Addition by wise.

Here is the call graph for this function:

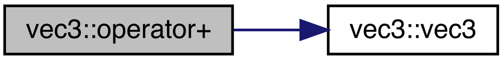


7.24.3.8 operator+() [2/2]

```
template<typename T>
vec3 vec3< T >::operator+ (
            const double c ) const  [inline]
```

Add scalar by wise.

Here is the call graph for this function:



7.24.3.9 operator+=() [1/2]

```
template<typename T>
const vec3& vec3< T >::operator+= (
              const vec3< T > & v )  [inline]
```

7.24.3.10 operator+=() [2/2]

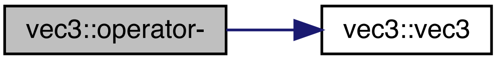
```
template<typename T>
const vec3& vec3< T >::operator+= (
              const double c )  [inline]
```

7.24.3.11 operator-() [1/3]

```
template<typename T>
vec3 vec3< T >::operator- (
              const vec3< T > & v ) const  [inline]
```

Subtraction by wise.

Here is the call graph for this function:

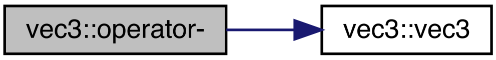


7.24.3.12 operator-() [2/3]

```
template<typename T>
vec3 vec3< T >::operator- (
              const double c ) const  [inline]
```

Subtract scalar by wise.

Here is the call graph for this function:

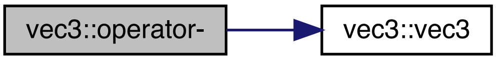


7.24.3.13 operator-() [3/3]

```
template<typename T>
vec3 vec3< T >::operator- ( ) const  [inline]
```

Opposite vector.

Here is the call graph for this function:



7.24.3.14 operator-=() [1/2]

```
template<typename T>
const vec3& vec3< T >::operator-= (
             const vec3< T > & v )  [inline]
```

7.24.3.15 operator-=() [2/2]

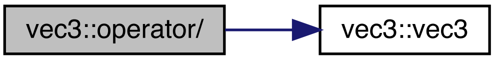
```
template<typename T>
const vec3& vec3< T >::operator-= (
             const double c )  [inline]
```

7.24.3.16 operator/() [1/2]

```
template<typename T>
vec3 vec3< T >::operator/ (
             const vec3< T > & v ) const  [inline]
```

Divition by wise.

Here is the call graph for this function:

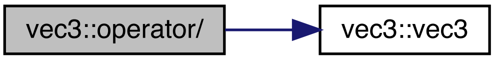


7.24.3.17 operator/() [2/2]

```
template<typename T>
vec3 vec3< T >::operator/ (
            const double c ) const  [inline]
```

Divide scalar by wise.

Here is the call graph for this function:



7.24.3.18 operator/=() [1/2]

```
template<typename T>
const vec3& vec3< T >::operator/= (
            const vec3< T > & v )  [inline]
```

7.24.3.19 operator/=() [2/2]

```
template<typename T>
const vec3& vec3< T >::operator/= (
            const double c )  [inline]
```

7.24.3.20 operator=()

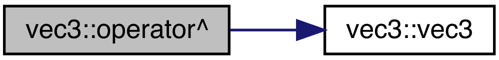
```
template<typename T>
const vec3& vec3< T >::operator= (
            const vec3< T > & v )  [inline]
```

7.24.3.21 operator^()

```
template<typename T>
vec3 vec3< T >::operator^ (
             const vec3< T > & v ) const  [inline]
```

Cross product.

Here is the call graph for this function:

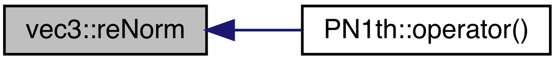


7.24.3.22 reNorm()

```
template<typename T>
double vec3< T >::reNorm ( ) const  [inline]
```

Calculate the inverse of the norm.

Here is the caller graph for this function:



7.24.3.23 setZero()

```
template<typename T>
void vec3< T >::setZero ( )  [inline]
```

7.24.4 Friends And Related Function Documentation

7.24.4.1 operator*

```
template<typename T>
vec3 operator* (
             const double c,
             const vec3< T > & v )  [friend]
```

7.24.4.2 operator+

```
template<typename T>
vec3 operator+ (
             const double c,
             const vec3< T > & v )  [friend]
```

7.24.4.3 operator-

```
template<typename T>
vec3 operator- (
             const double c,
             const vec3< T > & v )  [friend]
```

7.24.4.4 operator<<

```
template<typename T>
std::ostream& operator<< (
             std::ostream & output,
             const vec3< T > & v )  [friend]
```

Output to ostream.

7.24.4.5 operator>>

```
template<typename T>
std::istream& operator>> (
             std::istream & input,
             vec3< T > & v )  [friend]
```

Input from istream.

7.24.5 Member Data Documentation

7.24.5.1 x

```
template<typename T>
T vec3< T >::x
```

7.24.5.2 y

```
template<typename T>
T vec3< T >::y
```

7.24.5.3 z

```
template<typename T>
T vec3< T >::z
```

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

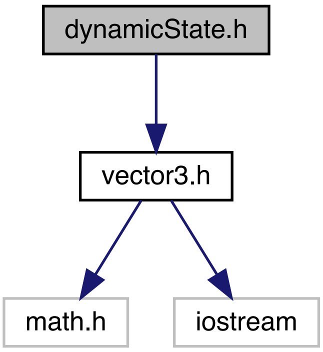
- vector3.h

8 File Documentation

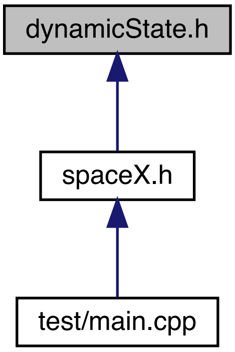
8.1 dynamicState.h File Reference

```
#include "vector3.h"
```

Include dependency graph for dynamicState.h:



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



Classes

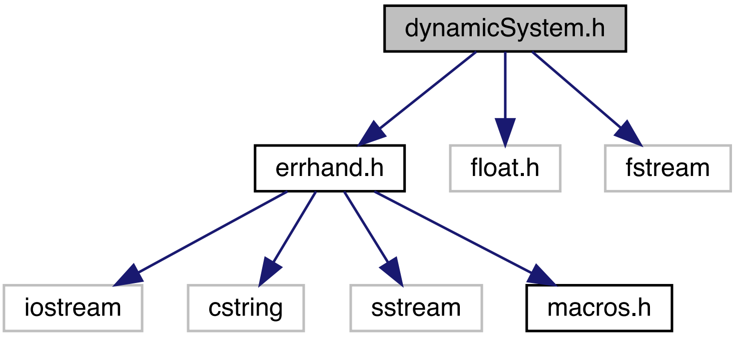
- class dynamics< DataType, N >

    Class of dynamical variable.

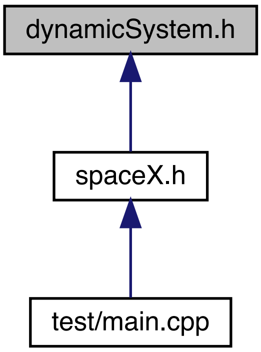
8.2 dynamicSystem.h File Reference

```
#include "errhand.h"
#include <float.h>
#include <fstream>
```

Include dependency graph for dynamicSystem.h:



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



Classes

- class dynamicSystem< ParticSys, Integrator, ODEiterator >

  A wrapper to make particle system, integrator and ODE iterator work together.

Typedefs

- template<typename ParticSys , template< typename > class Integrator, template< typename, typename > class ODEiterator>
  using spaceX = dynamicSystem< ParticSys, Integrator< ParticSys >, ODEiterator< ParticSys, Integrator< ParticSys > >>

  Alias of template name, linking the particle system, integrator and ODE iterator.

8.2.1 Typedef Documentation

8.2.1.1 spaceX

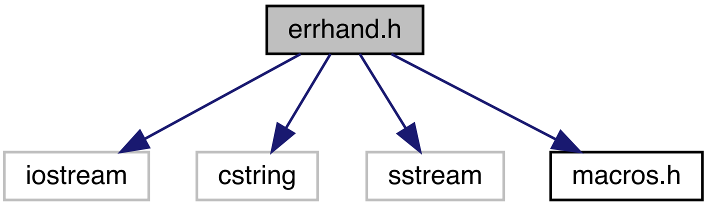
```
template<typename ParticSys , template< typename > class Integrator, template< typename,
typename > class ODEiterator>
using spaceX = dynamicSystem<ParticSys, Integrator<ParticSys>, ODEiterator<ParticSys, Integrator<Partic↩
Sys> >>
```

Alias of template name, linking the particle system, integrator and ODE iterator.

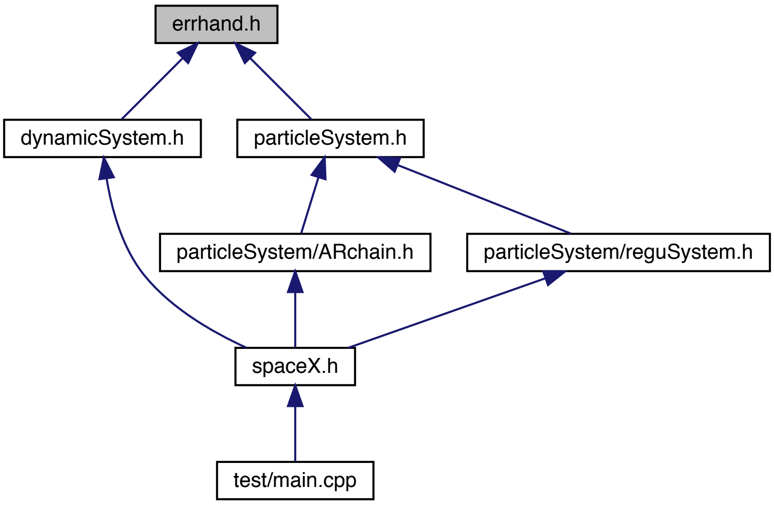
8.3 errhand.h File Reference

```
#include <iostream>
#include <cstring>
#include <sstream>
#include "macros.h"
```

Include dependency graph for errhand.h:



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



Classes

- class errhand

Namespaces

- NOTICE

Macros

- #define ANSI_COLOR_RED "\x1b[31m"
- #define ANSI_COLOR_GREEN "\x1b[32m"
- #define ANSI_COLOR_YELLOW "\x1b[33m"
- #define ANSI_COLOR_BLUE "\x1b[34m"
- #define ANSI_COLOR_MAGENTA "\x1b[35m"
- #define ANSI_COLOR_CYAN "\x1b[36m"
- #define ANSI_COLOR_RESET "\x1b[0m"
- #define NEWLINE printf("\n");

Functions

- void NOTICE::Telegram (const char ∗host, const char ∗msg)
- void NOTICE::Title (const char ∗T)
- void NOTICE::SubTitle (const char ∗T)
- void NOTICE::EraseLine ()
- void NOTICE::Line ()
- void NOTICE::SubLine ()
- void NOTICE::RunInfo (double timeLimit, double outputsize_terval, double tolerance)

Variables

- constexpr size_t NOTICE::WIDTH = 80
- bool NOTICE::Message = true

8.3.1 Macro Definition Documentation

8.3.1.1 ANSI_COLOR_BLUE

```
#define ANSI_COLOR_BLUE "\x1b[34m"
```

8.3.1.2 ANSI_COLOR_CYAN

```
#define ANSI_COLOR_CYAN "\x1b[36m"
```

8.3.1.3 ANSI_COLOR_GREEN

```
#define ANSI_COLOR_GREEN "\x1b[32m"
```

8.3.1.4 ANSI_COLOR_MAGENTA

```
#define ANSI_COLOR_MAGENTA "\x1b[35m"
```

8.3.1.5 ANSI_COLOR_RED

```
#define ANSI_COLOR_RED "\x1b[31m"
```

8.3.1.6 ANSI_COLOR_RESET

```
#define ANSI_COLOR_RESET "\x1b[0m"
```

8.3.1.7 ANSI_COLOR_YELLOW

```
#define ANSI_COLOR_YELLOW "\x1b[33m"
```

8.3.1.8 NEWLINE

```
#define NEWLINE printf("\n");
```

8.4 integrator/symplectic/symplectic10th.h File Reference

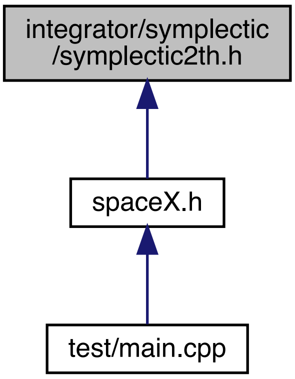
Classes

- class symplectic10th< ParticSys >

  Tenth order symplectic integrator.

8.5 integrator/symplectic/symplectic2th.h File Reference

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



Classes

- class symplectic2th< ParticSys >

  Second order symplectic integrator.

8.6 integrator/symplectic/symplectic4th.h File Reference

Classes

- class symplectic4th< ParticSys >

  Fourth order symplectic integrator.

8.7 integrator/symplectic/symplectic6th.h File Reference

Classes

- class symplectic6th< ParticSys >

  Sixth order symplectic integrator.

8.8 integrator/symplectic/symplectic8th.h File Reference

Classes

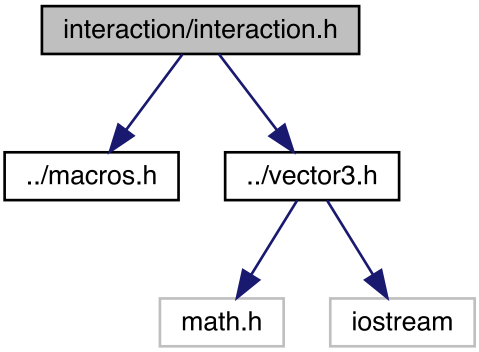
- class symplectic8th< ParticSys >

  Eighth order symplectic integrator.

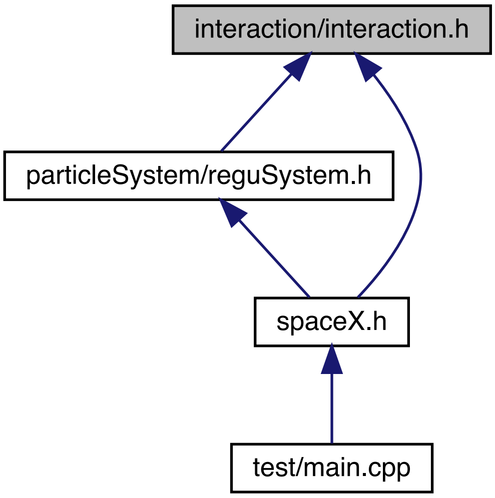
8.9 interaction/interaction.h File Reference

```
#include "../macros.h"
#include "../vector3.h"
```

Include dependency graph for interaction.h:



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



Classes

- class PN1th< Scalar >

  Post newtonian pair interaction functor(c++ std11)
- class Newtonian< Scalar >

  Marker of None velocity dependent force functor(c++ std11)

Variables

- constexpr double INV_C = 1 / C
- constexpr double INV_C2 = INV_C ∗ INV_C
- constexpr double INV_C3 = INV_C2 ∗ INV_C
- constexpr double INV_C4 = INV_C3 ∗ INV_C
- constexpr double INV_C5 = INV_C4 ∗ INV_C

8.9.1 Variable Documentation

8.9.1.1 INV_C

```
constexpr double INV_C = 1 / C
```

8.9.1.2 INV_C2

```
constexpr double INV_C2 = INV_C * INV_C
```

8.9.1.3 INV_C3

```
constexpr double INV_C3 = INV_C2 * INV_C
```

8.9.1.4 INV_C4

```
constexpr double INV_C4 = INV_C3 * INV_C
```

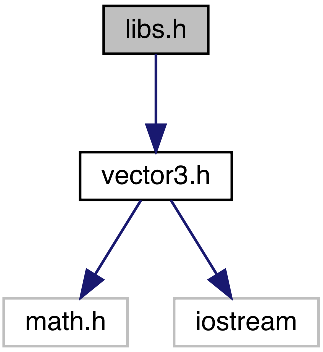
8.9.1.5 INV_C5

```
constexpr double INV_C5 = INV_C4 * INV_C
```

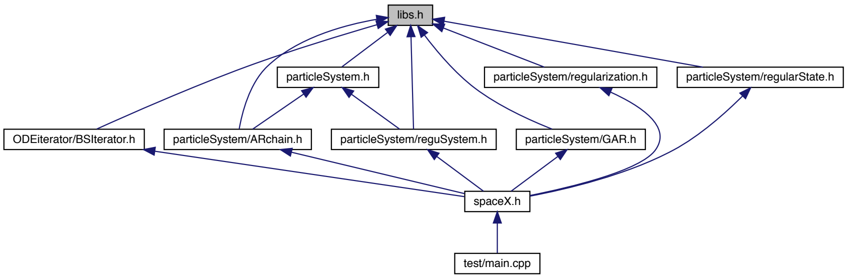
8.10 libs.h File Reference

```
#include "vector3.h"
```

Include dependency graph for libs.h:



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



Functions

- template<typename T1 , typename T2 >
  const T2 min (const T1 &x, const T2 &y)

  Self min()
- template<typename T1 , typename T2 >
  const T2 max (const T1 &x, const T2 &y)

  Self max()
- template<class T >
  const T abs (const T &x)

  Self abs()
- template<class T >
  void swap (T &a, T &b)

  Self swap()
- template<typename Scalar , size_t N>
  void KahanAdvance (std::array< vec3< Scalar >, N > &var, const std::array< vec3< Scalar >, N > &increase, std::array< vec3< Scalar >, N > &err, Scalar dt)

  Kahan Summation for Array.
- template<typename Scalar >
  void KahanAdvance (Scalar &var, const Scalar increase, Scalar &err)

  Kahan Summation for Scalar.
- template<typename Scalar , size_t N>
  void advanceVariable (std::array< vec3< Scalar >, N > &var, const std::array< vec3< Scalar >, N > &add, Scalar dt)

  Normal Summation of two Arrays.
- template<typename Scalar , size_t N>
  void MoveToCentralMassCoordinate (const std::array< Scalar, N > &mass, std::array< vec3< Scalar >, N > &phyVar)

  Move variables to central mass coordinates.
- template<typename Scalar , size_t N>
  double getKineticEnergy (const std::array< Scalar, N > &mass, const std::array< vec3< Scalar >, N > &vel)

  Calculate the kinetic energy of particles.
- template<typename Scalar , size_t N>
  double getPotentialEnergy (const std::array< Scalar, N > &mass, const std::array< vec3< Scalar >, N > &pos)

  Calculate the potential energy of particles.
- template<typename Scalar , size_t N>
  double getTotalEnergy (const std::array< Scalar, N > &mass, const std::array< vec3< Scalar >, N > &pos, const std::array< vec3< Scalar >, N > &vel)

  Calculate the total(potential + kinetic) energy of particles.
- template<typename T >
  void print (T &var)

  print an array. Used for debug

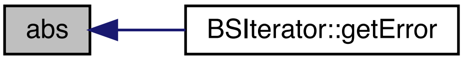
8.10.1 Function Documentation

8.10.1.1 abs()

```
template<class T >
const T abs (
             const T & x )  [inline]
```

Self abs()

Here is the caller graph for this function:



8.10.1.2 advanceVariable()

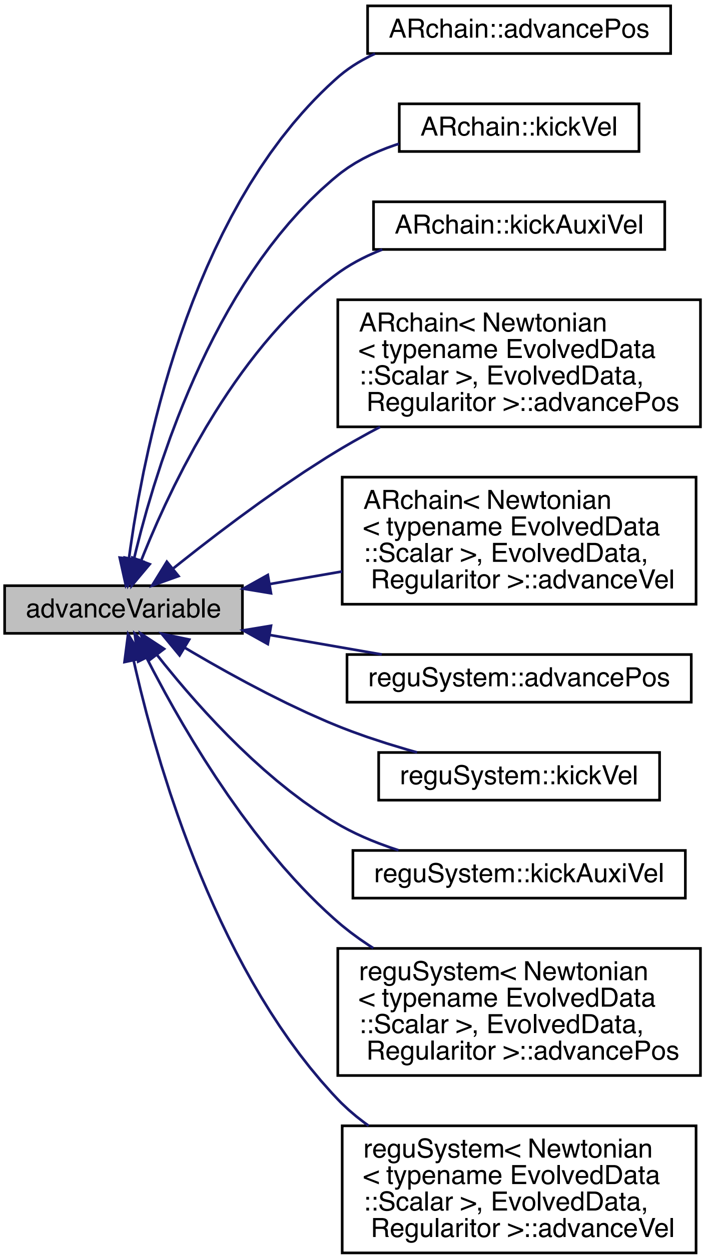
```
template<typename Scalar , size_t N>
void advanceVariable (
             std::array< vec3< Scalar >, N > & var,
             const std::array< vec3< Scalar >, N > & add,
             Scalar dt )
```

Normal Summation of two Arrays.

Parameters

var	Array of variable needs evolution.
increase	Array of inreament.
dt	Step size of advance.

Here is the caller graph for this function:


advanceVariable
ARchain::advancePos
ARchain::kickVel
ARchain::kickAuxiVel
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advancePos
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advanceVel
reguSystem::advancePos
reguSystem::kickVel
reguSystem::kickAuxiVel
reguSystem< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advancePos
reguSystem< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advanceVel

8.10.1.3 getKineticEnergy()

```
template<typename Scalar , size_t N>
double getKineticEnergy (
             const std::array< Scalar, N > & mass,
             const std::array< vec3< Scalar >, N > & vel )
```

Calculate the kinetic energy of particles.

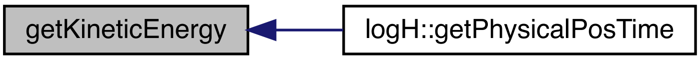
Parameters

mass	Array of mass.
vel	Array of velocity.

Returns

The kinetic energy.

Here is the caller graph for this function:



8.10.1.4 getPotentialEnergy()

```
template<typename Scalar , size_t N>
double getPotentialEnergy (
            const std::array< Scalar, N > & mass,
            const std::array< vec3< Scalar >, N > & pos )
```

Calculate the potential energy of particles.

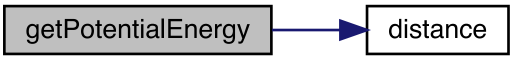
Parameters

mass	Array of mass.
pos	Array of position.

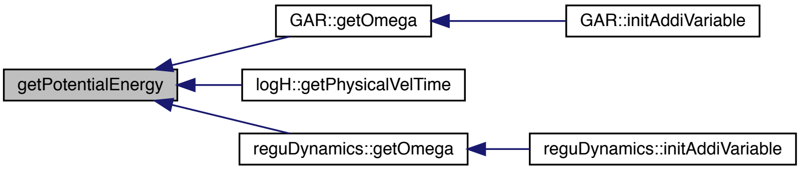
Returns

The potential energy.

Here is the call graph for this function:



Here is the caller graph for this function:



8.10.1.5 getTotalEnergy()

```
template<typename Scalar , size_t N>
double getTotalEnergy (
            const std::array< Scalar, N > & mass,
            const std::array< vec3< Scalar >, N > & pos,
            const std::array< vec3< Scalar >, N > & vel )  [inline]
```

Calculate the total(potential + kinetic) energy of particles.

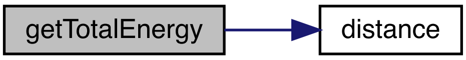
Parameters

mass	Array of mass.
pos	Array of position.
vel	Array of velocity.

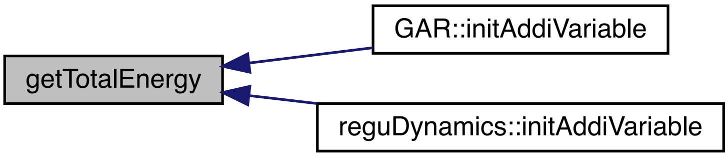
Returns

The total energy.

Here is the call graph for this function:



Here is the caller graph for this function:



8.10.1.6 KahanAdvance() [1/2]

```
template<typename Scalar , size_t N>
void KahanAdvance (
            std::array< vec3< Scalar >, N > & var,
            const std::array< vec3< Scalar >, N > & increase,
            std::array< vec3< Scalar >, N > & err,
            Scalar dt )
```

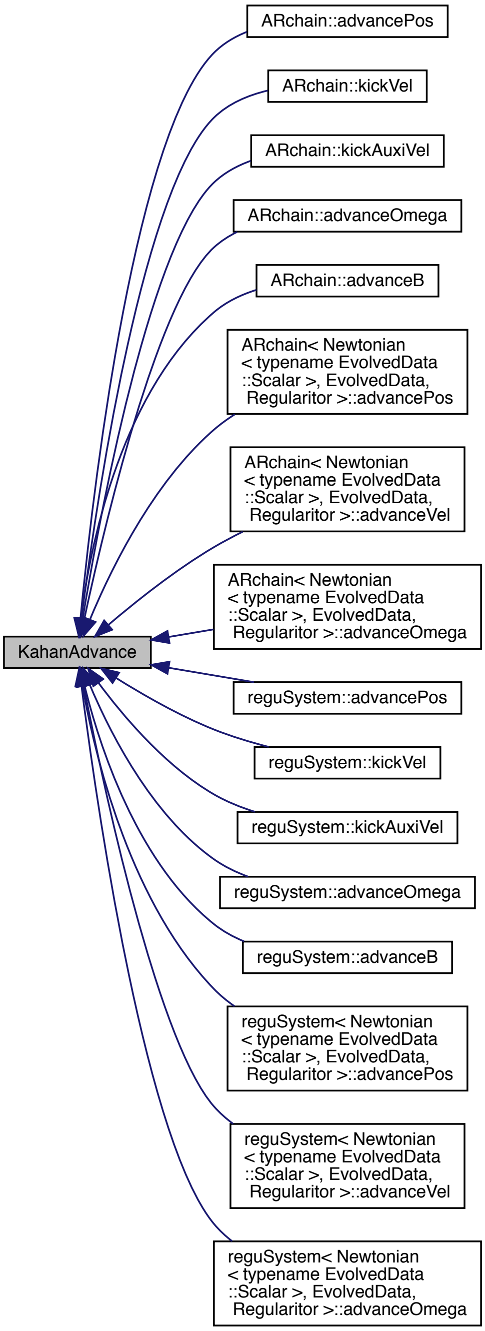
Kahan Summation for Array.

A way to reduce the round off error when adding a small number to a big one. See details in https://en.wikipedia.org/wiki/Kahan_summation_algorithm

Parameters

var	Array of variable needs evolution.
increase	Array of inreament.
err	Array of round off error from last addition.
dt	Step size of advance.

Here is the caller graph for this function:


KahanAdvance
ARchain::advancePos
ARchain::kickVel
ARchain::kickAuxiVel
ARchain::advanceOmega
ARchain::advanceB
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advancePos
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advanceVel
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advanceOmega
reguSystem::advancePos
reguSystem::kickVel
reguSystem::kickAuxiVel
reguSystem::advanceOmega
reguSystem::advanceB
reguSystem< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advancePos
reguSystem< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advanceVel
reguSystem< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advanceOmega

8.10.1.7 KahanAdvance() [2/2]

```
template<typename Scalar >
void KahanAdvance (
             Scalar & var,
             const Scalar increase,
             Scalar & err )
```

Kahan Summation for Scalar.

A way to reduce the round off error when adding a small number to a big one. See details in https://en.wikipedia.org/wiki/Kahan_summation_algorithm

Parameters

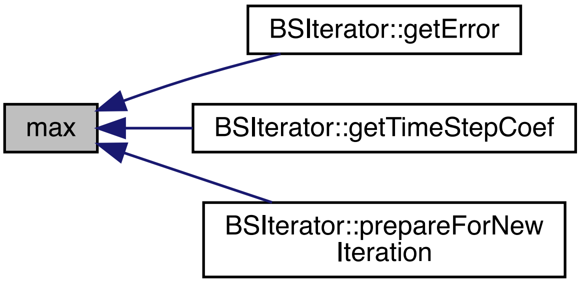
var	Scalar variable needs evolution.
increase	Scalar inreament.
err	Scalar round off error from last addition.

8.10.1.8 max()

```
template<typename T1 , typename T2 >
const T2 max (
              const T1 & x,
              const T2 & y )  [inline]
```

Self max()

Here is the caller graph for this function:

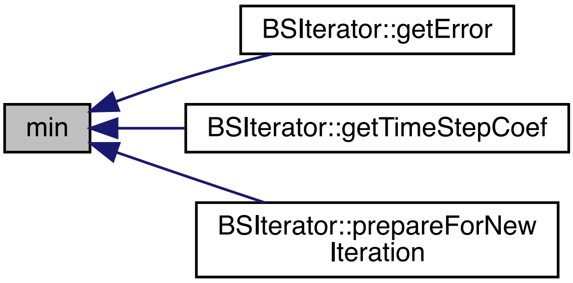

BSIterator::getError
max
BSIterator::getTimeStepCoef
BSIterator::prepareForNew Iteration

8.10.1.9 min()

```
template<typename T1 , typename T2 >
const T2 min (
              const T1 & x,
              const T2 & y )  [inline]
```

Self min()

Here is the caller graph for this function:


min
BSIterator::getError
BSIterator::getTimeStepCoef
BSIterator::prepareForNew Iteration

8.10.1.10 MoveToCentralMassCoordinate()

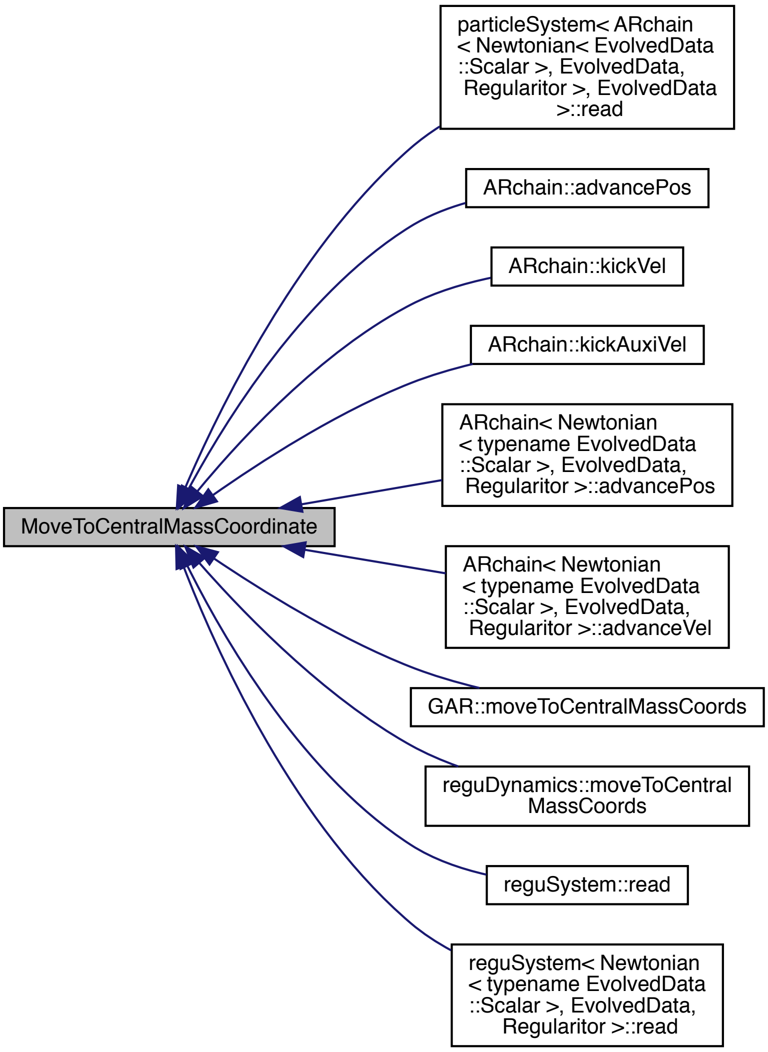
```
template<typename Scalar , size_t N>
void MoveToCentralMassCoordinate (
            const std::array< Scalar, N > & mass,
            std::array< vec3< Scalar >, N > & phyVar )
```

Move variables to central mass coordinates.

Parameters

mass	Array of mass.
phyVar	Array of variables need to be moved.

Here is the caller graph for this function:


particleSystem< ARchain < Newtonian< EvolvedData ::Scalar >, EvolvedData, Regularitor >, EvolvedData >::read
ARchain::advancePos
ARchain::kickVel
ARchain::kickAuxiVel
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advancePos
MoveToCentralMassCoordinate
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::advanceVel
GAR::moveToCentralMassCoords
reguDynamics::moveToCentral MassCoords
reguSystem::read
reguSystem< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::read

8.10.1.11 print()

```
template<typename T >
void print (
             T & var )
```

print an array. Used for debug

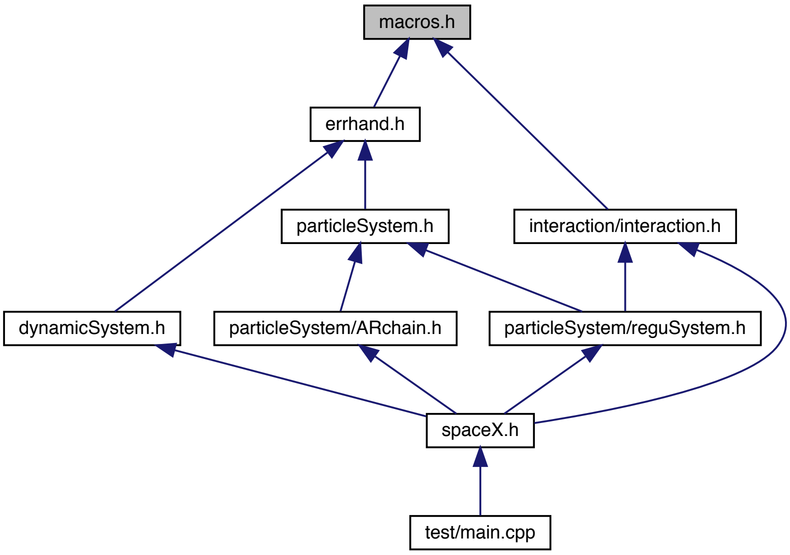
8.10.1.12 swap()

```
template<class T >
void swap (
            T & a,
            T & b )
```

Self swap()

8.11 macros.h File Reference

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



Enumerations

- enum PARTICTYPE {
  NEUTRONSTAR, STAR, BLACKHOLE, POsize_t,
  NONE = 0 }
- enum EVENTTYPE {
  TDE, MERGE, ESCAPE, DISRUPTED,
  UNEVENTFUL, HVS }
- enum INTEGRATORTYPE {
  INTEGRATORTYPE::DKDLEAPFROG, INTEGRATORTYPE::KDKLEAPFROG, INTEGRATORTYPE::SYM4,
  INTEGRATORTYPE::PEFRL,
  INTEGRATORTYPE::SYM6, INTEGRATORTYPE::SYM8, INTEGRATORTYPE::SYM10 }
- enum SYSTEMTYPE { SYSTEMTYPE::PLAIN, SYSTEMTYPE::CHAIN }
- enum REGUTYPE { REGUTYPE::LOGH, REGUTYPE::TTL, REGUTYPE::NONE }
- enum ITERTYPE { ITERTYPE::BSITER, ITERTYPE::SEQITER }

Variables

- constexpr double PI = 3.14159265358979323
- constexpr double AU = (PI / 648000)
- constexpr double PC = 1
- constexpr double M_SOLAR = 1
- constexpr double M_JUPITER = 0.9547919E-3
- constexpr double R_SOLAR = 2.25461E-8
- constexpr double YEAR = 6.694685210039141E-08
- constexpr double DAY = YEAR / 365.25636042
- constexpr double G = 1
- constexpr double V_UNIT = 6.54589713446219E-2
- constexpr double C = 299792.458 / V_UNIT
- constexpr double KM = 3.2407557442395564e-14

8.11.1 Enumeration Type Documentation

8.11.1.1 EVENTTYPE

```
enum EVENTTYPE
```

Enumerator

TDE	
MERGE	
ESCAPE	
DISRUPTED	
UNEVENTFUL	
HVS	

8.11.1.2 INTEGRATORTYPE

```
enum INTEGRATORTYPE [strong]
```

Enumerator

DKDLEAPFROG	
KDKLEAPFROG	
SYM4	
PEFRL	
SYM6	
SYM8	
SYM10	

8.11.1.3 ITERTYPE

```
enum ITERTYPE [strong]
```

Enumerator

BSITER	
SEQITER	

8.11.1.4 PARTICTYPE

```
enum PARTICTYPE
```

Enumerator

NEUTRONSTAR	
STAR	
BLACKHOLE	
POsize_t	
NONE	

8.11.1.5 REGUTYPE

```
enum REGUTYPE [strong]
```

Enumerator

LOGH	
TTL	
NONE	

8.11.1.6 SYSTEMTYPE

```
enum SYSTEMTYPE [strong]
```

Enumerator

PLAIN	
CHAIN	

8.11.2 Variable Documentation

8.11.2.1 AU

```
constexpr double AU = (PI / 648000)
```

8.11.2.2 C

```
constexpr double C = 299792.458 / V_UNIT
```

8.11.2.3 DAY

```
constexpr double DAY = YEAR / 365.25636042
```

8.11.2.4 G

```
constexpr double G = 1
```

8.11.2.5 KM

```
constexpr double KM = 3.2407557442395564e-14
```

8.11.2.6 M_JUPITER

```
constexpr double M_JUPITER = 0.9547919E-3
```

8.11.2.7 M_SOLAR

```
constexpr double M_SOLAR = 1
```

8.11.2.8 PC

```
constexpr double PC = 1
```

8.11.2.9 PI

```
constexpr double PI = 3.14159265358979323
```

8.11.2.10 R_SOLAR

```
constexpr double R_SOLAR = 2.25461E-8
```

8.11.2.11 V_UNIT

```
constexpr double V_UNIT = 6.54589713446219E-2
```

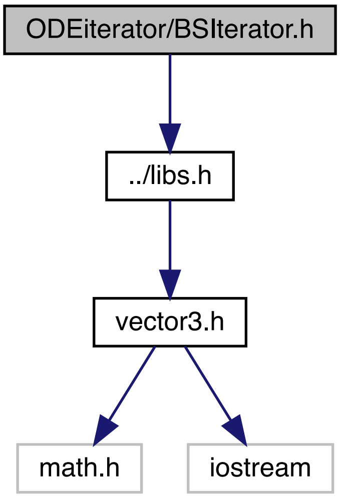
8.11.2.12 YEAR

```
constexpr double YEAR = 6.694685210039141E-08
```

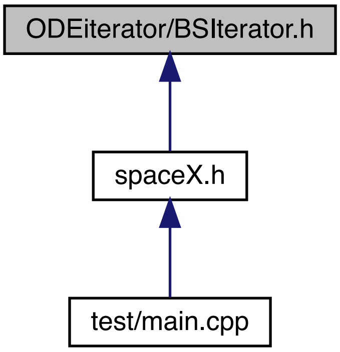
8.12 ODEiterator/BSIterator.h File Reference

```
#include "../libs.h"
```

Include dependency graph for BSIterator.h:



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



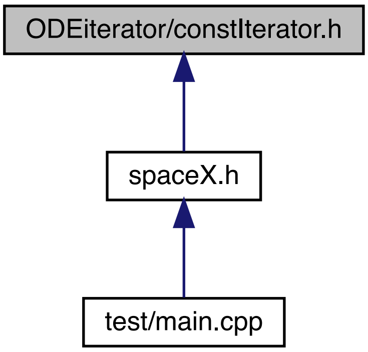
Classes

- class BSIterator< ParticSys, Integrator >

  Bulirsch-Stoer extrapolation algorithm.

8.13 ODEiterator/constIterator.h File Reference

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



Classes

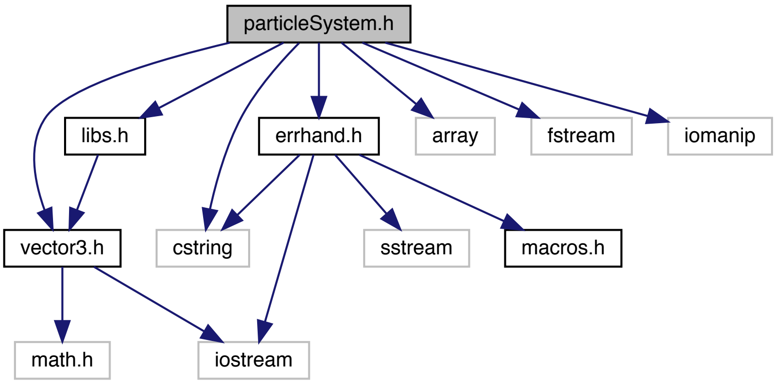
- class constIterator< ParticSys, Integrator >

  Most common iterator.

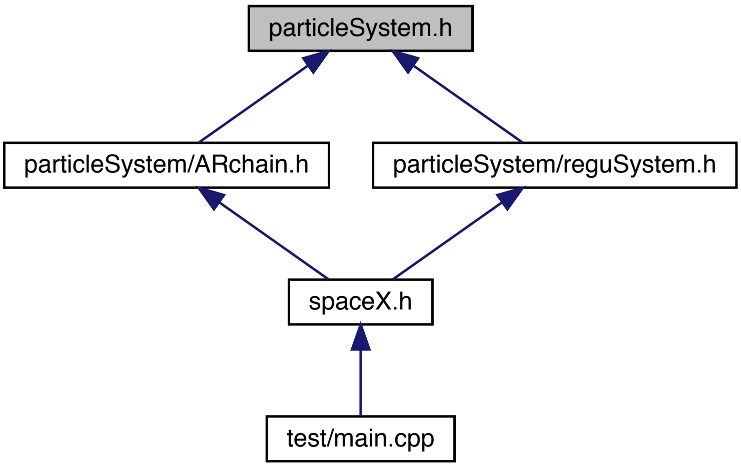
8.14 particleSystem.h File Reference

```
#include "vector3.h"
#include "libs.h"
#include "errhand.h"
#include <array>
#include <fstream>
#include <cstring>
#include <iomanip>
```

Include dependency graph for particleSystem.h:



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



Classes

- class particleSystem< Derived, EvolvedData >

  Base class of particle System.

Functions

- template<typename Derived , typename EvolvedData >
  std::ostream & operator<< (std::ostream &os, const particleSystem< Derived, EvolvedData > &data)

  Overload operator <<.
- template<typename Derived , typename EvolvedData >
  std::istream & operator>> (std::istream &is, particleSystem< Derived, EvolvedData > &data)

  Overload operator >>

8.14.1 Function Documentation

8.14.1.1 operator<<()

```
template<typename Derived , typename EvolvedData >
std::ostream& operator<< (
            std::ostream & os,
            const particleSystem< Derived, EvolvedData > & data )
```

Overload operator <<.

8.14.1.2 operator>>()

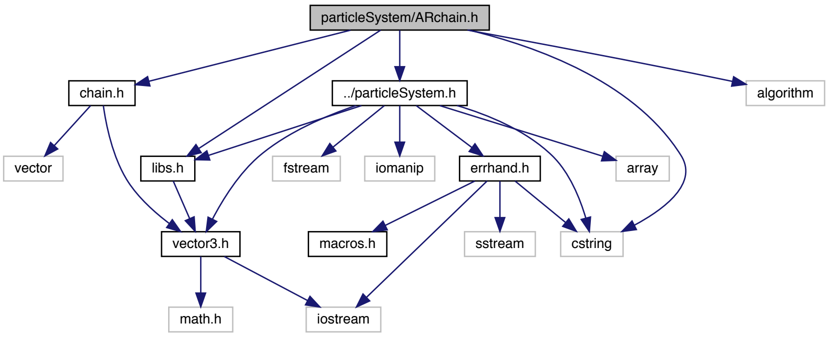
```
template<typename Derived , typename EvolvedData >
std::istream& operator>> (
            std::istream & is,
            particleSystem< Derived, EvolvedData > & data )
```

Overload operator >>

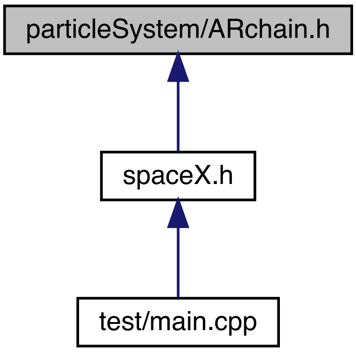
8.15 particleSystem/ARchain.h File Reference

```
#include "../particleSystem.h"
#include "../libs.h"
#include "chain.h"
#include <cstring>
#include <algorithm>
```

Include dependency graph for ARchain.h:



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



Classes

- class ARchain< Interaction, EvolvedData, Regularitor >

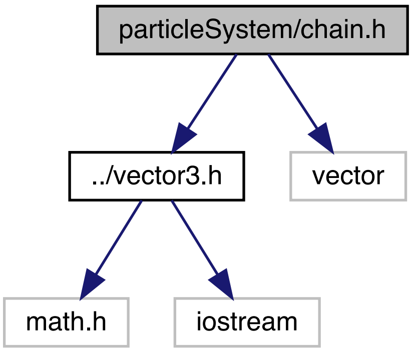
  Algorithmatic Regularization chain System.
- class ARchain< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >

  Partial specilization of template ARchain.

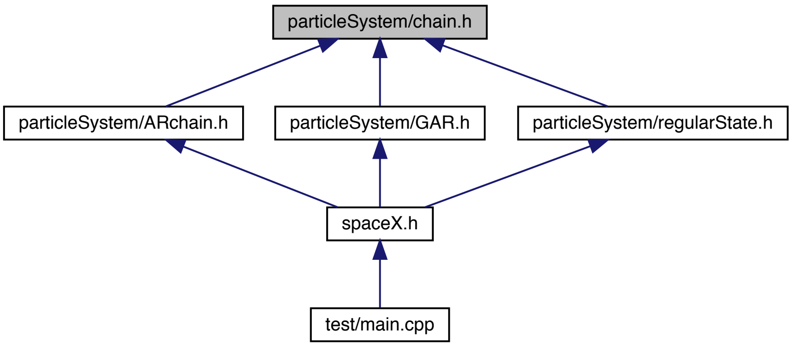
8.16 particleSystem/chain.h File Reference

```
#include "../vector3.h"
#include <vector>
```

Include dependency graph for chain.h:



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



Classes

- struct chain::Node< Scalar >

  Struture to store the relative distance and index of two particles.

Namespaces

- chain

Typedefs

- template<typename Scalar , size_t N>
  using chain::VectorArray = std::array< vec3< Scalar >, N >
- template<size_t N>
  using chain::IndexArray = std::array< size_t, N >
- template<typename Scalar , size_t N>
  using chain::NodeArray = std::array< Node< Scalar >, N >

Functions

- template<typename Scalar , size_t N>
  void chain::getChainIndex (const VectorArray< Scalar, N > &pos, IndexArray< N > &chainIndex)

  Calculate the mapping index from Cartesian coordinate to chain coordinate.
- template<typename Scalar , size_t N>
  void chain::createAdjMartix (const VectorArray< Scalar, N > &pos, NodeArray< Scalar, N ∗(N - 1)/2 > &AdjMatrix)

  Create the adjoint matrix for particle pairs.
- template<typename Scalar , size_t N>
  void chain::createChainIndex (NodeArray< Scalar, N ∗(N - 1)/2 > &AdjMatrix, IndexArray< N > &chainIndex)

  Create mapping index from adjoint matrix.
- template<size_t N>
  bool chain::IsDiff (const IndexArray< N > &Index1, const IndexArray< N > &Index2)

Check if two mapping indexes are the same.

- template<typename Scalar , size_t N>
  void chain::updateChain (VectorArray< Scalar, N > &pos, IndexArray< N > &chainIndex, IndexArray< N > &newIndex)

  Update the position chain.

- template<typename Scalar , size_t N>
  void chain::synChain (VectorArray< Scalar, N > &data, VectorArray< Scalar, N > &chainData, Index↩ Array< N > &chainIndex)

  Calulate the chain data from Cartesian data and chain index mapping.

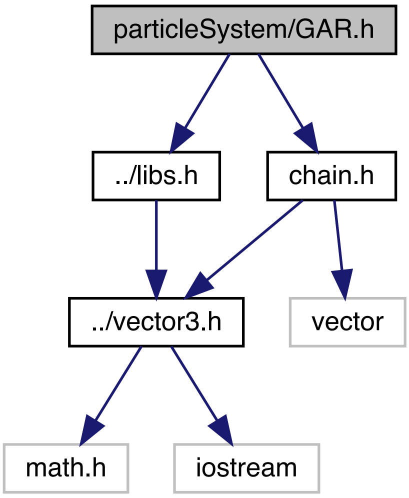
- template<typename Scalar , size_t N>
  void chain::synCartesian (VectorArray< Scalar, N > &chainData, VectorArray< Scalar, N > &data, IndexArray< N > &chainIndex)

  Calulate the Cartesian data from chain data and chain index mapping.

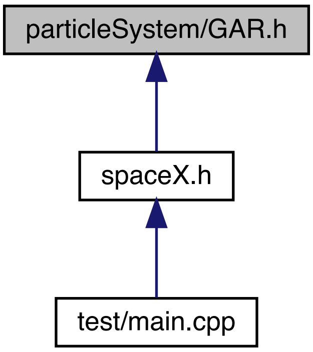
8.17 particleSystem/GAR.h File Reference

```
#include "chain.h"
#include "../libs.h"
```

Include dependency graph for GAR.h:



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



Classes

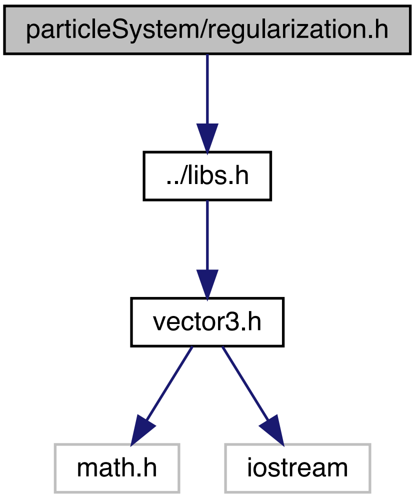
- class GAR< DataType, N >

  Class of velocity dependent dynamical system with regularization variables.

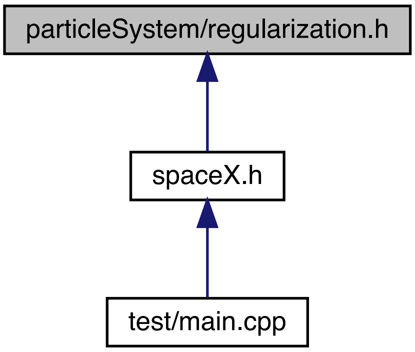
8.18 particleSystem/regularization.h File Reference

```
#include "../libs.h"
```

Include dependency graph for regularization.h:



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



Classes

- class logH< DynamicState >

  logH extention algorithmatic regularization interface

- class TTL< DynamicState >

  Time Transform Leapfrog algorithmatic regularization interface.

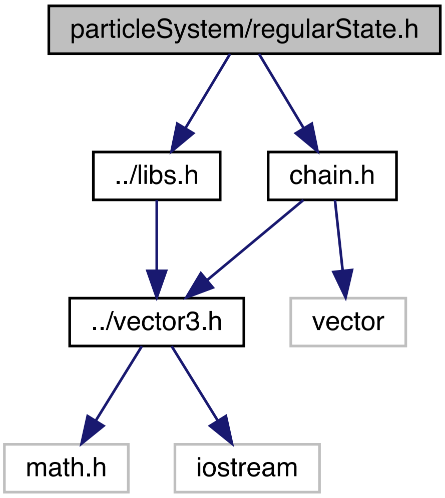
- class NoRegu< DynamicState >

  Ordinary algorithmatic regularization interface.

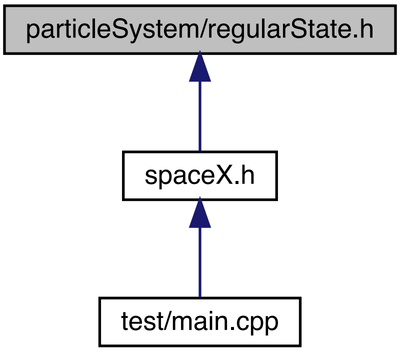
8.19 particleSystem/regularState.h File Reference

```
#include "chain.h"
#include "../libs.h"
```

Include dependency graph for regularState.h:



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



Classes

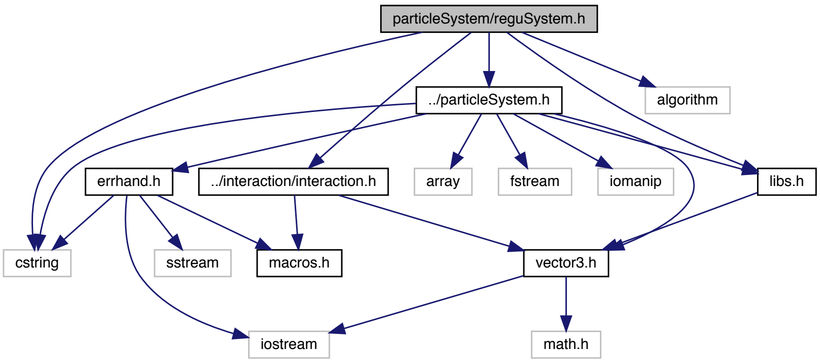
- class reguDynamics< DataType, N >

    Class of dynamical system with regularization variables.

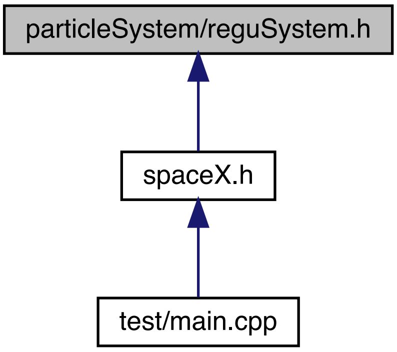
8.20 particleSystem/reguSystem.h File Reference

```
#include "../particleSystem.h"
#include "../interaction/interaction.h"
#include "../libs.h"
#include <cstring>
#include <algorithm>
```

Include dependency graph for reguSystem.h:



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



Classes

- class reguSystem< Interaction, EvolvedData, Regularitor >

  Regularized particle System.
- class reguSystem< Newtonian< typename EvolvedData::Scalar >, EvolvedData, Regularitor >

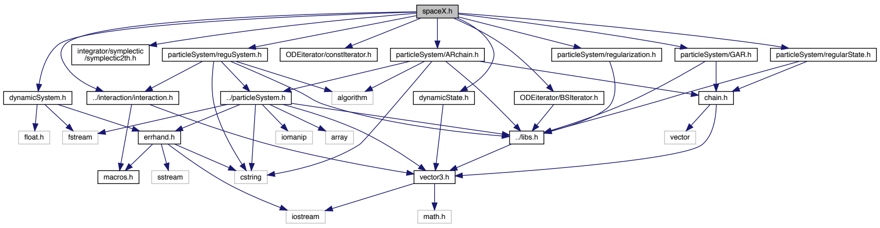
  Partial specialization of reguSystem for velocity independent system.

8.21 README.md File Reference

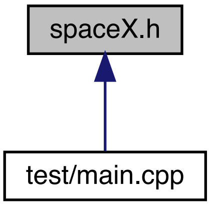
8.22 spaceX.h File Reference

```
#include "dynamicSystem.h"
#include "dynamicState.h"
#include "integrator/symplectic/symplectic2th.h"
#include "ODEiterator/BSIterator.h"
#include "ODEiterator/constIterator.h"
#include "particleSystem/reguSystem.h"
#include "particleSystem/ARchain.h"
#include "particleSystem/GAR.h"
#include "particleSystem/regularState.h"
#include "particleSystem/regularization.h"
#include "interaction/interaction.h"
```

Include dependency graph for spaceX.h:



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



Typedefs

- template<size_t N, template< typename > class Regularitor = logH, typename Scalar = double, template< typename, size_t > class EvolvedData = reguDynamics, template< typename > class Interaction = Newtonian>
  using NewtonianSystem = reguSystem< Interaction< Scalar >, EvolvedData< Scalar, N >, Regularitor< EvolvedData< Scalar, N > >>
- template<size_t N, template< typename > class Interaction, template< typename > class Regularitor = logH, typename Scalar = double, template< typename, size_t > class EvolvedData = GAR>
  using VelDepSystem = reguSystem< Interaction< Scalar >, EvolvedData< Scalar, N >, Regularitor< EvolvedData< Scalar, N > >>

- template<size_t N, template< typename > class Regularitor = logH, typename Scalar = double, template< typename, size_t > class EvolvedData = reguDynamics, template< typename > class Interaction = Newtonian>
  using AR_chain = ARchain< Interaction< Scalar >, EvolvedData< Scalar, N >, Regularitor< Evolved↩ Data< Scalar, N > >>
- template<size_t N, template< typename > class Interaction, template< typename > class Regularitor = logH, typename Scalar = double, template< typename, size_t > class EvolvedData = GAR>
  using VelARchain = ARchain< Interaction< Scalar >, EvolvedData< Scalar, N >, Regularitor< Evolved↩ Data< Scalar, N > >>

8.22.1 Typedef Documentation

8.22.1.1 AR_chain

```
template<size_t N, template< typename > class Regularitor = logH, typename Scalar = double,
template< typename, size_t > class EvolvedData = reguDynamics, template< typename > class
Interaction = Newtonian>
using AR_chain = ARchain<Interaction<Scalar>, EvolvedData<Scalar, N>, Regularitor<Evolved↩
Data<Scalar, N> >>
```

8.22.1.2 NewtonianSystem

```
template<size_t N, template< typename > class Regularitor = logH, typename Scalar = double,
template< typename, size_t > class EvolvedData = reguDynamics, template< typename > class
Interaction = Newtonian>
using NewtonianSystem = reguSystem<Interaction<Scalar>, EvolvedData<Scalar, N>, Regularitor<Evolved↩
Data<Scalar, N> >>
```

8.22.1.3 VelARchain

```
template<size_t N, template< typename > class Interaction, template< typename > class Regularitor
= logH, typename Scalar = double, template< typename, size_t > class EvolvedData = GAR>
using VelARchain = ARchain<Interaction<Scalar>, EvolvedData<Scalar, N>, Regularitor<Evolved↩
Data<Scalar, N> >>
```

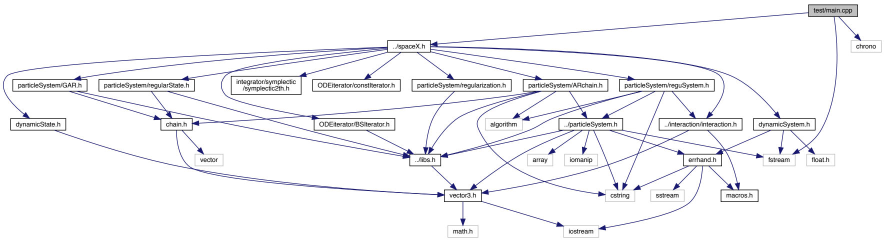
8.22.1.4 VelDepSystem

```
template<size_t N, template< typename > class Interaction, template< typename > class Regularitor
= logH, typename Scalar = double, template< typename, size_t > class EvolvedData = GAR>
using VelDepSystem = reguSystem<Interaction<Scalar>, EvolvedData<Scalar, N>, Regularitor<Evolved↩
Data<Scalar, N> >>
```

8.23 test/main.cpp File Reference

```
#include "../spaceX.h"
#include <chrono>
#include <fstream>
```

Include dependency graph for main.cpp:



Typedefs

- typedef std::chrono::time_point< std::chrono::high_resolution_clock > resolutionClock

Functions

- int main (int argc, char $**$argv)

8.23.1 Typedef Documentation

8.23.1.1 resolutionClock

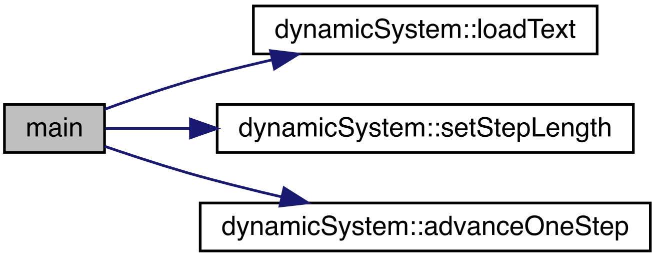
```
typedef std::chrono::time_point<std::chrono::high_resolution_clock> resolutionClock
```

8.23.2 Function Documentation

8.23.2.1 main()

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

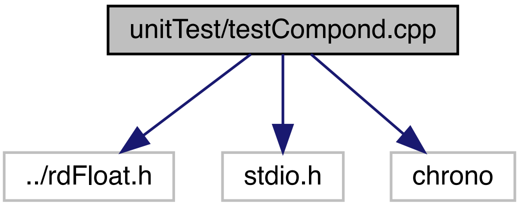
Here is the call graph for this function:



8.24 unitTest/testCompond.cpp File Reference

```
#include "../rdFloat.h"
#include <stdio.h>
#include <chrono>
```

Include dependency graph for testCompond.cpp:



Typedefs

- typedef std::chrono::time_point< std::chrono::high_resolution_clock > resolutionClock

Functions

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

8.24.1 Typedef Documentation

8.24.1.1 resolutionClock

```
typedef std::chrono::time_point<std::chrono::high_resolution_clock> resolutionClock
```

8.24.2 Function Documentation

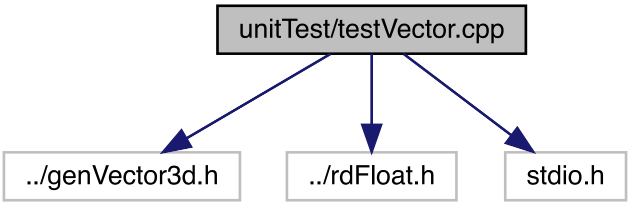
8.24.2.1 main()

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

8.25 unitTest/testVector.cpp File Reference

```
#include "../genVector3d.h"
#include "../rdFloat.h"
#include <stdio.h>
```

Include dependency graph for testVector.cpp:



Functions

- int main (int argc, char ∗∗argv)

8.25.1 Function Documentation

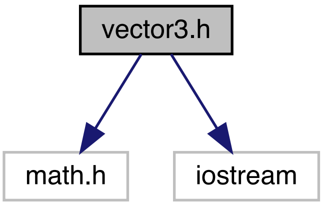
8.25.1.1 main()

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

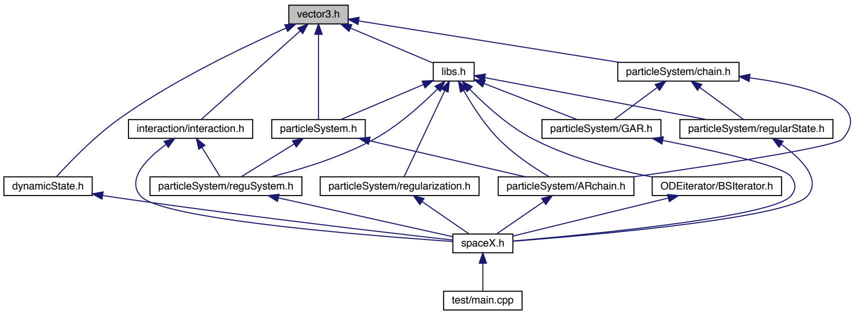
8.26 vector3.h File Reference

```
#include <math.h>
#include <iostream>
```

Include dependency graph for vector3.h:



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



Classes

- struct vec3< T >

  Self 3D vector class.

Typedefs

- typedef vec3< double > vec3d
- typedef vec3< float > vec3f
- typedef vec3< int > vec3i
- typedef vec3< char > vec3c

Functions

- template<typename T >
  T distance (const vec3< T > &v1, const vec3< T > &v2)

  Calculate the Euclid distance of two vectors.

8.26.1 Typedef Documentation

8.26.1.1 vec3c

```
typedef vec3<char> vec3c
```

8.26.1.2 vec3d

```
typedef vec3<double> vec3d
```

8.26.1.3 vec3f

```
typedef vec3<float> vec3f
```

8.26.1.4 vec3i

```
typedef vec3<int> vec3i
```

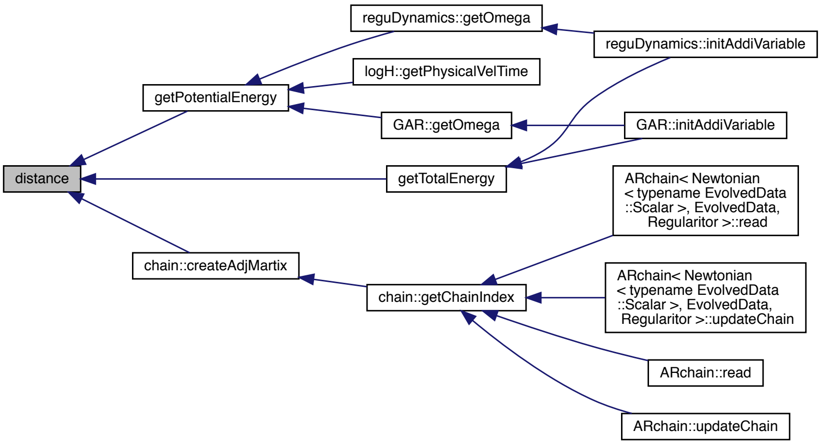
8.26.2 Function Documentation

8.26.2.1 distance()

```
template<typename T >
T distance (
             const vec3< T > & v1,
             const vec3< T > & v2 )  [inline]
```

Calculate the Euclid distance of two vectors.

Here is the caller graph for this function:


distance
getPotentialEnergy
chain::createAdjMartix
reguDynamics::getOmega
logH::getPhysicalVelTime
GAR::getOmega
getTotalEnergy
chain::getChainIndex
reguDynamics::initAddiVariable
GAR::initAddiVariable
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::read
ARchain< Newtonian < typename EvolvedData ::Scalar >, EvolvedData, Regularitor >::updateChain
ARchain::read
ARchain::updateChain

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