

glucat
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Chapter 4

File Index

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Chapter 5

Namespace Documentation

5.1 cga3 Namespace Reference

Definitions for 3D Conformal Geometric Algebra [DL].

Functions

- `template<typename Multivector_T > Multivector_T cga3 (const Multivector_T &x)`
Convert Euclidean 3D vector to Conformal Geometric Algebra null vector [DL (10.50)].
- `template<typename Multivector_T > Multivector_T cga3std (const Multivector_T &X)`
Convert CGA3 null vector to standard Conformal Geometric Algebra null vector [DL (10.52)].
- `template<typename Multivector_T > Multivector_T agc3 (const Multivector_T &X)`
Convert CGA3 null vector to Euclidean 3D vector [DL (10.50)].

5.1.1 Detailed Description

Definitions for 3D Conformal Geometric Algebra [DL].

5.1.2 Function Documentation

5.1.2.1 `template<typename Multivector_T > Multivector_T cga3::agc3 ( const Multivector_T & X ) [inline]`

Convert CGA3 null vector to Euclidean 3D vector [DL (10.50)].

Definition at line 138 of file PyClical.h.

References `cga3std()`, `PyClical::cl`, and `PyClical::ist`.

5.1.2.2 `template<typename Multivector_T > Multivector_T cga3::cga3 ( const Multivector_T & x ) [inline]`

Convert Euclidean 3D vector to Conformal Geometric Algebra null vector [DL (10.50)].

Definition at line 115 of file PyClical.h.

References `PyClical::cl`, `PyClical::ist`, and `PyClical::ninf3`.

5.1.2.3 `template<typename Multivector_T > Multivector_T cga3::cga3std ( const Multivector_T & X ) [inline]`

Convert CGA3 null vector to standard Conformal Geometric Algebra null vector [DL (10.52)].

Definition at line 126 of file PyClical.h.

References `PyClical::cl`, `PyClical::ist`, and `PyClical::ninf3`.

Referenced by `agc3()`.

5.2 glucat Namespace Reference

Namespaces

- [gen](#)
- [matrix](#)
- [timing](#)

Classes

- class [clifford_algebra](#)
clifford_algebra<> declares the operations of a Clifford algebra
- class [glucat_error](#)
Abstract exception class.
- class [error](#)
Specific exception class.
- class [framed_multi](#)
A framed_multi<Scalar_T,LO,HI> is a framed approximation to a multivector.
- class [matrix_multi](#)
A matrix_multi<Scalar_T,LO,HI> is a matrix approximation to a multivector.
- class [index_set_hash](#)
- class [sorted_range](#)
Sorted range for use with output.
- class [sorted_range< Sorted_Map_T, Sorted_Map_T >](#)
- struct [CTAssertion](#)
Compile time assertion.
- struct [CTAssertion< true >](#)
- class [compare_types](#)
Type comparison.
- class [compare_types< T, T >](#)
- class [bool_to_type](#)
Bool to type.
- struct [tuning](#)
Tuning policy.
- class [index_set](#)
Index set class based on std::bitset<> in Gnu standard C++ library.
- class [basis_table](#)
Table of basis elements used as a cache by basis_element()
- class [random_generator](#)
Random number generator with single instance per Scalar_T.
- class [numeric_traits](#)
Extra traits which extend numeric limits.
- class [control_t](#)
Parameters to control tests.

Typedefs

- typedef int [index_t](#)
Size of index_t should be enough to represent LO, HI.
- typedef unsigned long [set_value_t](#)
Size of set_value_t should be enough to contain index_set<LO,HI>
- typedef int(* [intfn](#))()
For exception catching: pointer to function returning int.
- typedef int(* [intintfn](#))(int)
For exception catching: pointer to function of int returning int.

Enumerations

- enum [precision_t](#) { [precision_demoted](#), [precision_same](#), [precision_promoted](#) }
Precision policy.

Functions

- template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T , const index_t LO, const index_t HI>
bool [operator!=](#) (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)
Test for inequality of multivectors.
- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
bool [operator!=](#) (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)
Test for inequality of multivector and scalar.
- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
bool [operator!=](#) (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)
Test for inequality of scalar and multivector.
- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [operator+](#) (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)
Geometric sum of multivector and scalar.
- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [operator+](#) (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)
Geometric sum of scalar and multivector.
- template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [operator+](#) (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)
Geometric sum.
- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [operator-](#) (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)
Geometric difference of multivector and scalar.
- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [operator-](#) (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)

Geometric difference of scalar and multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > operator- (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Geometric difference.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > operator* (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)`

Product of multivector and scalar.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > operator* (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)`

Product of scalar and multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > operator* (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Geometric product.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > operator^ (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Outer product.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > operator& (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Inner product.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > operator% (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Left contraction.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
Scalar_T star (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Hestenes scalar product.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > operator/ (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)`

Quotient of multivector and scalar.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > operator/ (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)`

Quotient of scalar and multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > operator/ (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Geometric quotient.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > operator| (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`
Transformation via twisted adjoint action.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > inv (const Multivector< Scalar_T, LO, HI > &val)`
Geometric multiplicative inverse.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > pow (const Multivector< Scalar_T, LO, HI > &lhs, int rhs)`
Integer power of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > pow (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`
Multivector power of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > outer\_pow (const Multivector< Scalar_T, LO, HI > &lhs, int rhs)`
Outer product power of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> Scalar_T scalar (const Multivector< Scalar_T, LO, HI > &val)`
Scalar part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> Scalar_T real (const Multivector< Scalar_T, LO, HI > &val)`
Real part: synonym for scalar part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> Scalar_T imag (const Multivector< Scalar_T, LO, HI > &val)`
Imaginary part: deprecated (always 0)
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > pure (const Multivector< Scalar_T, LO, HI > &val)`
Pure part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > even (const Multivector< Scalar_T, LO, HI > &val)`
Even part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > odd (const Multivector< Scalar_T, LO, HI > &val)`
Odd part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const std::vector< Scalar_T > vector\_part (const Multivector< Scalar_T, LO, HI > &val)`

Vector part of multivector, as a vector_t with respect to frame()

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > involute (const Multivector< Scalar_T, LO, HI > &val)`

Main involution, each {i} is replaced by -{i} in each term, eg. {1}{2} -> (-{2})*(-{1})*

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > reverse (const Multivector< Scalar_T, LO, HI > &val)`

Reversion, eg. {1}{2} -> {2}*{1}.*

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > conj (const Multivector< Scalar_T, LO, HI > &val)`

Conjugation, rev o invo == invo o rev.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
Scalar_T quad (const Multivector< Scalar_T, LO, HI > &val)`

*Scalar_T quadratic form == (rev(x)*x)(0)*

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
Scalar_T norm (const Multivector< Scalar_T, LO, HI > &val)`

Scalar_T norm == sum of norm of coordinates.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
Scalar_T abs (const Multivector< Scalar_T, LO, HI > &val)`

Absolute value == sqrt(norm)

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
Scalar_T max_abs (const Multivector< Scalar_T, LO, HI > &val)`

Maximum of absolute values of components of multivector: multivector infinity norm.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > complexifier (const Multivector< Scalar_T, LO, HI > &val)`

Square root of -1 which commutes with all members of the frame of the given multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > elliptic (const Multivector< Scalar_T, LO, HI > &val)`

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > sqrt (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const
bool prechecked=false)`

Square root of multivector with specified complexifier.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > sqrt (const Multivector< Scalar_T, LO, HI > &val)`

Square root of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > clifford_exp (const Multivector< Scalar_T, LO, HI > &val)`

Exponential of multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [log](#) (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const
bool prechecked=false)

Natural logarithm of multivector with specified complexifier.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [log](#) (const Multivector< Scalar_T, LO, HI > &val)

Natural logarithm of multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [cos](#) (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const
bool prechecked=false)

Cosine of multivector with specified complexifier.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [cos](#) (const Multivector< Scalar_T, LO, HI > &val)

Cosine of multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [acos](#) (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const
bool prechecked=false)

Inverse cosine of multivector with specified complexifier.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [acos](#) (const Multivector< Scalar_T, LO, HI > &val)

Inverse cosine of multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [cosh](#) (const Multivector< Scalar_T, LO, HI > &val)

Hyperbolic cosine of multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [acosh](#) (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const
bool prechecked=false)

Inverse hyperbolic cosine of multivector with specified complexifier.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [acosh](#) (const Multivector< Scalar_T, LO, HI > &val)

Inverse hyperbolic cosine of multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [sin](#) (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const
bool prechecked=false)

Sine of multivector with specified complexifier.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > sin (const Multivector< Scalar_T, LO, HI > &val)`

Sine of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > asin (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const
bool prechecked=false)`

Inverse sine of multivector with specified complexifier.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > asin (const Multivector< Scalar_T, LO, HI > &val)`

Inverse sine of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > sinh (const Multivector< Scalar_T, LO, HI > &val)`

Hyperbolic sine of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > asinh (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const
bool prechecked=false)`

Inverse hyperbolic sine of multivector with specified complexifier.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > asinh (const Multivector< Scalar_T, LO, HI > &val)`

Inverse hyperbolic sine of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > tan (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const
bool prechecked=false)`

Tangent of multivector with specified complexifier.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > tan (const Multivector< Scalar_T, LO, HI > &val)`

Tangent of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > atan (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const
bool prechecked=false)`

Inverse tangent of multivector with specified complexifier.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > atan (const Multivector< Scalar_T, LO, HI > &val)`

Inverse tangent of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > tanh (const Multivector< Scalar_T, LO, HI > &val)`
Hyperbolic tangent of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > atanh (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const`
`bool prechecked=false)`
Inverse hyperbolic tangent of multivector with specified complexifier.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > atanh (const Multivector< Scalar_T, LO, HI > &val)`
Inverse hyperbolic tangent of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`static void check\_complex (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI`
`> &i, const bool prechecked=false)`
Check that i is a valid complexifier for val.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed\_multi< Scalar_T,`
`LO, HI > operator\* (const framed\_multi< Scalar_T, LO, HI > &lhs, const framed\_multi< Scalar_T, LO, HI >`
`&rhs)`
Geometric product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed\_multi< Scalar_T,`
`LO, HI > operator^ (const framed\_multi< Scalar_T, LO, HI > &lhs, const framed\_multi< Scalar_T, LO, HI >`
`&rhs)`
Outer product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed\_multi< Scalar_T,`
`LO, HI > operator& (const framed\_multi< Scalar_T, LO, HI > &lhs, const framed\_multi< Scalar_T, LO, HI >`
`&rhs)`
Inner product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed\_multi< Scalar_T,`
`LO, HI > operator% (const framed\_multi< Scalar_T, LO, HI > &lhs, const framed\_multi< Scalar_T, LO, HI`
`> &rhs)`
Left contraction.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`Scalar_T star (const framed\_multi< Scalar_T, LO, HI > &lhs, const framed\_multi< Scalar_T, LO, HI > &rhs)`
Hestenes scalar product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed\_multi< Scalar_T,`
`LO, HI > operator/ (const framed\_multi< Scalar_T, LO, HI > &lhs, const framed\_multi< Scalar_T, LO, HI >`
`&rhs)`
Geometric quotient.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed\_multi< Scalar_T,`
`LO, HI > operator| (const framed\_multi< Scalar_T, LO, HI > &lhs, const framed\_multi< Scalar_T, LO, HI >`
`&rhs)`
Transformation via twisted adjoint action.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`std::istream & operator>> (std::istream &s, framed_multi< Scalar_T, LO, HI > &val)`
Read multivector from input.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`std::ostream & operator<< (std::ostream &os, const framed_multi< Scalar_T, LO, HI > &val)`
Write multivector to output.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`std::ostream & operator<< (std::ostream &os, const std::pair< const index_set< LO, HI >, Scalar_T > &term)`
Write term to output.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed_multi< Scalar_T,`
`LO, HI > exp (const framed_multi< Scalar_T, LO, HI > &val)`
Exponential of multivector.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`static Scalar_T crd_of_mult (const std::pair< const index_set< LO, HI >, Scalar_T > &lhs, const std::pair< const index_set< LO, HI >, Scalar_T > &rhs)`
Coordinate of product of terms.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const std::pair< const`
`index_set< LO, HI >, Scalar_T > operator* (const std::pair< const index_set< LO, HI >, Scalar_T > &lhs,`
`const std::pair< const index_set< LO, HI >, Scalar_T > &rhs)`
Product of terms.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed_multi< Scalar_T,`
`LO, HI > sqrt (const framed_multi< Scalar_T, LO, HI > &val, const framed_multi< Scalar_T, LO, HI > &i,`
`bool prechecked)`
Square root of multivector with specified complexifier.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed_multi< Scalar_T,`
`LO, HI > log (const framed_multi< Scalar_T, LO, HI > &val, const framed_multi< Scalar_T, LO, HI > &i,`
`bool prechecked)`
Natural logarithm of multivector with specified complexifier.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`static Scalar_T crd_of_mult (const std::pair< const index_set< LO, HI >, Scalar_T > &lhs, const std::pair< const index_set< LO, HI >, Scalar_T > &rhs)`
Coordinate of product of terms.
- `template<typename LHS_T , typename RHS_T >`
`LHS_T pos_mod (LHS_T lhs, RHS_T rhs)`
Modulo function which works reliably for lhs < 0.
- `template<const index_t LO, const index_t HI>`
`const index_set< LO, HI > operator^ (const index_set< LO, HI > &lhs, const index_set< LO, HI > &rhs)`
Symmetric set difference: exclusive or.
- `template<const index_t LO, const index_t HI>`
`const index_set< LO, HI > operator& (const index_set< LO, HI > &lhs, const index_set< LO, HI > &rhs)`
Set intersection: and.
- `template<const index_t LO, const index_t HI>`
`const index_set< LO, HI > operator| (const index_set< LO, HI > &lhs, const index_set< LO, HI > &rhs)`
Set union: or.
- `template<const index_t LO, const index_t HI>`
`int compare (const index_set< LO, HI > &a, const index_set< LO, HI > &b)`
"lexicographic compare" eg. {3,4,5} is less than {3,7,8}
- `_GLUCAT_CTAssert (sizeof(set_value_t) >= sizeof(std::bitset< DEFAULT_HI-DEFAULT_LO >), Default_index_set_too_big_for_value) template< const index_t LO`

- Size of set_value_t should be enough to contain bitset<DEFAULT_HI-DEFAULT_LO>*
- const [index_t](#) HI std::ostream & [operator<<](#) (std::ostream &os, const [index_set](#)< LO, HI > &ist)
Write out index set.
 - template<const [index_t](#) LO, const [index_t](#) HI>
std::istream & [operator>>](#) (std::istream &s, [index_set](#)< LO, HI > &ist)
Read in index set.
 - int [sign_of_square](#) ([index_t](#) j)
Square of generator [j].
 - template<const [index_t](#) LO, const [index_t](#) HI>
[index_t](#) [min_neg](#) (const [index_set](#)< LO, HI > &ist)
Minimum negative index, or 0 if none.
 - template<const [index_t](#) LO, const [index_t](#) HI>
[index_t](#) [max_pos](#) (const [index_set](#)< LO, HI > &ist)
Maximum positive index, or 0 if none.
 - static unsigned long [inverse_reversed_gray](#) (unsigned long x)
Inverse reversed Gray code.
 - static unsigned long [inverse_gray](#) (unsigned long x)
Inverse Gray code.
 - template<typename [Scalar_T](#) , const [index_t](#) LO, const [index_t](#) HI>
const [matrix_multi](#)< [Scalar_T](#),
LO, HI > [operator*](#) (const [matrix_multi](#)< [Scalar_T](#), LO, HI > &lhs, const [matrix_multi](#)< [Scalar_T](#), LO, HI > &rhs)
Geometric product.
 - template<typename [Scalar_T](#) , const [index_t](#) LO, const [index_t](#) HI>
const [matrix_multi](#)< [Scalar_T](#),
LO, HI > [operator^](#) (const [matrix_multi](#)< [Scalar_T](#), LO, HI > &lhs, const [matrix_multi](#)< [Scalar_T](#), LO, HI > &rhs)
Outer product.
 - template<typename [Scalar_T](#) , const [index_t](#) LO, const [index_t](#) HI>
const [matrix_multi](#)< [Scalar_T](#),
LO, HI > [operator&](#) (const [matrix_multi](#)< [Scalar_T](#), LO, HI > &lhs, const [matrix_multi](#)< [Scalar_T](#), LO, HI > &rhs)
Inner product.
 - template<typename [Scalar_T](#) , const [index_t](#) LO, const [index_t](#) HI>
const [matrix_multi](#)< [Scalar_T](#),
LO, HI > [operator%](#) (const [matrix_multi](#)< [Scalar_T](#), LO, HI > &lhs, const [matrix_multi](#)< [Scalar_T](#), LO, HI > &rhs)
Left contraction.
 - template<typename [Scalar_T](#) , const [index_t](#) LO, const [index_t](#) HI>
[Scalar_T](#) [star](#) (const [matrix_multi](#)< [Scalar_T](#), LO, HI > &lhs, const [matrix_multi](#)< [Scalar_T](#), LO, HI > &rhs)
Hestenes scalar product.
 - template<typename [Scalar_T](#) , const [index_t](#) LO, const [index_t](#) HI>
const [matrix_multi](#)< [Scalar_T](#),
LO, HI > [operator/](#) (const [matrix_multi](#)< [Scalar_T](#), LO, HI > &lhs, const [matrix_multi](#)< [Scalar_T](#), LO, HI > &rhs)
Geometric quotient.
 - template<typename [Scalar_T](#) , const [index_t](#) LO, const [index_t](#) HI>
const [matrix_multi](#)< [Scalar_T](#),
LO, HI > [operator|](#) (const [matrix_multi](#)< [Scalar_T](#), LO, HI > &lhs, const [matrix_multi](#)< [Scalar_T](#), LO, HI > &rhs)
Transformation via twisted adjoint action.
 - template<typename [Scalar_T](#) , const [index_t](#) LO, const [index_t](#) HI>
std::istream & [operator>>](#) (std::istream &s, [matrix_multi](#)< [Scalar_T](#), LO, HI > &val)
Read multivector from input.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`std::ostream & operator<< (std::ostream &os, const matrix\_multi< Scalar_T, LO, HI > &val)`
Write multivector to output.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const index\_set< LO, HI > reframe (const matrix\_multi< Scalar_T, LO, HI > &lhs, const matrix\_multi< Scalar_T, LO, HI > &rhs, matrix\_multi< Scalar_T, LO, HI > &lhs_reframed, matrix\_multi< Scalar_T, LO, HI > &rhs_reframed)`
Find a common frame for operands of a binary operator.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix\_multi< Scalar_T,`
`LO, HI > sqrt (const matrix\_multi< Scalar_T, LO, HI > &val, const matrix\_multi< Scalar_T, LO, HI > &i, bool`
`prechecked)`
Square root of multivector with specified complexifier.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix\_multi< Scalar_T,`
`LO, HI > matrix\_sqrt (const matrix\_multi< Scalar_T, LO, HI > &val, const matrix\_multi< Scalar_T, LO, HI >`
`&i)`
Square root of multivector with specified complexifier.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix\_multi< Scalar_T,`
`LO, HI > log (const matrix\_multi< Scalar_T, LO, HI > &val, const matrix\_multi< Scalar_T, LO, HI > &i, bool`
`prechecked)`
Natural logarithm of multivector with specified complexifier.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix\_multi< Scalar_T,`
`LO, HI > matrix\_log (const matrix\_multi< Scalar_T, LO, HI > &val, const matrix\_multi< Scalar_T, LO, HI >`
`&i)`
Natural logarithm of multivector with specified complexifier.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix\_multi< Scalar_T,`
`LO, HI > exp (const matrix\_multi< Scalar_T, LO, HI > &val)`
Exponential of multivector.
- `index\_t offset\_level (const index\_t p, const index\_t q)`
Determine the log2 dim corresponding to signature p, q.
- `template<typename Matrix_Index_T , const index_t LO, const index_t HI>`
`static Matrix_Index_T folded\_dim (const index\_set< LO, HI > &sub)`
Determine the matrix dimension of the fold of a subalgebra.
- `template<typename Multivector_T , typename Matrix_T , typename Basis_Matrix_T >`
`static Multivector_T fast (const Matrix_T &X, index\_t level)`
Inverse generalized Fast Fourier Transform.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`static const matrix\_multi`
`< Scalar_T, LO, HI > pade\_approx (const int array_size, const Scalar_T a[], const Scalar_T b[], const matrix-`
`multi< Scalar_T, LO, HI > &X)`
Pade' approximation.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`static void db\_step (matrix\_multi< Scalar_T, LO, HI > &M, matrix\_multi< Scalar_T, LO, HI > &Y)`
Single step of product form of Denman-Beavers square root iteration.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`static const matrix\_multi`
`< Scalar_T, LO, HI > db\_sqrt (const matrix\_multi< Scalar_T, LO, HI > &val)`
Product form of Denman-Beavers square root iteration.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`static const matrix\_multi`
`< Scalar_T, LO, HI > pade\_log (const matrix\_multi< Scalar_T, LO, HI > &val)`

- Pade' approximation of log.*
- template<typename Scalar_T , const index_t LO, const index_t HI>
static const [matrix_multi](#)
< Scalar_T, LO, HI > [cascade_log](#) (const [matrix_multi](#)< Scalar_T, LO, HI > &val)
Incomplete square root cascade and Pade' approximation of log.
- template<typename Scalar_T >
Scalar_T [log2](#) (const Scalar_T &x)
Log base 2 of scalar.
- template<typename Scalar_T >
[numeric_traits](#)< Scalar_T >
::promoted::type [to_promote](#) (const Scalar_T &val)
Cast to promote.
- template<typename Scalar_T >
[numeric_traits](#)< Scalar_T >
::demoted::type [to_demote](#) (const Scalar_T &val)
Cast to demote.
- int [try_catch](#) (intfn f)
Exception catching for functions returning int.
- int [try_catch](#) (intintfn f, int arg)
Exception catching for functions of int returning int.

Variables

- const double [MS_PER_S](#) = 1000.0
Timing constant: deprecated here - moved to [test/timing.h](#).
- const [index_t](#) [BITS_PER_CHAR](#) = std::numeric_limits<unsigned char>::digits
If radix of unsigned char is not 2, we can't easily determine number of bits from sizeof.
- const [index_t](#) [BITS_PER_SET_VALUE](#) = std::numeric_limits<[set_value_t](#)>::digits
Number of bits in set_value_t.
- const [index_t](#) [DEFAULT_LO](#) = -[index_t](#)([BITS_PER_SET_VALUE](#) / 2)
Default lowest index in an index set.
- const [index_t](#) [DEFAULT_HI](#) = [index_t](#)([BITS_PER_SET_VALUE](#) / 2)
Default highest index in an index set.
- const double [DEFAULT_TRUNCATION](#) = std::numeric_limits<float>::epsilon()
Default for truncation.
- const unsigned int [DEFAULT_Mult_Matrix_Threshold](#) = 8
- const unsigned int [DEFAULT_Div_Max_Steps](#) = 4
- const unsigned int [DEFAULT_Sqrt_Max_Steps](#) = 256
- const unsigned int [DEFAULT_Log_Max_Outer_Steps](#) = 256
- const unsigned int [DEFAULT_Log_Max_Inner_Steps](#) = 32
- const unsigned int [DEFAULT_Basis_Max_Count](#) = 12
- const unsigned int [DEFAULT_Fast_Size_Threshold](#) = 1 << 6
- const unsigned int [DEFAULT_Inv_Fast_Dim_Threshold](#) = 1 << 3
- const unsigned int [DEFAULT_Products_Size_Threshold](#) = 1 << 22
- const [precision_t](#) [DEFAULT_Function_Precision](#) = [precision_same](#)
- static const long double [l_pi](#) = 3.1415926535897932384626433832795029L
- static const long double [l_ln2](#) = 0.6931471805599453094172321214581766L

5.2.1 Typedef Documentation

5.2.1.1 typedef int glucat::index_t

Size of [index_t](#) should be enough to represent LO, HI.

Definition at line 77 of file [global.h](#).

5.2.1.2 `typedef int(* glucat::intfn)()`

For exception catching: pointer to function returning int.

Definition at line 37 of file `try_catch.h`.

5.2.1.3 `typedef int(* glucat::intintfn)(int)`

For exception catching: pointer to function of int returning int.

Definition at line 40 of file `try_catch.h`.

5.2.1.4 `typedef unsigned long glucat::set_value_t`

Size of `set_value_t` should be enough to contain `index_set<LO,HI>`

Definition at line 79 of file `global.h`.

5.2.2 Enumeration Type Documentation

5.2.2.1 `enum glucat::precision_t`

Precision policy.

Enumerator

precision_demoted

precision_same

precision_promoted

Definition at line 117 of file `global.h`.

5.2.3 Function Documentation

5.2.3.1 `glucat::GLUCAT_CTAssert ( sizeof(set_value_t) >=sizeof(std::bitset< DEFAULT_HI-DEFAULT_LO > ) , Default_index_set_too_big_for_value ) const`

Size of `set_value_t` should be enough to contain `bitset<DEFAULT_HI-DEFAULT_LO>`

Write out index set

5.2.3.2 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> Scalar_T glucat::abs ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Absolute value == `sqrt(norm)`

Definition at line 491 of file `clifford_algebra_imp.h`.

References `glucat::numeric_traits< Scalar_T >::sqrt()`.

Referenced by `PyClical.clifford::abs()`, `acos()`, `asin()`, `glucat::matrix::classify_eigenvalues()`, `clifford_to_str()`, `glucat::framed_multi< Scalar_T, LO, HI >::framed_multi()`, `matrix_log()`, and `matrix_sqrt()`.

5.2.3.3 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::acos (const Multivector< Scalar_T, LO, HI > & val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false) [inline]`

Inverse cosine of multivector with specified complexifier.

Definition at line 798 of file `clifford_algebra_imp.h`.

References `abs()`, `acosh()`, and `check_complex()`.

Referenced by `glucat::numeric_traits< Scalar_T >::acos()`, and `acos()`.

5.2.3.4 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::acos ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Inverse cosine of multivector.

Definition at line 818 of file `clifford_algebra_imp.h`.

References `acos()`, and `complexifier()`.

5.2.3.5 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::acosh (const Multivector< Scalar_T, LO, HI > & val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false) [inline]`

Inverse hyperbolic cosine of multivector with specified complexifier.

Definition at line 738 of file `clifford_algebra_imp.h`.

References `check_complex()`, `log()`, `norm()`, and `sqrt()`.

Referenced by `acos()`, and `acosh()`.

5.2.3.6 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::acosh ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Inverse hyperbolic cosine of multivector.

Definition at line 758 of file `clifford_algebra_imp.h`.

References `acosh()`, and `complexifier()`.

5.2.3.7 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::asin (const Multivector< Scalar_T, LO, HI > & val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false) [inline]`

Inverse sine of multivector with specified complexifier.

Definition at line 905 of file `clifford_algebra_imp.h`.

References `abs()`, `asinh()`, and `check_complex()`.

Referenced by `glucat::numeric_traits< Scalar_T >::asin()`, and `asin()`.

5.2.3.8 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::asin ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Inverse sine of multivector.

Definition at line 925 of file clifford_algebra_imp.h.

References `asin()`, and `complexifier()`.

```
5.2.3.9  template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t
        LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::asinh ( const Multivector< Scalar_T, LO, HI > &
        val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false )  [inline]
```

Inverse hyperbolic sine of multivector with specified complexifier.

Definition at line 845 of file clifford_algebra_imp.h.

References `check_complex()`, `log()`, `norm()`, and `sqrt()`.

Referenced by `asin()`, and `asinh()`.

```
5.2.3.10 template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t
        LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::asinh ( const Multivector< Scalar_T, LO, HI > &
        val )  [inline]
```

Inverse hyperbolic sine of multivector.

Definition at line 865 of file clifford_algebra_imp.h.

References `asinh()`, and `complexifier()`.

```
5.2.3.11 template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t
        LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::atan ( const Multivector< Scalar_T, LO, HI > &
        val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false )  [inline]
```

Inverse tangent of multivector with specified complexifier.

Definition at line 1005 of file clifford_algebra_imp.h.

References `atanh()`, `check_complex()`, and `scalar()`.

Referenced by `glucat::numeric_traits< Scalar_T >::atan()`, and `atan()`.

```
5.2.3.12 template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t
        LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::atan ( const Multivector< Scalar_T, LO, HI > &
        val )  [inline]
```

Inverse tangent of multivector.

Definition at line 1025 of file clifford_algebra_imp.h.

References `atan()`, and `complexifier()`.

```
5.2.3.13 template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t
        LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::atanh ( const Multivector< Scalar_T, LO, HI > &
        val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false )  [inline]
```

Inverse hyperbolic tangent of multivector with specified complexifier.

Definition at line 952 of file clifford_algebra_imp.h.

References `check_complex()`, `log()`, and `norm()`.

Referenced by `atan()`, and `atanh()`.

5.2.3.14 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::atanh ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Inverse hyperbolic tangent of multivector.

Definition at line 969 of file `clifford_algebra_imp.h`.

References `atanh()`, and `complexifier()`.

5.2.3.15 `template<typename Scalar_T, const index_t LO, const index_t HI> static const matrix_multi<Scalar_T,LO,HI> glucat::cascade_log ( const matrix_multi< Scalar_T, LO, HI > & val ) [static]`

Incomplete square root cascade and Pade' approximation of log.

Definition at line 1976 of file `matrix_multi_imp.h`.

References `db_step()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::isnan()`, `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::log_max_inner_steps`, `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::log_max_outer_steps`, `norm()`, `pade_log()`, and `pow()`.

Referenced by `matrix_log()`.

5.2.3.16 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> static void glucat::check_complex (const Multivector< Scalar_T, LO, HI > & val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false) [inline],[static]`

Check that *i* is a valid complexifier for *val*.

Definition at line 566 of file `clifford_algebra_imp.h`.

References `complexifier()`.

Referenced by `acos()`, `acosh()`, `asin()`, `asinh()`, `atan()`, `atanh()`, `cos()`, `log()`, `sin()`, `sqrt()`, and `tan()`.

5.2.3.17 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::clifford_exp ( const Multivector< Scalar_T, LO, HI > & val )`

Exponential of multivector.

Definition at line 604 of file `clifford_algebra_imp.h`.

References `exp()`, `log2()`, `pow()`, and `scalar()`.

Referenced by `exp()`.

5.2.3.18 `template<const index_t LO, const index_t HI> int glucat::compare ( const index_set< LO, HI > & a, const index_set< LO, HI > & b ) [inline]`

"lexicographic compare" eg. {3,4,5} is less than {3,7,8}

Lexicographic ordering of two sets: -1 if *a*<*b*, +1 if *a*>*b*, 0 if *a*==*b*.

Definition at line 573 of file `index_set_imp.h`.

References `glucat::index_set< LO, HI >::lex_less_than()`.

5.2.3.19 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::complexifier ( const Multivector< Scalar_T, LO, HI > & val )`

Square root of -1 which commutes with all members of the frame of the given multivector.

Definition at line 506 of file `clifford_algebra_imp.h`.

References `pos_mod()`.

Referenced by `acos()`, `acosh()`, `asin()`, `asinh()`, `atan()`, `atanh()`, `check_complex()`, `cos()`, `elliptic()`, `log()`, `sin()`, `sqrt()`, and `tan()`.

5.2.3.20 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::conj ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Conjugation, `rev o invo == invo o rev`.

Definition at line 467 of file `clifford_algebra_imp.h`.

5.2.3.21 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::cos (const Multivector< Scalar_T, LO, HI > & val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false)`

Cosine of multivector with specified complexifier.

Definition at line 765 of file `clifford_algebra_imp.h`.

References `check_complex()`, `exp()`, `PyClical::pi`, and `scalar()`.

Referenced by `glucat::numeric_traits< Scalar_T >::cos()`, `cos()`, and `tan()`.

5.2.3.22 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::cos ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Cosine of multivector.

Definition at line 789 of file `clifford_algebra_imp.h`.

References `complexifier()`, and `cos()`.

5.2.3.23 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::cosh ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Hyperbolic cosine of multivector.

Definition at line 720 of file `clifford_algebra_imp.h`.

References `exp()`, and `scalar()`.

Referenced by `glucat::numeric_traits< Scalar_T >::cosh()`, and `tanh()`.

5.2.3.24 `template<typename Scalar_T, const index_t LO, const index_t HI> static Scalar_T glucat::crd_of_mult ( const std::pair< const index_set< LO, HI >, Scalar_T > & lhs, const std::pair< const index_set< LO, HI >, Scalar_T > & rhs ) [inline],[static]`

Coordinate of product of terms.

Referenced by operator%(), operator&(), operator*(), and operator^().

5.2.3.25 `template<typename Scalar_T, const index_t LO, const index_t HI> static Scalar_T glucat::crd_of_mult ( const std::pair< const index_set< LO, HI >, Scalar_T > & lhs, const std::pair< const index_set< LO, HI >, Scalar_T > & rhs ) [inline],[static]`

Coordinate of product of terms.

Definition at line 1906 of file framed_multi_imp.h.

5.2.3.26 `template<typename Scalar_T, const index_t LO, const index_t HI> static const matrix_multi<Scalar_T,LO,HI> glucat::db_sqrt ( const matrix_multi< Scalar_T, LO, HI > & val ) [static]`

Product form of Denman-Beavers square root iteration.

Definition at line 1375 of file matrix_multi_imp.h.

References db_step(), norm(), pow(), and glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::sqrt_max_steps.

Referenced by matrix_sqrt().

5.2.3.27 `template<typename Scalar_T, const index_t LO, const index_t HI> static void glucat::db_step ( matrix_multi< Scalar_T, LO, HI > & M, matrix_multi< Scalar_T, LO, HI > & Y ) [inline],[static]`

Single step of product form of Denman-Beavers square root iteration.

Definition at line 1362 of file matrix_multi_imp.h.

References inv().

Referenced by cascade_log(), and db_sqrt().

5.2.3.28 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::elliptic ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Square root of -1 which commutes with all members of the frame of the given multivector The name "elliptic" is now deprecated: use "complexifier" instead.

Definition at line 557 of file clifford_algebra_imp.h.

References complexifier().

5.2.3.29 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::even ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Even part.

Definition at line 427 of file clifford_algebra_imp.h.

5.2.3.30 `template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI > glucat::exp ( const framed_multi< Scalar_T, LO, HI > & val )`

Exponential of multivector.

Definition at line 1947 of file framed_multi_imp.h.

References `clifford_exp()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::frame()`, `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::function_precision`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::isnan()`, `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::mult_matrix_threshold`, `precision_demoted`, `precision_promoted`, and `scalar()`.

Referenced by `clifford_exp()`, `cos()`, `cosh()`, `glucat::numeric_traits< Scalar_T >::exp()`, `exp()`, `matrix_log()`, `matrix_sqrt()`, `pow()`, `PyClical.clifford::pow()`, `sin()`, and `sinh()`.

5.2.3.31 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI > glucat::exp ( const matrix_multi< Scalar_T, LO, HI > & val )`

Exponential of multivector.

Definition at line 2140 of file `matrix_multi_imp.h`.

References `clifford_exp()`, `exp()`, `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::function_precision`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::isnan()`, `precision_demoted`, `precision_promoted`, and `scalar()`.

5.2.3.32 `template<typename Multivector_T, typename Matrix_T, typename Basis_Matrix_T> static Multivector_T glucat::fast ( const Matrix_T & X, index_t level ) [static]`

Inverse generalized Fast Fourier Transform.

Definition at line 1083 of file `matrix_multi_imp.h`.

References `glucat::matrix::signed_perm_nork()`.

5.2.3.33 `template<typename Matrix_Index_T, const index_t LO, const index_t HI> static Matrix_Index_T glucat::folded_dim ( const index_set< LO, HI > & sub ) [inline], [static]`

Determine the matrix dimension of the fold of a subalgebra.

Definition at line 91 of file `matrix_multi_imp.h`.

References `glucat::index_set< LO, HI >::count_neg()`, `glucat::index_set< LO, HI >::count_pos()`, and `offset_level()`.

5.2.3.34 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> Scalar_T glucat::imag ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Imaginary part: deprecated (always 0)

Definition at line 411 of file `clifford_algebra_imp.h`.

Referenced by `glucat::matrix::classify_eigenvalues()`.

5.2.3.35 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::inv ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Geometric multiplicative inverse.

Definition at line 321 of file `clifford_algebra_imp.h`.

Referenced by `db_step()`, `matrix_log()`, and `matrix_sqrt()`.

5.2.3.36 `static unsigned long glucat::inverse_gray ( unsigned long x ) [inline], [static]`

Inverse Gray code.

Definition at line 861 of file `index_set_imp.h`.

Referenced by `glucat::index_set< LO, HI >::sign_of_mult()`.

5.2.3.37 `static unsigned long glucat::inverse_reversed_gray ( unsigned long x ) [inline], [static]`

Inverse reversed Gray code.

Definition at line 844 of file `index_set_imp.h`.

Referenced by `glucat::index_set< LO, HI >::sign_of_mult()`.

5.2.3.38 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::involute ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Main involution, each $\{i\}$ is replaced by $\{-i\}$ in each term, eg. $\{1\}*\{2\} \rightarrow (-\{2\})*(-\{1\})$

Main involution, each $\{i\}$ is replaced by $\{-i\}$ in each term, eg. $\{1\} \rightarrow -\{1\}$.

Definition at line 451 of file `clifford_algebra_imp.h`.

5.2.3.39 `template<typename Scalar_T , const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI > glucat::log ( const matrix_multi< Scalar_T, LO, HI > & val, const matrix_multi< Scalar_T, LO, HI > & i, bool prechecked )`

Natural logarithm of multivector with specified complexifier.

Definition at line 2023 of file `matrix_multi_imp.h`.

References `check_complex()`, `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::function_precision`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::isnan()`, `matrix_log()`, `precision_demoted`, and `precision_promoted`.

5.2.3.40 `template<typename Scalar_T , const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI > glucat::log ( const framed_multi< Scalar_T, LO, HI > & val, const framed_multi< Scalar_T, LO, HI > & i, bool prechecked )`

Natural logarithm of multivector with specified complexifier.

Definition at line 1997 of file `framed_multi_imp.h`.

References `check_complex()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::isnan()`, `log()`, `PyClical::pi`, and `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::scalar()`.

5.2.3.41 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::log (const Multivector< Scalar_T, LO, HI > & val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false) [inline]`

Natural logarithm of multivector with specified complexifier.

Definition at line 704 of file clifford_algebra_imp.h.

Referenced by `acosh()`, `asinh()`, `atanh()`, `glucat::numeric_traits< Scalar_T >::log()`, `log()`, `matrix_log()`, `glucat::numeric_traits< Scalar_T >::NaN()`, `pow()`, and `PyClical.clifford::pow()`.

5.2.3.42 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::log ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Natural logarithm of multivector.

Definition at line 712 of file clifford_algebra_imp.h.

References `complexifier()`, and `log()`.

5.2.3.43 `template<typename Scalar_T > Scalar_T glucat::log2 ( const Scalar_T & x ) [inline]`

Log base 2 of scalar.

Definition at line 302 of file scalar.h.

References `glucat::numeric_traits< Scalar_T >::log2()`.

Referenced by `clifford_exp()`.

5.2.3.44 `template<typename Scalar_T , const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI > glucat::matrix_log ( const matrix_multi< Scalar_T, LO, HI > & val, const matrix_multi< Scalar_T, LO, HI > & i )`

Natural logarithm of multivector with specified complexifier.

Definition at line 2064 of file matrix_multi_imp.h.

References `abs()`, `glucat::matrix::both_eig_case`, `cascade_log()`, `glucat::matrix::classify_eigenvalues()`, `exp()`, `inv()`, `glucat::matrix::isnan()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::isnan()`, `log()`, `glucat::matrix::eig_genus< Matrix_T >::m_eig_case`, `glucat::matrix::eig_genus< Matrix_T >::m_safe_arg`, `glucat::matrix::negative_eig_case`, `norm()`, `PyClical::pi`, and `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::scalar()`.

Referenced by `log()`.

5.2.3.45 `template<typename Scalar_T , const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI > glucat::matrix_sqrt ( const matrix_multi< Scalar_T, LO, HI > & val, const matrix_multi< Scalar_T, LO, HI > & i )`

Square root of multivector with specified complexifier.

Definition at line 1645 of file matrix_multi_imp.h.

References `abs()`, `glucat::matrix::both_eig_case`, `glucat::matrix::classify_eigenvalues()`, `db_sqrt()`, `exp()`, `inv()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::isnan()`, `glucat::matrix::eig_genus< Matrix_T >::m_eig_case`, `glucat::matrix::eig_genus< Matrix_T >::m_safe_arg`, `glucat::matrix::negative_eig_case`, `norm()`, `pade_approx()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::scalar()`, and `sqrt()`.

Referenced by `sqrt()`.

5.2.3.46 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> Scalar_T glucat::max_abs ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Maximum of absolute values of components of multivector: multivector infinity norm.

Definition at line 499 of file clifford_algebra_imp.h.

5.2.3.47 `template<const index_t LO, const index_t HI> index_t glucat::max_pos (const index_set< LO, HI > & ist)
[inline]`

Maximum positive index, or 0 if none.

Definition at line 974 of file `index_set_imp.h`.

References `glucat::index_set< LO, HI >::max()`.

5.2.3.48 `template<const index_t LO, const index_t HI> index_t glucat::min_neg (const index_set< LO, HI > & ist)
[inline]`

Minimum negative index, or 0 if none.

Definition at line 967 of file `index_set_imp.h`.

References `glucat::index_set< LO, HI >::min()`.

5.2.3.49 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t
LO, const index_t HI> Scalar_T glucat::norm (const Multivector< Scalar_T, LO, HI > & val) [inline]`

Scalar_T norm == sum of norm of coordinates.

Definition at line 483 of file `clifford_algebra_imp.h`.

Referenced by `acosh()`, `asinh()`, `atanh()`, `cascade_log()`, `glucat::matrix::classify_eigenvalues()`, `db_sqrt()`, `matrix_log()`, and `matrix_sqrt()`.

5.2.3.50 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t
LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::odd (const Multivector< Scalar_T, LO, HI > &
val) [inline]`

Odd part.

Definition at line 435 of file `clifford_algebra_imp.h`.

5.2.3.51 `index_t glucat::offset_level ( const index_t p, const index_t q ) [inline]`

Determine the log2 dim corresponding to signature p, q.

Definition at line 76 of file `matrix_multi_imp.h`.

References `pos_mod()`.

Referenced by `glucat::matrix_multi< Scalar_T, LO, HI >::basis_element()`, and `folded_dim()`.

5.2.3.52 `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t,
const index_t > class RHS, typename Scalar_T , const index_t LO, const index_t HI> bool glucat::operator!= (const
Multivector< Scalar_T, LO, HI > & lhs, const RHS< Scalar_T, LO, HI > & rhs) [inline]`

Test for inequality of multivectors.

Definition at line 78 of file `clifford_algebra_imp.h`.

5.2.3.53 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t
LO, const index_t HI> bool glucat::operator!= (const Multivector< Scalar_T, LO, HI > & lhs, const Scalar_T & scr)
[inline]`

Test for inequality of multivector and scalar.

Definition at line 86 of file clifford_algebra_imp.h.

```
5.2.3.54  template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t
        LO, const index_t HI> bool glucat::operator!=( const Scalar_T & scr, const Multivector< Scalar_T, LO, HI > & rhs )
        [inline]
```

Test for inequality of scalar and multivector.

Definition at line 94 of file clifford_algebra_imp.h.

```
5.2.3.55  template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI >
        glucat::operator%( const matrix_multi< Scalar_T, LO, HI > & lhs, const matrix_multi< Scalar_T, LO, HI > & rhs )
        [inline]
```

Left contraction.

Definition at line 635 of file matrix_multi_imp.h.

```
5.2.3.56  template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI >
        glucat::operator%( const framed_multi< Scalar_T, LO, HI > & lhs, const framed_multi< Scalar_T, LO, HI > & rhs )
```

Left contraction.

Definition at line 719 of file framed_multi_imp.h.

References `_GLUCAT_HASH_SIZE_T`, `crd_of_mult()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::frame()`, and `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::products_size_threshold`.

```
5.2.3.57  template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t,
        const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO,
        HI > glucat::operator%( const Multivector< Scalar_T, LO, HI > & lhs, const RHS< Scalar_T, LO, HI > & rhs )
        [inline]
```

Left contraction.

Definition at line 243 of file clifford_algebra_imp.h.

```
5.2.3.58  template<const index_t LO, const index_t HI> const index_set< LO, HI > glucat::operator&( const index_set<
        LO, HI > & lhs, const index_set< LO, HI > & rhs ) [inline]
```

Set intersection: and.

Definition at line 186 of file index_set_imp.h.

```
5.2.3.59  template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI >
        glucat::operator&( const matrix_multi< Scalar_T, LO, HI > & lhs, const matrix_multi< Scalar_T, LO, HI > & rhs )
        [inline]
```

Inner product.

Definition at line 616 of file matrix_multi_imp.h.

5.2.3.60 `template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI >
glucat::operator& (const framed_multi< Scalar_T, LO, HI > & lhs, const framed_multi< Scalar_T, LO, HI > & rhs)`

Inner product.

Definition at line 601 of file framed_multi_imp.h.

References `_GLUCAT_HASH_SIZE_T`, `crd_of_mult()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::frame()`, and `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::products_size_threshold`.

5.2.3.61 `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator& (const Multivector< Scalar_T, LO, HI > & lhs, const RHS< Scalar_T, LO, HI > & rhs)
[inline]`

Inner product.

Definition at line 228 of file clifford_algebra_imp.h.

5.2.3.62 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI >
glucat::operator* (const matrix_multi< Scalar_T, LO, HI > & lhs, const matrix_multi< Scalar_T, LO, HI > & rhs)
[inline]`

Geometric product.

Definition at line 547 of file matrix_multi_imp.h.

References `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::isnan()`, `glucat::matrix_multi< Scalar_T, LO, HI >::m_frame`, `glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix`, and `re-frame()`.

5.2.3.63 `template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI >
glucat::operator* (const framed_multi< Scalar_T, LO, HI > & lhs, const framed_multi< Scalar_T, LO, HI > & rhs)`

Geometric product.

Definition at line 400 of file framed_multi_imp.h.

References `_GLUCAT_HASH_SIZE_T`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::frame()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::isnan()`, and `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::mult_matrix_threshold`.

5.2.3.64 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator* ( const Multivector< Scalar_T, LO, HI > & lhs, const Scalar_T & scr ) [inline]`

Product of multivector and scalar.

Definition at line 172 of file clifford_algebra_imp.h.

5.2.3.65 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator* ( const Scalar_T & scr, const Multivector< Scalar_T, LO, HI > & rhs ) [inline]`

Product of scalar and multivector.

Definition at line 183 of file clifford_algebra_imp.h.

```
5.2.3.66  template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t,
const index_t > class RHS, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO,
HI > glucat::operator* ( const Multivector< Scalar_T, LO, HI > & lhs, const RHS< Scalar_T, LO, HI > & rhs )
[inline]
```

Geometric product.

Definition at line 198 of file clifford_algebra_imp.h.

```
5.2.3.67  template<typename Scalar_T , const index_t LO, const index_t HI> const std::pair< const index_set< LO, HI >,
Scalar_T > glucat::operator* ( const std::pair< const index_set< LO, HI >, Scalar_T > & lhs, const std::pair<
const index_set< LO, HI >, Scalar_T > & rhs ) [inline]
```

Product of terms.

Definition at line 1914 of file framed_multi_imp.h.

References crd_of_mult().

```
5.2.3.68  template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t
LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator+ ( const Multivector< Scalar_T, LO, HI
> & lhs, const Scalar_T & scr ) [inline]
```

Geometric sum of multivector and scalar.

Definition at line 102 of file clifford_algebra_imp.h.

```
5.2.3.69  template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t
LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator+ ( const Scalar_T & scr, const
Multivector< Scalar_T, LO, HI > & rhs ) [inline]
```

Geometric sum of scalar and multivector.

Definition at line 113 of file clifford_algebra_imp.h.

```
5.2.3.70  template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t,
const index_t > class RHS, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO,
HI > glucat::operator+ ( const Multivector< Scalar_T, LO, HI > & lhs, const RHS< Scalar_T, LO, HI > & rhs )
[inline]
```

Geometric sum.

Definition at line 127 of file clifford_algebra_imp.h.

```
5.2.3.71  template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t
LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator- ( const Multivector< Scalar_T, LO, HI
> & lhs, const Scalar_T & scr ) [inline]
```

Geometric difference of multivector and scalar.

Definition at line 138 of file clifford_algebra_imp.h.

5.2.3.72 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator- ( const Scalar_T & scr, const Multivector< Scalar_T, LO, HI > & rhs ) [inline]`

Geometric difference of scalar and multivector.

Definition at line 149 of file `clifford_algebra_imp.h`.

5.2.3.73 `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator- (const Multivector< Scalar_T, LO, HI > & lhs, const RHS< Scalar_T, LO, HI > & rhs) [inline]`

Geometric difference.

Definition at line 161 of file `clifford_algebra_imp.h`.

5.2.3.74 `template<typename Scalar_T , const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI > glucat::operator/ ( const matrix_multi< Scalar_T, LO, HI > & lhs, const matrix_multi< Scalar_T, LO, HI > & rhs )`

Geometric quotient.

Definition at line 668 of file `matrix_multi_imp.h`.

References `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::div_max_steps`, `glucat::matrix::isnan()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::isnan()`, `glucat::matrix_multi< Scalar_T, LO, HI >::m_frame`, and `reframe()`.

5.2.3.75 `template<typename Scalar_T , const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI > glucat::operator/ ( const framed_multi< Scalar_T, LO, HI > & lhs, const framed_multi< Scalar_T, LO, HI > & rhs ) [inline]`

Geometric quotient.

Definition at line 914 of file `framed_multi_imp.h`.

References `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::frame()`.

5.2.3.76 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator/ ( const Multivector< Scalar_T, LO, HI > & lhs, const Scalar_T & scr ) [inline]`

Quotient of multivector and scalar.

Definition at line 269 of file `clifford_algebra_imp.h`.

5.2.3.77 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator/ ( const Scalar_T & scr, const Multivector< Scalar_T, LO, HI > & rhs ) [inline]`

Quotient of scalar and multivector.

Definition at line 280 of file `clifford_algebra_imp.h`.

5.2.3.78 `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator/ (const Multivector< Scalar_T, LO, HI > & lhs, const RHS< Scalar_T, LO, HI > & rhs)`
`[inline]`

Geometric quotient.

Definition at line 295 of file `clifford_algebra_imp.h`.

5.2.3.79 `template<typename Scalar_T , const index_t LO, const index_t HI> std::ostream & glucat::operator<< ( std::ostream & os, const matrix_multi< Scalar_T, LO, HI > & val )` `[inline]`

Write multivector to output.

Definition at line 1025 of file `matrix_multi_imp.h`.

5.2.3.80 `template<typename Scalar_T , const index_t LO, const index_t HI> std::ostream & glucat::operator<< ( std::ostream & os, const framed_multi< Scalar_T, LO, HI > & val )`

Write multivector to output.

Definition at line 1366 of file `framed_multi_imp.h`.

References `glucat::sorted_range< Map_T, Sorted_Map_T >::sorted_begin`, and `glucat::sorted_range< Map_T, Sorted_Map_T >::sorted_end`.

5.2.3.81 `template<typename Scalar_T , const index_t LO, const index_t HI> std::ostream & glucat::operator<< ( std::ostream & os, const std::pair< const index_set< LO, HI >, Scalar_T > & term )`

Write term to output.

Definition at line 1398 of file `framed_multi_imp.h`.

References `pow()`, and `glucat::numeric_traits< Scalar_T >::to_double()`.

5.2.3.82 `std::ostream & glucat::operator<< ( std::ostream & os, const index_set< LO, HI > & ist )`

Write out index set.

Definition at line 611 of file `index_set_imp.h`.

References `PyClical::ist`.

5.2.3.83 `template<typename Scalar_T , const index_t LO, const index_t HI> std::istream & glucat::operator>> ( std::istream & s, matrix_multi< Scalar_T, LO, HI > & val )` `[inline]`

Read multivector from input.

Definition at line 1035 of file `matrix_multi_imp.h`.

5.2.3.84 `template<typename Scalar_T , const index_t LO, const index_t HI> std::istream & glucat::operator>> ( std::istream & s, framed_multi< Scalar_T, LO, HI > & val )`

Read multivector from input.

Definition at line 1436 of file `framed_multi_imp.h`.

References `PyClical::ist`.

5.2.3.85 `template<const index_t LO, const index_t HI> std::istream & glucat::operator>> ( std::istream & s, index_set< LO, HI > & ist )`

Read in index set.

Definition at line 633 of file `index_set_imp.h`.

References `glucat::index_set< LO, HI >::set()`.

5.2.3.86 `template<const index_t LO, const index_t HI> const index_set< LO, HI > glucat::operator^ ( const index_set< LO, HI > & lhs, const index_set< LO, HI > & rhs ) [inline]`

Symmetric set difference: exclusive or.

Definition at line 161 of file `index_set_imp.h`.

5.2.3.87 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI > glucat::operator^ ( const matrix_multi< Scalar_T, LO, HI > & lhs, const matrix_multi< Scalar_T, LO, HI > & rhs ) [inline]`

Outer product.

Definition at line 597 of file `matrix_multi_imp.h`.

5.2.3.88 `template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI > glucat::operator^ ( const framed_multi< Scalar_T, LO, HI > & lhs, const framed_multi< Scalar_T, LO, HI > & rhs )`

Outer product.

Definition at line 501 of file `framed_multi_imp.h`.

References `_GLUCAT_HASH_SIZE_T`, `crd_of_mult()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::frame()`, and `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::products_size_threshold`.

5.2.3.89 `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::operator^ (const Multivector< Scalar_T, LO, HI > & lhs, const RHS< Scalar_T, LO, HI > & rhs) [inline]`

Outer product.

Definition at line 213 of file `clifford_algebra_imp.h`.

5.2.3.90 `template<const index_t LO, const index_t HI> const index_set< LO, HI > glucat::operator| ( const index_set< LO, HI > & lhs, const index_set< LO, HI > & rhs ) [inline]`

Set union: or.

Definition at line 211 of file `index_set_imp.h`.

5.2.3.91 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI > glucat::operator| ( const matrix_multi< Scalar_T, LO, HI > & lhs, const matrix_multi< Scalar_T, LO, HI > & rhs ) [inline]`

Transformation via twisted adjoint action.

Definition at line 777 of file `matrix_multi_imp.h`.

References `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::involute()`.

```
5.2.3.92  template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI >
          glucat::operator| ( const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T, LO, HI > &rhs )
          [inline]
```

Transformation via twisted adjoint action.

Definition at line 940 of file `framed_multi_imp.h`.

References `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::involute()`.

```
5.2.3.93  template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t,
          const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T,
          LO, HI > glucat::operator| ( const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs )
          [inline]
```

Transformation via twisted adjoint action.

Definition at line 310 of file `clifford_algebra_imp.h`.

```
5.2.3.94  template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t
          LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::outer_pow ( const Multivector< Scalar_T, LO, HI
          > &lhs, int rhs )
```

Outer product power of multivector.

Definition at line 384 of file `clifford_algebra_imp.h`.

```
5.2.3.95  template<typename Scalar_T, const index_t LO, const index_t HI> static const matrix_multi<Scalar_T,LO,HI>
          glucat::pade_approx ( const int array_size, const Scalar_T a[], const Scalar_T b[], const matrix_multi< Scalar_T, LO,
          HI > &X ) [inline],[static]
```

Pade' approximation.

Definition at line 1302 of file `matrix_multi_imp.h`.

References `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::isnan()`.

Referenced by `matrix_sqrt()`, and `pade_log()`.

```
5.2.3.96  template<typename Scalar_T, const index_t LO, const index_t HI> static const matrix_multi<Scalar_T,LO,HI>
          glucat::pade_log ( const matrix_multi< Scalar_T, LO, HI > &val ) [static]
```

Pade' approximation of log.

Definition at line 1955 of file `matrix_multi_imp.h`.

References `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::isnan()`, and `pade_approx()`.

Referenced by `cascade_log()`.

```
5.2.3.97  template<typename LHS_T, typename RHS_T > LHS_T glucat::pos_mod ( LHS_T lhs, RHS_T rhs ) [inline]
```

Modulo function which works reliably for `lhs < 0`.

Definition at line 187 of file global.h.

Referenced by `complexifier()`, `glucat::matrix_multi< Scalar_T, LO, HI >::fast_framed_multi()`, `glucat::framed_multi< Scalar_T, LO, HI >::fast_matrix_multi()`, `glucat::gen::generator_table< Matrix_T >::gen_vector()`, `offset_level()`, and `glucat::gen::generator_table< Matrix_T >::operator()`.

5.2.3.98 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::pow ( const Multivector< Scalar_T, LO, HI > & lhs, int rhs )`

Integer power of multivector.

Definition at line 328 of file clifford_algebra_imp.h.

Referenced by `cascade_log()`, `clifford_exp()`, `db_sqrt()`, `operator<<()`, and `glucat::numeric_traits< Scalar_T >::pow()`.

5.2.3.99 `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::pow (const Multivector< Scalar_T, LO, HI > & lhs, const RHS< Scalar_T, LO, HI > & rhs) [inline]`

Multivector power of multivector.

Definition at line 361 of file clifford_algebra_imp.h.

References `exp()`, and `log()`.

5.2.3.100 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::pure ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Pure part.

Definition at line 419 of file clifford_algebra_imp.h.

5.2.3.101 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> Scalar_T glucat::quad ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Scalar_T quadratic form == (rev(x)*x)(0)

Definition at line 475 of file clifford_algebra_imp.h.

5.2.3.102 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> Scalar_T glucat::real ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Real part: synonym for scalar part.

Definition at line 400 of file clifford_algebra_imp.h.

Referenced by `glucat::matrix::classify_eigenvalues()`.

5.2.3.103 `template<typename Scalar_T, const index_t LO, const index_t HI> const index_set< LO, HI > glucat::reframe (const matrix_multi< Scalar_T, LO, HI > & lhs, const matrix_multi< Scalar_T, LO, HI > & rhs, matrix_multi< Scalar_T, LO, HI > & lhs_reframed, matrix_multi< Scalar_T, LO, HI > & rhs_reframed) [inline]`

Find a common frame for operands of a binary operator.

Definition at line 350 of file matrix_multi_imp.h.

References `glucat::matrix_multi< Scalar_T, LO, HI >::m_frame`.

Referenced by `operator*()`, and `operator/()`.

5.2.3.104 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::reverse ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Reversion, eg. $\{1\}*\{2\} \rightarrow \{2\}*\{1\}$.

Definition at line 459 of file `clifford_algebra_imp.h`.

5.2.3.105 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> Scalar_T glucat::scalar ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Scalar part.

Definition at line 392 of file `clifford_algebra_imp.h`.

Referenced by `atan()`, `clifford_exp()`, `cos()`, `cosh()`, `exp()`, `glucat::framed_multi< Scalar_T, LO, HI >::fast()`, `sin()`, `sinh()`, `tan()`, and `tanh()`.

5.2.3.106 `int glucat::sign_of_square ( index_t j ) [inline]`

Square of generator $\{j\}$.

Square of generator index j .

Definition at line 960 of file `index_set_imp.h`.

5.2.3.107 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::sin (const Multivector< Scalar_T, LO, HI > & val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false)`

Sine of multivector with specified complexifier.

Definition at line 872 of file `clifford_algebra_imp.h`.

References `check_complex()`, `exp()`, `PyClical::pi`, and `scalar()`.

Referenced by `glucat::numeric_traits< Scalar_T >::sin()`, `sin()`, and `tan()`.

5.2.3.108 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::sin ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Sine of multivector.

Definition at line 896 of file `clifford_algebra_imp.h`.

References `complexifier()`, and `sin()`.

5.2.3.109 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::sinh ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Hyperbolic sine of multivector.

Definition at line 826 of file `clifford_algebra_imp.h`.

References `exp()`, and `scalar()`.

Referenced by `glucat::numeric_traits< Scalar_T >::sinh()`, and `tanh()`.

5.2.3.110 `template<typename Scalar_T , const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI > glucat::sqrt ( const matrix_multi< Scalar_T, LO, HI > & val, const matrix_multi< Scalar_T, LO, HI > & i, bool prechecked )`

Square root of multivector with specified complexifier.

Definition at line 1600 of file `matrix_multi_imp.h`.

References `check_complex()`, `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::function_precision`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::isnan()`, `matrix_sqrt()`, `precision_demoted`, and `precision_promoted`.

5.2.3.111 `template<typename Scalar_T , const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI > glucat::sqrt ( const framed_multi< Scalar_T, LO, HI > & val, const framed_multi< Scalar_T, LO, HI > & i, bool prechecked )`

Square root of multivector with specified complexifier.

Definition at line 1924 of file `framed_multi_imp.h`.

References `check_complex()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::isnan()`, `glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::scalar()`, and `sqrt()`.

5.2.3.112 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::sqrt (const Multivector< Scalar_T, LO, HI > & val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false) [inline]`

Square root of multivector with specified complexifier.

Definition at line 589 of file `clifford_algebra_imp.h`.

Referenced by `acosh()`, `asinh()`, `matrix_sqrt()`, `glucat::framed_multi< Scalar_T, LO, HI >::random()`, and `sqrt()`.

5.2.3.113 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::sqrt ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Square root of multivector.

Definition at line 597 of file `clifford_algebra_imp.h`.

References `complexifier()`, and `sqrt()`.

5.2.3.114 `template<typename Scalar_T , const index_t LO, const index_t HI> Scalar_T glucat::star ( const matrix_multi< Scalar_T, LO, HI > & lhs, const matrix_multi< Scalar_T, LO, HI > & rhs ) [inline]`

Hestenes scalar product.

Definition at line 654 of file `matrix_multi_imp.h`.

5.2.3.115 `template<typename Scalar_T , const index_t LO, const index_t HI> Scalar_T glucat::star ( const framed_multi< Scalar_T, LO, HI > & lhs, const framed_multi< Scalar_T, LO, HI > & rhs )`

Hestenes scalar product.

Definition at line 855 of file framed_multi_imp.h.

5.2.3.116 `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T , const index_t LO, const index_t HI> Scalar_T glucat::star (const Multivector< Scalar_T, LO, HI > & lhs, const RHS< Scalar_T, LO, HI > & rhs) [inline]`

Hestenes scalar product.

Definition at line 258 of file clifford_algebra_imp.h.

5.2.3.117 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::tan (const Multivector< Scalar_T, LO, HI > & val, const Multivector< Scalar_T, LO, HI > & i, const bool prechecked = false) [inline]`

Tangent of multivector with specified complexifier.

Definition at line 977 of file clifford_algebra_imp.h.

References check_complex(), cos(), scalar(), and sin().

Referenced by glucat::numeric_traits< Scalar_T >::tan(), and tan().

5.2.3.118 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::tan ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Tangent of multivector.

Definition at line 996 of file clifford_algebra_imp.h.

References complexifier(), and tan().

5.2.3.119 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::tanh ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Hyperbolic tangent of multivector.

Definition at line 933 of file clifford_algebra_imp.h.

References cosh(), scalar(), and sinh().

Referenced by glucat::numeric_traits< Scalar_T >::tanh().

5.2.3.120 `template<typename Scalar_T > numeric_traits<Scalar_T>::demoted::type glucat::to_demote ( const Scalar_T & val ) [inline]`

Cast to demote.

Definition at line 134 of file scalar_imp.h.

References glucat::numeric_traits< Scalar_T >::to_scalar_t().

5.2.3.121 `template<typename Scalar_T> numeric_traits<Scalar_T>::promoted::type glucat::to_promote ( const Scalar_T & val ) [inline]`

Cast to promote.

Definition at line 124 of file scalar_imp.h.

References `glucat::numeric_traits< Scalar_T >::to_scalar_t()`.

5.2.3.122 `int glucat::try_catch ( intfn f )`

Exception catching for functions returning int.

Definition at line 49 of file try_catch.h.

References `PyClical::e()`, and `glucat::glucat_error::print_error_msg()`.

Referenced by `glucat::control_t::call()`.

5.2.3.123 `int glucat::try_catch ( intintfn f, int arg )`

Exception catching for functions of int returning int.

Definition at line 64 of file try_catch.h.

References `PyClical::e()`, and `glucat::glucat_error::print_error_msg()`.

5.2.3.124 `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const std::vector< Scalar_T > glucat::vector_part ( const Multivector< Scalar_T, LO, HI > & val ) [inline]`

Vector part of multivector, as a `vector_t` with respect to `frame()`

Definition at line 443 of file clifford_algebra_imp.h.

5.2.4 Variable Documentation

5.2.4.1 `const index_t glucat::BITS_PER_CHAR = std::numeric_limits<unsigned char>::digits`

If radix of unsigned char is not 2, we can't easily determine number of bits from `sizeof`.

Number of bits per char is used to determine number of bits in `set_value_t`

Definition at line 100 of file global.h.

5.2.4.2 `const index_t glucat::BITS_PER_SET_VALUE = std::numeric_limits<set_value_t>::digits`

Number of bits in `set_value_t`.

Definition at line 103 of file global.h.

5.2.4.3 `const unsigned int glucat::DEFAULT_Basis_Max_Count = 12`

Definition at line 130 of file global.h.

5.2.4.4 `const unsigned int glucat::DEFAULT_Div_Max_Steps = 4`

Definition at line 126 of file global.h.

5.2.4.5 `const unsigned int glucat::DEFAULT_Fast_Size_Threshold = 1 << 6`

Definition at line 131 of file global.h.

5.2.4.6 `const precision_t glucat::DEFAULT_Function_Precision = precision_same`

Definition at line 134 of file global.h.

5.2.4.7 `const index_t glucat::DEFAULT_HI = index_t(BITS_PER_SET_VALUE / 2)`

Default highest index in an index set.

Definition at line 111 of file global.h.

5.2.4.8 `const unsigned int glucat::DEFAULT_Inv_Fast_Dim_Threshold = 1 << 3`

Definition at line 132 of file global.h.

5.2.4.9 `const index_t glucat::DEFAULT_LO = -index_t(BITS_PER_SET_VALUE / 2)`

Default lowest index in an index set.

Definition at line 109 of file global.h.

5.2.4.10 `const unsigned int glucat::DEFAULT_Log_Max_Inner_Steps = 32`

Definition at line 129 of file global.h.

5.2.4.11 `const unsigned int glucat::DEFAULT_Log_Max_Outer_Steps = 256`

Definition at line 128 of file global.h.

5.2.4.12 `const unsigned int glucat::DEFAULT_Mult_Matrix_Threshold = 8`

Definition at line 125 of file global.h.

5.2.4.13 `const unsigned int glucat::DEFAULT_Products_Size_Threshold = 1 << 22`

Definition at line 133 of file global.h.

5.2.4.14 `const unsigned int glucat::DEFAULT_Sqrt_Max_Steps = 256`

Definition at line 127 of file global.h.

5.2.4.15 `const double glucat::DEFAULT_TRUNCATION = std::numeric_limits<float>::epsilon()`

Default for truncation.

Definition at line 114 of file global.h.

5.2.4.16 `const long double glucat::l_ln2 = 0.6931471805599453094172321214581766L` `[static]`

Definition at line 41 of file `long_double.h`.

Referenced by `glucat::numeric_traits< Scalar_T >::ln_2()`.

5.2.4.17 `const long double glucat::l_pi = 3.1415926535897932384626433832795029L` `[static]`

Definition at line 40 of file `long_double.h`.

Referenced by `glucat::numeric_traits< Scalar_T >::pi()`.

5.2.4.18 `const double glucat::MS_PER_S = 1000.0`

Timing constant: deprecated here - moved to [test/timing.h](#).

Definition at line 83 of file `global.h`.

5.3 glucat::gen Namespace Reference

Classes

- class [generator_table](#)
Table of generators for specific signatures.

Typedefs

- typedef `std::pair< index\_t, index\_t >` `signature_t`
A signature is a pair of indices, p, q , with $p == \text{frame.max}()$, $q == -\text{frame.min}()$

Variables

- static const `index\_t offset_to_super [] = {0,-1, 0,-1,-2, 3, 2, 1}`
Offsets between the current signature and that of the real superalgebra.

5.3.1 Typedef Documentation

5.3.1.1 typedef `std::pair<index\_t, index\_t>` `glucat::gen::signature_t`

A signature is a pair of indices, p, q , with $p == \text{frame.max}()$, $q == -\text{frame.min}()$

Definition at line 43 of file `generation.h`.

5.3.2 Variable Documentation

5.3.2.1 `const index\_t glucat::gen::offset_to_super[] = {0,-1, 0,-1,-2, 3, 2, 1}` `[static]`

Offsets between the current signature and that of the real superalgebra.

Definition at line 81 of file `generation.h`.

Referenced by `glucat::matrix_multi< Scalar_T, LO, HI >::fast_framed_multi()`, `glucat::framed_multi< Scalar_T, LO, HI >::fast_matrix_multi()`, and `glucat::gen::generator_table< Matrix_T >::operator()()`.

5.4 glucat::matrix Namespace Reference

Classes

- struct [eig_genus](#)
Structure containing classification of eigenvalues.

Enumerations

- enum [eig_case_t](#) { [safe_eig_case](#), [negative_eig_case](#), [both_eig_case](#) }
Classification of eigenvalues of a matrix.

Functions

- template<typename LHS_T , typename RHS_T >
const RHS_T [kron](#) (const LHS_T &lhs, const RHS_T &rhs)
Kronecker tensor product of matrices - as per Matlab kron.
- template<typename LHS_T , typename RHS_T >
const RHS_T [mono_kron](#) (const LHS_T &lhs, const RHS_T &rhs)
Sparse Kronecker tensor product of monomial matrices.
- template<typename LHS_T , typename RHS_T >
const RHS_T [nork](#) (const LHS_T &lhs, const RHS_T &rhs, const bool mono=true)
Left inverse of Kronecker product.
- template<typename LHS_T , typename RHS_T >
const RHS_T [signed_perm_nork](#) (const LHS_T &lhs, const RHS_T &rhs)
Left inverse of Kronecker product where lhs is a signed permutation matrix.
- template<typename Matrix_T >
Matrix_T::size_type [nnz](#) (const Matrix_T &m)
Number of non-zeros.
- template<typename Matrix_T >
bool [isnan](#) (const Matrix_T &m)
Not a Number.
- template<typename Matrix_T >
const Matrix_T [unit](#) (const typename Matrix_T::size_type n)
Unit matrix - as per Matlab eye.
- template<typename LHS_T , typename RHS_T >
const RHS_T::expression_type [mono_prod](#) (const ublas::matrix_expression< LHS_T > &lhs, const ublas::matrix_expression< RHS_T > &rhs)
Product of monomial matrices.
- template<typename LHS_T , typename RHS_T >
const RHS_T::expression_type [sparse_prod](#) (const ublas::matrix_expression< LHS_T > &lhs, const ublas::matrix_expression< RHS_T > &rhs)
Product of sparse matrices.
- template<typename LHS_T , typename RHS_T >
const RHS_T::expression_type [prod](#) (const ublas::matrix_expression< LHS_T > &lhs, const ublas::matrix_expression< RHS_T > &rhs)
Product of matrices.
- template<typename Scalar_T , typename LHS_T , typename RHS_T >
Scalar_T [inner](#) (const LHS_T &lhs, const RHS_T &rhs)
*Inner product: $\sum(x(i,j)*y(i,j))/x.nrows()$*
- template<typename Matrix_T >
Matrix_T::value_type [norm_frob2](#) (const Matrix_T &val)

Square of Frobenius norm.

- `template<typename Matrix_T >`
`Matrix_T::value_type trace` (const Matrix_T &val)

Matrix trace.

- `template<typename Matrix_T >`
`ublas::vector< std::complex`
`< double > > eigenvalues` (const Matrix_T &val)

Eigenvalues of a matrix.

- `template<typename Matrix_T >`
`eig_genus< Matrix_T > classify_eigenvalues` (const Matrix_T &val)

Classify the eigenvalues of a matrix.

- `template<typename LHS_T , typename RHS_T >`
`void nork_range` (RHS_T &result, const typename LHS_T::const_iterator2 lhs_it2, const RHS_T &rhs, const
typename RHS_T::size_type res_s1, const typename RHS_T::size_type res_s2)

Utility routine for nork: calculate result for a range of indices.

- `template<typename Matrix_T >`
`static ublas::matrix< double,`
`ublas::column_major > to_lapack` (const Matrix_T &val)

Convert matrix to LAPACK format.

5.4.1 Enumeration Type Documentation

5.4.1.1 enum glucat::matrix::eig_case_t

Classification of eigenvalues of a matrix.

Enumerator

safe_eig_case

negative_eig_case

both_eig_case

Definition at line 127 of file matrix.h.

5.4.2 Function Documentation

5.4.2.1 `template<typename Matrix_T > eig_genus< Matrix_T > glucat::matrix::classify_eigenvalues ( const Matrix_T & val )`

Classify the eigenvalues of a matrix.

Definition at line 526 of file matrix_imp.h.

References `glucat::abs()`, `both_eig_case`, `eigenvalues()`, `glucat::imag()`, `glucat::matrix::eig_genus< Matrix_T >::m_eig_case`, `glucat::matrix::eig_genus< Matrix_T >::m_safe_arg`, `negative_eig_case`, `glucat::norm()`, `glucat::numeric_traits< Scalar_T >::pi()`, `PyClical::pi`, `glucat::real()`, and `safe_eig_case`.

Referenced by `glucat::matrix_log()`, and `glucat::matrix_sqrt()`.

5.4.2.2 `template<typename Matrix_T > ublas::vector< std::complex< double > > glucat::matrix::eigenvalues ( const Matrix_T & val )`

Eigenvalues of a matrix.

Definition at line 493 of file matrix_imp.h.

References to `_lapack()`.

Referenced by `classify_eigenvalues()`.

5.4.2.3 `template<typename Scalar_T , typename LHS_T , typename RHS_T > Scalar_T glucat::matrix::inner ( const LHS_T & lhs, const RHS_T & rhs )`

Inner product: $\sum(x(i,j)*y(i,j))/x.nrows()$

Inner product: $\sum(lhs(i,j)*rhs(i,j))/lhs.nrows()$

Definition at line 391 of file `matrix_imp.h`.

5.4.2.4 `template<typename Matrix_T > bool glucat::matrix::isnan ( const Matrix_T & m )`

Not a Number.

Definition at line 292 of file `matrix_imp.h`.

Referenced by `glucat::matrix_log()`, and `glucat::operator/()`.

5.4.2.5 `template<typename LHS_T , typename RHS_T > const RHS_T glucat::matrix::kron ( const LHS_T & lhs, const RHS_T & rhs )`

Kronecker tensor product of matrices - as per Matlab `kron`.

Definition at line 73 of file `matrix_imp.h`.

Referenced by `glucat::framed_multi< Scalar_T, LO, HI >::fast()`.

5.4.2.6 `template<typename LHS_T , typename RHS_T > const RHS_T glucat::matrix::mono_kron ( const LHS_T & lhs, const RHS_T & rhs )`

Sparse Kronecker tensor product of monomial matrices.

Definition at line 116 of file `matrix_imp.h`.

Referenced by `glucat::gen::generator_table< Matrix_T >::gen_from_pm1_qm1()`.

5.4.2.7 `template<typename LHS_T , typename RHS_T > const RHS_T::expression_type glucat::matrix::mono_prod ( const ublas::matrix_expression< LHS_T > & lhs, const ublas::matrix_expression< RHS_T > & rhs )`

Product of monomial matrices.

Definition at line 326 of file `matrix_imp.h`.

Referenced by `glucat::matrix_multi< Scalar_T, LO, HI >::basis_element()`, `glucat::gen::generator_table< Matrix_T >::gen_from_pm4_qp4()`, `glucat::gen::generator_table< Matrix_T >::gen_from_pp4_qm4()`, and `glucat::gen::generator_table< Matrix_T >::gen_from_qp1_pm1()`.

5.4.2.8 `template<typename Matrix_T > Matrix_T::size_type glucat::matrix::nnz ( const Matrix_T & m )`

Number of non-zeros.

Definition at line 269 of file `matrix_imp.h`.

Referenced by `glucat::framed_multi< Scalar_T, LO, HI >::framed_multi()`.

5.4.2.9 `template<typename LHS_T , typename RHS_T > const RHS_T glucat::matrix::nork ( const LHS_T & lhs, const RHS_T & rhs, const bool mono = true )`

Left inverse of Kronecker product.

Definition at line 188 of file `matrix_imp.h`.

References `norm_frob2()`.

5.4.2.10 `template<typename LHS_T , typename RHS_T > void glucat::matrix::nork_range ( RHS_T & result, const typename LHS_T::const_iterator2 lhs_it2, const RHS_T & rhs, const typename RHS_T::size_type res_s1, const typename RHS_T::size_type res_s2 )`

Utility routine for `nork`: calculate result for a range of indices.

Definition at line 155 of file `matrix_imp.h`.

References `glucat::numeric_traits< Scalar_T >::to_scalar_t()`.

5.4.2.11 `template<typename Matrix_T > Matrix_T::value_type glucat::matrix::norm_frob2 ( const Matrix_T & val )`

Square of Frobenius norm.

Definition at line 413 of file `matrix_imp.h`.

Referenced by `nork()`.

5.4.2.12 `template<typename LHS_T , typename RHS_T > const RHS_T::expression_type glucat::matrix::prod ( const ublas::matrix_expression< LHS_T > & lhs, const ublas::matrix_expression< RHS_T > & rhs ) [inline]`

Product of matrices.

Definition at line 373 of file `matrix_imp.h`.

5.4.2.13 `template<typename LHS_T , typename RHS_T > const RHS_T glucat::matrix::signed_perm_nork ( const LHS_T & lhs, const RHS_T & rhs )`

Left inverse of Kronecker product where `lhs` is a signed permutation matrix.

Definition at line 237 of file `matrix_imp.h`.

Referenced by `glucat::fast()`.

5.4.2.14 `template<typename LHS_T , typename RHS_T > const RHS_T::expression_type glucat::matrix::sparse_prod ( const ublas::matrix_expression< LHS_T > & lhs, const ublas::matrix_expression< RHS_T > & rhs ) [inline]`

Product of sparse matrices.

Definition at line 362 of file `matrix_imp.h`.

5.4.2.15 `template<typename Matrix_T > static ublas::matrix<double, ublas::column_major> glucat::matrix::to_lapack ( const Matrix_T & val ) [static]`

Convert matrix to LAPACK format.

Definition at line 461 of file `matrix_imp.h`.

Referenced by `eigenvalues()`.

5.4.2.16 `template<typename Matrix_T > Matrix_T::value_type glucat::matrix::trace ( const Matrix_T & val )`

Matrix trace.

Definition at line 437 of file `matrix_imp.h`.

References `glucat::numeric_traits< Scalar_T >::NaN()`.

5.4.2.17 `template<typename Matrix_T > const Matrix_T glucat::matrix::unit ( const typename Matrix_T::size_type n )`
`[inline]`

Unit matrix - as per Matlab `eye`.

Definition at line 317 of file `matrix_imp.h`.

5.5 glucat::timing Namespace Reference

Functions

- static double `elapsed` (clock_t cpu_time)
Elapsed time in milliseconds.

Variables

- const double `MS_PER_SEC` = 1000.0
Timing constant: milliseconds per second.
- const double `MS_PER_CLOCK` = `MS_PER_SEC` / `double(CLOCKS_PER_SEC)`
Timing constant: milliseconds per clock.
- const int `EXTRA_TRIALS` = 2
Timing constant: trial expansion factor.

5.5.1 Function Documentation

5.5.1.1 `static double glucat::timing::elapsed ( clock_t cpu_time )` `[inline]`, `[static]`

Elapsed time in milliseconds.

Definition at line 51 of file `timing.h`.

References `MS_PER_CLOCK`.

5.5.2 Variable Documentation

5.5.2.1 `const int glucat::timing::EXTRA_TRIALS = 2`

Timing constant: trial expansion factor.

Definition at line 45 of file `timing.h`.

5.5.2.2 `const double glucat::timing::MS_PER_CLOCK = MS_PER_SEC / double(CLOCKS_PER_SEC)`

Timing constant: milliseconds per clock.

Definition at line 42 of file `timing.h`.

Referenced by `elapsed()`.

5.5.2.3 `const double glucat::timing::MS_PER_SEC = 1000.0`

Timing constant: milliseconds per second.

Definition at line 39 of file `timing.h`.

5.6 PyClical Namespace Reference

Classes

- class `index_set`
- class `clifford`

Functions

- def `index_set_hidden_doctests`
- def `clifford_hidden_doctests`
- def `e`
- def `istpq`
- def `_test`

Variables

- string `__version__` = "0.8.2"
- tuple `tau` = `atan(clifford(1.0))`
- float `pi` = `tau/2.0`
- `cl` = `clifford`
- `ist` = `index_set`
- tuple `ninf3` = `e(4)`
- tuple `nbar3` = `e(4)`

5.6.1 Function Documentation

5.6.1.1 `def PyClical._test ( )` `[private]`

Definition at line 1913 of file `PyClical.pyx`.

5.6.1.2 `def PyClical.clifford_hidden_doctests ( )`

Tests for functions that Doctest cannot see.

For `clifford.__cinit__`: Construct an object of type `clifford`.

```
>>> print clifford(2)
2
>>> print clifford(2L)
2
>>> print clifford(2.0)
2
>>> print clifford(1.0e-1)
0.1
>>> print clifford("2")
2
>>> print clifford("2{1,2,3}")
2{1,2,3}
>>> print clifford(clifford("2{1,2,3}"))
```

```

2{1,2,3}
>>> print clifford("-{1}")
-{1}
>>> print clifford(2,index_set({1,2}))
2{1,2}
>>> print clifford([2,3],index_set({1,2}))
2{1}+3{2}
>>> print clifford([1,2])
Traceback (most recent call last):
...
TypeError: Cannot initialize clifford object from <type 'list'>.
>>> print clifford(None)
Traceback (most recent call last):
...
TypeError: Cannot initialize clifford object from <type 'NoneType'>.
>>> print clifford(None,[1,2])
Traceback (most recent call last):
...
TypeError: Cannot initialize clifford object from (<type 'NoneType'>, <type 'list'>).
>>> print clifford([1,2],[1,2])
Traceback (most recent call last):
...
TypeError: Cannot initialize clifford object from (<type 'list'>, <type 'list'>).
>>> print clifford("")
Traceback (most recent call last):
...
ValueError: Cannot initialize clifford object from invalid string ''.
>>> print clifford("{")
Traceback (most recent call last):
...
ValueError: Cannot initialize clifford object from invalid string '{'.
>>> print clifford("{1}")
Traceback (most recent call last):
...
ValueError: Cannot initialize clifford object from invalid string '{1'.
>>> print clifford("+")
Traceback (most recent call last):
...
ValueError: Cannot initialize clifford object from invalid string '+'.
>>> print clifford("-")
Traceback (most recent call last):
...
ValueError: Cannot initialize clifford object from invalid string '-'.
>>> print clifford("{1}+")
Traceback (most recent call last):
...
ValueError: Cannot initialize clifford object from invalid string '{1}+'.

For clifford.__richcmp__: Compare objects of type clifford.

>>> clifford("{1}") == clifford("1{1}")
True
>>> clifford("{1}") != clifford("1.0{1}")
False
>>> clifford("{1}") != clifford("1.0")
True
>>> clifford("{1,2}") == None
False
>>> clifford("{1,2}") != None
True
>>> None == clifford("{1,2}")
False
>>> None != clifford("{1,2}")
True

```

Definition at line 1243 of file PyClical.pyx.

5.6.1.3 def PyClical.e(obj)

Abbreviation for clifford(index_set(obj)).

```
>>> print e(1)
{1}
>>> print e(-1)
{-1}
>>> print e(0)
1
```

Definition at line 1887 of file PyClical.pyx.

Referenced by `glucat::matrix_multi< Scalar_T, LO, HI >.basis_element()`, `clifford_to_str()`, `glucat::framed_multi< Scalar_T, LO, HI >.framed_multi()`, `glucat::matrix_multi< Scalar_T, LO, HI >.matrix_multi()`, and `glucat.try_catch()`.

5.6.1.4 def PyClical.index_set_hidden_doctests ()

Tests for functions that Doctest cannot see.

For `index_set.__cinit__`: Construct `index_set`.

```
>>> print index_set(1)
{1}
>>> print index_set({1,2})
{1,2}
>>> print index_set(index_set({1,2}))
{1,2}
>>> print index_set({1,2})
{1,2}
>>> print index_set({1,2,1})
{1,2}
>>> print index_set({1,2,1})
{1,2}
>>> print index_set("")
{}
>>> print index_set("{")
Traceback (most recent call last):
...
ValueError: Cannot initialize index_set object from invalid string '{'.
>>> print index_set("{1}")
Traceback (most recent call last):
...
ValueError: Cannot initialize index_set object from invalid string '{1'.
>>> print index_set("{1,2,100}")
Traceback (most recent call last):
...
ValueError: Cannot initialize index_set object from invalid string '{1,2,100}'.
>>> print index_set({1,2,100})
Traceback (most recent call last):
...
IndexError: Cannot initialize index_set object from invalid set([1, 2, 100]).
>>> print index_set([1,2])
Traceback (most recent call last):
...
TypeError: Cannot initialize index_set object from <type 'list'>.
```

For `index_set.__richcmp__`: Compare two objects of class `index_set`.

```
>>> index_set(1) == index_set({1})
True
>>> index_set({1}) != index_set({1})
False
>>> index_set({1}) != index_set({2})
True
>>> index_set({1}) == index_set({2})
False
>>> index_set({1}) < index_set({2})
True
>>> index_set({1}) <= index_set({2})
True
>>> index_set({1}) > index_set({2})
False
>>> index_set({1}) >= index_set({2})
False
```

```

>>> None == index_set({1,2})
False
>>> None != index_set({1,2})
True
>>> None < index_set({1,2})
False
>>> None <= index_set({1,2})
False
>>> None > index_set({1,2})
False
>>> None >= index_set({1,2})
False
>>> index_set({1,2}) == None
False
>>> index_set({1,2}) != None
True
>>> index_set({1,2}) < None
False
>>> index_set({1,2}) <= None
False
>>> index_set({1,2}) > None
False
>>> index_set({1,2}) >= None
False

```

Definition at line 404 of file PyClical.pyx.

5.6.1.5 def PyClical.istpq (*p*, *q*)

Abbreviation for `index_set({-q,...p})`.

```

>>> print istpq(2,3)
{-3,-2,-1,1,2}

```

Definition at line 1900 of file PyClical.pyx.

5.6.2 Variable Documentation

5.6.2.1 string PyClical.__version__ = "0.8.2"

Definition at line 32 of file PyClical.pyx.

5.6.2.2 PyClical.cl = clifford

Definition at line 1859 of file PyClical.pyx.

Referenced by `cga3.agc3()`, `cga3.cga3()`, and `cga3.cga3std()`.

5.6.2.3 PyClical.ist = index_set

Definition at line 1879 of file PyClical.pyx.

Referenced by `cga3.agc3()`, `cga3.cga3()`, `cga3.cga3std()`, `glucat::framed_multi< Scalar_T, LO, HI >.framed_multi()`, `index_set_to_str()`, `glucat.operator<<()`, and `glucat.operator>>()`.

5.6.2.4 tuple PyClical.nbar3 = e(4)

Definition at line 1910 of file PyClical.pyx.

5.6.2.5 tuple PyClical.ninf3 = e(4)

Definition at line 1909 of file PyClical.pyx.

Referenced by `cga3.cga3()`, and `cga3.cga3std()`.

5.6.2.6 float PyClical.pi = tau/2.0

Definition at line 1857 of file PyClical.pyx.

Referenced by `glucat::matrix.classify_eigenvalues()`, `glucat.cos()`, `glucat.log()`, `glucat.matrix_log()`, and `glucat.sin()`.

5.6.2.7 tuple PyClical.tau = atan(clifford(1.0))

Definition at line 1856 of file PyClical.pyx.

5.7 std Namespace Reference

Classes

- struct `numeric_limits< glucat::framed_multi< Scalar_T, LO, HI > >`
Numeric limits for framed_multi inherit limits for the corresponding scalar type.
- struct `numeric_limits< glucat::matrix_multi< Scalar_T, LO, HI > >`
Numeric limits for matrix_multi inherit limits for the corresponding scalar type.

Chapter 6

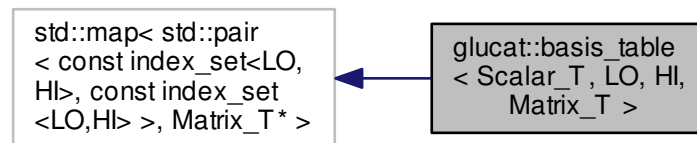
Class Documentation

6.1 `glucat::basis_table< Scalar_T, LO, HI, Matrix_T >` Class Template Reference

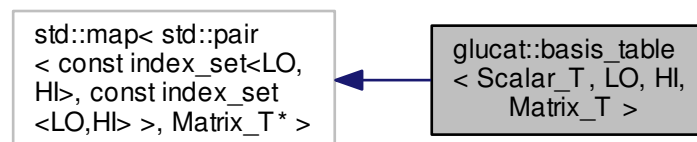
Table of basis elements used as a cache by `basis_element()`

```
#include <matrix_multi_imp.h>
```

Inheritance diagram for `glucat::basis_table< Scalar_T, LO, HI, Matrix_T >`:



Collaboration diagram for `glucat::basis_table< Scalar_T, LO, HI, Matrix_T >`:



Static Public Member Functions

- static `basis_table` & `basis` ()

Single instance of basis table.

Private Member Functions

- [basis_table](#) ()
- [~basis_table](#) ()
- [basis_table](#) (const [basis_table](#) &)
- [basis_table](#) & [operator=](#) (const [basis_table](#) &)

Friends

- class [friend_for_private_destructor](#)

6.1.1 Detailed Description

```
template<typename Scalar_T, const index_t LO, const index_t HI, typename Matrix_T>class glucat::basis_table< Scalar_T, LO, HI, Matrix_T >
```

Table of basis elements used as a cache by [basis_element](#)()

Definition at line 1218 of file [matrix_multi_imp.h](#).

6.1.2 Constructor & Destructor Documentation

6.1.2.1 `template<typename Scalar_T , const index_t LO, const index_t HI, typename Matrix_T > glucat::basis_table< Scalar_T, LO, HI, Matrix_T >::basis_table ( ) [inline], [private]`

Definition at line 1228 of file [matrix_multi_imp.h](#).

6.1.2.2 `template<typename Scalar_T , const index_t LO, const index_t HI, typename Matrix_T > glucat::basis_table< Scalar_T, LO, HI, Matrix_T >::~~basis_table ( ) [inline], [private]`

Definition at line 1229 of file [matrix_multi_imp.h](#).

6.1.2.3 `template<typename Scalar_T , const index_t LO, const index_t HI, typename Matrix_T > glucat::basis_table< Scalar_T, LO, HI, Matrix_T >::basis_table ( const basis_table< Scalar_T, LO, HI, Matrix_T > & ) [private]`

6.1.3 Member Function Documentation

6.1.3.1 `template<typename Scalar_T , const index_t LO, const index_t HI, typename Matrix_T > static basis_table& glucat::basis_table< Scalar_T, LO, HI, Matrix_T >::basis ( ) [inline], [static]`

Single instance of basis table.

Definition at line 1224 of file [matrix_multi_imp.h](#).

6.1.3.2 `template<typename Scalar_T , const index_t LO, const index_t HI, typename Matrix_T > basis_table& glucat::basis_table< Scalar_T, LO, HI, Matrix_T >::operator= ( const basis_table< Scalar_T, LO, HI, Matrix_T > & ) [private]`

6.1.4 Friends And Related Function Documentation

6.1.4.1 `template<typename Scalar_T , const index_t LO, const index_t HI, typename Matrix_T > friend class
friend_for_private_destructor [friend]`

Friend declaration to avoid compiler warning: "... only defines a private destructor and has no friends" Ref: Carlos O'Ryan, ACE <http://doc.ece.uci.edu>

Definition at line 1236 of file matrix_multi_imp.h.

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

- glucat/[matrix_multi_imp.h](#)

6.2 glucat::bool_to_type< truth_value > Class Template Reference

Bool to type.

```
#include <global.h>
```

Private Types

- enum { [value](#) = truth_value }

6.2.1 Detailed Description

```
template<bool truth_value>class glucat::bool_to_type< truth_value >
```

Bool to type.

Definition at line 69 of file global.h.

6.2.2 Member Enumeration Documentation

6.2.2.1 `template<bool truth_value> anonymous enum [private]`

Enumerator

value

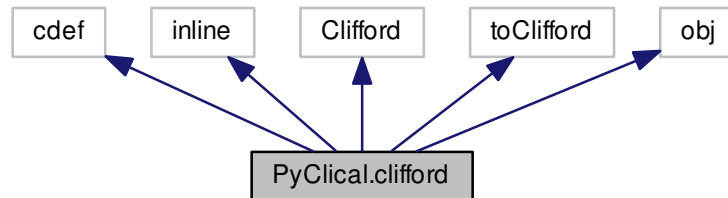
Definition at line 72 of file global.h.

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

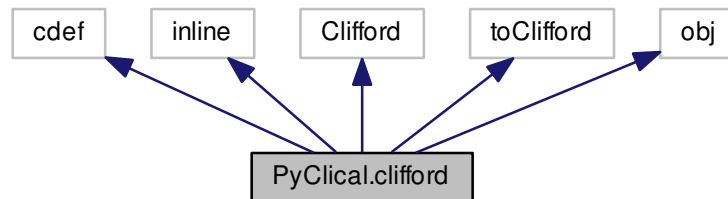
- glucat/[global.h](#)

6.3 PyClical.clifford Class Reference

Inheritance diagram for PyClical.clifford:



Collaboration diagram for PyClical.clifford:



Public Member Functions

- def [__cinit__](#)
- def [__dealloc__](#)
- def [__contains__](#)
- def [__iter__](#)
- def [reframe](#)
- def [__richcmp__](#)
- def [__getitem__](#)
- def [__neg__](#)
- def [__pos__](#)
- def [__add__](#)
- def [__iadd__](#)
- def [__sub__](#)
- def [__isub__](#)
- def [__mul__](#)
- def [__imul__](#)
- def [__mod__](#)
- def [__imod__](#)
- def [__and__](#)

- def [__iand__](#)
- def [__xor__](#)
- def [__ixor__](#)
- def [__div__](#)
- def [__idiv__](#)
- def [inv](#)
- def [__or__](#)
- def [__ior__](#)
- def [__pow__](#)
- def [pow](#)
- def [outer_pow](#)
- def [__call__](#)
- def [scalar](#)
- def [pure](#)
- def [even](#)
- def [odd](#)
- def [vector_part](#)
- def [involute](#)
- def [reverse](#)
- def [conj](#)
- def [quad](#)
- def [norm](#)
- def [abs](#)
- def [max_abs](#)
- def [truncated](#)
- def [isnan](#)
- def [frame](#)
- def [__repr__](#)
- def [__str__](#)

Public Attributes

- [instance](#)

6.3.1 Detailed Description

Python class clifford wraps C++ class Clifford.

Definition at line 532 of file PyClical.pyx.

6.3.2 Member Function Documentation

6.3.2.1 def PyClical.clifford.__add__(*lhs*, *rhs*)

Geometric sum.

```
>>> print clifford(1) + clifford("{2}")
1+{2}
>>> print clifford("{1}") + clifford("{2}")
{1}+{2}
```

Definition at line 739 of file PyClical.pyx.

6.3.2.2 def PyClical.clifford.__and__(lhs, rhs)

Inner product.

```
>>> print clifford("{1}") & clifford("{2}")
0
>>> print clifford(2) & clifford("{2}")
0
>>> print clifford("{1}") & clifford("{1}")
1
>>> print clifford("{1}") & clifford("{1,2}")
{2}
```

Definition at line 835 of file PyClical.pyx.

6.3.2.3 def PyClical.clifford.__call__(self, grade)

Pure grade-vector part.

```
>>> print clifford("{1}") (1)
{1}
>>> print clifford("{1}") (0)
0
>>> print clifford("1+{1}+{1,2}") (0)
1
>>> print clifford("1+{1}+{1,2}") (1)
{1}
>>> print clifford("1+{1}+{1,2}") (2)
{1,2}
>>> print clifford("1+{1}+{1,2}") (3)
0
```

Definition at line 1019 of file PyClical.pyx.

6.3.2.4 def PyClical.clifford.__cinit__(self, other = 0, ixt = None)

Construct an object of type clifford.

```
>>> print clifford(2)
2
>>> print clifford(2L)
2
>>> print clifford(2.0)
2
>>> print clifford(1.0e-1)
0.1
>>> print clifford("2")
2
>>> print clifford("2{1,2,3}")
2{1,2,3}
>>> print clifford(clifford("2{1,2,3}"))
2{1,2,3}
>>> print clifford("-{1}")
-{1}
>>> print clifford(2, index_set ({1,2}))
2{1,2}
>>> print clifford([2,3], index_set ({1,2}))
2{1}+3{2}
```

Definition at line 563 of file PyClical.pyx.

6.3.2.5 def PyClical.clifford.__contains__(self, x)

Not applicable.


```
>>> x=clifford(index_set({-3,4,7})); -3 in x
Traceback (most recent call last):
...
TypeError: Not applicable.
```

Definition at line 626 of file PyClical.pyx.

6.3.2.6 def PyClical.clifford.__dealloc__(self)

Clean up by deallocating the instance of C++ class Clifford.

Definition at line 620 of file PyClical.pyx.

References PyClical.index_set.instance, and PyClical.clifford.instance.

6.3.2.7 def PyClical.clifford.__div__(lhs, rhs)

Geometric quotient.

```
>>> print clifford("{1}") / clifford("{2}")
{1,2}
>>> print clifford(2) / clifford("{2}")
2{2}
>>> print clifford("{1}") / clifford("{1}")
1
>>> print clifford("{1}") / clifford("{1,2}")
-{2}
```

Definition at line 895 of file PyClical.pyx.

6.3.2.8 def PyClical.clifford.__getitem__(self, ixt)

Subscripting: map from index set to scalar coordinate.

```
>>> clifford("{1}")[index_set(1)]
1.0
>>> clifford("{1}")[index_set({1})]
1.0
>>> clifford("{1}")[index_set({1,2})]
0.0
>>> clifford("2{1,2}")[index_set({1,2})]
2.0
```

Definition at line 706 of file PyClical.pyx.

6.3.2.9 def PyClical.clifford.__iadd__(self, rhs)

Geometric sum.

```
>>> x = clifford(1); x += clifford("{2}"); print x
1+{2}
```

Definition at line 750 of file PyClical.pyx.

6.3.2.10 def PyClical.clifford.__iand__(self, rhs)

Inner product.

```
>>> x = clifford("{1}"); x &= clifford("{2}"); print x
0
```

```
>>> x = clifford(2); x &= clifford("{2}"); print x
0
>>> x = clifford("{1}"); x &= clifford("{1}"); print x
1
>>> x = clifford("{1}"); x &= clifford("{1,2}"); print x
{2}
```

Definition at line 850 of file PyClical.pyx.

6.3.2.11 def PyClical.clifford.__idiv__(self, rhs)

Geometric quotient.

```
>>> x = clifford("{1}"); x /= clifford("{2}"); print x
{1,2}
>>> x = clifford(2); x /= clifford("{2}"); print x
2{2}
>>> x = clifford("{1}"); x /= clifford("{1}"); print x
1
>>> x = clifford("{1}"); x /= clifford("{1,2}"); print x
-{2}
```

Definition at line 910 of file PyClical.pyx.

6.3.2.12 def PyClical.clifford.__imod__(self, rhs)

Contraction.

```
>>> x = clifford("{1}"); x %= clifford("{2}"); print x
0
>>> x = clifford(2); x %= clifford("{2}"); print x
2{2}
>>> x = clifford("{1}"); x %= clifford("{1}"); print x
1
>>> x = clifford("{1}"); x %= clifford("{1,2}"); print x
{2}
```

Definition at line 820 of file PyClical.pyx.

6.3.2.13 def PyClical.clifford.__imul__(self, rhs)

Geometric product.

```
>>> x = clifford(2); x *= clifford("{2}"); print x
2{2}
>>> x = clifford("{1}"); x *= clifford("{2}"); print x
{1,2}
>>> x = clifford("{1}"); x *= clifford("{1,2}"); print x
{2}
```

Definition at line 792 of file PyClical.pyx.

6.3.2.14 def PyClical.clifford.__ior__(self, rhs)

Transform left hand side, using right hand side as a transformation.

```
>>> x=clifford("{1,2}") * pi/2; y=clifford("{1}"); y|=x; print y
-{1}
>>> x=clifford("{1,2}") * pi/2; y=clifford("{1}"); y|=exp(x); print y
-{1}
```

Definition at line 949 of file PyClical.pyx.

6.3.2.15 def PyClical.clifford.__isub__(self, rhs)

Geometric difference.

```
>>> x = clifford(1); x -= clifford("{2}"); print x
1-{2}
```

Definition at line 770 of file PyClical.pyx.

6.3.2.16 def PyClical.clifford.__iter__(self)

Not applicable.

```
>>> for a in clifford(index_set((-3,4,7))): print a,
Traceback (most recent call last):
...
TypeError: Not applicable.
```

Definition at line 637 of file PyClical.pyx.

6.3.2.17 def PyClical.clifford.__ixor__(self, rhs)

Outer product.

```
>>> x = clifford("{1}"); x ^= clifford("{2}"); print x
{1,2}
>>> x = clifford(2); x ^= clifford("{2}"); print x
2{2}
>>> x = clifford("{1}"); x ^= clifford("{1}"); print x
0
>>> x = clifford("{1}"); x ^= clifford("{1,2}"); print x
0
```

Definition at line 880 of file PyClical.pyx.

6.3.2.18 def PyClical.clifford.__mod__(lhs, rhs)

Contraction.

```
>>> print clifford("{1}") % clifford("{2}")
0
>>> print clifford(2) % clifford("{2}")
2{2}
>>> print clifford("{1}") % clifford("{1}")
1
>>> print clifford("{1}") % clifford("{1,2}")
{2}
```

Definition at line 805 of file PyClical.pyx.

6.3.2.19 def PyClical.clifford.__mul__(lhs, rhs)

Geometric product.

```
>>> print clifford("{1}") * clifford("{2}")
{1,2}
>>> print clifford(2) * clifford("{2}")
2{2}
>>> print clifford("{1}") * clifford("{1,2}")
{2}
```

Definition at line 779 of file PyClical.pyx.

6.3.2.20 def PyClical.clifford.__neg__(self)

Unary -.

```
>>> print -clifford("{1}")
-{1}
```

Definition at line 721 of file PyClical.pyx.

6.3.2.21 def PyClical.clifford.__or__(lhs, rhs)

Transform left hand side, using right hand side as a transformation.

```
>>> x=clifford("{1,2}") * pi/2; y=clifford("{1}"); print y|x
-{1}
>>> x=clifford("{1,2}") * pi/2; y=clifford("{1}"); print y|exp(x)
-{1}
```

Definition at line 938 of file PyClical.pyx.

6.3.2.22 def PyClical.clifford.__pos__(self)

Unary +.

```
>>> print +clifford("{1}")
{1}
```

Definition at line 730 of file PyClical.pyx.

6.3.2.23 def PyClical.clifford.__pow__(self, m, dummy)

Power: self to the m.

```
>>> x=clifford("{1}"); print x ** 2
1
>>> x=clifford("2"); print x ** 2
4
>>> x=clifford("2+{1}"); print x ** 0
1
>>> x=clifford("2+{1}"); print x ** 1
2+{1}
>>> x=clifford("2+{1}"); print x ** 2
5+4{1}
>>> i=clifford("{1,2}"); print exp(pi/2) * (i ** i)
1
```

Definition at line 960 of file PyClical.pyx.

References PyClical.clifford.pow().

6.3.2.24 def PyClical.clifford.__repr__(self)

The "official" string representation of self.

```
>>> clifford("1+3{-1}+2{1,2}+4{-2,7}").__repr__()
'clifford("1+3{-1}+2{1,2}+4{-2,7}")'
```

Definition at line 1225 of file PyClical.pyx.

References clifford_to_repr().

6.3.2.25 def PyClical.clifford.__richcmp__(lhs, rhs, int, op)

Compare objects of type clifford.

```
>>> clifford("{1}") == clifford("1{1}")
True
>>> clifford("{1}") != clifford("1.0{1}")
False
>>> clifford("{1}") != clifford("1.0")
True
>>> clifford("{1,2}") == None
False
>>> clifford("{1,2}") != None
True
>>> None == clifford("{1,2}")
False
>>> None != clifford("{1,2}")
True
```

Definition at line 671 of file PyClical.pyx.

6.3.2.26 def PyClical.clifford.__str__(self)

The "informal" string representation of self.

```
>>> clifford("1+3{-1}+2{1,2}+4{-2,7}").__str__()
'1+3{-1}+2{1,2}+4{-2,7}'
```

Definition at line 1234 of file PyClical.pyx.

References clifford_to_str().

6.3.2.27 def PyClical.clifford.__sub__(lhs, rhs)

Geometric difference.

```
>>> print clifford(1) - clifford("{2}")
1-{2}
>>> print clifford("{1}") - clifford("{2}")
{1}-{2}
```

Definition at line 759 of file PyClical.pyx.

6.3.2.28 def PyClical.clifford.__xor__(lhs, rhs)

Outer product.

```
>>> print clifford("{1}") ^ clifford("{2}")
{1,2}
>>> print clifford(2) ^ clifford("{2}")
2{2}
>>> print clifford("{1}") ^ clifford("{1}")
0
>>> print clifford("{1}") ^ clifford("{1,2}")
0
```

Definition at line 865 of file PyClical.pyx.

6.3.2.29 def PyClical.clifford.abs(self)

Absolute value: square root of norm.

```
>>> clifford("1+{-1}+{1,2}+{1,2,3}").abs()
2.0
```

Definition at line 1174 of file PyClical.pyx.

References `glucat.abs()`.

6.3.2.30 `def PyClical.clifford.conj ( self )`

Conjugation, reverse o involute == involute o reverse.

```
>>> print (clifford("{1}").conj())
-{1}
>>> print (clifford("{2}") * clifford("{1}")).conj()
{1,2}
>>> print (clifford("{1}") * clifford("{2}")).conj()
-{1,2}
>>> print clifford("1+{1}+{1,2}").conj()
1-{1}-{1,2}
```

Definition at line 1137 of file PyClical.pyx.

6.3.2.31 `def PyClical.clifford.even ( self )`

Even part of multivector, sum of even grade terms.

```
>>> print clifford("1+{1}+{1,2}").even()
1+{1,2}
```

Definition at line 1060 of file PyClical.pyx.

6.3.2.32 `def PyClical.clifford.frame ( self )`

Subalgebra generated by all generators of terms of given multivector.

```
>>> print clifford("1+3{-1}+2{1,2}+4{-2,7}").frame()
{-2,-1,1,2,7}
>>> s=clifford("1+3{-1}+2{1,2}+4{-2,7}").frame(); type(s)
<type 'PyClical.index_set'>
```

Definition at line 1214 of file PyClical.pyx.

6.3.2.33 `def PyClical.clifford.inv ( self )`

Geometric multiplicative inverse.

```
>>> x = clifford("{1}"); print x.inv()
{1}
>>> x = clifford(2); print x.inv()
0.5
>>> x = clifford("{1,2}"); print x.inv()
-{1,2}
```

Definition at line 925 of file PyClical.pyx.

6.3.2.34 `def PyClical.clifford.involute ( self )`

Main involution, each `{i}` is replaced by `-{i}` in each term, eg. `clifford("{1}") -> -clifford("{1}")`.

```
>>> print clifford("{1}").involute()
-{1}
>>> print (clifford("{2}") * clifford("{1}")).involute()
-{1,2}
```

```
>>> print (clifford("{1}") * clifford("{2}")).involute()
{1,2}
>>> print clifford("1+{1}+{1,2}").involute()
1-{1}+{1,2}
```

Definition at line 1106 of file PyClical.pyx.

6.3.2.35 def PyClical.clifford.isnan (self)

Check if a multivector contains any IEEE NaN values.

```
>>> clifford().isnan()
False
```

Definition at line 1205 of file PyClical.pyx.

6.3.2.36 def PyClical.clifford.max_abs (self)

Maximum of absolute values of components of multivector: multivector infinity norm.

```
>>> clifford("1+{-1}+{1,2}+{1,2,3}").max_abs()
1.0
>>> clifford("3+2{1}+{1,2}").max_abs()
3.0
```

Definition at line 1183 of file PyClical.pyx.

6.3.2.37 def PyClical.clifford.norm (self)

Norm == sum of squares of coordinates.

```
>>> clifford("1+{1}+{1,2}").norm()
3.0
>>> clifford("1+{-1}+{1,2}+{1,2,3}").norm()
4.0
```

Definition at line 1163 of file PyClical.pyx.

6.3.2.38 def PyClical.clifford.odd (self)

Odd part of multivector, sum of odd grade terms.

```
>>> print clifford("1+{1}+{1,2}").odd()
{1}
```

Definition at line 1069 of file PyClical.pyx.

6.3.2.39 def PyClical.clifford.outer_pow (self, m)

Outer product power.

```
>>> x=clifford("2+{1}"); print x.outer_pow(0)
1
>>> x=clifford("2+{1}"); print x.outer_pow(1)
2+{1}
>>> x=clifford("2+{1}"); print x.outer_pow(2)
4+4{1}
>>> print clifford("1+{1}+{1,2}").outer_pow(3)
1+3{1}+3{1,2}
```

Definition at line 1003 of file PyClical.pyx.

6.3.2.40 def PyClical.clifford.pow (self, m)

Power: self to the m.

```
>>> x=clifford("{1}"); print x.pow(2)
1
>>> x=clifford("2"); print x.pow(2)
4
>>> x=clifford("2+{1}"); print x.pow(0)
1
>>> x=clifford("2+{1}"); print x.pow(1)
2+{1}
>>> x=clifford("2+{1}"); print x.pow(2)
5+4{1}
>>> print clifford("1+{1}+{1,2}").pow(3)
1+3{1}+3{1,2}
>>> i=clifford("{1,2}");print exp(pi/2) * i.pow(i)
1
```

Definition at line 979 of file PyClical.pyx.

References `glucat.exp()`, and `glucat.log()`.

Referenced by `PyClical.clifford.__pow__()`.

6.3.2.41 def PyClical.clifford.pure (self)

Pure part.

```
>>> print clifford("1+{1}+{1,2}").pure()
{1}+{1,2}
>>> print clifford("{1,2}").pure()
{1,2}
```

Definition at line 1049 of file PyClical.pyx.

6.3.2.42 def PyClical.clifford.quad (self)

Quadratic form == (rev(x)*x)(0).

```
>>> print clifford("1+{1}+{1,2}").quad()
3.0
>>> print clifford("1+{-1}+{1,2}+{1,2,3}").quad()
2.0
```

Definition at line 1152 of file PyClical.pyx.

6.3.2.43 def PyClical.clifford.reframe (self, ixt)

Put self into a larger frame, containing the union of `self.frame()` and index set `ixt`. This can be used to make multiplication faster, by multiplying within a common frame.

```
>>> clifford("2+3{1}").reframe(index_set({1,2,3}))
clifford("2+3{1}")
>>> s=index_set({1,2,3});t=index_set({-3,-2,-1});x=random_clifford(s); x.reframe(t).frame() == (s|t);
True
```

Definition at line 648 of file PyClical.pyx.

6.3.2.44 def PyClical.clifford.reverse (self)

Reversion, eg. `clifford("{1})*clifford("{2}") -> clifford("{2})*clifford("{1}").`


```
>>> print clifford("{1}").reverse()
{1}
>>> print (clifford("{2}") * clifford("{1}")).reverse()
{1,2}
>>> print (clifford("{1}") * clifford("{2}")).reverse()
-{1,2}
>>> print clifford("1+{1}+{1,2}").reverse()
1+{1}-{1,2}
```

Definition at line 1122 of file PyClical.pyx.

6.3.2.45 def PyClical.clifford.scalar(self)

Scalar part.

```
>>> clifford("1+{1}+{1,2}").scalar()
1.0
>>> clifford("{1,2}").scalar()
0.0
```

Definition at line 1038 of file PyClical.pyx.

6.3.2.46 def PyClical.clifford.truncated(self, limit)

Remove all terms of self with relative size smaller than limit.

```
>>> clifford("1e8+{1}+1e-8{1,2}").truncated(1.0e-6)
clifford("100000000")
>>> clifford("1e4+{1}+1e-4{1,2}").truncated(1.0e-6)
clifford("10000+{1}")
```

Definition at line 1194 of file PyClical.pyx.

6.3.2.47 def PyClical.clifford.vector_part(self, frm = None)

Vector part of multivector, as a Python list, with respect to frm.

```
>>> print clifford("1+2{1}+3{2}+4{1,2}").vector_part()
[2.0, 3.0]
>>> print clifford("1+2{1}+3{2}+4{1,2}").vector_part(index_set({-1,1,2}))
[0.0, 2.0, 3.0]
```

Definition at line 1078 of file PyClical.pyx.

6.3.3 Member Data Documentation

6.3.3.1 PyClical.clifford.instance

Definition at line 592 of file PyClical.pyx.

Referenced by PyClical.clifford.__dealloc__().

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

- [pyclical/PyClical.pyx](#)

6.4 glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T > Class Template Reference

clifford_algebra<> declares the operations of a Clifford algebra

```
#include <clifford_algebra.h>
```

Public Types

- typedef Scalar_T [scalar_t](#)
- typedef Index_Set_T [index_set_t](#)
- typedef Multivector_T [multivector_t](#)
- typedef std::pair< const [index_set_t](#), Scalar_T > [pair_t](#)
- typedef std::vector< Scalar_T > [vector_t](#)

Public Member Functions

- virtual [~clifford_algebra](#) ()
- virtual bool [operator==](#) (const [multivector_t](#) &val) const =0
Test for equality of multivectors.
- virtual bool [operator==](#) (const Scalar_T &scr) const =0
Test for equality of multivector and scalar.
- virtual [multivector_t](#) & [operator+=](#) (const [multivector_t](#) &rhs)=0
Geometric sum.
- virtual [multivector_t](#) & [operator+=](#) (const Scalar_T &scr)=0
Geometric sum of multivector and scalar.
- virtual [multivector_t](#) & [operator-=](#) (const [multivector_t](#) &rhs)=0
Geometric difference.
- virtual const [multivector_t](#) [operator-](#) () const =0
Unary -.
- virtual [multivector_t](#) & [operator*=](#) (const Scalar_T &scr)=0
Product of multivector and scalar.
- virtual [multivector_t](#) & [operator*=](#) (const [multivector_t](#) &rhs)=0
Geometric product.
- virtual [multivector_t](#) & [operator%=](#) (const [multivector_t](#) &rhs)=0
Contraction.
- virtual [multivector_t](#) & [operator&=](#) (const [multivector_t](#) &rhs)=0
Inner product.
- virtual [multivector_t](#) & [operator^=](#) (const [multivector_t](#) &rhs)=0
Outer product.
- virtual [multivector_t](#) & [operator/=](#) (const Scalar_T &scr)=0
Quotient of multivector and scalar.
- virtual [multivector_t](#) & [operator/=](#) (const [multivector_t](#) &rhs)=0
Geometric quotient.
- virtual [multivector_t](#) & [operator|=](#) (const [multivector_t](#) &rhs)=0
Transformation via twisted adjoint action.
- virtual const [multivector_t](#) [inv](#) () const =0
Geometric multiplicative inverse.
- virtual const [multivector_t](#) [pow](#) (int m) const =0
**this to the m*
- virtual const [multivector_t](#) [outer_pow](#) (int m) const =0
Outer product power.
- virtual const [index_set_t](#) [frame](#) () const =0
Subalgebra generated by all generators of terms of given multivector.
- virtual [index_t](#) [grade](#) () const =0

- Maximum of the grades of each term.*
- virtual Scalar_T `operator[]` (const `index_set_t` ist) const =0
- Subscripting: map from index set to scalar coordinate.*
- virtual const `multivector_t operator()` (`index_t` grade) const =0
- Pure grade-vector part.*
- virtual Scalar_T `scalar` () const =0
- Scalar part.*
- virtual const `multivector_t pure` () const =0
- Pure part.*
- virtual const `multivector_t even` () const =0
- Even part of multivector, sum of even grade terms.*
- virtual const `multivector_t odd` () const =0
- Odd part of multivector, sum of odd grade terms.*
- virtual const `vector_t vector_part` () const =0
- Vector part of multivector, as a vector_t with respect to `frame()`*
- virtual const `vector_t vector_part` (const `index_set_t` frm, const bool prechecked) const =0
- Vector part of multivector, as a vector_t with respect to frm.*
- virtual const `multivector_t involute` () const =0
- Main involution, each {i} is replaced by -{i} in each term, eg. {1} -> -{1}.*
- virtual const `multivector_t reverse` () const =0
- Reversion, eg. {1}*{2} -> {2}*{1}.*
- virtual const `multivector_t conj` () const =0
- Conjugation, reverse o involute == involute o reverse.*
- virtual Scalar_T `quad` () const =0
- Scalar_T quadratic form == (rev(x)*x)(0)*
- virtual Scalar_T `norm` () const =0
- Scalar_T norm == sum of norm of coordinates.*
- virtual Scalar_T `max_abs` () const =0
- Maximum of absolute values of components of multivector: multivector infinity norm.*
- virtual const `multivector_t truncated` (const Scalar_T &limit=Scalar_T(DEFAULT_TRUNCATION)) const =0
- Remove all terms with relative size smaller than limit.*
- virtual bool `isnan` () const =0
- Check if a multivector contains any IEEE NaN values.*
- virtual void `write` (const std::string &msg="") const =0
- Write formatted multivector to output.*
- virtual void `write` (std::ofstream &ofile, const std::string &msg="") const =0
- Write formatted multivector to file.*

Static Public Member Functions

- static const std::string `classname` ()

6.4.1 Detailed Description

template<typename Scalar_T, typename Index_Set_T, typename Multivector_T>class glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >

`clifford_algebra<>` declares the operations of a Clifford algebra

Definition at line 42 of file `clifford_algebra.h`.

6.4.2 Member Typedef Documentation

6.4.2.1 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> typedef Index_Set_T
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::index_set_t`

Definition at line 46 of file clifford_algebra.h.

6.4.2.2 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> typedef Multivector_T
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::multivector_t`

Definition at line 47 of file clifford_algebra.h.

6.4.2.3 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> typedef std::pair< const
index_set_t, Scalar_T > glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::pair_t`

Definition at line 48 of file clifford_algebra.h.

6.4.2.4 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> typedef Scalar_T
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::scalar_t`

Definition at line 45 of file clifford_algebra.h.

6.4.2.5 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> typedef std::vector<Scalar_T>
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::vector_t`

Definition at line 49 of file clifford_algebra.h.

6.4.3 Constructor & Destructor Documentation

6.4.3.1 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual glucat::clifford_algebra<
Scalar_T, Index_Set_T, Multivector_T >::~~clifford_algebra () [inline],[virtual]`

Definition at line 53 of file clifford_algebra.h.

6.4.4 Member Function Documentation

6.4.4.1 `template<typename Scalar_T , typename Index_Set_T , typename Multivector_T > const std::string
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::classname () [static]`

Definition at line 66 of file clifford_algebra_imp.h.

6.4.4.2 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::conj () const [pure virtual]`

Conjugation, reverse o involute == involute o reverse.

6.4.4.3 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::even () const [pure virtual]`

Even part of multivector, sum of even grade terms.

Referenced by glucat::framed_multi< Scalar_T, LO, HI >::fast_matrix_multi().

6.4.4.4 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const index_set_t
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::frame () const [pure virtual]`

Subalgebra generated by all generators of terms of given multivector.

6.4.4.5 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual index_t
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::grade () const [pure virtual]`

Maximum of the grades of each term.

6.4.4.6 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::inv () const [pure virtual]`

Geometric multiplicative inverse.

6.4.4.7 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::involute () const [pure virtual]`

Main involution, each {i} is replaced by -{i} in each term, eg. {1} -> -{1}.

6.4.4.8 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual bool
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::isnan () const [pure virtual]`

Check if a multivector contains any IEEE NaN values.

6.4.4.9 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual Scalar_T
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::max_abs () const [pure virtual]`

Maximum of absolute values of components of multivector: multivector infinity norm.

6.4.4.10 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual Scalar_T
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::norm () const [pure virtual]`

Scalar_T norm == sum of norm of coordinates.

6.4.4.11 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::odd () const [pure virtual]`

Odd part of multivector, sum of odd grade terms.

Referenced by glucat::framed_multi< Scalar_T, LO, HI >::fast_matrix_multi().

6.4.4.12 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual multivector_t&
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator%=(const multivector_t & rhs)
[pure virtual]`

Contraction.

6.4.4.13 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual multivector_t& glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator&= ( const multivector_t & rhs )` [pure virtual]

Inner product.

6.4.4.14 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator() ( index_t grade ) const` [pure virtual]

Pure grade-vector part.

6.4.4.15 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual multivector_t& glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator*= ( const Scalar_T & scr )` [pure virtual]

Product of multivector and scalar.

6.4.4.16 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual multivector_t& glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator*= ( const multivector_t & rhs )` [pure virtual]

Geometric product.

6.4.4.17 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual multivector_t& glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator+= ( const multivector_t & rhs )` [pure virtual]

Geometric sum.

6.4.4.18 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual multivector_t& glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator+= ( const Scalar_T & scr )` [pure virtual]

Geometric sum of multivector and scalar.

6.4.4.19 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator- ( ) const` [pure virtual]

Unary -.

6.4.4.20 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual multivector_t& glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator-= ( const multivector_t & rhs )` [pure virtual]

Geometric difference.

6.4.4.21 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual multivector_t& glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator/= ( const Scalar_T & scr )` [pure virtual]

Quotient of multivector and scalar.

6.4.4.22 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual multivector_t& glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator/=( const multivector_t & rhs ) [pure virtual]`

Geometric quotient.

6.4.4.23 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual bool glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator==( const multivector_t & val ) const [pure virtual]`

Test for equality of multivectors.

6.4.4.24 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual bool glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator==( const Scalar_T & scr ) const [pure virtual]`

Test for equality of multivector and scalar.

6.4.4.25 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual Scalar_T glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator[]( const index_set_t ist ) const [pure virtual]`

Subscripting: map from index set to scalar coordinate.

6.4.4.26 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual multivector_t& glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator^=( const multivector_t & rhs ) [pure virtual]`

Outer product.

6.4.4.27 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual multivector_t& glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::operator|=( const multivector_t & rhs ) [pure virtual]`

Transformation via twisted adjoint action.

6.4.4.28 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::outer_pow( int m ) const [pure virtual]`

Outer product power.

6.4.4.29 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::pow( int m ) const [pure virtual]`

*this to the m

6.4.4.30 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::pure( ) const [pure virtual]`

Pure part.

6.4.4.31 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual Scalar_T
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::quad () const [pure virtual]`

Scalar_T quadratic form == (rev(x)*x)(0)

6.4.4.32 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::reverse () const [pure virtual]`

Reversion, eg. {1}*{2} -> {2}*{1}.

6.4.4.33 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual Scalar_T
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::scalar () const [pure virtual]`

Scalar part.

6.4.4.34 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const multivector_t
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::truncated (const Scalar_T & limit =
Scalar_T(DEFAULT_TRUNCATION)) const [pure virtual]`

Remove all terms with relative size smaller than limit.

6.4.4.35 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const vector_t
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::vector_part () const [pure
virtual]`

Vector part of multivector, as a vector_t with respect to [frame\(\)](#)

6.4.4.36 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual const vector_t
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::vector_part (const index_set_t frm, const
bool prechecked) const [pure virtual]`

Vector part of multivector, as a vector_t with respect to frm.

6.4.4.37 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual void
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::write (const std::string & msg = " ") const
[pure virtual]`

Write formatted multivector to output.

6.4.4.38 `template<typename Scalar_T, typename Index_Set_T, typename Multivector_T> virtual void
glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >::write (std::ofstream & ofile, const std::string
& msg = " ") const [pure virtual]`

Write formatted multivector to file.

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

- [glucat/clifford_algebra.h](#)
- [glucat/clifford_algebra_imp.h](#)

6.5 glucat::compare_types< LHS_T, RHS_T > Class Template Reference

Type comparison.

```
#include <global.h>
```

Public Types

- enum { [are_same](#) = false }

6.5.1 Detailed Description

```
template<typename LHS_T, typename RHS_T>class glucat::compare_types< LHS_T, RHS_T >
```

Type comparison.

Definition at line 54 of file global.h.

6.5.2 Member Enumeration Documentation

6.5.2.1 template<typename LHS_T , typename RHS_T > anonymous enum

Enumerator

are_same

Definition at line 57 of file global.h.

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

- glucat/[global.h](#)

6.6 glucat::compare_types< T, T > Class Template Reference

```
#include <global.h>
```

Public Types

- enum { [are_same](#) = true }

6.6.1 Detailed Description

```
template<typename T>class glucat::compare_types< T, T >
```

Definition at line 60 of file global.h.

6.6.2 Member Enumeration Documentation

6.6.2.1 template<typename T > anonymous enum

Enumerator

are_same

Definition at line 63 of file global.h.

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

- [glucat/global.h](#)

6.7 glucat::control_t Class Reference

Parameters to control tests.

```
#include <control.h>
```

Public Member Functions

- int [call](#) ([intfn](#) f) const
Call a function that returns int.
- int [call](#) ([intintfn](#) f, int arg) const
Call a function of int that returns int.

Static Public Member Functions

- static const [control_t](#) & [control](#) (int argc, char **argv)
- static bool [verbose](#) ()
Produce more detailed output from tests.

Private Member Functions

- bool [valid](#) () const
- bool [catch_exceptions](#) () const
- [control_t](#) (int argc, char **argv)
Constructor from program arguments.
- [control_t](#) ()
- [~control_t](#) ()
- [control_t](#) (const [control_t](#) &)
- [control_t](#) & [operator=](#) (const [control_t](#) &)

Private Attributes

- bool [m_valid](#)
Test parameters are valid.
- bool [m_catch_exceptions](#)
Catch exceptions.

Static Private Attributes

- static bool [m_verbose_output](#) = false
Produce more detailed output from tests.

Friends

- class [friend_for_private_destructor](#)

6.7.1 Detailed Description

Parameters to control tests.

Definition at line 39 of file control.h.

6.7.2 Constructor & Destructor Documentation

6.7.2.1 glucat::control_t::control_t(int argc, char ** argv) [private]

Constructor from program arguments.

Test control constructor from program arguments.

Definition at line 89 of file control.h.

References GLUCAT_PACKAGE_NAME, GLUCAT_VERSION, m_catch_exceptions, m_valid, m_verbose_output, and valid().

6.7.2.2 glucat::control_t::control_t() [inline], [private]

Definition at line 59 of file control.h.

6.7.2.3 glucat::control_t::~~control_t() [inline], [private]

Definition at line 60 of file control.h.

6.7.2.4 glucat::control_t::control_t(const control_t &) [private]

6.7.3 Member Function Documentation

6.7.3.1 int glucat::control_t::call(intfn f) const [inline]

Call a function that returns int.

Definition at line 137 of file control.h.

References catch_exceptions(), glucat::try_catch(), and valid().

6.7.3.2 int glucat::control_t::call(intintfn f, int arg) const [inline]

Call a function of int that returns int.

Definition at line 151 of file control.h.

References catch_exceptions(), glucat::try_catch(), and valid().

6.7.3.3 bool glucat::control_t::catch_exceptions() const [inline], [private]

Definition at line 49 of file control.h.

References m_catch_exceptions.

Referenced by call().

6.7.3.4 `static const control_t& glucat::control_t::control ( int argc, char ** argv )` `[inline],[static]`

Single instance Ref: Scott Meyers, "Effective C++" Second Edition, Addison-Wesley, 1998.

Definition at line 71 of file control.h.

6.7.3.5 `control_t& glucat::control_t::operator= ( const control_t & )` `[private]`

6.7.3.6 `bool glucat::control_t::valid ( ) const` `[inline],[private]`

Definition at line 44 of file control.h.

References `m_valid`.

Referenced by `call()`, and `control_t()`.

6.7.3.7 `static bool glucat::control_t::verbose ( )` `[inline],[static]`

Produce more detailed output from tests.

Definition at line 80 of file control.h.

References `m_verbose_output`.

6.7.4 Friends And Related Function Documentation

6.7.4.1 `friend class friend_for_private_destructor` `[friend]`

Friend declaration to avoid compiler warning: "... only defines a private destructor and has no friends" Ref: Carlos O'Ryan, ACE <http://doc.ece.uci.edu>

Definition at line 67 of file control.h.

6.7.5 Member Data Documentation

6.7.5.1 `bool glucat::control_t::m_catch_exceptions` `[private]`

Catch exceptions.

Definition at line 48 of file control.h.

Referenced by `catch_exceptions()`, and `control_t()`.

6.7.5.2 `bool glucat::control_t::m_valid` `[private]`

Test parameters are valid.

Definition at line 43 of file control.h.

Referenced by `control_t()`, and `valid()`.

6.7.5.3 `bool glucat::control_t::m_verbose_output = false` `[static],[private]`

Produce more detailed output from tests.

Definition at line 53 of file control.h.

Referenced by `control_t()`, and `verbose()`.

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

- [test/control.h](#)

6.8 glucat::CTAssertion< bool > Struct Template Reference

Compile time assertion.

```
#include <global.h>
```

6.8.1 Detailed Description

```
template<bool>struct glucat::CTAssertion< bool >
```

Compile time assertion.

Definition at line 46 of file global.h.

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

- [glucat/global.h](#)

6.9 glucat::CTAssertion< true > Struct Template Reference

```
#include <global.h>
```

6.9.1 Detailed Description

```
template<>struct glucat::CTAssertion< true >
```

Definition at line 47 of file global.h.

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

- [glucat/global.h](#)

6.10 glucat::numeric_traits< Scalar_T >::demoted<> Struct Template Reference

Demoted type for long double.

```
#include <long_double.h>
```

Public Types

- typedef long double [type](#)
- typedef float [type](#)

6.10.1 Detailed Description

```
template<typename Scalar_T>template<>struct glucat::numeric_traits< Scalar_T >::demoted<>
```

Demoted type for long double.

Demoted type.

Definition at line 47 of file long_double.h.

6.10.2 Member Typedef Documentation

6.10.2.1 `template<typename Scalar_T > typedef long double glucat::numeric_traits< Scalar_T >::demoted<>::type`

Definition at line 49 of file `long_double.h`.

6.10.2.2 `template<typename Scalar_T > typedef float glucat::numeric_traits< Scalar_T >::demoted<>::type`

Definition at line 147 of file `scalar.h`.

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

- [glucat/long_double.h](#)
- [glucat/scalar.h](#)

6.11 glucat::matrix::eig_genus< Matrix_T > Struct Template Reference

Structure containing classification of eigenvalues.

```
#include <matrix.h>
```

Public Types

- typedef `Matrix_T::value_type` [Scalar_T](#)

Public Attributes

- [eig_case_t m_eig_case](#)
What kind of eigenvalues does the matrix contain?
- [Scalar_T m_safe_arg](#)
Argument such that $\exp(\pi \cdot m_safe_arg)$ lies between arguments of eigenvalues.

6.11.1 Detailed Description

```
template<typename Matrix_T> struct glucat::matrix::eig_genus< Matrix_T >
```

Structure containing classification of eigenvalues.

Definition at line 131 of file `matrix.h`.

6.11.2 Member Typedef Documentation

6.11.2.1 `template<typename Matrix_T> typedef Matrix_T::value_type glucat::matrix::eig_genus< Matrix_T >::Scalar_T`

Definition at line 133 of file `matrix.h`.

6.11.3 Member Data Documentation

6.11.3.1 `template<typename Matrix_T> eig_case_t glucat::matrix::eig_genus< Matrix_T >::m_eig_case`

What kind of eigenvalues does the matrix contain?

Definition at line 135 of file matrix.h.

Referenced by glucat::matrix::classify_eigenvalues(), glucat::matrix_log(), and glucat::matrix_sqrt().

6.11.3.2 `template<typename Matrix_T> Scalar_T glucat::matrix::eig_genus< Matrix_T >::m_safe_arg`

Argument such that $\exp(\pi - m_safe_arg)$ lies between arguments of eigenvalues.

Definition at line 137 of file matrix.h.

Referenced by glucat::matrix::classify_eigenvalues(), glucat::matrix_log(), and glucat::matrix_sqrt().

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

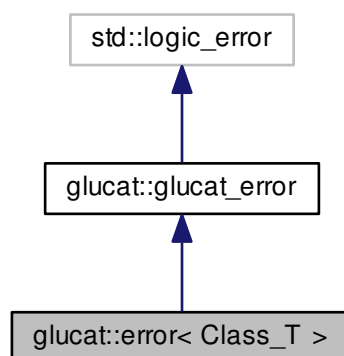
- [glucat/matrix.h](#)

6.12 glucat::error< Class_T > Class Template Reference

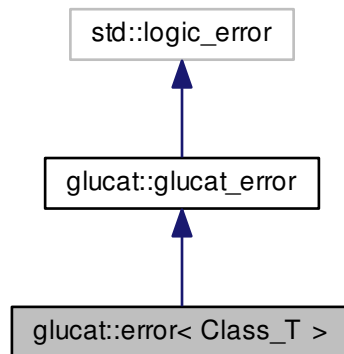
Specific exception class.

```
#include <errors.h>
```

Inheritance diagram for glucat::error< Class_T >:



Collaboration diagram for `glucat::error< Class_T >`:



Public Member Functions

- `error` (const std::string &msg)
Specific exception class.
- `error` (const std::string &context, const std::string &msg)
- virtual const std::string `heading` () const throw ()
- virtual const std::string `classname` () const throw ()
- virtual void `print_error_msg` () const

Additional Inherited Members

6.12.1 Detailed Description

```
template<class Class_T>class glucat::error< Class_T >
```

Specific exception class.

Definition at line 57 of file errors.h.

6.12.2 Constructor & Destructor Documentation

6.12.2.1 `template<class Class_T > glucat::error< Class_T >::error ( const std::string & msg )`

Specific exception class.

Definition at line 39 of file errors_imp.h.

6.12.2.2 `template<class Class_T > glucat::error< Class_T >::error ( const std::string & context, const std::string & msg )`

Definition at line 45 of file errors_imp.h.

6.12.3 Member Function Documentation

6.12.3.1 `template<class Class_T > const std::string glucat::error< Class_T >::classname ( ) const throw )`
`[virtual]`

Implements [glucat::glucat_error](#).

Definition at line 58 of file `errors_imp.h`.

6.12.3.2 `template<class Class_T > const std::string glucat::error< Class_T >::heading ( ) const throw )` `[virtual]`

Implements [glucat::glucat_error](#).

Definition at line 52 of file `errors_imp.h`.

6.12.3.3 `template<class Class_T > void glucat::error< Class_T >::print_error_msg ( ) const` `[virtual]`

Implements [glucat::glucat_error](#).

Definition at line 64 of file `errors_imp.h`.

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

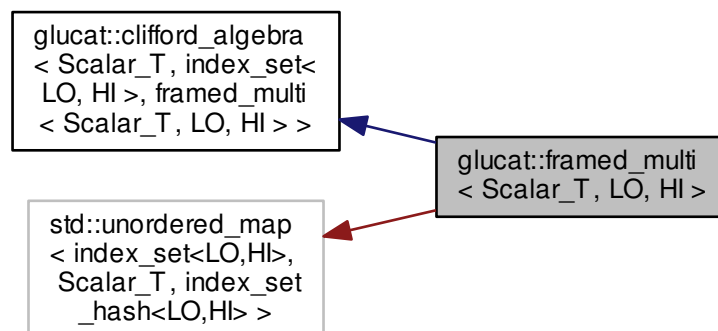
- [glucat/errors.h](#)
- [glucat/errors_imp.h](#)

6.13 glucat::framed_multi< Scalar_T, LO, HI > Class Template Reference

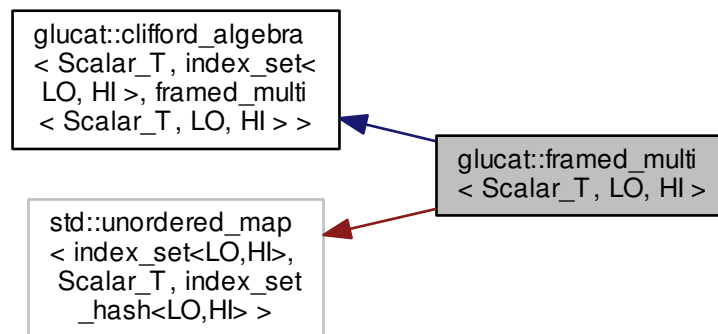
A `framed_multi<Scalar_T,LO,HI>` is a framed approximation to a multivector.

`#include <framed_multi.h>`

Inheritance diagram for `glucat::framed_multi< Scalar_T, LO, HI >`:



Collaboration diagram for `glucat::framed_multi< Scalar_T, LO, HI >`:



Classes

- class [hash_size_t](#)
- class [var_term](#)

Variable term.

Public Types

- typedef [framed_multi](#) [multivector_t](#)
- typedef [multivector_t](#) [framed_multi_t](#)
- typedef `Scalar_T` [scalar_t](#)
- typedef `index_set< LO, HI >` [index_set_t](#)
- typedef `std::pair< const index\_set\_t, Scalar_T >` [term_t](#)
- typedef `std::vector< Scalar_T >` [vector_t](#)
- typedef `error< multivector\_t >` [error_t](#)
- typedef `matrix_multi< Scalar_T, LO, HI >` [matrix_multi_t](#)

Public Member Functions

- [~framed_multi](#) ()
Destructor.
- [framed_multi](#) ()
Default constructor.
- `template<typename Other_Scalar_T >`
[framed_multi](#) (const [framed_multi](#)< Other_Scalar_T, LO, HI > &val)
Construct a multivector from a multivector with a different scalar type.
- `template<typename Other_Scalar_T >`
[framed_multi](#) (const [framed_multi](#)< Other_Scalar_T, LO, HI > &val, const [index_set_t](#) frm, const bool prechecked=false)
Construct a multivector, within a given frame, from a given multivector.
- [framed_multi](#) (const [framed_multi_t](#) &val, const [index_set_t](#) frm, const bool prechecked=false)

- Construct a multivector, within a given frame, from a given multivector.*

 - `framed_multi` (const `index_set_t` ist, const `Scalar_T` &crd=`Scalar_T`(1))

Construct a multivector from an index set and a scalar coordinate.
- `framed_multi` (const `index_set_t` ist, const `Scalar_T` &crd, const `index_set_t` frm, const bool prechecked=false)

Construct a multivector, within a given frame, from an index set and a scalar coordinate.
- `framed_multi` (const `Scalar_T` &scr, const `index_set_t` frm=`index_set_t`())

Construct a multivector from a scalar (within a frame, if given)
- `framed_multi` (const int scr, const `index_set_t` frm=`index_set_t`())

Construct a multivector from an int (within a frame, if given)
- `framed_multi` (const `vector_t` &vec, const `index_set_t` frm, const bool prechecked=false)

Construct a multivector, within a given frame, from a given vector.
- `framed_multi` (const std::string &str)

Construct a multivector from a string: eg: "3+2{1,2}-6.1e-2{2,3}".
- `framed_multi` (const std::string &str, const `index_set_t` frm, const bool prechecked=false)

Construct a multivector, within a given frame, from a string: eg: "3+2{1,2}-6.1e-2{2,3}".
- `framed_multi` (const char *str)

Construct a multivector from a char: eg: "3+2{1,2}-6.1e-2{2,3}".*
- `framed_multi` (const char *str, const `index_set_t` frm, const bool prechecked=false)

Construct a multivector, within a given frame, from a char: eg: "3+2{1,2}-6.1e-2{2,3}".*
- template<typename Other_Scalar_T >
`framed_multi` (const `matrix_multi`< Other_Scalar_T, LO, HI > &val)

Construct a multivector from a matrix_multi_t.
- template<typename Other_Scalar_T >
const `matrix_multi`
< Other_Scalar_T, LO, HI > `fast_matrix_multi` (const `index_set_t` frm) const

Use generalized FFT to construct a matrix_multi_t.
- const `framed_multi_t` `fast_framed_multi` () const

Use inverse generalized FFT to construct a framed_multi_t.
- `_GLUCAT_CLIFFORD_ALGEBRA_OPERATIONS`
unsigned long `nbr_terms` () const

Number of terms.
- `multivector_t` & `operator+=` (const `term_t` &term)

Add a term, if non-zero.

Static Public Member Functions

- static const std::string `classname` ()

Class name used in messages.
- static const `framed_multi_t` `random` (const `index_set_t` frm, `Scalar_T` fill=`Scalar_T`(1))

Random multivector within a frame.

Private Types

- typedef class `var_term` `var_term_t`
- typedef `matrix_multi_t::matrix_t` `matrix_t`
- typedef std::map< `index_set_t`,
`Scalar_T`, std::less< const
`index_set_t` > > `sorted_map_t`
- typedef std::unordered_map
< `index_set_t`, `Scalar_T`,
`index_set_hash`< LO, HI > > `map_t`

- typedef std::pair< const [multivector_t](#), const [multivector_t](#) > [framed_pair_t](#)
- typedef map_t::size_type [size_type](#)
- typedef map_t::iterator [iterator](#)
- typedef map_t::const_iterator [const_iterator](#)

Private Member Functions

- [framed_multi](#) (const [hash_size_t](#) &hash_size)
Private constructor using hash_size.
- [multivector_t fold](#) (const [index_set_t](#) frm) const
Subalgebra isomorphism: fold each term within the given frame.
- [multivector_t unfold](#) (const [index_set_t](#) frm) const
Subalgebra isomorphism: unfold each term within the given frame.
- [multivector_t & centre_pm4_qp4](#) ([index_t](#) &p, [index_t](#) &q)
Subalgebra isomorphism: $R_{\{p,q\}}$ to $R_{\{p-4,q+4\}}$.
- [multivector_t & centre_pp4_qm4](#) ([index_t](#) &p, [index_t](#) &q)
Subalgebra isomorphism: $R_{\{p,q\}}$ to $R_{\{p+4,q-4\}}$.
- [multivector_t & centre_qp1_pm1](#) ([index_t](#) &p, [index_t](#) &q)
Subalgebra isomorphism: $R_{\{p,q\}}$ to $R_{\{q+1,p-1\}}$.
- const [framed_pair_t divide](#) (const [index_set_t](#) ist) const
Divide multivector into part divisible by [index_set](#) and remainder.
- const [matrix_t fast](#) (const [index_t](#) level, const bool odd) const
Generalized FFT from [framed_multi_t](#) to [matrix_t](#).

Friends

- template<typename Other_Scalar_T, const [index_t](#) Other_LO, const [index_t](#) Other_HI>
class [matrix_multi](#)
- template<typename Other_Scalar_T, const [index_t](#) Other_LO, const [index_t](#) Other_HI>
class [framed_multi](#)
- const [framed_multi_t operator*](#) (const [framed_multi_t](#) &lhs, const [framed_multi_t](#) &rhs)
- const [framed_multi_t operator^](#) (const [framed_multi_t](#) &lhs, const [framed_multi_t](#) &rhs)
- const [framed_multi_t operator&](#) (const [framed_multi_t](#) &lhs, const [framed_multi_t](#) &rhs)
- const [framed_multi_t operator%](#) (const [framed_multi_t](#) &lhs, const [framed_multi_t](#) &rhs)
- [Scalar_T star](#) (const [framed_multi_t](#) &lhs, const [framed_multi_t](#) &rhs)
- const [framed_multi_t operator/](#) (const [framed_multi_t](#) &lhs, const [framed_multi_t](#) &rhs)
- const [framed_multi_t operator|](#) (const [framed_multi_t](#) &lhs, const [framed_multi_t](#) &rhs)
- std::istream & [operator>>](#) (std::istream &s, [multivector_t](#) &val)
- std::ostream & [operator<<](#) (std::ostream &os, const [multivector_t](#) &val)
- std::ostream & [operator<<](#) (std::ostream &os, const [term_t](#) &term)
- const [framed_multi_t exp](#) (const [framed_multi_t](#) &val)

6.13.1 Detailed Description

template<typename [Scalar_T](#), const [index_t](#) LO, const [index_t](#) HI> class glucat::framed_multi< [Scalar_T](#), LO, HI >

A [framed_multi](#)<[Scalar_T](#),LO,HI> is a framed approximation to a multivector.

Definition at line 65 of file [framed_multi.h](#).

6.13.2 Member Typedef Documentation

6.13.2.1 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef map_t::const_iterator glucat::framed_multi< Scalar_T, LO, HI >::const_iterator [private]`

Definition at line 196 of file framed_multi.h.

6.13.2.2 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef error<multivector_t> glucat::framed_multi< Scalar_T, LO, HI >::error_t`

Definition at line 155 of file framed_multi.h.

6.13.2.3 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef multivector_t glucat::framed_multi< Scalar_T, LO, HI >::framed_multi_t`

Definition at line 150 of file framed_multi.h.

6.13.2.4 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef std::pair< const multivector_t, const multivector_t > glucat::framed_multi< Scalar_T, LO, HI >::framed_pair_t [private]`

Definition at line 193 of file framed_multi.h.

6.13.2.5 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef index_set<LO,HI> glucat::framed_multi< Scalar_T, LO, HI >::index_set_t`

Definition at line 152 of file framed_multi.h.

6.13.2.6 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef map_t::iterator glucat::framed_multi< Scalar_T, LO, HI >::iterator [private]`

Definition at line 195 of file framed_multi.h.

6.13.2.7 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef std::unordered_map< index_set_t, Scalar_T, index_set_hash<LO,HI> > glucat::framed_multi< Scalar_T, LO, HI >::map_t [private]`

Definition at line 175 of file framed_multi.h.

6.13.2.8 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef matrix_multi<Scalar_T,LO,HI> glucat::framed_multi< Scalar_T, LO, HI >::matrix_multi_t`

Definition at line 156 of file framed_multi.h.

6.13.2.9 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef matrix_multi_t::matrix_t glucat::framed_multi< Scalar_T, LO, HI >::matrix_t [private]`

Definition at line 165 of file framed_multi.h.

6.13.2.10 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef framed_multi glucat::framed_multi< Scalar_T, LO, HI >::multivector_t`

Definition at line 149 of file framed_multi.h.

6.13.2.11 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef Scalar_T glucat::framed_multi< Scalar_T, LO, HI >::scalar_t`

Definition at line 151 of file framed_multi.h.

6.13.2.12 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef map_t::size_type glucat::framed_multi< Scalar_T, LO, HI >::size_type [private]`

Definition at line 194 of file framed_multi.h.

6.13.2.13 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef std::map< index_set_t, Scalar_T, std::less<const index_set_t> > glucat::framed_multi< Scalar_T, LO, HI >::sorted_map_t [private]`

Definition at line 172 of file framed_multi.h.

6.13.2.14 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef std::pair<const index_set_t, Scalar_T> glucat::framed_multi< Scalar_T, LO, HI >::term_t`

Definition at line 153 of file framed_multi.h.

6.13.2.15 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef class var_term glucat::framed_multi< Scalar_T, LO, HI >::var_term_t [private]`

Definition at line 164 of file framed_multi.h.

6.13.2.16 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef std::vector<Scalar_T> glucat::framed_multi< Scalar_T, LO, HI >::vector_t`

Definition at line 154 of file framed_multi.h.

6.13.3 Constructor & Destructor Documentation

6.13.3.1 `template<typename Scalar_T, const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::~~framed_multi ( ) [inline]`

Destructor.

Definition at line 202 of file framed_multi.h.

6.13.3.2 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::framed_multi ( )`

Default constructor.

Definition at line 67 of file framed_multi_imp.h.

Referenced by `glucat::framed_multi< Scalar_T, LO, HI >::framed_multi()`.

6.13.3.3 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::framed_multi ( const hash_size_t & hash_size ) [private]`

Private constructor using hash_size.

Definition at line 74 of file framed_multi_imp.h.

```
6.13.3.4  template<typename Scalar_T , const index_t LO, const index_t HI> template<typename Other_Scalar_T >
          glucat::framed_multi< Scalar_T, LO, HI >::framed_multi ( const framed_multi< Other_Scalar_T, LO, HI > &
          val )
```

Construct a multivector from a multivector with a different scalar type.

Definition at line 82 of file framed_multi_imp.h.

```
6.13.3.5  template<typename Scalar_T , const index_t LO, const index_t HI> template<typename Other_Scalar_T >
          glucat::framed_multi< Scalar_T, LO, HI >::framed_multi ( const framed_multi< Other_Scalar_T, LO, HI > &
          val, const index_set_t frm, const bool prechecked = false )
```

Construct a multivector, within a given frame, from a given multivector.

Definition at line 97 of file framed_multi_imp.h.

```
6.13.3.6  template<typename Scalar_T , const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI
          >::framed_multi ( const framed_multi_t & val, const index_set_t frm, const bool prechecked = false )
```

Construct a multivector, within a given frame, from a given multivector.

Definition at line 112 of file framed_multi_imp.h.

```
6.13.3.7  template<typename Scalar_T , const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI
          >::framed_multi ( const index_set_t ist, const Scalar_T & crd = Scalar_T(1) )
```

Construct a multivector from an index set and a scalar coordinate.

Definition at line 120 of file framed_multi_imp.h.

```
6.13.3.8  template<typename Scalar_T , const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI
          >::framed_multi ( const index_set_t ist, const Scalar_T & crd, const index_set_t frm, const bool prechecked
          = false )
```

Construct a multivector, within a given frame, from an index set and a scalar coordinate.

Definition at line 130 of file framed_multi_imp.h.

```
6.13.3.9  template<typename Scalar_T , const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI
          >::framed_multi ( const Scalar_T & scr, const index_set_t frm = index_set_t() )
```

Construct a multivector from a scalar (within a frame, if given)

Definition at line 143 of file framed_multi_imp.h.

```
6.13.3.10 template<typename Scalar_T , const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI
          >::framed_multi ( const int scr, const index_set_t frm = index_set_t() )
```

Construct a multivector from an int (within a frame, if given)

Definition at line 153 of file framed_multi_imp.h.

6.13.3.11 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::framed_multi ( const vector_t & vec, const index_set_t frm, const bool prechecked = false )`

Construct a multivector, within a given frame, from a given vector.

Definition at line 163 of file framed_multi_imp.h.

References glucat::index_set< LO, HI >::count(), glucat::index_set< LO, HI >::max(), and glucat::index_set< LO, HI >::min().

6.13.3.12 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::framed_multi ( const std::string & str )`

Construct a multivector from a string: eg: "3+2{1,2}-6.1e-2{2,3}".

Definition at line 186 of file framed_multi_imp.h.

6.13.3.13 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::framed_multi ( const std::string & str, const index_set_t frm, const bool prechecked = false )`

Construct a multivector, within a given frame, from a string: eg: "3+2{1,2}-6.1e-2{2,3}".

Definition at line 202 of file framed_multi_imp.h.

6.13.3.14 `template<typename Scalar_T, const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::framed_multi ( const char * str ) [inline]`

Construct a multivector from a char*: eg: "3+2{1,2}-6.1e-2{2,3}".

Definition at line 238 of file framed_multi.h.

References glucat::framed_multi< Scalar_T, LO, HI >::framed_multi().

6.13.3.15 `template<typename Scalar_T, const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::framed_multi ( const char * str, const index_set_t frm, const bool prechecked = false ) [inline]`

Construct a multivector, within a given frame, from a char*: eg: "3+2{1,2}-6.1e-2{2,3}".

Definition at line 241 of file framed_multi.h.

References glucat::framed_multi< Scalar_T, LO, HI >::framed_multi().

6.13.3.16 `template<typename Scalar_T , const index_t LO, const index_t HI> template<typename Other_Scalar_T > glucat::framed_multi< Scalar_T, LO, HI >::framed_multi ( const matrix_multi< Other_Scalar_T, LO, HI > & val )`

Construct a multivector from a matrix_multi_t.

Definition at line 215 of file framed_multi_imp.h.

References _GLUCAT_HASH_SIZE_T, glucat::abs(), glucat::matrix_multi< Scalar_T, LO, HI >::basis_element(), glucat::index_set< LO, HI >::count(), PyClical::e(), glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::frame(), glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::inv_fast_dim_threshold, PyClical::ist, glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix, glucat::matrix::nnz(), and glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, matrix_multi< Scalar_T, LO, HI > >::norm().

6.13.4 Member Function Documentation

6.13.4.1 `template<typename Scalar_T, const index_t LO, const index_t HI> framed_multi< Scalar_T, LO, HI > & glucat::framed_multi< Scalar_T, LO, HI >::centre_pm4_qp4 ( index_t & p, index_t & q ) [private]`

Subalgebra isomorphism: $R_{\{p,q\}}$ to $R_{\{p-4,q+4\}}$.

Definition at line 1655 of file framed_multi_imp.h.

References glucat::index_set< LO, HI >::max().

Referenced by glucat::matrix_multi< Scalar_T, LO, HI >::fast_framed_multi(), and glucat::framed_multi< Scalar_T, LO, HI >::fast_matrix_multi().

6.13.4.2 `template<typename Scalar_T, const index_t LO, const index_t HI> framed_multi< Scalar_T, LO, HI > & glucat::framed_multi< Scalar_T, LO, HI >::centre_pp4_qm4 ( index_t & p, index_t & q ) [private]`

Subalgebra isomorphism: $R_{\{p,q\}}$ to $R_{\{p+4,q-4\}}$.

Definition at line 1700 of file framed_multi_imp.h.

References glucat::index_set< LO, HI >::min().

Referenced by glucat::matrix_multi< Scalar_T, LO, HI >::fast_framed_multi(), and glucat::framed_multi< Scalar_T, LO, HI >::fast_matrix_multi().

6.13.4.3 `template<typename Scalar_T, const index_t LO, const index_t HI> framed_multi< Scalar_T, LO, HI > & glucat::framed_multi< Scalar_T, LO, HI >::centre_qp1_pm1 ( index_t & p, index_t & q ) [private]`

Subalgebra isomorphism: $R_{\{p,q\}}$ to $R_{\{q+1,p-1\}}$.

Definition at line 1745 of file framed_multi_imp.h.

Referenced by glucat::matrix_multi< Scalar_T, LO, HI >::fast_framed_multi(), and glucat::framed_multi< Scalar_T, LO, HI >::fast_matrix_multi().

6.13.4.4 `template<typename Scalar_T, const index_t LO, const index_t HI> const std::string glucat::framed_multi< Scalar_T, LO, HI >::classname ( ) [static]`

Class name used in messages.

Definition at line 53 of file framed_multi_imp.h.

6.13.4.5 `template<typename Scalar_T, const index_t LO, const index_t HI> const std::pair< const framed_multi< Scalar_T, LO, HI >, const framed_multi< Scalar_T, LO, HI > > glucat::framed_multi< Scalar_T, LO, HI >::divide ( const index_set_t ist ) const [private]`

Divide multivector into part divisible by [index_set](#) and remainder.

Divide multivector into quotient with terms divisible by index set, and remainder.

Definition at line 1781 of file framed_multi_imp.h.

Referenced by glucat::framed_multi< Scalar_T, LO, HI >::fast().

6.13.4.6 `template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI >::matrix_t glucat::framed_multi< Scalar_T, LO, HI >::fast ( const index_t level, const bool odd ) const [private]`

Generalized FFT from framed_multi_t to matrix_t.

Definition at line 1800 of file framed_multi_imp.h.

References `glucat::framed_multi< Scalar_T, LO, HI >::divide()`, `glucat::framed_multi< Scalar_T, LO, HI >::fast()`, `glucat::matrix::kron()`, and `glucat::scalar()`.

Referenced by `glucat::framed_multi< Scalar_T, LO, HI >::fast()`, and `glucat::framed_multi< Scalar_T, LO, HI >::fast_matrix_multi()`.

6.13.4.7 `template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI >
glucat::framed_multi< Scalar_T, LO, HI >::fast_framed_multi () const [inline]`

Use inverse generalized FFT to construct a `framed_multi_t`.

Definition at line 1898 of file framed_multi_imp.h.

6.13.4.8 `template<typename Scalar_T, const index_t LO, const index_t HI> template<typename Other_Scalar_T> const
matrix_multi< Other_Scalar_T, LO, HI > glucat::framed_multi< Scalar_T, LO, HI >::fast_matrix_multi (const
index_set_t frm) const`

Use generalized FFT to construct a `matrix_multi_t`.

Definition at line 1866 of file framed_multi_imp.h.

References `glucat::framed_multi< Scalar_T, LO, HI >::centre_pm4_qp4()`, `glucat::framed_multi< Scalar_T, LO, HI >::centre_pp4_qm4()`, `glucat::framed_multi< Scalar_T, LO, HI >::centre_qp1_pm1()`, `glucat::index_set< L-
O, HI >::count_neg()`, `glucat::index_set< LO, HI >::count_pos()`, `glucat::clifford_algebra< Scalar_T, Index_Set-
_T, Multivector_T >::even()`, `glucat::framed_multi< Scalar_T, LO, HI >::fast()`, `glucat::clifford_algebra< Scalar_T,
Index_Set_T, Multivector_T >::odd()`, `glucat::gen::offset_to_super`, and `glucat::pos_mod()`.

6.13.4.9 `template<typename Scalar_T, const index_t LO, const index_t HI> framed_multi< Scalar_T, LO, HI >
glucat::framed_multi< Scalar_T, LO, HI >::fold (const index_set_t frm) const [private]`

Subalgebra isomorphism: fold each term within the given frame.

Definition at line 1614 of file framed_multi_imp.h.

References `glucat::index_set< LO, HI >::is_contiguous()`.

6.13.4.10 `template<typename Scalar_T, const index_t LO, const index_t HI> unsigned long glucat::framed_multi<
Scalar_T, LO, HI >::nbr_terms () const`

Number of terms.

Definition at line 1545 of file framed_multi_imp.h.

6.13.4.11 `template<typename Scalar_T, const index_t LO, const index_t HI> framed_multi< Scalar_T, LO, HI > &
glucat::framed_multi< Scalar_T, LO, HI >::operator+=(const term_t & term) [inline]`

Add a term, if non-zero.

Insert a term into a multivector, add terms with same index set.

Geometric sum.

Geometric sum of multivector and scalar.

Definition at line 329 of file framed_multi_imp.h.

```
6.13.4.12  template<typename Scalar_T , const index_t LO, const index_t HI> const framed_multi< Scalar_T, LO, HI >
           glucat::framed_multi< Scalar_T, LO, HI >::random ( const index_set_t frm, Scalar_T fill = Scalar_T(1)
           ) [static]
```

Random multivector within a frame.

Definition at line 1273 of file framed_multi_imp.h.

References glucat::index_set< LO, HI >::count(), and glucat::sqrt().

Referenced by glucat::matrix_multi< Scalar_T, LO, HI >::random().

```
6.13.4.13  template<typename Scalar_T , const index_t LO, const index_t HI> framed_multi< Scalar_T, LO, HI >
           glucat::framed_multi< Scalar_T, LO, HI >::unfold ( const index_set_t frm ) const [private]
```

Subalgebra isomorphism: unfold each term within the given frame.

Definition at line 1634 of file framed_multi_imp.h.

References glucat::index_set< LO, HI >::is_contiguous().

Referenced by glucat::matrix_multi< Scalar_T, LO, HI >::fast_framed_multi().

6.13.5 Friends And Related Function Documentation

```
6.13.5.1  template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi_t exp ( const
           framed_multi_t & val ) [friend]
```

```
6.13.5.2  template<typename Scalar_T, const index_t LO, const index_t HI> template<typename Other_Scalar_T , const
           index_t Other_LO, const index_t Other_HI> friend class framed_multi [friend]
```

Definition at line 160 of file framed_multi.h.

```
6.13.5.3  template<typename Scalar_T, const index_t LO, const index_t HI> template<typename Other_Scalar_T , const
           index_t Other_LO, const index_t Other_HI> friend class matrix_multi [friend]
```

Definition at line 158 of file framed_multi.h.

```
6.13.5.4  template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi_t operator% ( const
           framed_multi_t & lhs, const framed_multi_t & rhs ) [friend]
```

```
6.13.5.5  template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi_t operator& ( const
           framed_multi_t & lhs, const framed_multi_t & rhs ) [friend]
```

```
6.13.5.6  template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi_t operator* ( const
           framed_multi_t & lhs, const framed_multi_t & rhs ) [friend]
```

```
6.13.5.7  template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi_t operator/ ( const
           framed_multi_t & lhs, const framed_multi_t & rhs ) [friend]
```

```
6.13.5.8  template<typename Scalar_T, const index_t LO, const index_t HI> std::ostream& operator<< ( std::ostream & os,
           const multivector_t & val ) [friend]
```

```
6.13.5.9  template<typename Scalar_T, const index_t LO, const index_t HI> std::ostream& operator<< ( std::ostream & os,
           const term_t & term ) [friend]
```

6.13.5.10 `template<typename Scalar_T, const index_t LO, const index_t HI> std::istream& operator>> ( std::istream & s, multivector_t & val ) [friend]`

6.13.5.11 `template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi_t operator^ ( const framed_multi_t & lhs, const framed_multi_t & rhs ) [friend]`

6.13.5.12 `template<typename Scalar_T, const index_t LO, const index_t HI> const framed_multi_t operator| ( const framed_multi_t & lhs, const framed_multi_t & rhs ) [friend]`

6.13.5.13 `template<typename Scalar_T, const index_t LO, const index_t HI> Scalar_T star ( const framed_multi_t & lhs, const framed_multi_t & rhs ) [friend]`

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

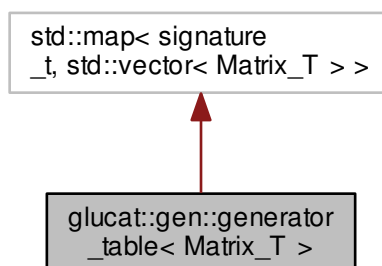
- [glucat/framed_multi.h](#)
- [glucat/framed_multi_imp.h](#)

6.14 glucat::gen::generator_table< Matrix_T > Class Template Reference

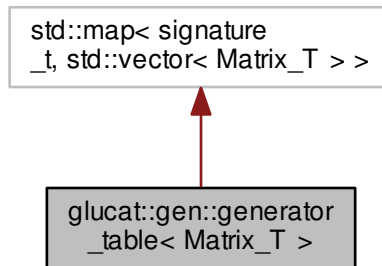
Table of generators for specific signatures.

```
#include <generation.h>
```

Inheritance diagram for glucat::gen::generator_table< Matrix_T >:



Collaboration diagram for glucat::gen::generator_table< Matrix_T >:



Public Member Functions

- `const Matrix_T * operator()` (const `index_t` p, const `index_t` q)
Pointer to generators for a specific signature.

Static Public Member Functions

- static `generator_table`
 < Matrix_T > & `generator` ()
Single instance of generator table.

Private Member Functions

- `const std::vector< Matrix_T > & gen_vector` (const `index_t` p, const `index_t` q)
Construct a vector of generators for a specific signature.
- `void gen_from_pm1_qm1` (const `std::vector< Matrix_T >` &old, const `signature_t` sig)
Construct generators for p,q given generators for p-1,q-1.
- `void gen_from_pm4_qp4` (const `std::vector< Matrix_T >` &old, const `signature_t` sig)
Construct generators for p,q given generators for p-4,q+4.
- `void gen_from_pp4_qm4` (const `std::vector< Matrix_T >` &old, const `signature_t` sig)
Construct generators for p,q given generators for p+4,q-4.
- `void gen_from_qp1_pm1` (const `std::vector< Matrix_T >` &old, const `signature_t` sig)
Construct generators for p,q given generators for q+1,p-1.
- `generator_table` ()
- `~generator_table` ()
- `generator_table` (const `generator_table` &)
- `generator_table & operator=` (const `generator_table` &)

Friends

- class `friend_for_private_destructor`

6.14.1 Detailed Description

```
template<class Matrix_T>class glucat::gen::generator_table< Matrix_T >
```

Table of generators for specific signatures.

Definition at line 47 of file generation.h.

6.14.2 Constructor & Destructor Documentation

```
6.14.2.1 template<class Matrix_T> glucat::gen::generator_table< Matrix_T >::generator_table ( ) [inline],
[private]
```

Definition at line 69 of file generation.h.

```
6.14.2.2 template<class Matrix_T> glucat::gen::generator_table< Matrix_T >::~~generator_table ( )
[inline], [private]
```

Definition at line 70 of file generation.h.

```
6.14.2.3 template<class Matrix_T> glucat::gen::generator_table< Matrix_T >::generator_table ( const
generator_table< Matrix_T > & ) [private]
```

6.14.3 Member Function Documentation

```
6.14.3.1 template<class Matrix_T > void glucat::gen::generator_table< Matrix_T >::gen_from_pm1_qm1 ( const
std::vector< Matrix_T > & old, const signature_t sig ) [private]
```

Construct generators for p,q given generators for p-1,q-1.

Definition at line 127 of file generation_imp.h.

References glucat::matrix::mono_kron().

```
6.14.3.2 template<class Matrix_T > void glucat::gen::generator_table< Matrix_T >::gen_from_pm4_qp4 ( const
std::vector< Matrix_T > & old, const signature_t sig ) [private]
```

Construct generators for p,q given generators for p-4,q+4.

Definition at line 164 of file generation_imp.h.

References glucat::matrix::mono_prod().

```
6.14.3.3 template<class Matrix_T > void glucat::gen::generator_table< Matrix_T >::gen_from_pp4_qm4 ( const
std::vector< Matrix_T > & old, const signature_t sig ) [private]
```

Construct generators for p,q given generators for p+4,q-4.

Definition at line 195 of file generation_imp.h.

References glucat::matrix::mono_prod().

```
6.14.3.4 template<class Matrix_T > void glucat::gen::generator_table< Matrix_T >::gen_from_qp1_pm1 ( const
std::vector< Matrix_T > & old, const signature_t sig ) [private]
```

Construct generators for p,q given generators for q+1,p-1.

Definition at line 225 of file generation_imp.h.

References glucat::matrix::mono_prod().

```
6.14.3.5  template<class Matrix_T > const std::vector< Matrix_T > & glucat::gen::generator_table< Matrix_T
>::gen_vector ( const index_t p, const index_t q )  [private]
```

Construct a vector of generators for a specific signature.

Definition at line 80 of file generation_imp.h.

References glucat::pos_mod().

```
6.14.3.6  template<class Matrix_T > generator_table< Matrix_T > & glucat::gen::generator_table< Matrix_T
>::generator ( )  [static]
```

Single instance of generator table.

Definition at line 50 of file generation_imp.h.

Referenced by glucat::matrix_multi< Scalar_T, LO, HI >::basis_element().

```
6.14.3.7  template<class Matrix_T > const Matrix_T * glucat::gen::generator_table< Matrix_T >::operator() ( const
index_t p, const index_t q )  [inline]
```

Pointer to generators for a specific signature.

Definition at line 59 of file generation_imp.h.

References glucat::gen::offset_to_super, and glucat::pos_mod().

```
6.14.3.8  template<class Matrix_T> generator_table& glucat::gen::generator_table< Matrix_T >::operator= ( const
generator_table< Matrix_T > & )  [private]
```

6.14.4 Friends And Related Function Documentation

```
6.14.4.1  template<class Matrix_T> friend class friend_for_private_destructor  [friend]
```

Friend declaration to avoid compiler warning: "... only defines a private destructor and has no friends" Ref: Carlos O'Ryan, ACE <http://doc.ece.uci.edu>

Definition at line 77 of file generation.h.

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

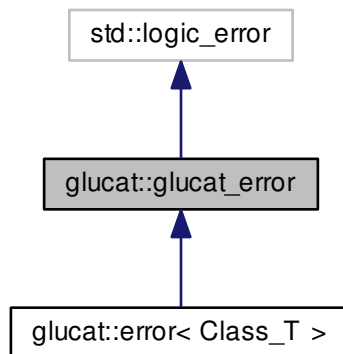
- [glucat/generation.h](#)
- [glucat/generation_imp.h](#)

6.15 glucat::glucat_error Class Reference

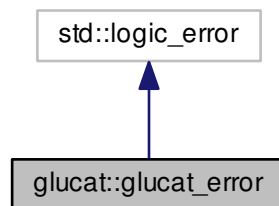
Abstract exception class.

```
#include <errors.h>
```

Inheritance diagram for `glucat::glucat_error`:



Collaboration diagram for `glucat::glucat_error`:



Public Member Functions

- `glucat_error` (const std::string &context, const std::string &msg)
- `~glucat_error` () throw ()
- virtual const std::string `heading` () const =0 throw ()
- virtual const std::string `classname` () const =0 throw ()
- virtual void `print_error_msg` () const =0

Public Attributes

- std::string `name`

6.15.1 Detailed Description

Abstract exception class.

Definition at line 41 of file `errors.h`.

6.15.2 Constructor & Destructor Documentation

6.15.2.1 `glucat::glucat_error::glucat_error ( const std::string & context, const std::string & msg )` `[inline]`

Definition at line 44 of file errors.h.

6.15.2.2 `glucat::glucat_error::~glucat_error ( ) throw` `[inline]`

Definition at line 47 of file errors.h.

6.15.3 Member Function Documentation

6.15.3.1 `virtual const std::string glucat::glucat_error::classname ( ) const throw` `[pure virtual]`

Implemented in [glucat::error< Class_T >](#).

6.15.3.2 `virtual const std::string glucat::glucat_error::heading ( ) const throw` `[pure virtual]`

Implemented in [glucat::error< Class_T >](#).

6.15.3.3 `virtual void glucat::glucat_error::print_error_msg ( ) const` `[pure virtual]`

Implemented in [glucat::error< Class_T >](#).

Referenced by `glucat::try_catch()`.

6.15.4 Member Data Documentation

6.15.4.1 `std::string glucat::glucat_error::name`

Definition at line 52 of file errors.h.

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

- [glucat/errors.h](#)

6.16 glucat::framed_multi< Scalar_T, LO, HI >::hash_size_t Class Reference

Public Member Functions

- [hash_size_t](#) (size_t hash_size)
- [size_t operator\(\)](#) () const

Private Attributes

- [size_t n](#)

6.16.1 Detailed Description

`template<typename Scalar_T, const index_t LO, const index_t HI>class glucat::framed_multi< Scalar_T, LO, HI >::hash_size_t`

Definition at line 180 of file framed_multi.h.

6.16.2 Constructor & Destructor Documentation

6.16.2.1 `template<typename Scalar_T, const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::hash_size_t::hash_size_t( size_t hash_size ) [inline]`

Definition at line 183 of file framed_multi.h.

6.16.3 Member Function Documentation

6.16.3.1 `template<typename Scalar_T, const index_t LO, const index_t HI> size_t glucat::framed_multi< Scalar_T, LO, HI >::hash_size_t::operator()( ) const [inline]`

Definition at line 186 of file framed_multi.h.

References glucat::framed_multi< Scalar_T, LO, HI >::hash_size_t::n.

6.16.4 Member Data Documentation

6.16.4.1 `template<typename Scalar_T, const index_t LO, const index_t HI> size_t glucat::framed_multi< Scalar_T, LO, HI >::hash_size_t::n [private]`

Definition at line 189 of file framed_multi.h.

Referenced by glucat::framed_multi< Scalar_T, LO, HI >::hash_size_t::operator()().

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

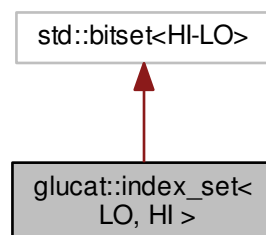
- glucat/[framed_multi.h](#)

6.17 glucat::index_set< LO, HI > Class Template Reference

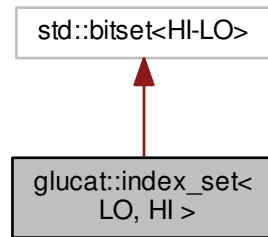
Index set class based on std::bitset<> in Gnu standard C++ library.

```
#include <index_set.h>
```

Inheritance diagram for glucat::index_set< LO, HI >:



Collaboration diagram for glucat::index_set< LO, HI >:



Classes

- class [reference](#)
Index set member reference.

Public Types

- typedef [index_set](#) [index_set_t](#)
- typedef std::pair< [index_t](#),
[index_t](#) > [index_pair_t](#)

Public Member Functions

- [index_set](#) ()
Default constructor creates an empty set.
- [index_set](#) (const [bitset_t](#) bst)
Constructor from `bitset_t`.
- [index_set](#) (const [index_t](#) idx)
Constructor from `index`.
- [index_set](#) (const [set_value_t](#) folded_val, const [index_set_t](#) frm, const bool prechecked=false)
Constructor from set value of an index set folded within the given frame.
- [index_set](#) (const [index_pair_t](#) &range, const bool prechecked=false)
Constructor from range of indices from `range.first` to `range.second`.
- [index_set](#) (const std::string &str)
Constructor from string.
- bool [operator==](#) (const [index_set_t](#) rhs) const
Equality.
- bool [operator!=](#) (const [index_set_t](#) rhs) const
Inequality.
- [index_set_t](#) [operator~](#) () const
Set complement: not.
- [index_set_t](#) & [operator^](#) = (const [index_set_t](#) rhs)
Symmetric set difference: exclusive or.
- [index_set_t](#) & [operator&=](#) (const [index_set_t](#) rhs)

- Set intersection: and.*

 - `index_set_t & operator|=(const index_set_t rhs)`

Set union: or.

 - `bool operator[] (const index_t idx) const`

Subscripting: Test idx for membership: test value of bit idx.

 - `bool test (const index_t idx) const`

Test idx for membership: test value of bit idx.

 - `index_set_t & set ()`

Include all indices except 0: set all bits except 0.

 - `index_set_t & set (const index_t idx)`

Include idx: Set bit at idx if idx != 0.

 - `index_set_t & set (const index_t idx, const int val)`

Set membership of idx to val if idx != 0: Set bit at idx to val if idx != 0.

 - `index_set_t & reset ()`

Make set empty: Set all bits to 0.

 - `index_set_t & reset (const index_t idx)`

Exclude idx: Set bit at idx to 0.

 - `index_set_t & flip ()`

Set complement, except 0: flip all bits, except 0.

 - `index_set_t & flip (const index_t idx)`

Complement membership of idx if idx != 0: flip bit at idx if idx != 0.

 - `index_t count () const`

Cardinality: Number of indices included in set.

 - `index_t count_neg () const`

Number of negative indices included in set.

 - `index_t count_pos () const`

Number of positive indices included in set.

 - `index_t min () const`

Minimum member.

 - `index_t max () const`

Maximum member.

 - `bool operator< (const index_set_t rhs) const`

Less than operator used for comparisons, map, etc.

 - `bool is_contiguous () const`

Determine if the index set is contiguous, ie. has no gaps.

 - `const index_set_t fold () const`

Fold this index set within itself as a frame.

 - `const index_set_t fold (const index_set_t frm, const bool prechecked=false) const`

Fold this index set within the given frame.

 - `const index_set_t unfold (const index_set_t frm, const bool prechecked=false) const`

Unfold this index set within the given frame.

 - `set_value_t value_of_fold (const index_set_t frm) const`

The set value of the fold of this index set within the given frame.

 - `int sign_of_mult (const index_set_t ist) const`

Sign of geometric product of two Clifford basis elements.

 - `int sign_of_square () const`

Sign of geometric square of a Clifford basis element.

 - `size_t hash_fn () const`

Hash function.

 - `reference operator[] (index_t idx)`

Subscripting: Element access.

Static Public Member Functions

- static const std::string [classname](#) ()

Static Public Attributes

- static const [index_t v_lo](#) = LO
- static const [index_t v_hi](#) = HI

Private Types

- typedef std::bitset< HI-LO > [bitset_t](#)
- typedef [error](#)< [index_set](#) > [error_t](#)

Private Member Functions

- [BOOST_STATIC_ASSERT](#) ((LO<=0)&&(0<=HI)&&(LO< HI)&&(-LO< _GLUCAT_BITS_PER_ULON-
G)&&(HI< _GLUCAT_BITS_PER_ULONG)&&(HI-LO<=_GLUCAT_BITS_PER_ULONG))
- bool [lex_less_than](#) (const [index_set_t](#) rhs) const
*Lexicographic ordering of two sets: *this < rhs.*

Friends

- class [reference](#)
- const [index_set_t operator^](#) (const [index_set_t](#) &lhs, const [index_set_t](#) &rhs)
- const [index_set_t operator&](#) (const [index_set_t](#) &lhs, const [index_set_t](#) &rhs)
- const [index_set_t operator|](#) (const [index_set_t](#) &lhs, const [index_set_t](#) &rhs)
- int [compare](#) (const [index_set_t](#) &lhs, const [index_set_t](#) &rhs)

6.17.1 Detailed Description

template<const index_t LO, const index_t HI>class glucat::index_set< LO, HI >

Index set class based on std::bitset<> in Gnu standard C++ library.

Definition at line 45 of file index_set.h.

6.17.2 Member Typedef Documentation

6.17.2.1 template<const index_t LO, const index_t HI> typedef std::bitset<HI-LO> glucat::index_set< LO, HI
>::bitset_t [private]

Definition at line 81 of file index_set.h.

6.17.2.2 template<const index_t LO, const index_t HI> typedef error<index_set> glucat::index_set< LO, HI
>::error_t [private]

Definition at line 82 of file index_set.h.

6.17.2.3 `template<const index_t LO, const index_t HI> typedef std::pair<index_t,index_t> glucat::index_set< LO, HI >::index_pair_t`

Definition at line 85 of file `index_set.h`.

6.17.2.4 `template<const index_t LO, const index_t HI> typedef index_set glucat::index_set< LO, HI >::index_set_t`

Definition at line 84 of file `index_set.h`.

6.17.3 Constructor & Destructor Documentation

6.17.3.1 `template<const index_t LO, const index_t HI> glucat::index_set< LO, HI >::index_set ( ) [inline]`

Default constructor creates an empty set.

Definition at line 92 of file `index_set.h`.

6.17.3.2 `template<const index_t LO, const index_t HI> glucat::index_set< LO, HI >::index_set ( const bitset_t bst )`

Constructor from `bitset_t`.

Definition at line 61 of file `index_set_imp.h`.

6.17.3.3 `template<const index_t LO, const index_t HI> glucat::index_set< LO, HI >::index_set ( const index_t idx )`

Constructor from index.

Constructor from index value.

Definition at line 55 of file `index_set_imp.h`.

6.17.3.4 `template<const index_t LO, const index_t HI> glucat::index_set< LO, HI >::index_set ( const set_value_t folded_val, const index_set_t frm, const bool prechecked = false )`

Constructor from set value of an index set folded within the given frame.

Definition at line 68 of file `index_set_imp.h`.

References `glucat::index_set< LO, HI >::count()`, `glucat::index_set< LO, HI >::fold()`, `glucat::index_set< LO, HI >::min()`, and `glucat::index_set< LO, HI >::unfold()`.

6.17.3.5 `template<const index_t LO, const index_t HI> glucat::index_set< LO, HI >::index_set ( const index_pair_t & range, const bool prechecked = false )`

Constructor from range of indices from `range.first` to `range.second`.

Definition at line 82 of file `index_set_imp.h`.

6.17.3.6 `template<const index_t LO, const index_t HI> glucat::index_set< LO, HI >::index_set ( const std::string & str )`

Constructor from string.

Definition at line 102 of file `index_set_imp.h`.

6.17.4 Member Function Documentation

6.17.4.1 `template<const index_t LO, const index_t HI> glucat::index_set< LO, HI >::BOOST_STATIC_ASSERT ( (LO<=0)&&(0<=HI)&&(LO< HI)&&(-LO< _GLUCAT_BITS_PER_ULONG)&&(HI< _GLUCAT_BITS_PER_ULONG)&&(HI-LO<=_GLUCAT_BITS_PER_ULONG) )` `[private]`

6.17.4.2 `template<const index_t LO, const index_t HI> const std::string glucat::index_set< LO, HI >::classname ( )` `[inline], [static]`

Definition at line 49 of file `index_set_imp.h`.

6.17.4.3 `template<const index_t LO, const index_t HI> index_t glucat::index_set< LO, HI >::count ( ) const` `[inline]`

Cardinality: Number of indices included in set.

Definition at line 344 of file `index_set_imp.h`.

Referenced by `glucat::index_set< LO, HI >::count_neg()`, `glucat::index_set< LO, HI >::count_pos()`, `glucat::framed_multi< Scalar_T, LO, HI >::framed_multi()`, `glucat::index_set< LO, HI >::index_set()`, `glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi()`, `glucat::index_set< LO, HI >::operator<()`, and `glucat::framed_multi< Scalar_T, LO, HI >::random()`.

6.17.4.4 `template<const index_t LO, const index_t HI> index_t glucat::index_set< LO, HI >::count_neg ( ) const` `[inline]`

Number of negative indices included in set.

Definition at line 364 of file `index_set_imp.h`.

References `glucat::index_set< LO, HI >::count()`.

Referenced by `glucat::framed_multi< Scalar_T, LO, HI >::fast_matrix_multi()`, and `glucat::folded_dim()`.

6.17.4.5 `template<const index_t LO, const index_t HI> index_t glucat::index_set< LO, HI >::count_pos ( ) const` `[inline]`

Number of positive indices included in set.

Definition at line 376 of file `index_set_imp.h`.

References `glucat::index_set< LO, HI >::count()`.

Referenced by `glucat::framed_multi< Scalar_T, LO, HI >::fast_matrix_multi()`, and `glucat::folded_dim()`.

6.17.4.6 `template<const index_t LO, const index_t HI> index_set< LO, HI > & glucat::index_set< LO, HI >::flip ( )` `[inline]`

Set complement, except 0: flip all bits, except 0.

Definition at line 319 of file `index_set_imp.h`.

6.17.4.7 `template<const index_t LO, const index_t HI> index_set< LO, HI > & glucat::index_set< LO, HI >::flip ( const index_t idx )` `[inline]`

Complement membership of `idx` if `idx != 0`: flip bit at `idx` if `idx != 0`.

Definition at line 330 of file `index_set_imp.h`.

6.17.4.8 `template<const index_t LO, const index_t HI> const index_set< LO, HI > glucat::index_set< LO, HI >::fold ( ) const [inline]`

Fold this index set within itself as a frame.

Definition at line 748 of file `index_set_imp.h`.

Referenced by `glucat::matrix_multi< Scalar_T, LO, HI >::basis_element()`, `glucat::index_set< LO, HI >::index_set()`, and `glucat::index_set< LO, HI >::value_of_fold()`.

6.17.4.9 `template<const index_t LO, const index_t HI> const index_set< LO, HI > glucat::index_set< LO, HI >::fold ( const index_set_t frm, const bool prechecked = false ) const`

Fold this index set within the given frame.

Definition at line 756 of file `index_set_imp.h`.

References `glucat::index_set< LO, HI >::max()`, `glucat::index_set< LO, HI >::min()`, `glucat::index_set< LO, HI >::set()`, and `glucat::index_set< LO, HI >::test()`.

6.17.4.10 `template<const index_t LO, const index_t HI> size_t glucat::index_set< LO, HI >::hash_fn ( ) const [inline]`

Hash function.

Definition at line 948 of file `index_set_imp.h`.

Referenced by `glucat::index_set_hash< LO, HI >::operator()()`.

6.17.4.11 `template<const index_t LO, const index_t HI> bool glucat::index_set< LO, HI >::is_contiguous ( ) const [inline]`

Determine if the index set is contiguous, ie. has no gaps.

Determine if the index set is contiguous, ie. has no gaps when 0 is included.

Definition at line 732 of file `index_set_imp.h`.

Referenced by `glucat::framed_multi< Scalar_T, LO, HI >::fold()`, and `glucat::framed_multi< Scalar_T, LO, HI >::unfold()`.

6.17.4.12 `template<const index_t LO, const index_t HI> bool glucat::index_set< LO, HI >::lex_less_than ( const index_set_t rhs ) const [inline], [private]`

Lexicographic ordering of two sets: `*this < rhs`.

Definition at line 588 of file `index_set_imp.h`.

Referenced by `glucat::compare()`.

6.17.4.13 `template<const index_t LO, const index_t HI> index_t glucat::index_set< LO, HI >::max ( ) const`

Maximum member.

Maximum member, or 0 if none.

Definition at line 550 of file `index_set_imp.h`.

Referenced by `PyClical.index_set::__iter__()`, `glucat::matrix_multi< Scalar_T, LO, HI >::basis_element()`, `glucat::framed_multi< Scalar_T, LO, HI >::centre_pm4_qp4()`, `glucat::index_set< LO, HI >::fold()`, `glucat::framed_multi< Scalar_T, LO, HI >::framed_multi()`, `glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi()`, `glucat::max_pos()`, and `glucat::index_set< LO, HI >::unfold()`.

6.17.4.14 `template<const index_t LO, const index_t HI> index_t glucat::index_set< LO, HI >::min ( ) const`

Minimum member.

Minimum member, or 0 if none.

Definition at line 461 of file index_set_imp.h.

Referenced by PyClical.index_set::__iter__(), glucat::matrix_multi< Scalar_T, LO, HI >::basis_element(), glucat::framed_multi< Scalar_T, LO, HI >::centre_pp4_qm4(), glucat::index_set< LO, HI >::fold(), glucat::framed_multi< Scalar_T, LO, HI >::framed_multi(), glucat::index_set< LO, HI >::index_set(), glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi(), glucat::min_neg(), glucat::index_set< LO, HI >::unfold(), and glucat::index_set< LO, HI >::value_of_fold().

6.17.4.15 `template<const index_t LO, const index_t HI> bool glucat::index_set< LO, HI >::operator!= ( const index_set_t rhs ) const [inline]`

Inequality.

Definition at line 130 of file index_set_imp.h.

6.17.4.16 `template<const index_t LO, const index_t HI> index_set< LO, HI > & glucat::index_set< LO, HI >::operator&= ( const index_set_t rhs ) [inline]`

Set intersection: and.

Definition at line 174 of file index_set_imp.h.

6.17.4.17 `template<const index_t LO, const index_t HI> bool glucat::index_set< LO, HI >::operator< ( const index_set_t rhs ) const [inline]`

Less than operator used for comparisons, map, etc.

Definition at line 597 of file index_set_imp.h.

References glucat::index_set< LO, HI >::count().

6.17.4.18 `template<const index_t LO, const index_t HI> bool glucat::index_set< LO, HI >::operator== ( const index_set_t rhs ) const [inline]`

Equality.

Definition at line 119 of file index_set_imp.h.

6.17.4.19 `template<const index_t LO, const index_t HI> bool glucat::index_set< LO, HI >::operator[] ( const index_t idx ) const [inline]`

Subscripting: Test idx for membership: test value of bit idx.

Definition at line 232 of file index_set_imp.h.

6.17.4.20 `template<const index_t LO, const index_t HI> index_set< LO, HI >::reference glucat::index_set< LO, HI >::operator[] ( index_t idx ) [inline]`

Subscripting: Element access.

Definition at line 224 of file index_set_imp.h.

6.17.4.21 `template<const index_t LO, const index_t HI> index_set< LO, HI > & glucat::index_set< LO, HI >::operator^=( const index_set_t rhs ) [inline]`

Symmetric set difference: exclusive or.

Definition at line 149 of file `index_set_imp.h`.

6.17.4.22 `template<const index_t LO, const index_t HI> index_set< LO, HI > & glucat::index_set< LO, HI >::operator|=( const index_set_t rhs ) [inline]`

Set union: or.

Definition at line 199 of file `index_set_imp.h`.

6.17.4.23 `template<const index_t LO, const index_t HI> index_set< LO, HI > glucat::index_set< LO, HI >::operator~( ) const [inline]`

Set complement: not.

Definition at line 141 of file `index_set_imp.h`.

6.17.4.24 `template<const index_t LO, const index_t HI> index_set< LO, HI > & glucat::index_set< LO, HI >::reset ( ) [inline]`

Make set empty: Set all bits to 0.

Definition at line 294 of file `index_set_imp.h`.

6.17.4.25 `template<const index_t LO, const index_t HI> index_set< LO, HI > & glucat::index_set< LO, HI >::reset ( const index_t idx ) [inline]`

Exclude idx: Set bit at idx to 0.

Definition at line 305 of file `index_set_imp.h`.

6.17.4.26 `template<const index_t LO, const index_t HI> index_set< LO, HI > & glucat::index_set< LO, HI >::set ( ) [inline]`

Include all indices except 0: set all bits except 0.

Definition at line 255 of file `index_set_imp.h`.

Referenced by `glucat::index_set< LO, HI >::fold()`, `glucat::operator>>()`, and `glucat::index_set< LO, HI >::unfold()`.

6.17.4.27 `template<const index_t LO, const index_t HI> index_set< LO, HI > & glucat::index_set< LO, HI >::set ( const index_t idx ) [inline]`

Include idx: Set bit at idx if idx != 0.

Definition at line 266 of file `index_set_imp.h`.

6.17.4.28 `template<const index_t LO, const index_t HI> index_set< LO, HI > & glucat::index_set< LO, HI >::set ( const index_t idx, const int val ) [inline]`

Set membership of idx to val if idx != 0: Set bit at idx to val if idx != 0.

Definition at line 280 of file `index_set_imp.h`.

6.17.4.29 `template<const index_t LO, const index_t HI> int glucat::index_set< LO, HI >::sign_of_mult ( const index_set_t ist ) const`

Sign of geometric product of two Clifford basis elements.

Definition at line 879 of file index_set_imp.h.

References glucat::inverse_gray(), and glucat::inverse_reversed_gray().

6.17.4.30 `template<const index_t LO, const index_t HI> int glucat::index_set< LO, HI >::sign_of_square ( ) const [inline]`

Sign of geometric square of a Clifford basis element.

Definition at line 928 of file index_set_imp.h.

6.17.4.31 `template<const index_t LO, const index_t HI> bool glucat::index_set< LO, HI >::test ( const index_t idx ) const [inline]`

Test idx for membership: test value of bit idx.

Definition at line 240 of file index_set_imp.h.

Referenced by glucat::index_set< LO, HI >::fold(), and glucat::index_set< LO, HI >::unfold().

6.17.4.32 `template<const index_t LO, const index_t HI> const index_set< LO, HI > glucat::index_set< LO, HI >::unfold ( const index_set_t frm, const bool prechecked = false ) const`

Unfold this index set within the given frame.

Definition at line 794 of file index_set_imp.h.

References glucat::index_set< LO, HI >::max(), glucat::index_set< LO, HI >::min(), glucat::index_set< LO, HI >::set(), and glucat::index_set< LO, HI >::test().

Referenced by glucat::index_set< LO, HI >::index_set().

6.17.4.33 `template<const index_t LO, const index_t HI> set_value_t glucat::index_set< LO, HI >::value_of_fold ( const index_set_t frm ) const [inline]`

The set value of the fold of this index set within the given frame.

Definition at line 828 of file index_set_imp.h.

References glucat::index_set< LO, HI >::fold(), and glucat::index_set< LO, HI >::min().

6.17.5 Friends And Related Function Documentation

6.17.5.1 `template<const index_t LO, const index_t HI> int compare ( const index_set_t & lhs, const index_set_t & rhs ) [friend]`

6.17.5.2 `template<const index_t LO, const index_t HI> const index_set_t operator& ( const index_set_t & lhs, const index_set_t & rhs ) [friend]`

6.17.5.3 `template<const index_t LO, const index_t HI> const index_set_t operator^ ( const index_set_t & lhs, const index_set_t & rhs ) [friend]`

6.17.5.4 `template<const index_t LO, const index_t HI> const index_set_t operator| ( const index_set_t & lhs, const index_set_t & rhs ) [friend]`

6.17.5.5 `template<const index_t LO, const index_t HI> friend class reference` [`friend`]

Definition at line 173 of file `index_set.h`.

6.17.6 Member Data Documentation

6.17.6.1 `template<const index_t LO, const index_t HI> const index_t glucat::index_set< LO, HI >::v_hi = HI`
[`static`]

Definition at line 88 of file `index_set.h`.

6.17.6.2 `template<const index_t LO, const index_t HI> const index_t glucat::index_set< LO, HI >::v_lo = LO`
[`static`]

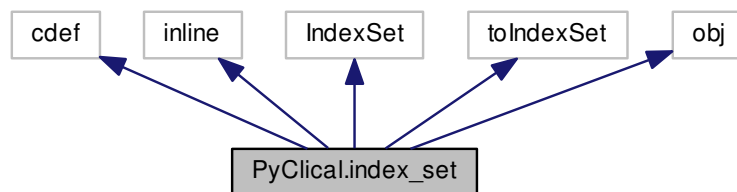
Definition at line 87 of file `index_set.h`.

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

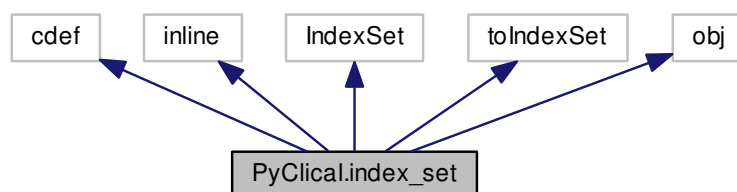
- [glucat/index_set.h](#)
- [glucat/index_set_imp.h](#)

6.18 PyClical.index_set Class Reference

Inheritance diagram for `PyClical.index_set`:



Collaboration diagram for `PyClical.index_set`:



Public Member Functions

- [def __cinit__](#)
- [def __dealloc__](#)
- [def __richcmp__](#)
- [def __setitem__](#)
- [def __getitem__](#)
- [def __contains__](#)
- [def __iter__](#)
- [def __invert__](#)
- [def __xor__](#)
- [def __ixor__](#)
- [def __and__](#)
- [def __iand__](#)
- [def __or__](#)
- [def __ior__](#)
- [def count](#)
- [def count_neg](#)
- [def count_pos](#)
- [def min](#)
- [def max](#)
- [def hash_fn](#)
- [def sign_of_mult](#)
- [def sign_of_square](#)
- [def __repr__](#)
- [def __str__](#)

Public Attributes

- [instance](#)

6.18.1 Detailed Description

Return the C++ IndexSet instance wrapped by `index_set(obj)`.

Python class `index_set` wraps C++ class `IndexSet`.

Definition at line 39 of file `PyClical.pyx`.

6.18.2 Member Function Documentation

6.18.2.1 `def PyClical.index_set.__and__( lhs, rhs )`

Set intersection: `and`.

```
>>> print index_set({1}) & index_set({2})
{}
>>> print index_set({1,2}) & index_set({2})
{2}
```

Definition at line 269 of file `PyClical.pyx`.

6.18.2.2 def PyClical.index_set.__cinit__(self, other = 0)

Construct an object of type index_set.

```
>>> print index_set(1)
{1}
>>> print index_set({1,2})
{1,2}
>>> print index_set(index_set({1,2}))
{1,2}
>>> print index_set({1,2})
{1,2}
>>> print index_set({1,2,1})
{1,2}
>>> print index_set("{1,2,1}")
{1,2}
>>> print index_set("")
{}
```

Definition at line 73 of file PyClical.pyx.

6.18.2.3 def PyClical.index_set.__contains__(self, idx)

Check that an index_set object contains the index idx: idx in self.

```
>>> 1 in index_set({1})
True
>>> 2 in index_set({1})
False
>>> -1 in index_set({2})
False
>>> 1 in index_set({2})
False
>>> 2 in index_set({2})
True
>>> 33 in index_set({2})
False
```

Definition at line 208 of file PyClical.pyx.

6.18.2.4 def PyClical.index_set.__dealloc__(self)

Clean up by deallocating the instance of C++ class IndexSet.

Definition at line 114 of file PyClical.pyx.

References PyClical.index_set.instance.

6.18.2.5 def PyClical.index_set.__getitem__(self, idx)

Get the value of an index_set object at an index.

```
>>> index_set({1})[1]
True
>>> index_set({1})[2]
False
>>> index_set({2})[-1]
False
>>> index_set({2})[1]
False
>>> index_set({2})[2]
True
>>> index_set({2})[33]
False
```

Definition at line 189 of file PyClical.pyx.

6.18.2.6 `def PyClical.index_set.__iand__( self, rhs )`

Set intersection: and.

```
>>> x = index_set({1}); x &= index_set({2}); print x
{}
>>> x = index_set({1,2}); x &= index_set({2}); print x
{2}
```

Definition at line 280 of file PyClical.pyx.

6.18.2.7 `def PyClical.index_set.__invert__( self )`

Set complement: not.

```
>>> print ~index_set({-16,-15,-14,-13,-12,-11,-10,-9,-8,-7,-6,-5,-4,-3,-2,-1,1,2,3,4,5,6,7,8,9,10,11,12,13,14,
{-32,-31,-30,-29,-28,-27,-26,-25,-24,-23,-22,-21,-20,-19,-18,-17,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,
```

Definition at line 238 of file PyClical.pyx.

6.18.2.8 `def PyClical.index_set.__ior__( self, rhs )`

Set union: or.

```
>>> x = index_set({1}); x |= index_set({2}); print x
{1,2}
>>> x = index_set({1,2}); x |= index_set({2}); print x
{1,2}
```

Definition at line 302 of file PyClical.pyx.

6.18.2.9 `def PyClical.index_set.__iter__( self )`

Iterate over the indices of an index_set.

```
>>> for i in index_set({-3,4,7}): print i,
-3 4 7
```

Definition at line 227 of file PyClical.pyx.

References `glucat::index_set< LO, HI >.max()`, `PyClical.index_set.max()`, `glucat::index_set< LO, HI >.min()`, and `PyClical.index_set.min()`.

6.18.2.10 `def PyClical.index_set.__ixor__( self, rhs )`

Symmetric set difference: exclusive or.

```
>>> x = index_set({1}); x ^= index_set({2}); print x
{1,2}
>>> x = index_set({1,2}); x ^= index_set({2}); print x
{1}
```

Definition at line 258 of file PyClical.pyx.

6.18.2.11 `def PyClical.index_set.__or__( lhs, rhs )`

Set union: or.

```
>>> print index_set({1}) | index_set({2})
{1,2}
>>> print index_set({1,2}) | index_set({2})
{1,2}
```

Definition at line 291 of file PyClical.pyx.

6.18.2.12 def PyClical.index_set.__repr__(self)

The “official” string representation of self.

```
>>> index_set({1,2}).__repr__()
'index_set({1,2})'
>>> repr(index_set({1,2}))
'index_set({1,2})'
```

Definition at line 382 of file PyClical.pyx.

References `index_set_to_repr()`.

6.18.2.13 def PyClical.index_set.__richcmp__(lhs, rhs, int, op)

Compare two objects of class `index_set`.

```
>>> index_set(1) == index_set({1})
True
>>> index_set({1}) != index_set({1})
False
>>> index_set({1}) != index_set({2})
True
>>> index_set({1}) == index_set({2})
False
>>> index_set({1}) < index_set({2})
True
>>> index_set({1}) <= index_set({2})
True
>>> index_set({1}) > index_set({2})
False
>>> index_set({1}) >= index_set({2})
False
```

Definition at line 120 of file PyClical.pyx.

6.18.2.14 def PyClical.index_set.__setitem__(self, idx, val)

Set the value of an `index_set` object at index `idx` to value `val`.

```
>>> s=index_set({1}); s[2] = True; print s
{1,2}
>>> s=index_set({1,2}); s[1] = False; print s
{2}
```

Definition at line 177 of file PyClical.pyx.

6.18.2.15 def PyClical.index_set.__str__(self)

The “informal” string representation of self.

```
>>> index_set({1,2}).__str__()
'{1,2}'
>>> str(index_set({1,2}))
'{1,2}'
```

Definition at line 393 of file PyClical.pyx.

References `index_set_to_str()`.

6.18.2.16 def PyClical.index_set.__xor__(lhs, rhs)

Symmetric set difference: exclusive or.

```
>>> print index_set({1}) ^ index_set({2})
{1,2}
>>> print index_set({1,2}) ^ index_set({2})
{1}
```

Definition at line 247 of file PyClical.pyx.

6.18.2.17 def PyClical.index_set.count(self)

Cardinality: Number of indices included in set.

```
>>> index_set({-1,1,2}).count()
3
```

Definition at line 313 of file PyClical.pyx.

6.18.2.18 def PyClical.index_set.count_neg(self)

Number of negative indices included in set.

```
>>> index_set({-1,1,2}).count_neg()
1
```

Definition at line 322 of file PyClical.pyx.

6.18.2.19 def PyClical.index_set.count_pos(self)

Number of positive indices included in set.

```
>>> index_set({-1,1,2}).count_pos()
2
```

Definition at line 331 of file PyClical.pyx.

6.18.2.20 def PyClical.index_set.hash_fn(self)

Hash function.

Definition at line 358 of file PyClical.pyx.

6.18.2.21 def PyClical.index_set.max(self)

Maximum member.

```
>>> index_set({-1,1,2}).max()
2
```

Definition at line 349 of file PyClical.pyx.

Referenced by PyClical.index_set.__iter__().

6.18.2.22 `def PyClical.index_set.min ( self )`

Minimum member.

```
>>> index_set({-1,1,2}).min()
-1
```

Definition at line 340 of file PyClical.pyx.

Referenced by `PyClical.index_set.__iter__()`.

6.18.2.23 `def PyClical.index_set.sign_of_mult ( self, rhs )`

Sign of geometric product of two Clifford basis elements.

```
>>> s = index_set({1,2}); t=index_set({-1}); s.sign_of_mult(t)
1
```

Definition at line 364 of file PyClical.pyx.

6.18.2.24 `def PyClical.index_set.sign_of_square ( self )`

Sign of geometric square of a Clifford basis element.

```
>>> s = index_set({1,2}); s.sign_of_square()
-1
```

Definition at line 373 of file PyClical.pyx.

6.18.3 Member Data Documentation**6.18.3.1** `PyClical.index_set.instance`

Definition at line 94 of file PyClical.pyx.

Referenced by `PyClical.index_set.__dealloc__()`, and `PyClical.clifford.__dealloc__()`.

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

- [pyclical/PyClical.pyx](#)

6.19 `glucat::index_set_hash< LO, HI >` Class Template Reference

```
#include <framed_multi.h>
```

Public Types

- typedef [index_set< LO, HI >](#) [index_set_t](#)

Public Member Functions

- [size_t operator\(\)](#) ([index_set_t](#) val) const

6.19.1 Detailed Description

```
template<const index_t LO, const index_t HI>class glucat::index_set_hash< LO, HI >
```

Definition at line 126 of file framed_multi.h.

6.19.2 Member Typedef Documentation

6.19.2.1 `template<const index_t LO, const index_t HI> typedef index_set<LO,HI> glucat::index_set_hash< LO, HI >::index_set_t`

Definition at line 129 of file framed_multi.h.

6.19.3 Member Function Documentation

6.19.3.1 `template<const index_t LO, const index_t HI> size_t glucat::index_set_hash< LO, HI >::operator() ( index_set_t val ) const [inline]`

Definition at line 130 of file framed_multi.h.

References `glucat::index_set< LO, HI >::hash_fn()`.

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

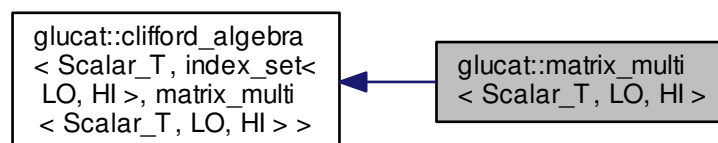
- [glucat/framed_multi.h](#)

6.20 glucat::matrix_multi< Scalar_T, LO, HI > Class Template Reference

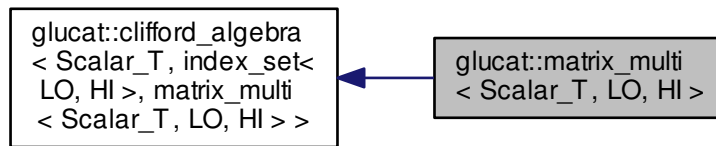
A `matrix_multi<Scalar_T,LO,HI>` is a matrix approximation to a multivector.

```
#include <framed_multi.h>
```

Inheritance diagram for `glucat::matrix_multi< Scalar_T, LO, HI >`:



Collaboration diagram for `glucat::matrix_multi< Scalar_T, LO, HI >`:



Public Types

- typedef `matrix_multi` `multivector_t`
- typedef `multivector_t` `matrix_multi_t`
- typedef `Scalar_T` `scalar_t`
- typedef `index_set< LO, HI >` `index_set_t`
- typedef `std::pair< const index_set_t, Scalar_T >` `term_t`
- typedef `std::vector< Scalar_T >` `vector_t`
- typedef `error< multivector_t >` `error_t`
- typedef `framed_multi< Scalar_T, LO, HI >` `framed_multi_t`

Public Member Functions

- `~matrix_multi ()`
Destructor.
- `matrix_multi ()`
Default constructor.
- `template<typename Other_Scalar_T > matrix_multi (const matrix_multi< Other_Scalar_T, LO, HI > &val)`
Construct a multivector from a multivector with a different scalar type.
- `template<typename Other_Scalar_T > matrix_multi (const matrix_multi< Other_Scalar_T, LO, HI > &val, const index_set_t frm, const bool prechecked=false)`
Construct a multivector, within a given frame, from a given multivector.
- `matrix_multi (const multivector_t &val, const index_set_t frm, const bool prechecked=false)`
Construct a multivector, within a given frame, from a given multivector.
- `matrix_multi (const index_set_t ist, const Scalar_T &crd=Scalar_T(1))`
Construct a multivector from an index set and a scalar coordinate.
- `matrix_multi (const index_set_t ist, const Scalar_T &crd, const index_set_t frm, const bool prechecked=false)`
Construct a multivector, within a given frame, from an index set and a scalar coordinate.
- `matrix_multi (const Scalar_T &scr, const index_set_t frm=index_set_t())`
Construct a multivector from a scalar (within a frame, if given)
- `matrix_multi (const int scr, const index_set_t frm=index_set_t())`
Construct a multivector from an int (within a frame, if given)
- `matrix_multi (const vector_t &vec, const index_set_t frm, const bool prechecked=false)`
Construct a multivector, within a given frame, from a given vector.

- `matrix_multi` (const std::string &str)
Construct a multivector from a string: eg: "3+2{1,2}-6.1e-2{2,3}".
- `matrix_multi` (const std::string &str, const `index_set_t` frm, const bool prechecked=false)
Construct a multivector, within a given frame, from a string: eg: "3+2{1,2}-6.1e-2{2,3}".
- `matrix_multi` (const char *str)
Construct a multivector from a char: eg: "3+2{1,2}-6.1e-2{2,3}".*
- `matrix_multi` (const char *str, const `index_set_t` frm, const bool prechecked=false)
Construct a multivector, within a given frame, from a char: eg: "3+2{1,2}-6.1e-2{2,3}".*
- template<typename Other_Scalar_T >
`matrix_multi` (const `framed_multi`< Other_Scalar_T, LO, HI > &val)
Construct a multivector from a framed_multi_t.
- template<typename Other_Scalar_T >
`matrix_multi` (const `framed_multi`< Other_Scalar_T, LO, HI > &val, const `index_set_t` frm, const bool prechecked=false)
Construct a multivector, within a given frame, from a framed_multi_t.
- const `matrix_multi_t` `fast_matrix_multi` (const `index_set_t` frm) const
Use generalized FFT to construct a matrix_multi_t.
- template<typename Other_Scalar_T >
const `framed_multi`
< Other_Scalar_T, LO, HI > `fast_framed_multi` () const
Use inverse generalized FFT to construct a framed_multi_t.
- `_GLUCAT_CLIFFORD_ALGEBRA_OPERATIONS`
`multivector_t` & `operator=` (const `multivector_t` &rhs)
Assignment operator.
- `multivector_t` & `operator+=` (const `term_t` &rhs)
Add a term, if non-zero.

Static Public Member Functions

- static const std::string `classname` ()
Class name used in messages.
- static const `matrix_multi_t` `random` (const `index_set_t` frm, Scalar_T fill=Scalar_T(1))
Random multivector within a frame.

Private Types

- typedef ublas::row_major `orientation_t`
- typedef
ublas::compressed_matrix< int,
`orientation_t` > `basis_matrix_t`
- typedef
ublas::compressed_matrix
< Scalar_T, `orientation_t` > `matrix_t`
- typedef matrix_t::size_type `matrix_index_t`

Private Member Functions

- template<typename Matrix_T >
`matrix_multi` (const Matrix_T &mtx, const `index_set_t` frm)
Construct a multivector within a given frame from a given matrix.
- `matrix_multi` (const `matrix_t` &mtx, const `index_set_t` frm)
Construct a multivector within a given frame from a given matrix.
- const `basis_matrix_t` `basis_element` (const `index_set`< LO, HI > &ist) const
Create a basis element matrix within the current frame.

Private Attributes

- [index_set_t m_frame](#)
Index set representing the frame for the subalgebra which contains the multivector.
- [matrix_t m_matrix](#)
Matrix value representing the multivector within the folded frame.

Friends

- `template<typename Other_Scalar_T , const index_t Other_LO, const index_t Other_HI>`
`class framed_multi`
- `template<typename Other_Scalar_T , const index_t Other_LO, const index_t Other_HI>`
`class matrix_multi`
- `const matrix_multi_t operator* (const matrix_multi_t &lhs, const matrix_multi_t &rhs)`
- `const matrix_multi_t operator^ (const matrix_multi_t &lhs, const matrix_multi_t &rhs)`
- `const matrix_multi_t operator& (const matrix_multi_t &lhs, const matrix_multi_t &rhs)`
- `const matrix_multi_t operator% (const matrix_multi_t &lhs, const matrix_multi_t &rhs)`
- `Scalar_T star (const matrix_multi_t &lhs, const matrix_multi_t &rhs)`
- `const matrix_multi_t operator/ (const matrix_multi_t &lhs, const matrix_multi_t &rhs)`
- `const matrix_multi_t operator| (const matrix_multi_t &lhs, const matrix_multi_t &rhs)`
- `std::istream & operator>> (std::istream &s, multivector_t &val)`
- `std::ostream & operator<< (std::ostream &os, const multivector_t &val)`
- `std::ostream & operator<< (std::ostream &os, const term_t &term)`
- `template<typename Other_Scalar_T , const index_t Other_LO, const index_t Other_HI>`
`const index_set< Other_LO,`
`Other_HI > reframe (const matrix_multi< Other_Scalar_T, Other_LO, Other_HI > &lhs, const matrix_multi<`
`Other_Scalar_T, Other_LO, Other_HI > &rhs, matrix_multi< Other_Scalar_T, Other_LO, Other_HI > &lhs_`
`reframed, matrix_multi< Other_Scalar_T, Other_LO, Other_HI > &rhs_reframed)`
- `template<typename Other_Scalar_T , const index_t Other_LO, const index_t Other_HI>`
`const matrix_multi`
`< Other_Scalar_T, Other_LO,`
`Other_HI > matrix_sqrt (const matrix_multi< Other_Scalar_T, Other_LO, Other_HI > &val, const matrix_`
`multi< Other_Scalar_T, Other_LO, Other_HI > &i)`
- `template<typename Other_Scalar_T , const index_t Other_LO, const index_t Other_HI>`
`const matrix_multi`
`< Other_Scalar_T, Other_LO,`
`Other_HI > matrix_log (const matrix_multi< Other_Scalar_T, Other_LO, Other_HI > &val, const matrix_`
`multi< Other_Scalar_T, Other_LO, Other_HI > &i)`

6.20.1 Detailed Description

```
template<typename Scalar_T, const index_t LO, const index_t HI> class glucat::matrix_multi< Scalar_T, LO, HI >
```

A `matrix_multi<Scalar_T,LO,HI>` is a matrix approximation to a multivector.

Definition at line 68 of file `framed_multi.h`.

6.20.2 Member Typedef Documentation

6.20.2.1 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef ublas::compressed_matrix< int,`
`orientation_t > glucat::matrix_multi< Scalar_T, LO, HI >::basis_matrix_t [private]`

Definition at line 152 of file `matrix_multi.h`.

6.20.2.2 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef error<multivector_t>
glucat::matrix_multi< Scalar_T, LO, HI >::error_t`

Definition at line 142 of file matrix_multi.h.

6.20.2.3 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef framed_multi<Scalar_T,LO,HI>
glucat::matrix_multi< Scalar_T, LO, HI >::framed_multi_t`

Definition at line 143 of file matrix_multi.h.

6.20.2.4 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef index_set<LO,HI>
glucat::matrix_multi< Scalar_T, LO, HI >::index_set_t`

Definition at line 139 of file matrix_multi.h.

6.20.2.5 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef matrix_t::size_type
glucat::matrix_multi< Scalar_T, LO, HI >::matrix_index_t [private]`

Definition at line 159 of file matrix_multi.h.

6.20.2.6 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef multivector_t glucat::matrix_multi<
Scalar_T, LO, HI >::matrix_multi_t`

Definition at line 137 of file matrix_multi.h.

6.20.2.7 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef ublas::compressed_matrix< Scalar_T,
orientation_t > glucat::matrix_multi< Scalar_T, LO, HI >::matrix_t [private]`

Definition at line 157 of file matrix_multi.h.

6.20.2.8 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef matrix_multi glucat::matrix_multi<
Scalar_T, LO, HI >::multivector_t`

Definition at line 136 of file matrix_multi.h.

6.20.2.9 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef ublas::row_major
glucat::matrix_multi< Scalar_T, LO, HI >::orientation_t [private]`

Definition at line 150 of file matrix_multi.h.

6.20.2.10 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef Scalar_T glucat::matrix_multi<
Scalar_T, LO, HI >::scalar_t`

Definition at line 138 of file matrix_multi.h.

6.20.2.11 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef std::pair<const index_set_t,
Scalar_T> glucat::matrix_multi< Scalar_T, LO, HI >::term_t`

Definition at line 140 of file matrix_multi.h.

6.20.2.12 `template<typename Scalar_T, const index_t LO, const index_t HI> typedef std::vector<Scalar_T>
glucat::matrix_multi< Scalar_T, LO, HI >::vector_t`

Definition at line 141 of file `matrix_multi.h`.

6.20.3 Constructor & Destructor Documentation

6.20.3.1 `template<typename Scalar_T, const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI
>::~matrix_multi () [inline]`

Destructor.

Definition at line 165 of file `matrix_multi.h`.

6.20.3.2 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI
>::matrix_multi ()`

Default constructor.

Definition at line 97 of file `matrix_multi_imp.h`.

References `glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix`.

Referenced by `glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi()`.

6.20.3.3 `template<typename Scalar_T , const index_t LO, const index_t HI> template<typename Other_Scalar_T >
glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi (const matrix_multi< Other_Scalar_T, LO, HI > &
val)`

Construct a multivector from a multivector with a different scalar type.

Definition at line 106 of file `matrix_multi_imp.h`.

References `glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix`.

6.20.3.4 `template<typename Scalar_T , const index_t LO, const index_t HI> template<typename Other_Scalar_T >
glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi (const matrix_multi< Other_Scalar_T, LO, HI > &
val, const index_set_t frm, const bool prechecked = false)`

Construct a multivector, within a given frame, from a given multivector.

Definition at line 128 of file `matrix_multi_imp.h`.

References `glucat::matrix_multi< Scalar_T, LO, HI >::m_frame`, and `glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix`.

6.20.3.5 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI
>::matrix_multi (const multivector_t & val, const index_set_t frm, const bool prechecked = false)`

Construct a multivector, within a given frame, from a given multivector.

Definition at line 156 of file `matrix_multi_imp.h`.

References `glucat::matrix_multi< Scalar_T, LO, HI >::m_frame`, and `glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix`.

6.20.3.6 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const index_set_t ist, const Scalar_T & crd = Scalar_T(1) )`

Construct a multivector from an index set and a scalar coordinate.

Definition at line 168 of file matrix_multi_imp.h.

References glucat::matrix_multi< Scalar_T, LO, HI >::m_frame, and glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix.

6.20.3.7 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const index_set_t ist, const Scalar_T & crd, const index_set_t frm, const bool prechecked = false )`

Construct a multivector, within a given frame, from an index set and a scalar coordinate.

Definition at line 180 of file matrix_multi_imp.h.

References glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix.

6.20.3.8 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const Scalar_T & scr, const index_set_t frm = index_set_t () )`

Construct a multivector from a scalar (within a frame, if given)

Definition at line 194 of file matrix_multi_imp.h.

References glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix.

6.20.3.9 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const int scr, const index_set_t frm = index_set_t () )`

Construct a multivector from an int (within a frame, if given)

Definition at line 206 of file matrix_multi_imp.h.

6.20.3.10 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const vector_t & vec, const index_set_t frm, const bool prechecked = false )`

Construct a multivector, within a given frame, from a given vector.

Definition at line 212 of file matrix_multi_imp.h.

References glucat::index_set< LO, HI >::count(), glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix, glucat::index_set< LO, HI >::max(), and glucat::index_set< LO, HI >::min().

6.20.3.11 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const std::string & str )`

Construct a multivector from a string: eg: "3+2{1,2}-6.1e-2{2,3}".

Definition at line 239 of file matrix_multi_imp.h.

6.20.3.12 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const std::string & str, const index_set_t frm, const bool prechecked = false )`

Construct a multivector, within a given frame, from a string: eg: "3+2{1,2}-6.1e-2{2,3}".

Definition at line 245 of file matrix_multi_imp.h.

6.20.3.13 `template<typename Scalar_T, const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const char * str ) [inline]`

Construct a multivector from a char*: eg: "3+2{1,2}-6.1e-2{2,3}".

Definition at line 196 of file matrix_multi.h.

References glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi().

6.20.3.14 `template<typename Scalar_T, const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const char * str, const index_set_t frm, const bool prechecked = false ) [inline]`

Construct a multivector, within a given frame, from a char*: eg: "3+2{1,2}-6.1e-2{2,3}".

Definition at line 199 of file matrix_multi.h.

References glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi().

6.20.3.15 `template<typename Scalar_T , const index_t LO, const index_t HI> template<typename Other_Scalar_T > glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const framed_multi< Other_Scalar_T, LO, HI > & val )`

Construct a multivector from a framed_multi_t.

Definition at line 252 of file matrix_multi_imp.h.

References PyClical::e(), glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::fast_size_threshold, glucat::matrix_multi< Scalar_T, LO, HI >::m_frame, and glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix.

6.20.3.16 `template<typename Scalar_T , const index_t LO, const index_t HI> template<typename Other_Scalar_T > glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const framed_multi< Other_Scalar_T, LO, HI > & val, const index_set_t frm, const bool prechecked = false )`

Construct a multivector, within a given frame, from a framed_multi_t.

Definition at line 279 of file matrix_multi_imp.h.

References PyClical::e(), glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::fast_size_threshold, and glucat::clifford_algebra< Scalar_T, index_set< LO, HI >, framed_multi< Scalar_T, LO, HI > >::frame().

6.20.3.17 `template<typename Scalar_T , const index_t LO, const index_t HI> template<typename Matrix_T > glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const Matrix_T & mtx, const index_set_t frm ) [private]`

Construct a multivector within a given frame from a given matrix.

Definition at line 307 of file matrix_multi_imp.h.

References glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix.

6.20.3.18 `template<typename Scalar_T , const index_t LO, const index_t HI> glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi ( const matrix_t & mtx, const index_set_t frm ) [private]`

Construct a multivector within a given frame from a given matrix.

Definition at line 328 of file matrix_multi_imp.h.

6.20.4 Member Function Documentation

6.20.4.1 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI >::basis_matrix_t glucat::matrix_multi< Scalar_T, LO, HI >::basis_element ( const index_set< LO, HI > & ist ) const` `[private]`

Create a basis element matrix within the current frame.

Definition at line 1243 of file `matrix_multi_imp.h`.

References `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >::basis_max_count`, `PyClical::e()`, `glucat::index_set< LO, HI >::fold()`, `glucat::gen::generator_table< Matrix_T >::generator()`, `glucat::index_set< LO, HI >::max()`, `glucat::index_set< LO, HI >::min()`, `glucat::matrix::mono_prod()`, and `glucat::offset_level()`.

Referenced by `glucat::framed_multi< Scalar_T, LO, HI >::framed_multi()`.

6.20.4.2 `template<typename Scalar_T, const index_t LO, const index_t HI> const std::string glucat::matrix_multi< Scalar_T, LO, HI >::classname ( )` `[static]`

Class name used in messages.

Definition at line 69 of file `matrix_multi_imp.h`.

6.20.4.3 `template<typename Scalar_T, const index_t LO, const index_t HI> template<typename Other_Scalar_T> const framed_multi< Other_Scalar_T, LO, HI > glucat::matrix_multi< Scalar_T, LO, HI >::fast_framed_multi ( ) const`

Use inverse generalized FFT to construct a `framed_multi_t`.

Definition at line 1166 of file `matrix_multi_imp.h`.

References `glucat::framed_multi< Scalar_T, LO, HI >::centre_pm4_qp4()`, `glucat::framed_multi< Scalar_T, LO, HI >::centre_pp4_qm4()`, `glucat::framed_multi< Scalar_T, LO, HI >::centre_qp1_pm1()`, `glucat::gen::offset_to_super`, `glucat::pos_mod()`, and `glucat::framed_multi< Scalar_T, LO, HI >::unfold()`.

6.20.4.4 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI > glucat::matrix_multi< Scalar_T, LO, HI >::fast_matrix_multi ( const index_set_t frm ) const` `[inline]`

Use generalized FFT to construct a `matrix_multi_t`.

Definition at line 1153 of file `matrix_multi_imp.h`.

6.20.4.5 `template<typename Scalar_T, const index_t LO, const index_t HI> matrix_multi< Scalar_T, LO, HI > & glucat::matrix_multi< Scalar_T, LO, HI >::operator+=( const term_t & rhs )` `[inline]`

Add a term, if non-zero.

Geometric sum.

Geometric sum of multivector and scalar.

Definition at line 470 of file `matrix_multi_imp.h`.

6.20.4.6 `template<typename Scalar_T, const index_t LO, const index_t HI> matrix_multi< Scalar_T, LO, HI > & glucat::matrix_multi< Scalar_T, LO, HI >::operator=( const multivector_t & rhs )`

Assignment operator.

Definition at line 336 of file `matrix_multi_imp.h`.

References `glucat::matrix_multi< Scalar_T, LO, HI >::m_frame`, and `glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix`.

6.20.4.7 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi< Scalar_T, LO, HI >`
`glucat::matrix_multi< Scalar_T, LO, HI >::random ( const index_set_t frm, Scalar_T fill = Scalar_T(1) )`
`[static]`

Random multivector within a frame.

Definition at line 996 of file `matrix_multi_imp.h`.

References `glucat::framed_multi< Scalar_T, LO, HI >::random()`.

6.20.5 Friends And Related Function Documentation

6.20.5.1 `template<typename Scalar_T, const index_t LO, const index_t HI> template<typename Other_Scalar_T, const`
`index_t Other_LO, const index_t Other_HI> friend class framed_multi [friend]`

Definition at line 145 of file `matrix_multi.h`.

6.20.5.2 `template<typename Scalar_T, const index_t LO, const index_t HI> template<typename Other_Scalar_T, const`
`index_t Other_LO, const index_t Other_HI> const matrix_multi<Other_Scalar_T,Other_LO,Other_HI> matrix_log`
`( const matrix_multi< Other_Scalar_T, Other_LO, Other_HI > & val, const matrix_multi< Other_Scalar_T,`
`Other_LO, Other_HI > & i ) [friend]`

6.20.5.3 `template<typename Scalar_T, const index_t LO, const index_t HI> template<typename Other_Scalar_T, const`
`index_t Other_LO, const index_t Other_HI> friend class matrix_multi [friend]`

Definition at line 147 of file `matrix_multi.h`.

6.20.5.4 `template<typename Scalar_T, const index_t LO, const index_t HI> template<typename Other_Scalar_T, const`
`index_t Other_LO, const index_t Other_HI> const matrix_multi<Other_Scalar_T,Other_LO,Other_HI> matrix_sqrt`
`( const matrix_multi< Other_Scalar_T, Other_LO, Other_HI > & val, const matrix_multi< Other_Scalar_T,`
`Other_LO, Other_HI > & i ) [friend]`

6.20.5.5 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi_t operator% ( const`
`matrix_multi_t & lhs, const matrix_multi_t & rhs ) [friend]`

6.20.5.6 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi_t operator& ( const`
`matrix_multi_t & lhs, const matrix_multi_t & rhs ) [friend]`

6.20.5.7 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi_t operator* ( const`
`matrix_multi_t & lhs, const matrix_multi_t & rhs ) [friend]`

6.20.5.8 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi_t operator/ ( const`
`matrix_multi_t & lhs, const matrix_multi_t & rhs ) [friend]`

6.20.5.9 `template<typename Scalar_T, const index_t LO, const index_t HI> std::ostream& operator<< ( std::ostream & os,`
`const multivector_t & val ) [friend]`

6.20.5.10 `template<typename Scalar_T, const index_t LO, const index_t HI> std::ostream& operator<< ( std::ostream & os,`
`const term_t & term ) [friend]`

6.20.5.11 `template<typename Scalar_T, const index_t LO, const index_t HI> std::istream& operator>> ( std::istream & s, multivector_t & val ) [friend]`

6.20.5.12 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi_t operator^ ( const matrix_multi_t & lhs, const matrix_multi_t & rhs ) [friend]`

6.20.5.13 `template<typename Scalar_T, const index_t LO, const index_t HI> const matrix_multi_t operator| ( const matrix_multi_t & lhs, const matrix_multi_t & rhs ) [friend]`

6.20.5.14 `template<typename Scalar_T, const index_t LO, const index_t HI> template<typename Other_Scalar_T, const index_t Other_LO, const index_t Other_HI> const index_set<Other_LO,Other_HI> reframe (const matrix_multi< Other_Scalar_T, Other_LO, Other_HI > & lhs, const matrix_multi< Other_Scalar_T, Other_LO, Other_HI > & rhs, matrix_multi< Other_Scalar_T, Other_LO, Other_HI > & lhs_reframed, matrix_multi< Other_Scalar_T, Other_LO, Other_HI > & rhs_reframed) [friend]`

6.20.5.15 `template<typename Scalar_T, const index_t LO, const index_t HI> Scalar_T star ( const matrix_multi_t & lhs, const matrix_multi_t & rhs ) [friend]`

6.20.6 Member Data Documentation

6.20.6.1 `template<typename Scalar_T, const index_t LO, const index_t HI> index_set_t glucat::matrix_multi< Scalar_T, LO, HI >::m_frame [private]`

Index set representing the frame for the subalgebra which contains the multivector.

Definition at line 275 of file `matrix_multi.h`.

Referenced by `glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi()`, `glucat::operator*()`, `glucat::operator/()`, `glucat::matrix_multi< Scalar_T, LO, HI >::operator=()`, and `glucat::reframe()`.

6.20.6.2 `template<typename Scalar_T, const index_t LO, const index_t HI> matrix_t glucat::matrix_multi< Scalar_T, LO, HI >::m_matrix [private]`

Matrix value representing the multivector within the folded frame.

Definition at line 277 of file `matrix_multi.h`.

Referenced by `glucat::framed_multi< Scalar_T, LO, HI >::framed_multi()`, `glucat::matrix_multi< Scalar_T, LO, HI >::matrix_multi()`, `glucat::operator*()`, and `glucat::matrix_multi< Scalar_T, LO, HI >::operator=()`.

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

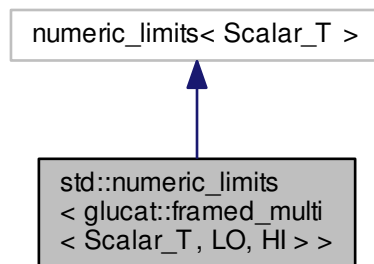
- [glucat/framed_multi.h](#)
- [glucat/matrix_multi.h](#)
- [glucat/matrix_multi_imp.h](#)

6.21 `std::numeric_limits< glucat::framed_multi< Scalar_T, LO, HI > >` Struct Template Reference

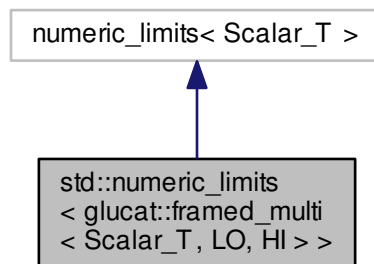
Numeric limits for `framed_multi` inherit limits for the corresponding scalar type.

```
#include <framed_multi.h>
```

Inheritance diagram for `std::numeric_limits< glucat::framed_multi< Scalar_T, LO, HI > >`:



Collaboration diagram for `std::numeric_limits< glucat::framed_multi< Scalar_T, LO, HI > >`:



6.21.1 Detailed Description

```
template<typename Scalar_T, const glucat::index_t LO, const glucat::index_t HI>struct std::numeric_limits< glucat::framed_multi< Scalar_T, LO, HI > >
```

Numeric limits for `framed_multi` inherit limits for the corresponding scalar type.

Definition at line 374 of file `framed_multi.h`.

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

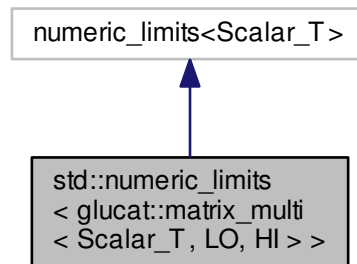
- [glucat/framed_multi.h](#)

6.22 std::numeric_limits< glucat::matrix_multi< Scalar_T, LO, HI > > Struct Template Reference

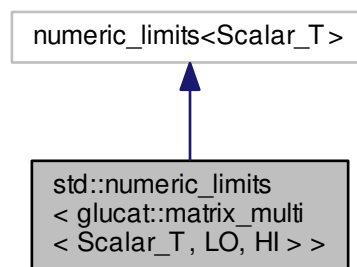
Numeric limits for `matrix_multi` inherit limits for the corresponding scalar type.

```
#include <matrix_multi.h>
```

Inheritance diagram for `std::numeric_limits< glucat::matrix_multi< Scalar_T, LO, HI > >`:



Collaboration diagram for `std::numeric_limits< glucat::matrix_multi< Scalar_T, LO, HI > >`:



6.22.1 Detailed Description

```
template<typename Scalar_T, const glucat::index_t LO, const glucat::index_t HI>struct std::numeric_limits< glucat::matrix_multi< Scalar_T, LO, HI > >
```

Numeric limits for `matrix_multi` inherit limits for the corresponding scalar type.

Definition at line 293 of file `matrix_multi.h`.

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

- [glucat/matrix_multi.h](#)

6.23 glucat::numeric_traits< Scalar_T > Class Template Reference

Extra traits which extend numeric limits.

```
#include <scalar.h>
```

Classes

- struct [demoted](#)
Demoted type for long double.
- struct [promoted](#)
Promoted type.

Public Member Functions

- `template<>`
long double [pi](#) ()
- `template<>`
long double [ln_2](#) ()
- `template<>`
float [to_scalar_t](#) (const Other_Scalar_T &val)
- `template<>`
double [to_scalar_t](#) (const Other_Scalar_T &val)
- `template<>`
long double [to_scalar_t](#) (const dd_real &val)
- `template<>`
long double [to_scalar_t](#) (const qd_real &val)
- `template<>`
dd_real [to_scalar_t](#) (const long double &val)
- `template<>`
dd_real [to_scalar_t](#) (const qd_real &val)
- `template<>`
qd_real [to_scalar_t](#) (const long double &val)
- `template<>`
qd_real [to_scalar_t](#) (const dd_real &val)

Static Public Member Functions

- static bool [isInf](#) (const Scalar_T &val)
Smart isinf.
- static bool [isNaN](#) (const Scalar_T &val)
Smart isnan.
- static bool [isNaN_or_isInf](#) (const Scalar_T &val)
Smart isnan or isinf.
- static Scalar_T [NaN](#) ()
Smart NaN.
- static int [to_int](#) (const Scalar_T &val)
Cast to int.
- static double [to_double](#) (const Scalar_T &val)
Cast to double.
- `template<typename Other_Scalar_T >`
static Scalar_T [to_scalar_t](#) (const Other_Scalar_T &val)
Cast to Scalar_T.
- static Scalar_T [fmod](#) (const Scalar_T &lhs, const Scalar_T &rhs)
Modulo function for scalar.
- static Scalar_T [conj](#) (const Scalar_T &val)
Complex conjugate of scalar.
- static Scalar_T [real](#) (const Scalar_T &val)
Real part of scalar.

- static Scalar_T [imag](#) (const Scalar_T &val)
Imaginary part of scalar.
- static Scalar_T [abs](#) (const Scalar_T &val)
Absolute value of scalar.
- static Scalar_T [pi](#) ()
Pi.
- static Scalar_T [ln_2](#) ()
log(2)
- static Scalar_T [pow](#) (const Scalar_T &val, int n)
Integer power.
- static Scalar_T [sqrt](#) (const Scalar_T &val)
Square root of scalar.
- static Scalar_T [exp](#) (const Scalar_T &val)
Exponential.
- static Scalar_T [log](#) (const Scalar_T &val)
Logarithm of scalar.
- static Scalar_T [log2](#) (const Scalar_T &val)
Log base 2.
- static Scalar_T [cos](#) (const Scalar_T &val)
Cosine of scalar.
- static Scalar_T [acos](#) (const Scalar_T &val)
Inverse cosine of scalar.
- static Scalar_T [cosh](#) (const Scalar_T &val)
Hyperbolic cosine of scalar.
- static Scalar_T [sin](#) (const Scalar_T &val)
Sine of scalar.
- static Scalar_T [asin](#) (const Scalar_T &val)
Inverse sine of scalar.
- static Scalar_T [sinh](#) (const Scalar_T &val)
Hyperbolic sine of scalar.
- static Scalar_T [tan](#) (const Scalar_T &val)
Tangent of scalar.
- static Scalar_T [atan](#) (const Scalar_T &val)
Inverse tangent of scalar.
- static Scalar_T [tanh](#) (const Scalar_T &val)
Hyperbolic tangent of scalar.

Static Private Member Functions

- static bool [isInf](#) (const Scalar_T &val, [bool_to_type](#)< false >)
Smart isinf specialised for Scalar_T without infinity.
- static bool [isInf](#) (const Scalar_T &val, [bool_to_type](#)< true >)
Smart isinf specialised for Scalar_T with infinity.
- static bool [isNaN](#) (const Scalar_T &val, [bool_to_type](#)< false >)
Smart isnan specialised for Scalar_T without quiet NaN.
- static bool [isNaN](#) (const Scalar_T &val, [bool_to_type](#)< true >)
Smart isnan specialised for Scalar_T with quiet NaN.

6.23.1 Detailed Description

```
template<typename Scalar_T>class glucat::numeric_traits< Scalar_T >
```

Extra traits which extend numeric limits.

Definition at line 46 of file scalar.h.

6.23.2 Member Function Documentation

6.23.2.1 `template<typename Scalar_T > static Scalar_T glucat::numeric_traits< Scalar_T >::abs ( const Scalar_T & val ) [inline],[static]`

Absolute value of scalar.

Definition at line 181 of file scalar.h.

References UBLAS_ABS.

6.23.2.2 `template<typename Scalar_T > static Scalar_T glucat::numeric_traits< Scalar_T >::acos ( const Scalar_T & val ) [inline],[static]`

Inverse cosine of scalar.

Definition at line 244 of file scalar.h.

References glucat::acos().

6.23.2.3 `template<typename Scalar_T > static Scalar_T glucat::numeric_traits< Scalar_T >::asin ( const Scalar_T & val ) [inline],[static]`

Inverse sine of scalar.

Definition at line 265 of file scalar.h.

References glucat::asin().

6.23.2.4 `template<typename Scalar_T > static Scalar_T glucat::numeric_traits< Scalar_T >::atan ( const Scalar_T & val ) [inline],[static]`

Inverse tangent of scalar.

Definition at line 286 of file scalar.h.

References glucat::atan().

6.23.2.5 `template<typename Scalar_T > static Scalar_T glucat::numeric_traits< Scalar_T >::conj ( const Scalar_T & val ) [inline],[static]`

Complex conjugate of scalar.

Definition at line 160 of file scalar.h.

6.23.2.6 `template<typename Scalar_T > static Scalar_T glucat::numeric_traits< Scalar_T >::cos ( const Scalar_T & val ) [inline],[static]`

Cosine of scalar.

Definition at line 237 of file scalar.h.

References glucat::cos().

6.23.2.7 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T >::cosh ( const Scalar_T & val ) [inline],[static]`

Hyperbolic cosine of scalar.

Definition at line 251 of file scalar.h.

References glucat::cosh().

6.23.2.8 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T >::exp ( const Scalar_T & val ) [inline],[static]`

Exponential.

Definition at line 216 of file scalar.h.

References glucat::exp().

6.23.2.9 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T >::fmod ( const Scalar_T & lhs, const Scalar_T & rhs ) [inline],[static]`

Modulo function for scalar.

Definition at line 153 of file scalar.h.

6.23.2.10 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T >::imag ( const Scalar_T & val ) [inline],[static]`

Imaginary part of scalar.

Definition at line 174 of file scalar.h.

6.23.2.11 `template<typename Scalar_T> static bool glucat::numeric_traits< Scalar_T >::isInf ( const Scalar_T & val, bool_to_type< false > ) [inline],[static],[private]`

Smart isinf specialised for Scalar_T without infinity.

Definition at line 53 of file scalar.h.

Referenced by glucat::numeric_traits< Scalar_T >::isInf(), and glucat::numeric_traits< Scalar_T >::isNaN_or_isInf().

6.23.2.12 `template<typename Scalar_T> static bool glucat::numeric_traits< Scalar_T >::isInf ( const Scalar_T & val, bool_to_type< true > ) [inline],[static],[private]`

Smart isinf specialised for Scalar_T with infinity.

Definition at line 60 of file scalar.h.

References _GLUCAT_ISINF.

6.23.2.13 `template<typename Scalar_T> static bool glucat::numeric_traits< Scalar_T >::isInf ( const Scalar_T & val ) [inline],[static]`

Smart isinf.

Definition at line 82 of file scalar.h.

References `glucat::numeric_traits< Scalar_T >::isInf()`.

6.23.2.14 `template<typename Scalar_T> static bool glucat::numeric_traits< Scalar_T >::isNaN ( const Scalar_T & val, bool_to_type< false > ) [inline], [static], [private]`

Smart `isnan` specialised for `Scalar_T` without quiet NaN.

Definition at line 67 of file `scalar.h`.

Referenced by `glucat::numeric_traits< Scalar_T >::isNaN()`, and `glucat::numeric_traits< Scalar_T >::isNaN_or_isInf()`.

6.23.2.15 `template<typename Scalar_T> static bool glucat::numeric_traits< Scalar_T >::isNaN ( const Scalar_T & val, bool_to_type< true > ) [inline], [static], [private]`

Smart `isnan` specialised for `Scalar_T` with quiet NaN.

Definition at line 74 of file `scalar.h`.

References `_GLUCAT_ISNAN`.

6.23.2.16 `template<typename Scalar_T> static bool glucat::numeric_traits< Scalar_T >::isNaN ( const Scalar_T & val ) [inline], [static]`

Smart `isnan`.

Definition at line 92 of file `scalar.h`.

References `glucat::numeric_traits< Scalar_T >::isNaN()`.

6.23.2.17 `template<typename Scalar_T> static bool glucat::numeric_traits< Scalar_T >::isNaN_or_isInf ( const Scalar_T & val ) [inline], [static]`

Smart `isnan` or `isinf`.

Definition at line 102 of file `scalar.h`.

References `glucat::numeric_traits< Scalar_T >::isInf()`, and `glucat::numeric_traits< Scalar_T >::isNaN()`.

6.23.2.18 `template<> long double glucat::numeric_traits< long double >::ln_2 ( ) [inline]`

Definition at line 83 of file `long_double.h`.

References `glucat::l_ln2`.

6.23.2.19 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T >::ln_2 ( ) [inline], [static]`

`log(2)`

Definition at line 195 of file `scalar.h`.

Referenced by `glucat::numeric_traits< Scalar_T >::log2()`.

6.23.2.20 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T >::log ( const Scalar_T & val ) [inline], [static]`

Logarithm of scalar.

Definition at line 223 of file scalar.h.

References glucat::log().

Referenced by glucat::numeric_traits< Scalar_T >::log2().

6.23.2.21 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T >::log2 ( const Scalar_T & val ) [inline],[static]`

Log base 2.

Definition at line 230 of file scalar.h.

References glucat::numeric_traits< Scalar_T >::ln_2(), and glucat::numeric_traits< Scalar_T >::log().

Referenced by glucat::log2().

6.23.2.22 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T >::NaN ( ) [inline],[static]`

Smart NaN.

Definition at line 114 of file scalar.h.

References glucat::log().

Referenced by glucat::matrix::trace().

6.23.2.23 `template<> long double glucat::numeric_traits< long double >::pi ( ) [inline]`

Definition at line 75 of file long_double.h.

References glucat::l_pi.

6.23.2.24 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T >::pi ( ) [inline],[static]`

Pi.

Definition at line 188 of file scalar.h.

Referenced by glucat::matrix::classify_eigenvalues().

6.23.2.25 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T >::pow ( const Scalar_T & val, int n ) [inline],[static]`

Integer power.

Definition at line 202 of file scalar.h.

References glucat::pow().

6.23.2.26 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T >::real ( const Scalar_T & val ) [inline],[static]`

Real part of scalar.

Definition at line 167 of file scalar.h.

6.23.2.27 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T>::sin ( const Scalar_T & val ) [inline],[static]`

Sine of scalar.

Definition at line 258 of file scalar.h.

References glucat::sin().

6.23.2.28 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T>::sinh ( const Scalar_T & val ) [inline],[static]`

Hyperbolic sine of scalar.

Definition at line 272 of file scalar.h.

References glucat::sinh().

6.23.2.29 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T>::sqrt ( const Scalar_T & val ) [inline],[static]`

Square root of scalar.

Definition at line 209 of file scalar.h.

References UBLAS_SQRT.

Referenced by glucat::abs().

6.23.2.30 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T>::tan ( const Scalar_T & val ) [inline],[static]`

Tangent of scalar.

Definition at line 279 of file scalar.h.

References glucat::tan().

6.23.2.31 `template<typename Scalar_T> static Scalar_T glucat::numeric_traits< Scalar_T>::tanh ( const Scalar_T & val ) [inline],[static]`

Hyperbolic tangent of scalar.

Definition at line 293 of file scalar.h.

References glucat::tanh().

6.23.2.32 `template<typename Scalar_T> static double glucat::numeric_traits< Scalar_T>::to_double ( const Scalar_T & val ) [inline],[static]`

Cast to double.

Definition at line 132 of file scalar.h.

Referenced by glucat::operator<<(), and glucat::numeric_traits< Scalar_T>::to_scalar_t().

6.23.2.33 `template<typename Scalar_T> static int glucat::numeric_traits< Scalar_T>::to_int ( const Scalar_T & val ) [inline],[static]`

Cast to int.

Definition at line 125 of file scalar.h.

6.23.2.34 `template<> float glucat::numeric_traits< float >::to_scalar_t ( const Other_Scalar_T & val ) [inline]`

Cast to float

Definition at line 52 of file scalar_imp.h.

References glucat::numeric_traits< Scalar_T >::to_double().

6.23.2.35 `template<> double glucat::numeric_traits< double >::to_scalar_t ( const Other_Scalar_T & val ) [inline]`

Definition at line 61 of file scalar_imp.h.

References glucat::numeric_traits< Scalar_T >::to_double().

6.23.2.36 `template<> long double glucat::numeric_traits< long double >::to_scalar_t ( const dd_real & val ) [inline]`

Definition at line 71 of file scalar_imp.h.

6.23.2.37 `template<> long double glucat::numeric_traits< long double >::to_scalar_t ( const qd_real & val ) [inline]`

Definition at line 80 of file scalar_imp.h.

6.23.2.38 `template<> dd_real glucat::numeric_traits< dd_real >::to_scalar_t ( const long double & val ) [inline]`

Definition at line 89 of file scalar_imp.h.

6.23.2.39 `template<> dd_real glucat::numeric_traits< dd_real >::to_scalar_t ( const qd_real & val ) [inline]`

Definition at line 98 of file scalar_imp.h.

6.23.2.40 `template<> qd_real glucat::numeric_traits< qd_real >::to_scalar_t ( const long double & val ) [inline]`

Definition at line 107 of file scalar_imp.h.

6.23.2.41 `template<> qd_real glucat::numeric_traits< qd_real >::to_scalar_t ( const dd_real & val ) [inline]`

Definition at line 116 of file scalar_imp.h.

6.23.2.42 `template<typename Scalar_T > template<typename Other_Scalar_T > static Scalar_T glucat::numeric_traits< Scalar_T >::to_scalar_t ( const Other_Scalar_T & val ) [inline], [static]`

Cast to Scalar_T.

Definition at line 140 of file scalar.h.

Referenced by glucat::matrix::nork_range(), glucat::to_demote(), and glucat::to_promote().

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

- glucat/[scalar.h](#)

6.24 glucat::numeric_traits< Scalar_T >::promoted Struct Reference

Promoted type.

```
#include <scalar.h>
```

Public Types

- typedef double [type](#)

6.24.1 Detailed Description

```
template<typename Scalar_T>struct glucat::numeric_traits< Scalar_T >::promoted
```

Promoted type.

Definition at line 144 of file scalar.h.

6.24.2 Member Typedef Documentation

6.24.2.1 `template<typename Scalar_T > typedef double glucat::numeric_traits< Scalar_T >::promoted::type`

Definition at line 144 of file scalar.h.

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

- glucat/[scalar.h](#)

6.25 glucat::random_generator< Scalar_T > Class Template Reference

Random number generator with single instance per Scalar_T.

```
#include <random.h>
```

Public Member Functions

- `Scalar_T` [uniform](#) ()
- `Scalar_T` [normal](#) ()

Static Public Member Functions

- static [random_generator](#) & [generator](#) ()
Single instance of Random number generator.

Private Member Functions

- [random_generator](#) (const [random_generator](#) &)
- [random_generator](#) & [operator=](#) (const [random_generator](#) &)
- [random_generator](#) ()
- [~random_generator](#) ()

Private Attributes

- std::mt19937 [uint_gen](#)
- std::uniform_real_distribution< double > [uniform_dist](#)
- std::normal_distribution< double > [normal_dist](#)

Static Private Attributes

- static const unsigned long [seed](#) = 19590921UL

Friends

- class [friend_for_private_destructor](#)

6.25.1 Detailed Description

`template<typename Scalar_T>class glucat::random_generator< Scalar_T >`

Random number generator with single instance per Scalar_T.

Definition at line 47 of file random.h.

6.25.2 Constructor & Destructor Documentation

6.25.2.1 `template<typename Scalar_T > glucat::random_generator< Scalar_T >::random_generator ( const random_generator< Scalar_T > & ) [private]`

6.25.2.2 `template<typename Scalar_T > glucat::random_generator< Scalar_T >::random_generator ( ) [inline], [private]`

Definition at line 83 of file random.h.

References `glucat::random_generator< Scalar_T >::seed`, and `glucat::random_generator< Scalar_T >::uint_gen`.

6.25.2.3 `template<typename Scalar_T > glucat::random_generator< Scalar_T >::~~random_generator ( ) [inline], [private]`

Definition at line 87 of file random.h.

6.25.3 Member Function Documentation

6.25.3.1 `template<typename Scalar_T > static random_generator& glucat::random_generator< Scalar_T >::generator ( ) [inline], [static]`

Single instance of Random number generator.

Definition at line 51 of file random.h.

6.25.3.2 `template<typename Scalar_T > Scalar_T glucat::random_generator< Scalar_T >::normal ( ) [inline]`

Definition at line 93 of file random.h.

References `glucat::random_generator< Scalar_T >::normal_dist`, and `glucat::random_generator< Scalar_T >::uint_gen`.

6.25.3.3 `template<typename Scalar_T > random_generator& glucat::random_generator< Scalar_T >::operator= (const random_generator< Scalar_T > & ) [private]`

6.25.3.4 `template<typename Scalar_T > Scalar_T glucat::random_generator< Scalar_T >::uniform ( ) [inline]`

Definition at line 91 of file random.h.

References `glucat::random_generator< Scalar_T >::uint_gen`, and `glucat::random_generator< Scalar_T >::uniform_dist`.

6.25.4 Friends And Related Function Documentation

6.25.4.1 `template<typename Scalar_T > friend class friend_for_private_destructor [friend]`

Friend declaration to avoid compiler warning: "... only defines a private destructor and has no friends" Ref: Carlos O'Ryan, ACE <http://doc.ece.uci.edu>

Definition at line 56 of file random.h.

6.25.5 Member Data Documentation

6.25.5.1 `template<typename Scalar_T > std::normal_distribution<double> glucat::random_generator< Scalar_T >::normal_dist [private]`

Definition at line 81 of file random.h.

Referenced by `glucat::random_generator< Scalar_T >::normal()`.

6.25.5.2 `template<typename Scalar_T > const unsigned long glucat::random_generator< Scalar_T >::seed = 19590921UL [static],[private]`

Definition at line 59 of file random.h.

Referenced by `glucat::random_generator< Scalar_T >::random_generator()`.

6.25.5.3 `template<typename Scalar_T > std::mt19937 glucat::random_generator< Scalar_T >::uint_gen [private]`

Definition at line 79 of file random.h.

Referenced by `glucat::random_generator< Scalar_T >::normal()`, `glucat::random_generator< Scalar_T >::random_generator()`, and `glucat::random_generator< Scalar_T >::uniform()`.

6.25.5.4 `template<typename Scalar_T > std::uniform_real_distribution<double> glucat::random_generator< Scalar_T >::uniform_dist [private]`

Definition at line 80 of file random.h.

Referenced by `glucat::random_generator< Scalar_T >::uniform()`.

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

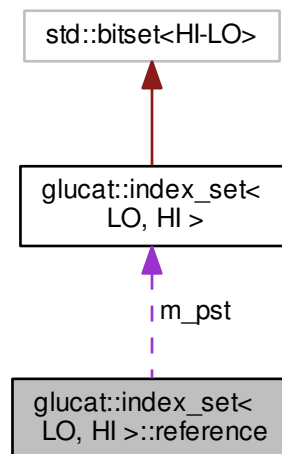
- [glucat/random.h](#)

6.26 glucat::index_set< LO, HI >::reference Class Reference

Index set member reference.

```
#include <index_set.h>
```

Collaboration diagram for glucat::index_set< LO, HI >::reference:



Public Member Functions

- [reference](#) ([index_set_t](#) &ist, [index_t](#) idx)
index_set reference
- [~reference](#) ()
- [reference](#) & [operator=](#) (const bool x)
for b[i] = x;
- [reference](#) & [operator=](#) (const [reference](#) &j)
for b[i] = b[j];
- bool [operator~](#) () const
Flips a bit.
- [operator bool](#) () const
for x = b[i];
- [reference](#) & [flip](#) ()
for b[i].flip();

Private Member Functions

- [reference](#) ()
Private default constructor is left undefined.

Private Attributes

- [index_set_t](#) * m_pst
- [index_t](#) m_idx

Friends

- class [index_set](#)

6.26.1 Detailed Description

`template<const index_t LO, const index_t HI>class glucat::index_set< LO, HI >::reference`

Index set member reference.

Definition at line 177 of file `index_set.h`.

6.26.2 Constructor & Destructor Documentation

6.26.2.1 `template<const index_t LO, const index_t HI> glucat::index_set< LO, HI >::reference::reference ( )`
`[private]`

Private default constructor is left undefined.

6.26.2.2 `template<const index_t LO, const index_t HI> glucat::index_set< LO, HI >::reference::reference ( index_set_t & ist, index_t idx )` `[inline]`

[index_set](#) reference

Definition at line 983 of file `index_set_imp.h`.

6.26.2.3 `template<const index_t LO, const index_t HI> glucat::index_set< LO, HI >::reference::~reference ( )`
`[inline]`

Definition at line 184 of file `index_set.h`.

6.26.3 Member Function Documentation

6.26.3.1 `template<const index_t LO, const index_t HI> index_set< LO, HI >::reference & glucat::index_set< LO, HI >::reference::flip ( )` `[inline]`

for `b[i].flip()`;

Definition at line 1036 of file `index_set_imp.h`.

References `glucat::index_set< LO, HI >::reference::flip()`.

Referenced by `glucat::index_set< LO, HI >::reference::flip()`.

6.26.3.2 `template<const index_t LO, const index_t HI> glucat::index_set< LO, HI >::reference::operator bool ( ) const`
`[inline]`

for `x = b[i]`;

Definition at line 1028 of file `index_set_imp.h`.

6.26.3.3 `template<const index_t LO, const index_t HI> index_set< LO, HI >::reference & glucat::index_set< LO, HI >::reference::operator= ( const bool x )` `[inline]`

for `b[i] = x`;

Definition at line 993 of file index_set_imp.h.

6.26.3.4 `template<const index_t LO, const index_t HI> index_set< LO, HI >::reference & glucat::index_set< LO, HI >::reference::operator= ( const reference & j ) [inline]`

for b[i] = b[j];

Definition at line 1007 of file index_set_imp.h.

References glucat::index_set< LO, HI >::reference::m_idx, and glucat::index_set< LO, HI >::reference::m_pst.

6.26.3.5 `template<const index_t LO, const index_t HI> bool glucat::index_set< LO, HI >::reference::operator~ ( ) const [inline]`

Flips a bit.

flips the bit

Definition at line 1021 of file index_set_imp.h.

6.26.4 Friends And Related Function Documentation

6.26.4.1 `template<const index_t LO, const index_t HI> friend class index_set [friend]`

Definition at line 178 of file index_set.h.

6.26.5 Member Data Documentation

6.26.5.1 `template<const index_t LO, const index_t HI> index_t glucat::index_set< LO, HI >::reference::m_idx [private]`

Definition at line 198 of file index_set.h.

Referenced by glucat::index_set< LO, HI >::reference::operator=().

6.26.5.2 `template<const index_t LO, const index_t HI> index_set_t* glucat::index_set< LO, HI >::reference::m_pst [private]`

Definition at line 197 of file index_set.h.

Referenced by glucat::index_set< LO, HI >::reference::operator=().

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

- glucat/[index_set.h](#)
- glucat/[index_set_imp.h](#)

6.27 glucat::sorted_range< Map_T, Sorted_Map_T > Class Template Reference

Sorted range for use with output.

`#include <framed_multi_imp.h>`

Public Types

- typedef Map_T [map_t](#)
- typedef Sorted_Map_T [sorted_map_t](#)
- typedef
Sorted_Map_T::const_iterator [sorted_iterator](#)

Public Member Functions

- [sorted_range](#) (Sorted_Map_T &sorted_val, const Map_T &val)

Public Attributes

- [sorted_iterator](#) [sorted_begin](#)
- [sorted_iterator](#) [sorted_end](#)

6.27.1 Detailed Description

template<typename Map_T, typename Sorted_Map_T>class glucat::sorted_range< Map_T, Sorted_Map_T >

Sorted range for use with output.

Definition at line 1326 of file framed_multi_imp.h.

6.27.2 Member Typedef Documentation

6.27.2.1 template<typename Map_T, typename Sorted_Map_T> typedef Map_T glucat::sorted_range< Map_T, Sorted_Map_T >::map_t

Definition at line 1329 of file framed_multi_imp.h.

6.27.2.2 template<typename Map_T, typename Sorted_Map_T> typedef Sorted_Map_T::const_iterator glucat::sorted_range< Map_T, Sorted_Map_T >::sorted_iterator

Definition at line 1331 of file framed_multi_imp.h.

6.27.2.3 template<typename Map_T, typename Sorted_Map_T> typedef Sorted_Map_T glucat::sorted_range< Map_T, Sorted_Map_T >::sorted_map_t

Definition at line 1330 of file framed_multi_imp.h.

6.27.3 Constructor & Destructor Documentation

6.27.3.1 template<typename Map_T, typename Sorted_Map_T> glucat::sorted_range< Map_T, Sorted_Map_T >::sorted_range (Sorted_Map_T & sorted_val, const Map_T & val) [inline]

Definition at line 1333 of file framed_multi_imp.h.

References glucat::sorted_range< Map_T, Sorted_Map_T >::sorted_begin, and glucat::sorted_range< Map_T, Sorted_Map_T >::sorted_end.

6.27.4 Member Data Documentation

6.27.4.1 `template<typename Map_T, typename Sorted_Map_T> sorted_iterator glucat::sorted_range< Map_T, Sorted_Map_T >::sorted_begin`

Definition at line 1343 of file framed_multi_imp.h.

Referenced by `glucat::operator<<()`, and `glucat::sorted_range< Map_T, Sorted_Map_T >::sorted_range()`.

6.27.4.2 `template<typename Map_T, typename Sorted_Map_T> sorted_iterator glucat::sorted_range< Map_T, Sorted_Map_T >::sorted_end`

Definition at line 1344 of file framed_multi_imp.h.

Referenced by `glucat::operator<<()`, and `glucat::sorted_range< Map_T, Sorted_Map_T >::sorted_range()`.

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

- [glucat/framed_multi_imp.h](#)

6.28 glucat::sorted_range< Sorted_Map_T, Sorted_Map_T > Class Template Reference

```
#include <framed_multi_imp.h>
```

Public Types

- typedef Sorted_Map_T [map_t](#)
- typedef Sorted_Map_T [sorted_map_t](#)
- typedef
Sorted_Map_T::const_iterator [sorted_iterator](#)

Public Member Functions

- [sorted_range](#) (Sorted_Map_T &sorted_val, const Sorted_Map_T &val)

Public Attributes

- [sorted_iterator](#) [sorted_begin](#)
- [sorted_iterator](#) [sorted_end](#)

6.28.1 Detailed Description

```
template<typename Sorted_Map_T> class glucat::sorted_range< Sorted_Map_T, Sorted_Map_T >
```

Definition at line 1348 of file framed_multi_imp.h.

6.28.2 Member Typedef Documentation

6.28.2.1 `template<typename Sorted_Map_T > typedef Sorted_Map_T glucat::sorted_range< Sorted_Map_T, Sorted_Map_T >::map_t`

Definition at line 1351 of file framed_multi_imp.h.

6.28.2.2 `template<typename Sorted_Map_T > typedef Sorted_Map_T::const_iterator glucat::sorted_range< Sorted_Map_T, Sorted_Map_T >::sorted_iterator`

Definition at line 1353 of file `framed_multi_imp.h`.

6.28.2.3 `template<typename Sorted_Map_T > typedef Sorted_Map_T glucat::sorted_range< Sorted_Map_T, Sorted_Map_T >::sorted_map_t`

Definition at line 1352 of file `framed_multi_imp.h`.

6.28.3 Constructor & Destructor Documentation

6.28.3.1 `template<typename Sorted_Map_T > glucat::sorted_range< Sorted_Map_T, Sorted_Map_T >::sorted_range ( Sorted_Map_T & sorted_val, const Sorted_Map_T & val ) [inline]`

Definition at line 1355 of file `framed_multi_imp.h`.

6.28.4 Member Data Documentation

6.28.4.1 `template<typename Sorted_Map_T > sorted_iterator glucat::sorted_range< Sorted_Map_T, Sorted_Map_T >::sorted_begin`

Definition at line 1359 of file `framed_multi_imp.h`.

6.28.4.2 `template<typename Sorted_Map_T > sorted_iterator glucat::sorted_range< Sorted_Map_T, Sorted_Map_T >::sorted_end`

Definition at line 1360 of file `framed_multi_imp.h`.

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

- [glucat/framed_multi_imp.h](#)

6.29 glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision > Struct Template Reference

Tuning policy.

```
#include <global.h>
```

Public Types

- enum { [mult_matrix_threshold](#) = Mult_Matrix_Threshold }
Minimum index count needed to invoke matrix multiplication algorithm.
- enum { [div_max_steps](#) = Div_Max_Steps }
Maximum steps of iterative refinement in division algorithm.
- enum { [sqrt_max_steps](#) = Sqrt_Max_Steps }
Maximum number of steps in square root iteration.
- enum { [log_max_outer_steps](#) = Log_Max_Outer_Steps }

Maximum number of incomplete square roots in cascade log algorithm.

- enum { [log_max_inner_steps](#) = Log_Max_Inner_Steps }
Maximum number of steps in incomplete square root within cascade log algorithm.
- enum { [basis_max_count](#) = Basis_Max_Count }
Maximum index count of folded frames in basis cache.
- enum { [fast_size_threshold](#) = Fast_Size_Threshold }
Minimum map size needed to invoke generalized FFT.
- enum { [inv_fast_dim_threshold](#) = Inv_Fast_Dim_Threshold }
Minimum matrix dimension needed to invoke inverse generalized FFT.
- enum { [products_size_threshold](#) = Products_Size_Threshold }
Minimum size needed for to invoke faster products algorithms.

Static Public Attributes

- static const [precision_t function_precision](#) = Function_Precision
Precision used for exp, log and sqrt functions.

6.29.1 Detailed Description

template<unsigned int Mult_Matrix_Threshold = DEFAULT_Mult_Matrix_Threshold, unsigned int Div_Max_Steps = DEFAULT_Div_Max_Steps, unsigned int Sqrt_Max_Steps = DEFAULT_Sqrt_Max_Steps, unsigned int Log_Max_Outer_Steps = DEFAULT_Log_Max_Outer_Steps, unsigned int Log_Max_Inner_Steps = DEFAULT_Log_Max_Inner_Steps, unsigned int Basis_Max_Count = DEFAULT_Basis_Max_Count, unsigned int Fast_Size_Threshold = DEFAULT_Fast_Size_Threshold, unsigned int Inv_Fast_Dim_Threshold = DEFAULT_Inv_Fast_Dim_Threshold, unsigned int Products_Size_Threshold = DEFAULT_Products_Size_Threshold, precision_t Function_Precision = DEFAULT_Function_Precision>struct glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >

Tuning policy.

Definition at line 151 of file global.h.

6.29.2 Member Enumeration Documentation

6.29.2.1 template<unsigned int Mult_Matrix_Threshold = DEFAULT_Mult_Matrix_Threshold, unsigned int Div_Max_Steps = DEFAULT_Div_Max_Steps, unsigned int Sqrt_Max_Steps = DEFAULT_Sqrt_Max_Steps, unsigned int Log_Max_Outer_Steps = DEFAULT_Log_Max_Outer_Steps, unsigned int Log_Max_Inner_Steps = DEFAULT_Log_Max_Inner_Steps, unsigned int Basis_Max_Count = DEFAULT_Basis_Max_Count, unsigned int Fast_Size_Threshold = DEFAULT_Fast_Size_Threshold, unsigned int Inv_Fast_Dim_Threshold = DEFAULT_Inv_Fast_Dim_Threshold, unsigned int Products_Size_Threshold = DEFAULT_Products_Size_Threshold, precision_t Function_Precision = DEFAULT_Function_Precision> anonymous enum

Minimum matrix dimension needed to invoke inverse generalized FFT.

Enumerator

inv_fast_dim_threshold

Definition at line 174 of file global.h.

6.29.2.2 `template<unsigned int Mult_Matrix_Threshold = DEFAULT_Mult_Matrix_Threshold, unsigned int Div_Max_Steps = DEFAULT_Div_Max_Steps, unsigned int Sqrt_Max_Steps = DEFAULT_Sqrt_Max_Steps, unsigned int Log_Max_Outer_Steps = DEFAULT_Log_Max_Outer_Steps, unsigned int Log_Max_Inner_Steps = DEFAULT_Log_Max_Inner_Steps, unsigned int Basis_Max_Count = DEFAULT_Basis_Max_Count, unsigned int Fast_Size_Threshold = DEFAULT_Fast_Size_Threshold, unsigned int Inv_Fast_Dim_Threshold = DEFAULT_Inv_Fast_Dim_Threshold, unsigned int Products_Size_Threshold = DEFAULT_Products_Size_Threshold, precision_t Function_Precision = DEFAULT_Function_Precision> anonymous enum`

Minimum size needed for to invoke faster products algorithms.

Enumerator

products_size_threshold

Definition at line 177 of file global.h.

6.29.2.3 `template<unsigned int Mult_Matrix_Threshold = DEFAULT_Mult_Matrix_Threshold, unsigned int Div_Max_Steps = DEFAULT_Div_Max_Steps, unsigned int Sqrt_Max_Steps = DEFAULT_Sqrt_Max_Steps, unsigned int Log_Max_Outer_Steps = DEFAULT_Log_Max_Outer_Steps, unsigned int Log_Max_Inner_Steps = DEFAULT_Log_Max_Inner_Steps, unsigned int Basis_Max_Count = DEFAULT_Basis_Max_Count, unsigned int Fast_Size_Threshold = DEFAULT_Fast_Size_Threshold, unsigned int Inv_Fast_Dim_Threshold = DEFAULT_Inv_Fast_Dim_Threshold, unsigned int Products_Size_Threshold = DEFAULT_Products_Size_Threshold, precision_t Function_Precision = DEFAULT_Function_Precision> anonymous enum`

Minimum index count needed to invoke matrix multiplication algorithm.

Enumerator

mult_matrix_threshold

Definition at line 155 of file global.h.

6.29.2.4 `template<unsigned int Mult_Matrix_Threshold = DEFAULT_Mult_Matrix_Threshold, unsigned int Div_Max_Steps = DEFAULT_Div_Max_Steps, unsigned int Sqrt_Max_Steps = DEFAULT_Sqrt_Max_Steps, unsigned int Log_Max_Outer_Steps = DEFAULT_Log_Max_Outer_Steps, unsigned int Log_Max_Inner_Steps = DEFAULT_Log_Max_Inner_Steps, unsigned int Basis_Max_Count = DEFAULT_Basis_Max_Count, unsigned int Fast_Size_Threshold = DEFAULT_Fast_Size_Threshold, unsigned int Inv_Fast_Dim_Threshold = DEFAULT_Inv_Fast_Dim_Threshold, unsigned int Products_Size_Threshold = DEFAULT_Products_Size_Threshold, precision_t Function_Precision = DEFAULT_Function_Precision> anonymous enum`

Maximum steps of iterative refinement in division algorithm.

Enumerator

div_max_steps

Definition at line 158 of file global.h.

6.29.2.5 `template<unsigned int Mult_Matrix_Threshold = DEFAULT_Mult_Matrix_Threshold, unsigned int Div_Max_Steps = DEFAULT_Div_Max_Steps, unsigned int Sqrt_Max_Steps = DEFAULT_Sqrt_Max_Steps, unsigned int Log_Max_Outer_Steps = DEFAULT_Log_Max_Outer_Steps, unsigned int Log_Max_Inner_Steps = DEFAULT_Log_Max_Inner_Steps, unsigned int Basis_Max_Count = DEFAULT_Basis_Max_Count, unsigned int Fast_Size_Threshold = DEFAULT_Fast_Size_Threshold, unsigned int Inv_Fast_Dim_Threshold = DEFAULT_Inv_Fast_Dim_Threshold, unsigned int Products_Size_Threshold = DEFAULT_Products_Size_Threshold, precision_t Function_Precision = DEFAULT_Function_Precision> anonymous enum`

Maximum number of steps in square root iteration.

Enumerator

sqrt_max_steps

Definition at line 161 of file global.h.

```
6.29.2.6  template<unsigned int Mult_Matrix_Threshold = DEFAULT_Mult_Matrix_Threshold, unsigned int Div_Max_Steps =
          = DEFAULT_Div_Max_Steps, unsigned int Sqrt_Max_Steps = DEFAULT_Sqrt_Max_Steps, unsigned
          int Log_Max_Outer_Steps = DEFAULT_Log_Max_Outer_Steps, unsigned int Log_Max_Inner_Steps =
          = DEFAULT_Log_Max_Inner_Steps, unsigned int Basis_Max_Count = DEFAULT_Basis_Max_Count, unsigned
          int Fast_Size_Threshold = DEFAULT_Fast_Size_Threshold, unsigned int Inv_Fast_Dim_Threshold =
          = DEFAULT_Inv_Fast_Dim_Threshold, unsigned int Products_Size_Threshold = DEFAULT_Products_Size_Threshold,
          precision_t Function_Precision = DEFAULT_Function_Precision> anonymous enum
```

Maximum number of incomplete square roots in cascade log algorithm.

Enumerator

log_max_outer_steps

Definition at line 164 of file global.h.

```
6.29.2.7  template<unsigned int Mult_Matrix_Threshold = DEFAULT_Mult_Matrix_Threshold, unsigned int Div_Max_Steps =
          = DEFAULT_Div_Max_Steps, unsigned int Sqrt_Max_Steps = DEFAULT_Sqrt_Max_Steps, unsigned
          int Log_Max_Outer_Steps = DEFAULT_Log_Max_Outer_Steps, unsigned int Log_Max_Inner_Steps =
          = DEFAULT_Log_Max_Inner_Steps, unsigned int Basis_Max_Count = DEFAULT_Basis_Max_Count, unsigned
          int Fast_Size_Threshold = DEFAULT_Fast_Size_Threshold, unsigned int Inv_Fast_Dim_Threshold =
          = DEFAULT_Inv_Fast_Dim_Threshold, unsigned int Products_Size_Threshold = DEFAULT_Products_Size_Threshold,
          precision_t Function_Precision = DEFAULT_Function_Precision> anonymous enum
```

Maximum number of steps in incomplete square root within cascade log algorithm.

Enumerator

log_max_inner_steps

Definition at line 166 of file global.h.

```
6.29.2.8  template<unsigned int Mult_Matrix_Threshold = DEFAULT_Mult_Matrix_Threshold, unsigned int Div_Max_Steps =
          = DEFAULT_Div_Max_Steps, unsigned int Sqrt_Max_Steps = DEFAULT_Sqrt_Max_Steps, unsigned
          int Log_Max_Outer_Steps = DEFAULT_Log_Max_Outer_Steps, unsigned int Log_Max_Inner_Steps =
          = DEFAULT_Log_Max_Inner_Steps, unsigned int Basis_Max_Count = DEFAULT_Basis_Max_Count, unsigned
          int Fast_Size_Threshold = DEFAULT_Fast_Size_Threshold, unsigned int Inv_Fast_Dim_Threshold =
          = DEFAULT_Inv_Fast_Dim_Threshold, unsigned int Products_Size_Threshold = DEFAULT_Products_Size_Threshold,
          precision_t Function_Precision = DEFAULT_Function_Precision> anonymous enum
```

Maximum index count of folded frames in basis cache.

Enumerator

basis_max_count

Definition at line 169 of file global.h.

6.29.2.9 `template<unsigned int Mult_Matrix_Threshold = DEFAULT_Mult_Matrix_Threshold, unsigned int Div_Max_Steps = DEFAULT_Div_Max_Steps, unsigned int Sqrt_Max_Steps = DEFAULT_Sqrt_Max_Steps, unsigned int Log_Max_Outer_Steps = DEFAULT_Log_Max_Outer_Steps, unsigned int Log_Max_Inner_Steps = DEFAULT_Log_Max_Inner_Steps, unsigned int Basis_Max_Count = DEFAULT_Basis_Max_Count, unsigned int Fast_Size_Threshold = DEFAULT_Fast_Size_Threshold, unsigned int Inv_Fast_Dim_Threshold = DEFAULT_Inv_Fast_Dim_Threshold, unsigned int Products_Size_Threshold = DEFAULT_Products_Size_Threshold, precision_t Function_Precision = DEFAULT_Function_Precision> anonymous enum`

Minimum map size needed to invoke generalized FFT.

Enumerator

fast_size_threshold

Definition at line 172 of file global.h.

6.29.3 Member Data Documentation

6.29.3.1 `template<unsigned int Mult_Matrix_Threshold = DEFAULT_Mult_Matrix_Threshold, unsigned int Div_Max_Steps = DEFAULT_Div_Max_Steps, unsigned int Sqrt_Max_Steps = DEFAULT_Sqrt_Max_Steps, unsigned int Log_Max_Outer_Steps = DEFAULT_Log_Max_Outer_Steps, unsigned int Log_Max_Inner_Steps = DEFAULT_Log_Max_Inner_Steps, unsigned int Basis_Max_Count = DEFAULT_Basis_Max_Count, unsigned int Fast_Size_Threshold = DEFAULT_Fast_Size_Threshold, unsigned int Inv_Fast_Dim_Threshold = DEFAULT_Inv_Fast_Dim_Threshold, unsigned int Products_Size_Threshold = DEFAULT_Products_Size_Threshold, precision_t Function_Precision = DEFAULT_Function_Precision> const precision_t glucat::tuning<Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision>::function_precision = Function_Precision [static]`

Precision used for exp, log and sqrt functions.

Definition at line 180 of file global.h.

Referenced by `glucat::exp()`, `glucat::log()`, and `glucat::sqrt()`.

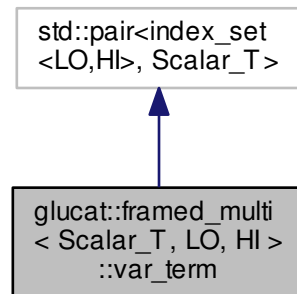
The documentation for this struct was generated from the following file:

- [glucat/global.h](#)

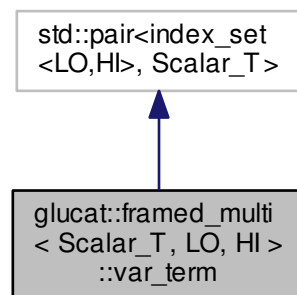
6.30 `glucat::framed_multi< Scalar_T, LO, HI >::var_term` Class Reference

Variable term.

Inheritance diagram for glucat::framed_multi< Scalar_T, LO, HI >::var_term:



Collaboration diagram for glucat::framed_multi< Scalar_T, LO, HI >::var_term:



Public Types

- typedef std::pair< [index_set](#) < LO, HI >, Scalar_T > [var_pair_t](#)

Public Member Functions

- [~var_term](#) ()
Destructor.
- [var_term](#) ()
Default constructor.
- [var_term_t](#) & [operator*=](#) (const [term_t](#) &rhs)
Product of variable term and term.

Static Public Member Functions

- static const std::string `classname` ()
Class name used in messages.

Public Attributes

- `__pad0__`: `var_pair_t`(ist
Construct a variable term from an index set and a scalar coordinate.
- `crd` {}

6.30.1 Detailed Description

template<typename Scalar_T, const index_t LO, const index_t HI> class glucat::framed_multi< Scalar_T, LO, HI >::var_term

Variable term.

Definition at line 308 of file framed_multi.h.

6.30.2 Member Typedef Documentation

6.30.2.1 template<typename Scalar_T, const index_t LO, const index_t HI> typedef std::pair<index_set<LO,HI>, Scalar_T> glucat::framed_multi< Scalar_T, LO, HI >::var_term::var_pair_t

Definition at line 312 of file framed_multi.h.

6.30.3 Constructor & Destructor Documentation

6.30.3.1 template<typename Scalar_T, const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::var_term::~~var_term () [inline]

Destructor.

Definition at line 318 of file framed_multi.h.

6.30.3.2 template<typename Scalar_T, const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::var_term::var_term () [inline]

Default constructor.

Definition at line 320 of file framed_multi.h.

6.30.4 Member Function Documentation

6.30.4.1 template<typename Scalar_T, const index_t LO, const index_t HI> static const std::string glucat::framed_multi< Scalar_T, LO, HI >::var_term::classname () [inline], [static]

Class name used in messages.

Definition at line 315 of file framed_multi.h.

6.30.4.2 `template<typename Scalar_T, const index_t LO, const index_t HI> var_term_t& glucat::framed_multi< Scalar_T, LO, HI >::var_term::operator*=( const term_t & rhs ) [inline]`

Product of variable term and term.

Definition at line 328 of file `framed_multi.h`.

6.30.5 Member Data Documentation

6.30.5.1 `template<typename Scalar_T, const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::var_term::__pad0__`

Construct a variable term from an index set and a scalar coordinate.

Definition at line 322 of file `framed_multi.h`.

6.30.5.2 `template<typename Scalar_T, const index_t LO, const index_t HI> glucat::framed_multi< Scalar_T, LO, HI >::var_term::crd { }`

Definition at line 326 of file `framed_multi.h`.

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

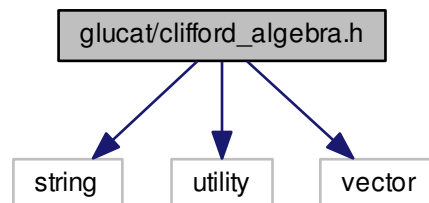
- [glucat/framed_multi.h](#)

Chapter 7

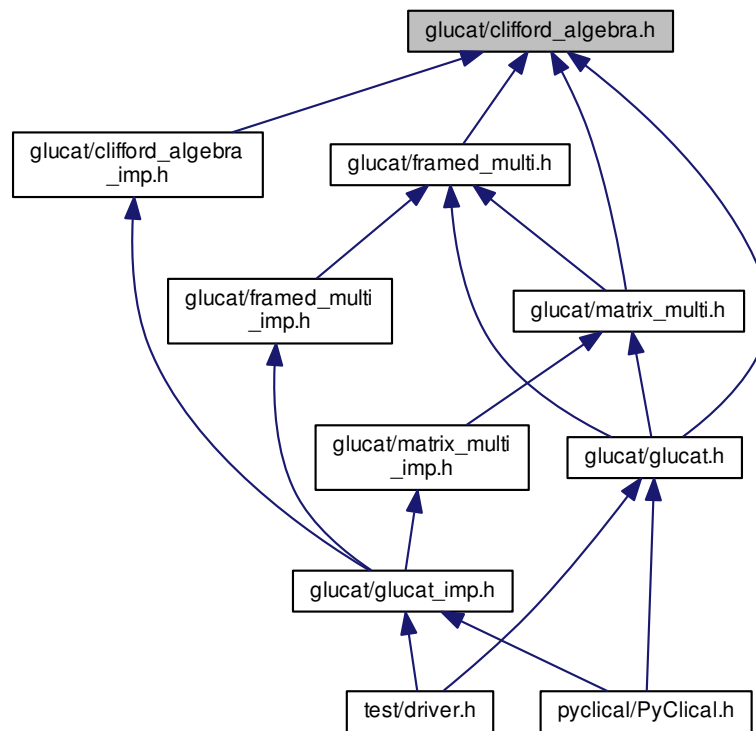
File Documentation

7.1 glucat/clifford_algebra.h File Reference

```
#include <string>
#include <utility>
#include <vector>
Include dependency graph for clifford_algebra.h:
```



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



Classes

- class `glucat::clifford_algebra< Scalar_T, Index_Set_T, Multivector_T >`
clifford_algebra<> declares the operations of a Clifford algebra

Namespaces

- `glucat`

Macros

- `#define _GLUCAT_CLIFFORD_ALGEBRA_OPERATIONS`

Functions

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>`
`bool glucat::operator!= (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`
Test for inequality of multivectors.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>`
`bool glucat::operator!= (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)`

Test for inequality of multivector and scalar.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
bool [glucat::operator!=](#) (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)

Test for inequality of scalar and multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::operator+](#) (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)

Geometric sum of multivector and scalar.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::operator+](#) (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)

Geometric sum of scalar and multivector.

- template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::operator+](#) (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)

Geometric sum.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::operator-](#) (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)

Geometric difference of multivector and scalar.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::operator-](#) (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)

Geometric difference of scalar and multivector.

- template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::operator-](#) (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)

Geometric difference.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::operator*](#) (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)

Product of multivector and scalar.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::operator*](#) (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)

Product of scalar and multivector.

- template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::operator*](#) (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)

Geometric product.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::operator^ (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Outer product.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::operator& (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Inner product.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::operator% (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Left contraction.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
Scalar_T glucat::star (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Hestenes scalar product.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::operator/ (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)`

Quotient of multivector and scalar.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::operator/ (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)`

Quotient of scalar and multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::operator/ (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Geometric quotient.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::operator| (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Transformation via twisted adjoint action.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::inv (const Multivector< Scalar_T, LO, HI > &val)`

Geometric multiplicative inverse.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::pow (const Multivector< Scalar_T, LO, HI > &lhs, int rhs)`

Integer power of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::pow (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`
Multivector power of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::outer_pow (const Multivector< Scalar_T, LO, HI > &lhs, int rhs)`
Outer product power of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> Scalar_T glucat::scalar (const Multivector< Scalar_T, LO, HI > &val)`
Scalar part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> Scalar_T glucat::real (const Multivector< Scalar_T, LO, HI > &val)`
Real part: synonym for scalar part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> Scalar_T glucat::imag (const Multivector< Scalar_T, LO, HI > &val)`
Imaginary part: deprecated (always 0)
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::pure (const Multivector< Scalar_T, LO, HI > &val)`
Pure part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::even (const Multivector< Scalar_T, LO, HI > &val)`
Even part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::odd (const Multivector< Scalar_T, LO, HI > &val)`
Odd part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const std::vector< Scalar_T > glucat::vector_part (const Multivector< Scalar_T, LO, HI > &val)`
Vector part of multivector, as a vector_t with respect to frame()
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::involute (const Multivector< Scalar_T, LO, HI > &val)`
Main involution, each {i} is replaced by -{i} in each term, eg. {1}{2} -> (-{2})*(-{1})*
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::reverse (const Multivector< Scalar_T, LO, HI > &val)`
Reversion, eg. {1}{2} -> {2}*{1}.*
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI> const Multivector< Scalar_T, LO, HI > glucat::conj (const Multivector< Scalar_T, LO, HI > &val)`

Conjugation, rev o invo == invo o rev.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`

`Scalar_T glucat::quad (const Multivector< Scalar_T, LO, HI > &val)`

*Scalar_T quadratic form == (rev(x)*x)(0)*

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`

`Scalar_T glucat::norm (const Multivector< Scalar_T, LO, HI > &val)`

Scalar_T norm == sum of norm of coordinates.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`

`Scalar_T glucat::abs (const Multivector< Scalar_T, LO, HI > &val)`

Absolute value == sqrt(norm)

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`

`Scalar_T glucat::max_abs (const Multivector< Scalar_T, LO, HI > &val)`

Maximum of absolute values of components of multivector: multivector infinity norm.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`

`const Multivector< Scalar_T,
LO, HI > glucat::complexifier (const Multivector< Scalar_T, LO, HI > &val)`

Square root of -1 which commutes with all members of the frame of the given multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`

`const Multivector< Scalar_T,
LO, HI > glucat::elliptic (const Multivector< Scalar_T, LO, HI > &val)`

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`

`const Multivector< Scalar_T,
LO, HI > glucat::sqrt (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i,
const bool prechecked=false)`

Square root of multivector with specified complexifier.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`

`const Multivector< Scalar_T,
LO, HI > glucat::sqrt (const Multivector< Scalar_T, LO, HI > &val)`

Square root of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`

`const Multivector< Scalar_T,
LO, HI > glucat::clifford_exp (const Multivector< Scalar_T, LO, HI > &val)`

Exponential of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`

`const Multivector< Scalar_T,
LO, HI > glucat::log (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i,
const bool prechecked=false)`

Natural logarithm of multivector with specified complexifier.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`

`const Multivector< Scalar_T,
LO, HI > glucat::log (const Multivector< Scalar_T, LO, HI > &val)`

Natural logarithm of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::cos (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i,
 const bool prechecked=false)`
Cosine of multivector with specified complexifier.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::cos (const Multivector< Scalar_T, LO, HI > &val)`
Cosine of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::acos (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i,
 const bool prechecked=false)`
Inverse cosine of multivector with specified complexifier.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::acos (const Multivector< Scalar_T, LO, HI > &val)`
Inverse cosine of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::cosh (const Multivector< Scalar_T, LO, HI > &val)`
Hyperbolic cosine of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::acosh (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i,
 const bool prechecked=false)`
Inverse hyperbolic cosine of multivector with specified complexifier.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::acosh (const Multivector< Scalar_T, LO, HI > &val)`
Inverse hyperbolic cosine of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::sin (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i,
 const bool prechecked=false)`
Sine of multivector with specified complexifier.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::sin (const Multivector< Scalar_T, LO, HI > &val)`
Sine of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::asin (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i,
 const bool prechecked=false)`
Inverse sine of multivector with specified complexifier.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::asin (const Multivector< Scalar_T, LO, HI > &val)
Inverse sine of multivector.`
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::sinh (const Multivector< Scalar_T, LO, HI > &val)
Hyperbolic sine of multivector.`
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::asinh (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)
Inverse hyperbolic sine of multivector with specified complexifier.`
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::asinh (const Multivector< Scalar_T, LO, HI > &val)
Inverse hyperbolic sine of multivector.`
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::tan (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)
Tangent of multivector with specified complexifier.`
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::tan (const Multivector< Scalar_T, LO, HI > &val)
Tangent of multivector.`
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::atan (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)
Inverse tangent of multivector with specified complexifier.`
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::atan (const Multivector< Scalar_T, LO, HI > &val)
Inverse tangent of multivector.`
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::tanh (const Multivector< Scalar_T, LO, HI > &val)
Hyperbolic tangent of multivector.`
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::atanh (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)
Inverse hyperbolic tangent of multivector with specified complexifier.`

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::atanh (const Multivector< Scalar_T, LO, HI > &val)`

Inverse hyperbolic tangent of multivector.

7.1.1 Macro Definition Documentation

7.1.1.1 #define _GLUCAT_CLIFFORD_ALGEBRA_OPERATIONS

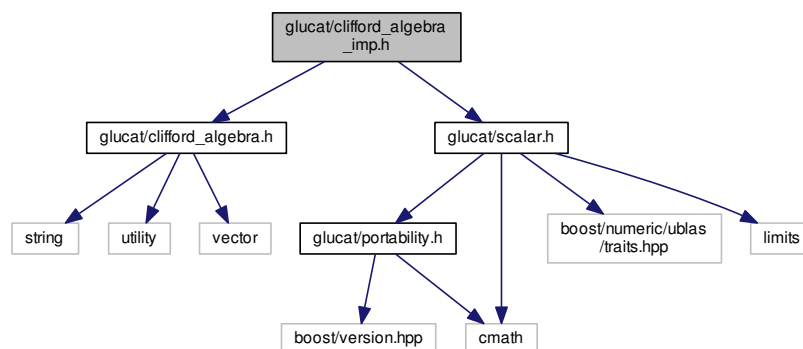
Definition at line 134 of file clifford_algebra.h.

7.2 glucat/clifford_algebra_imp.h File Reference

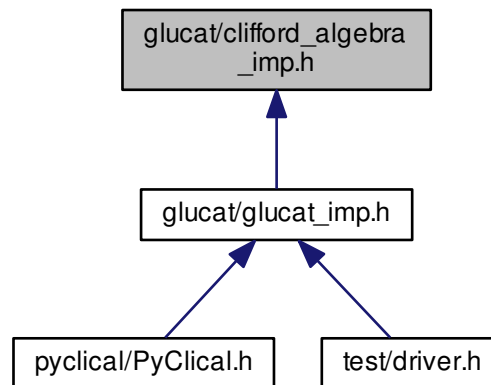
```
#include <glucat/clifford_algebra.h>
```

```
#include <glucat/scalar.h>
```

Include dependency graph for clifford_algebra_imp.h:



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



Namespaces

- [glucat](#)

Functions

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>`
`bool glucat::operator!= (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`
Test for inequality of multivectors.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>`
`bool glucat::operator!= (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)`
Test for inequality of multivector and scalar.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>`
`bool glucat::operator!= (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)`
Test for inequality of scalar and multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>`
`const Multivector< Scalar_T, LO, HI > glucat::operator+ (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)`
Geometric sum of multivector and scalar.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T, const index_t LO, const index_t HI>`
`const Multivector< Scalar_T, LO, HI > glucat::operator+ (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)`
Geometric sum of scalar and multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t > class RHS, typename Scalar_T, const index_t LO, const index_t HI>`
`const Multivector< Scalar_T, LO, HI > glucat::operator+ (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Geometric sum.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator- (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)`

Geometric difference of multivector and scalar.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator- (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)`

Geometric difference of scalar and multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t >`
`class RHS, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator- (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI >`
`&rhs)`

Geometric difference.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator* (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)`

Product of multivector and scalar.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator* (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)`

Product of scalar and multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t >`
`class RHS, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator* (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI >`
`&rhs)`

Geometric product.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t >`
`class RHS, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator^ (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI >`
`&rhs)`

Outer product.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t >`
`class RHS, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator& (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI >`
`&rhs)`

Inner product.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t >`
`class RHS, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator% (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI >`
`&rhs)`

Left contraction.

- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t >`
`class RHS, typename Scalar_T , const index_t LO, const index_t HI>`
`Scalar_T glucat::star (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`

Hestenes scalar product.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator/ (const Multivector< Scalar_T, LO, HI > &lhs, const Scalar_T &scr)`
Quotient of multivector and scalar.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator/ (const Scalar_T &scr, const Multivector< Scalar_T, LO, HI > &rhs)`
Quotient of scalar and multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t >`
`class RHS, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator/ (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`
Geometric quotient.
- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t >`
`class RHS, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::operator| (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`
Transformation via twisted adjoint action.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::inv (const Multivector< Scalar_T, LO, HI > &val)`
Geometric multiplicative inverse.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::pow (const Multivector< Scalar_T, LO, HI > &lhs, int rhs)`
Integer power of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, template< typename, const index_t, const index_t >`
`class RHS, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::pow (const Multivector< Scalar_T, LO, HI > &lhs, const RHS< Scalar_T, LO, HI > &rhs)`
Multivector power of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`const Multivector< Scalar_T,`
`LO, HI > glucat::outer\_pow (const Multivector< Scalar_T, LO, HI > &lhs, int rhs)`
Outer product power of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`Scalar_T glucat::scalar (const Multivector< Scalar_T, LO, HI > &val)`
Scalar part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`Scalar_T glucat::real (const Multivector< Scalar_T, LO, HI > &val)`
Real part: synonym for scalar part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>`
`Scalar_T glucat::imag (const Multivector< Scalar_T, LO, HI > &val)`
Imaginary part: deprecated (always 0)

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::pure (const Multivector< Scalar_T, LO, HI > &val)`
Pure part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::even (const Multivector< Scalar_T, LO, HI > &val)`
Even part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::odd (const Multivector< Scalar_T, LO, HI > &val)`
Odd part.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const std::vector< Scalar_T > glucat::vector_part (const Multivector< Scalar_T, LO, HI > &val)`
Vector part of multivector, as a vector_t with respect to frame()
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::involute (const Multivector< Scalar_T, LO, HI > &val)`
Main involution, each {i} is replaced by -{i} in each term, eg. {1}{2} -> (-{2})*(-{1})*
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::reverse (const Multivector< Scalar_T, LO, HI > &val)`
Reversion, eg. {1}{2} -> {2}*{1}.*
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::conj (const Multivector< Scalar_T, LO, HI > &val)`
Conjugation, rev o invo == invo o rev.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 Scalar_T glucat::quad (const Multivector< Scalar_T, LO, HI > &val)`
*Scalar_T quadratic form == (rev(x)*x)(0)*
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 Scalar_T glucat::norm (const Multivector< Scalar_T, LO, HI > &val)`
Scalar_T norm == sum of norm of coordinates.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 Scalar_T glucat::abs (const Multivector< Scalar_T, LO, HI > &val)`
Absolute value == sqrt(norm)
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 Scalar_T glucat::max_abs (const Multivector< Scalar_T, LO, HI > &val)`
Maximum of absolute values of components of multivector: multivector infinity norm.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::complexifier (const Multivector< Scalar_T, LO, HI > &val)`
Square root of -1 which commutes with all members of the frame of the given multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::elliptic (const Multivector< Scalar_T, LO, HI > &val)`
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 static void glucat::check_complex (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)`
Check that i is a valid complexifier for val.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::sqrt (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)`
Square root of multivector with specified complexifier.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::sqrt (const Multivector< Scalar_T, LO, HI > &val)`
Square root of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::clifford_exp (const Multivector< Scalar_T, LO, HI > &val)`
Exponential of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::log (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)`
Natural logarithm of multivector with specified complexifier.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::log (const Multivector< Scalar_T, LO, HI > &val)`
Natural logarithm of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::cosh (const Multivector< Scalar_T, LO, HI > &val)`
Hyperbolic cosine of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::acosh (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)`
Inverse hyperbolic cosine of multivector with specified complexifier.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::acosh (const Multivector< Scalar_T, LO, HI > &val)`
Inverse hyperbolic cosine of multivector.
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
 const Multivector< Scalar_T,
 LO, HI > glucat::cos (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)`

Cosine of multivector with specified complexifier.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::cos](#) (const Multivector< Scalar_T, LO, HI > &val)

Cosine of multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::acos](#) (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)

Inverse cosine of multivector with specified complexifier.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::acos](#) (const Multivector< Scalar_T, LO, HI > &val)

Inverse cosine of multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::sinh](#) (const Multivector< Scalar_T, LO, HI > &val)

Hyperbolic sine of multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::asinh](#) (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)

Inverse hyperbolic sine of multivector with specified complexifier.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::asinh](#) (const Multivector< Scalar_T, LO, HI > &val)

Inverse hyperbolic sine of multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::sin](#) (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)

Sine of multivector with specified complexifier.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::sin](#) (const Multivector< Scalar_T, LO, HI > &val)

Sine of multivector.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::asin](#) (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i, const bool prechecked=false)

Inverse sine of multivector with specified complexifier.

- template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > [glucat::asin](#) (const Multivector< Scalar_T, LO, HI > &val)

Inverse sine of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::tanh (const Multivector< Scalar_T, LO, HI > &val)`

Hyperbolic tangent of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::atanh (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI >
&i, const bool prechecked=false)`

Inverse hyperbolic tangent of multivector with specified complexifier.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::atanh (const Multivector< Scalar_T, LO, HI > &val)`

Inverse hyperbolic tangent of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::tan (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI > &i,
const bool prechecked=false)`

Tangent of multivector with specified complexifier.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::tan (const Multivector< Scalar_T, LO, HI > &val)`

Tangent of multivector.

- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::atan (const Multivector< Scalar_T, LO, HI > &val, const Multivector< Scalar_T, LO, HI >
&i, const bool prechecked=false)`

Inverse tangent of multivector with specified complexifier.

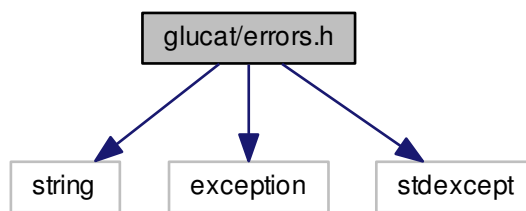
- `template<template< typename, const index_t, const index_t > class Multivector, typename Scalar_T , const index_t LO, const index_t HI>
const Multivector< Scalar_T,
LO, HI > glucat::atan (const Multivector< Scalar_T, LO, HI > &val)`

Inverse tangent of multivector.

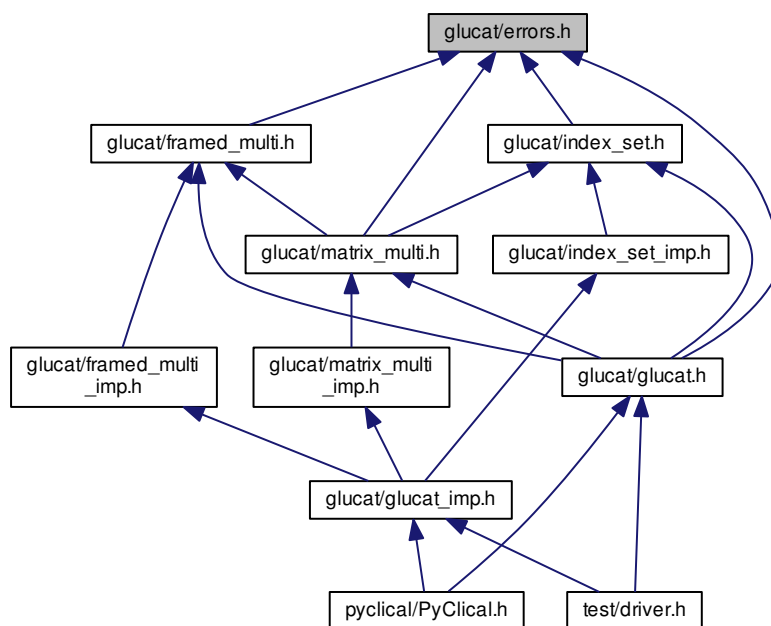
7.3 `glucat/errors.h` File Reference

```
#include <string>
#include <exception>
#include <stdexcept>
```


Include dependency graph for errors.h:



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



Classes

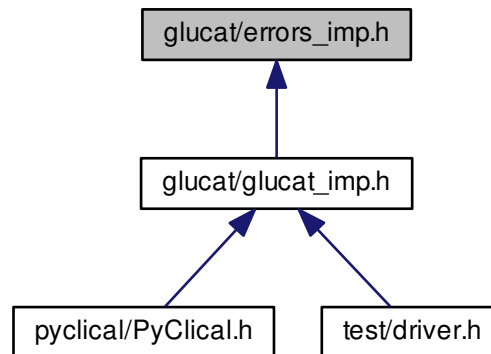
- class [glucat::glucat_error](#)
Abstract exception class.
- class [glucat::error< Class_T >](#)
Specific exception class.

Namespaces

- [glucat](#)

7.4 glucat/errors_imp.h File Reference

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



Namespaces

- [glucat](#)

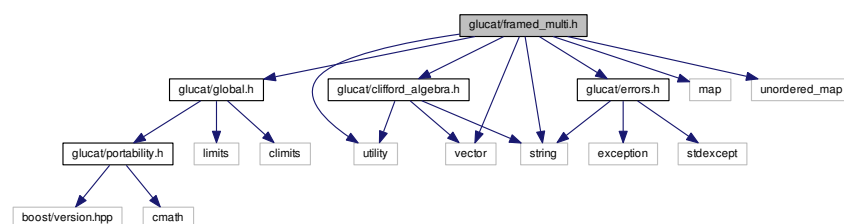
7.5 glucat/framed_multi.h File Reference

```

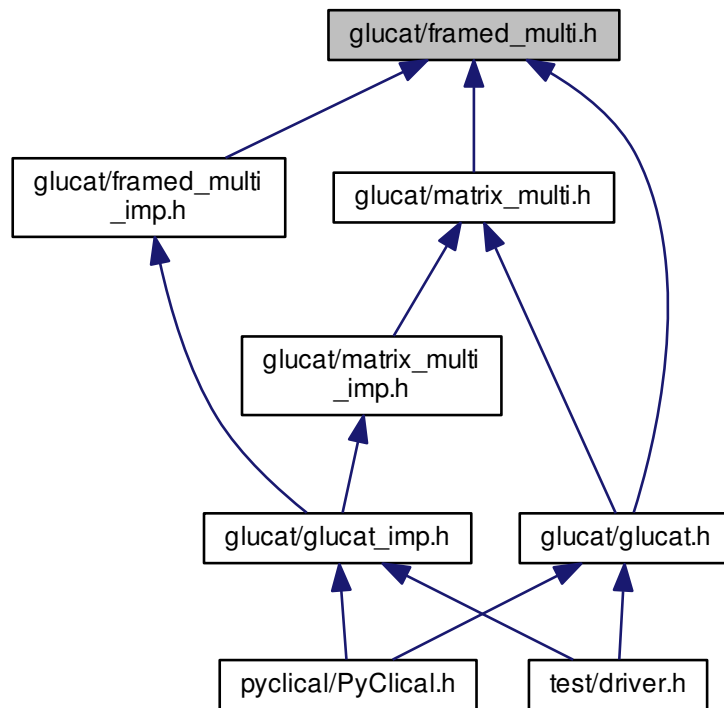
#include "glucat/global.h"
#include "glucat/errors.h"
#include "glucat/clifford_algebra.h"
#include <string>
#include <utility>
#include <map>
#include <vector>
#include <unordered_map>

```

Include dependency graph for `framed_multi.h`:



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



Classes

- class [glucat::framed_multi< Scalar_T, LO, HI >](#)
A *framed_multi<Scalar_T,LO,HI>* is a framed approximation to a multivector.
- class [glucat::matrix_multi< Scalar_T, LO, HI >](#)
A *matrix_multi<Scalar_T,LO,HI>* is a matrix approximation to a multivector.
- class [glucat::index_set_hash< LO, HI >](#)
- class [glucat::framed_multi< Scalar_T, LO, HI >](#)
A *framed_multi<Scalar_T,LO,HI>* is a framed approximation to a multivector.
- class [glucat::framed_multi< Scalar_T, LO, HI >::hash_size_t](#)
- class [glucat::framed_multi< Scalar_T, LO, HI >::var_term](#)
Variable term.
- struct [std::numeric_limits< glucat::framed_multi< Scalar_T, LO, HI > >](#)
Numeric limits for *framed_multi* inherit limits for the corresponding scalar type.

Namespaces

- [glucat](#)
- [std](#)

Macros

- [#define _GLUCAT_MAP_IS_HASH](#)

Functions

- template<typename Scalar_T , const index_t LO, const index_t HI>
 const framed_multi< Scalar_T,
 LO, HI > [glucat::operator*](#) (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,
 LO, HI > &rhs)
Geometric product.
- template<typename Scalar_T , const index_t LO, const index_t HI>
 const framed_multi< Scalar_T,
 LO, HI > [glucat::operator^](#) (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,
 LO, HI > &rhs)
Outer product.
- template<typename Scalar_T , const index_t LO, const index_t HI>
 const framed_multi< Scalar_T,
 LO, HI > [glucat::operator&](#) (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,
 LO, HI > &rhs)
Inner product.
- template<typename Scalar_T , const index_t LO, const index_t HI>
 const framed_multi< Scalar_T,
 LO, HI > [glucat::operator%](#) (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,
 LO, HI > &rhs)
Left contraction.
- template<typename Scalar_T , const index_t LO, const index_t HI>
 Scalar_T [glucat::star](#) (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T, LO, HI
 > &rhs)
Hestenes scalar product.
- template<typename Scalar_T , const index_t LO, const index_t HI>
 const framed_multi< Scalar_T,
 LO, HI > [glucat::operator/](#) (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,
 LO, HI > &rhs)
Geometric quotient.
- template<typename Scalar_T , const index_t LO, const index_t HI>
 const framed_multi< Scalar_T,
 LO, HI > [glucat::operator|](#) (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,
 LO, HI > &rhs)
Transformation via twisted adjoint action.
- template<typename Scalar_T , const index_t LO, const index_t HI>
 std::istream & [glucat::operator>>](#) (std::istream &s, framed_multi< Scalar_T, LO, HI > &val)
Read multivector from input.
- template<typename Scalar_T , const index_t LO, const index_t HI>
 std::ostream & [glucat::operator<<](#) (std::ostream &os, const framed_multi< Scalar_T, LO, HI > &val)
Write multivector to output.
- template<typename Scalar_T , const index_t LO, const index_t HI>
 std::ostream & [glucat::operator<<](#) (std::ostream &os, const std::pair< const index_set< LO, HI >, Scalar_T
 > &term)
Write term to output.
- template<typename Scalar_T , const index_t LO, const index_t HI>
 const framed_multi< Scalar_T,
 LO, HI > [glucat::exp](#) (const framed_multi< Scalar_T, LO, HI > &val)
Exponential of multivector.
- template<typename Scalar_T , const index_t LO, const index_t HI>
 static Scalar_T [glucat::crd_of_mult](#) (const std::pair< const index_set< LO, HI >, Scalar_T > &lhs, const
 std::pair< const index_set< LO, HI >, Scalar_T > &rhs)
Coordinate of product of terms.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const std::pair< const`
`index_set< LO, HI >, Scalar_T > glucat::operator\* (const std::pair< const index_set< LO, HI >, Scalar_T`
`> &lhs, const std::pair< const index_set< LO, HI >, Scalar_T > &rhs)`

Product of terms.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed_multi< Scalar_T,`
`LO, HI > glucat::sqrt (const framed_multi< Scalar_T, LO, HI > &val, const framed_multi< Scalar_T, LO, HI`
`> &i, bool prechecked)`

Square root of multivector with specified complexifier.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed_multi< Scalar_T,`
`LO, HI > glucat::log (const framed_multi< Scalar_T, LO, HI > &val, const framed_multi< Scalar_T, LO, HI`
`> &i, bool prechecked)`

Natural logarithm of multivector with specified complexifier.

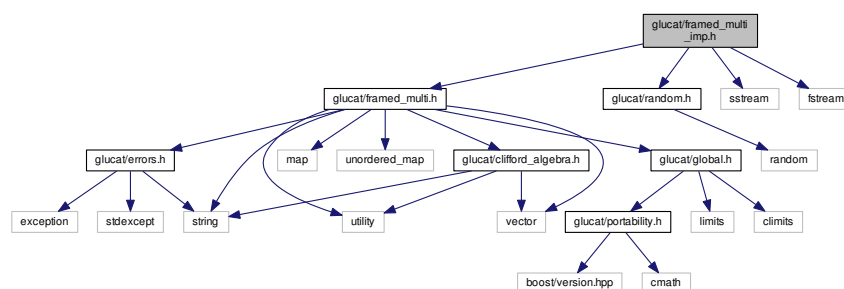
7.5.1 Macro Definition Documentation

7.5.1.1 #define _GLUCAT_MAP_IS_HASH

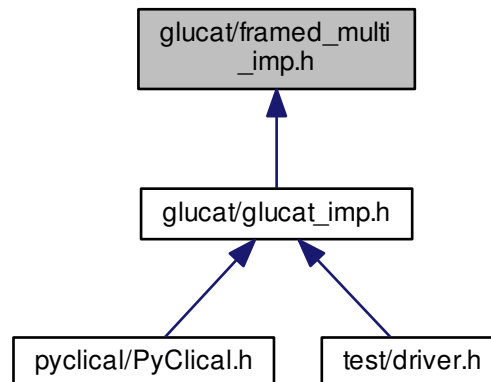
Definition at line 55 of file framed_multi.h.

7.6 glucat/framed_multi_imp.h File Reference

```
#include "glucat/framed_multi.h"
#include "glucat/random.h"
#include <sstream>
#include <fstream>
Include dependency graph for framed_multi_imp.h:
```



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



Classes

- class `glucat::sorted_range< Map_T, Sorted_Map_T >`
Sorted range for use with output.
- class `glucat::sorted_range< Sorted_Map_T, Sorted_Map_T >`

Namespaces

- `glucat`

Macros

- `#define _GLUCAT_HASH_N(x)`
- `#define _GLUCAT_HASH_SIZE_T(x)`

Functions

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed_multi< Scalar_T,`
`LO, HI > glucat::operator\* (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,`
`LO, HI > &rhs)`
Geometric product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed_multi< Scalar_T,`
`LO, HI > glucat::operator^ (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,`
`LO, HI > &rhs)`
Outer product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const framed_multi< Scalar_T,`
`LO, HI > glucat::operator& (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,`
`LO, HI > &rhs)`

Inner product.

- template<typename Scalar_T , const index_t LO, const index_t HI>
const framed_multi< Scalar_T,
LO, HI > [glucat::operator%](#) (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,
LO, HI > &rhs)

Left contraction.

- template<typename Scalar_T , const index_t LO, const index_t HI>
Scalar_T [glucat::star](#) (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T, LO, HI
> &rhs)

Hestenes scalar product.

- template<typename Scalar_T , const index_t LO, const index_t HI>
const framed_multi< Scalar_T,
LO, HI > [glucat::operator/](#) (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,
LO, HI > &rhs)

Geometric quotient.

- template<typename Scalar_T , const index_t LO, const index_t HI>
const framed_multi< Scalar_T,
LO, HI > [glucat::operator|](#) (const framed_multi< Scalar_T, LO, HI > &lhs, const framed_multi< Scalar_T,
LO, HI > &rhs)

Transformation via twisted adjoint action.

- template<typename Scalar_T , const index_t LO, const index_t HI>
std::ostream & [glucat::operator<<](#) (std::ostream &os, const framed_multi< Scalar_T, LO, HI > &val)

Write multivector to output.

- template<typename Scalar_T , const index_t LO, const index_t HI>
std::ostream & [glucat::operator<<](#) (std::ostream &os, const std::pair< const index_set< LO, HI >, Scalar_T
> &term)

Write term to output.

- template<typename Scalar_T , const index_t LO, const index_t HI>
std::istream & [glucat::operator>>](#) (std::istream &s, framed_multi< Scalar_T, LO, HI > &val)

Read multivector from input.

- template<typename Scalar_T , const index_t LO, const index_t HI>
static Scalar_T [glucat::crd_of_mult](#) (const std::pair< const index_set< LO, HI >, Scalar_T > &lhs, const
std::pair< const index_set< LO, HI >, Scalar_T > &rhs)

Coordinate of product of terms.

- template<typename Scalar_T , const index_t LO, const index_t HI>
const std::pair< const
index_set< LO, HI >, Scalar_T > [glucat::operator*](#) (const std::pair< const index_set< LO, HI >, Scalar_T
> &lhs, const std::pair< const index_set< LO, HI >, Scalar_T > &rhs)

Product of terms.

- template<typename Scalar_T , const index_t LO, const index_t HI>
const framed_multi< Scalar_T,
LO, HI > [glucat::sqrt](#) (const framed_multi< Scalar_T, LO, HI > &val, const framed_multi< Scalar_T, LO, HI
> &i, bool prechecked)

Square root of multivector with specified complexifier.

- template<typename Scalar_T , const index_t LO, const index_t HI>
const framed_multi< Scalar_T,
LO, HI > [glucat::exp](#) (const framed_multi< Scalar_T, LO, HI > &val)

Exponential of multivector.

- template<typename Scalar_T , const index_t LO, const index_t HI>
const framed_multi< Scalar_T,
LO, HI > [glucat::log](#) (const framed_multi< Scalar_T, LO, HI > &val, const framed_multi< Scalar_T, LO, HI
> &i, bool prechecked)

Natural logarithm of multivector with specified complexifier.

7.6.1 Macro Definition Documentation

7.6.1.1 `#define _GLUCAT_HASH_N( x )`

Definition at line 60 of file `framed_multi_imp.h`.

7.6.1.2 `#define _GLUCAT_HASH_SIZE_T( x )`

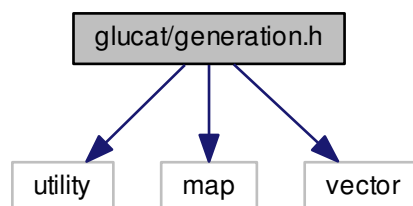
Definition at line 61 of file `framed_multi_imp.h`.

Referenced by `glucat::framed_multi< Scalar_T, LO, HI >::framed_multi()`, `glucat::operator%()`, `glucat::operator&()`, `glucat::operator*()`, and `glucat::operator^()`.

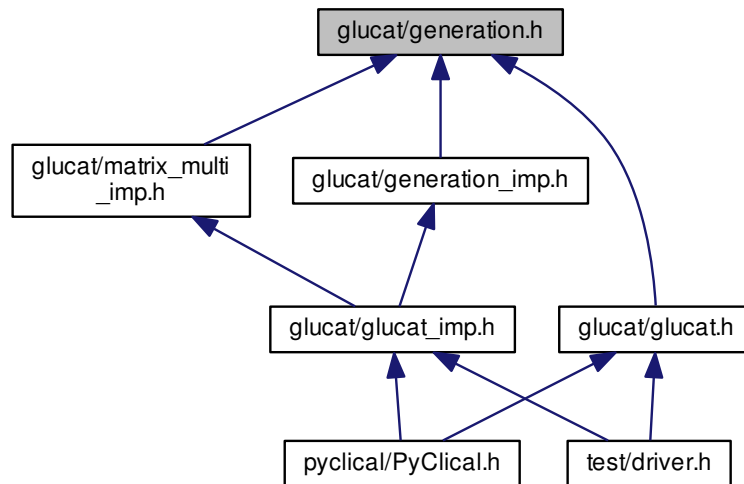
7.7 `glucat/generation.h` File Reference

```
#include <utility>
#include <map>
#include <vector>
```

Include dependency graph for `generation.h`:



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



Classes

- class [glucat::gen::generator_table< Matrix_T >](#)
Table of generators for specific signatures.

Namespaces

- [glucat](#)
- [glucat::gen](#)

Typedefs

- typedef std::pair< index_t,
index_t > [glucat::gen::signature_t](#)
A signature is a pair of indices, p, q, with p == frame.max(), q == -frame.min()

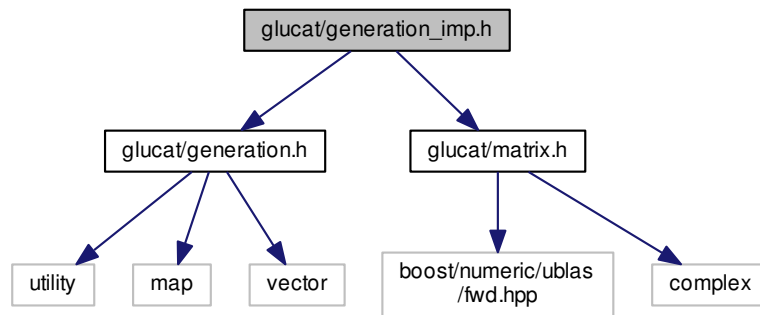
Variables

- static const index_t [glucat::gen::offset_to_super](#) [] = {0,-1, 0,-1,-2, 3, 2, 1}
Offsets between the current signature and that of the real superalgebra.

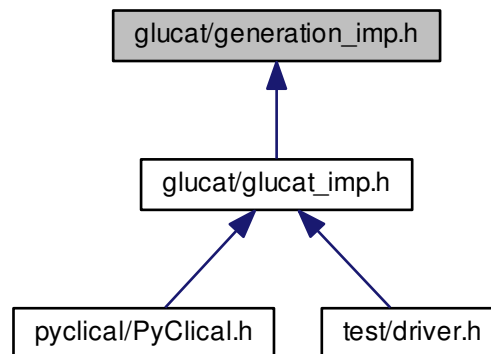
7.8 glucat/generation_imp.h File Reference

```
#include "glucat/generation.h"
#include "glucat/matrix.h"
```

Include dependency graph for generation_imp.h:



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



Namespaces

- [glucat](#)
- [glucat::gen](#)

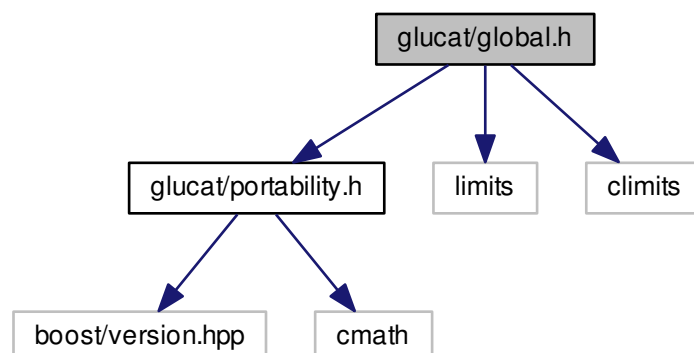
7.9 glucat/global.h File Reference

```

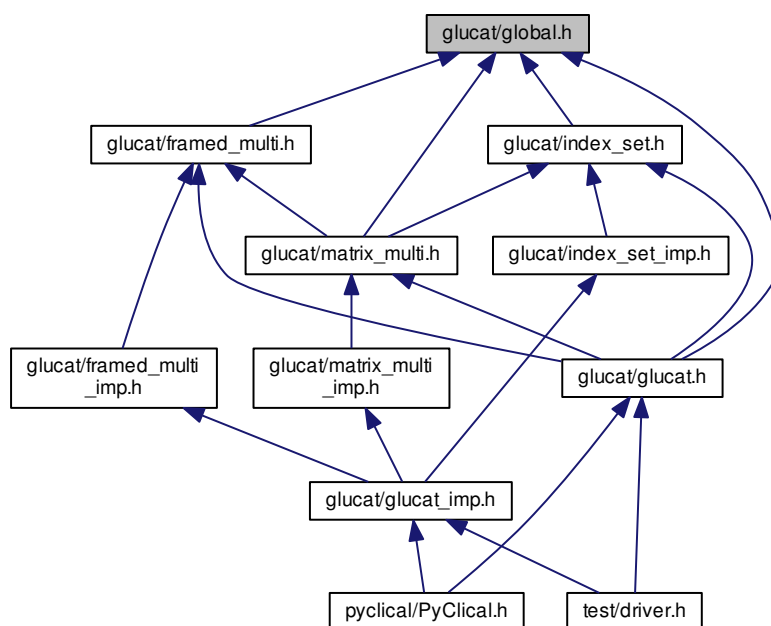
#include "glucat/portability.h"
#include <limits>
#include <climits>

```

Include dependency graph for global.h:



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



Classes

- struct `glucat::CTAssertion< bool >`
Compile time assertion.
- struct `glucat::CTAssertion< true >`
- class `glucat::compare_types< LHS_T, RHS_T >`
Type comparison.

- class `glucat::compare_types< T, T >`
- class `glucat::bool_to_type< truth_value >`
Bool to type.
- struct `glucat::tuning< Mult_Matrix_Threshold, Div_Max_Steps, Sqrt_Max_Steps, Log_Max_Outer_Steps, Log_Max_Inner_Steps, Basis_Max_Count, Fast_Size_Threshold, Inv_Fast_Dim_Threshold, Products_Size_Threshold, Function_Precision >`
Tuning policy.

Namespaces

- `glucat`

Macros

- `#define _GLUCAT_CTAssert(expr, msg) namespace { struct msg { glucat::CTAssertion<(expr)> ERROR_ ##msg; }; }`

Typedefs

- typedef int `glucat::index_t`
Size of index_t should be enough to represent LO, HI.
- typedef unsigned long `glucat::set_value_t`
Size of set_value_t should be enough to contain index_set<LO,HI>

Enumerations

- enum `glucat::precision_t` { `glucat::precision_demoted`, `glucat::precision_same`, `glucat::precision_promoted` }
Precision policy.

Functions

- template<typename LHS_T, typename RHS_T >
`LHS_T glucat::pos_mod (LHS_T lhs, RHS_T rhs)`
Modulo function which works reliably for lhs < 0.

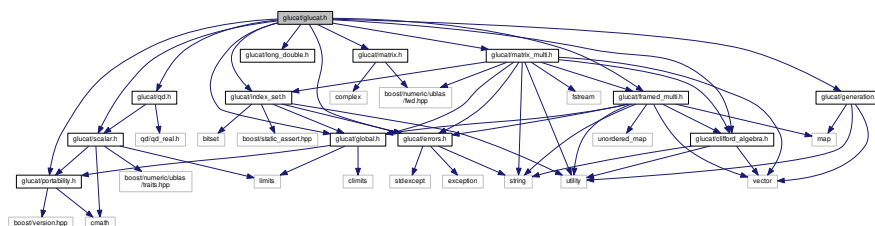
Variables

- const double `glucat::MS_PER_S` = 1000.0
Timing constant: deprecated here - moved to `test/timing.h`.
- const index_t `glucat::BITS_PER_CHAR` = `std::numeric_limits<unsigned char>::digits`
If radix of unsigned char is not 2, we can't easily determine number of bits from sizeof.
- const index_t `glucat::BITS_PER_SET_VALUE` = `std::numeric_limits<set_value_t>::digits`
Number of bits in set_value_t.
- const index_t `glucat::DEFAULT_LO` = `-index_t(BITS_PER_SET_VALUE / 2)`
Default lowest index in an index set.
- const index_t `glucat::DEFAULT_HI` = `index_t(BITS_PER_SET_VALUE / 2)`
Default highest index in an index set.
- const double `glucat::DEFAULT_TRUNCATION` = `std::numeric_limits<float>::epsilon()`
Default for truncation.
- const unsigned int `glucat::DEFAULT_Mult_Matrix_Threshold` = 8

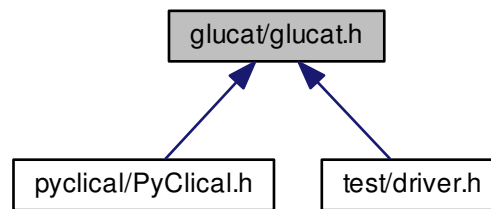
- ### 7.9.1 Macro Definition Documentation

Definition at line 48 of file global.h.

```
#include "glucat/portability.h"
#include "glucat/global.h"
#include "glucat/errors.h"
#include "glucat/index_set.h"
#include "glucat/scalar.h"
#include "glucat/long_double.h"
#include "glucat/qd.h"
#include "glucat/clifford_algebra.h"
#include "glucat/framed_multi.h"
#include "glucat/generation.h"
#include "glucat/matrix.h"
#include "glucat/matrix_multi.h"
Include dependency graph for glucat.h:
```

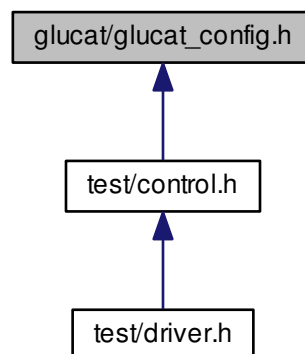


This graph shows which files directly or indirectly include this file:



7.11 glucat/glucat_config.h File Reference

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



Macros

- #define [GLUCAT_HAVE_INTTYPES_H](#) 1
- #define [GLUCAT_HAVE_MEMORY_H](#) 1
- #define [GLUCAT_HAVE_STDINT_H](#) 1
- #define [GLUCAT_HAVE_STDLIB_H](#) 1
- #define [GLUCAT_HAVE_STRINGS_H](#) 1
- #define [GLUCAT_HAVE_STRING_H](#) 1
- #define [GLUCAT_HAVE_SYS_STAT_H](#) 1
- #define [GLUCAT_HAVE_SYS_TYPES_H](#) 1
- #define [GLUCAT_HAVE_UNISTD_H](#) 1
- #define [GLUCAT_PACKAGE](#) "glucat"
- #define [GLUCAT_PACKAGE_BUGREPORT](#) ""
- #define [GLUCAT_PACKAGE_NAME](#) "glucat"

- `#define GLUCAT_PACKAGE_STRING "glucat 0.8.2"`
- `#define GLUCAT_PACKAGE_TARNAME "glucat"`
- `#define GLUCAT_PACKAGE_URL ""`
- `#define GLUCAT_PACKAGE_VERSION "0.8.2"`
- `#define GLUCAT_STDC_HEADERS 1`
- `#define GLUCAT_VERSION "0.8.2"`

7.11.1 Macro Definition Documentation

7.11.1.1 `#define GLUCAT_HAVE_INTTYPES_H 1`

Definition at line 10 of file glucat_config.h.

7.11.1.2 `#define GLUCAT_HAVE_MEMORY_H 1`

Definition at line 18 of file glucat_config.h.

7.11.1.3 `#define GLUCAT_HAVE_STDINT_H 1`

Definition at line 23 of file glucat_config.h.

7.11.1.4 `#define GLUCAT_HAVE_STDLIB_H 1`

Definition at line 28 of file glucat_config.h.

7.11.1.5 `#define GLUCAT_HAVE_STRING_H 1`

Definition at line 38 of file glucat_config.h.

7.11.1.6 `#define GLUCAT_HAVE_STRINGS_H 1`

Definition at line 33 of file glucat_config.h.

7.11.1.7 `#define GLUCAT_HAVE_SYS_STAT_H 1`

Definition at line 43 of file glucat_config.h.

7.11.1.8 `#define GLUCAT_HAVE_SYS_TYPES_H 1`

Definition at line 48 of file glucat_config.h.

7.11.1.9 `#define GLUCAT_HAVE_UNISTD_H 1`

Definition at line 53 of file glucat_config.h.

7.11.1.10 `#define GLUCAT_PACKAGE "glucat"`

Definition at line 58 of file glucat_config.h.

7.11.1.11 `#define GLUCAT_PACKAGE_BUGREPORT ""`

Definition at line 63 of file `glucat_config.h`.

7.11.1.12 `#define GLUCAT_PACKAGE_NAME "glucat"`

Definition at line 68 of file `glucat_config.h`.

Referenced by `glucat::control_t::control_t()`.

7.11.1.13 `#define GLUCAT_PACKAGE_STRING "glucat 0.8.2"`

Definition at line 73 of file `glucat_config.h`.

7.11.1.14 `#define GLUCAT_PACKAGE_TARNAME "glucat"`

Definition at line 78 of file `glucat_config.h`.

7.11.1.15 `#define GLUCAT_PACKAGE_URL ""`

Definition at line 83 of file `glucat_config.h`.

7.11.1.16 `#define GLUCAT_PACKAGE_VERSION "0.8.2"`

Definition at line 88 of file `glucat_config.h`.

7.11.1.17 `#define GLUCAT_STDC_HEADERS 1`

Definition at line 93 of file `glucat_config.h`.

7.11.1.18 `#define GLUCAT_VERSION "0.8.2"`

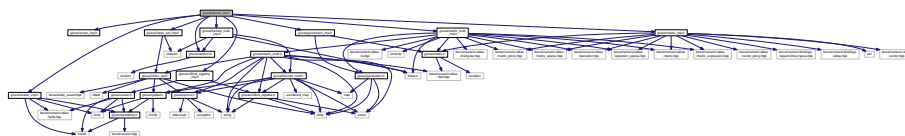
Definition at line 98 of file `glucat_config.h`.

Referenced by `glucat::control_t::control_t()`.

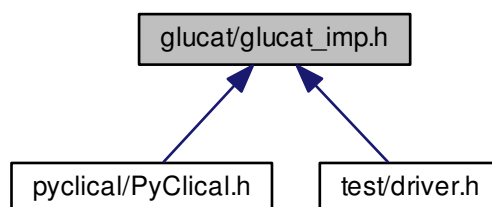
7.12 `glucat/glucat_imp.h` File Reference

```
#include "glucat/errors_imp.h"
#include "glucat/index_set_imp.h"
#include "glucat/scalar_imp.h"
#include "glucat/clifford_algebra_imp.h"
#include "glucat/random.h"
#include "glucat/framed_multi_imp.h"
#include "glucat/matrix_imp.h"
#include "glucat/generation_imp.h"
#include "glucat/matrix_multi_imp.h"
```


Include dependency graph for glucat_imp.h:



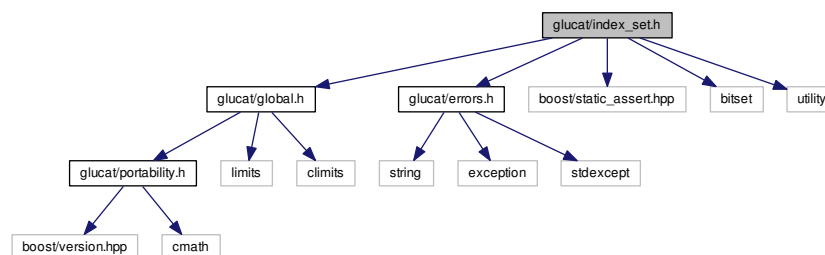
This graph shows which files directly or indirectly include this file:



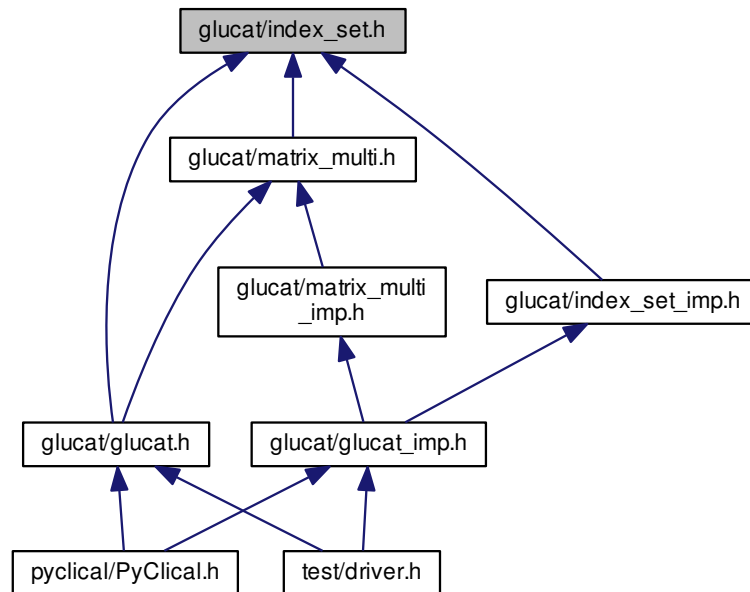
7.13 glucat/index_set.h File Reference

```
#include "glucat/global.h"
#include "glucat/errors.h"
#include <boost/static_assert.hpp>
#include <bitset>
#include <utility>
```

Include dependency graph for index_set.h:



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



Classes

- class [glucat::index_set< LO, HI >](#)
Index set class based on `std::bitset<>` in Gnu standard C++ library.
- class [glucat::index_set< LO, HI >](#)
Index set class based on `std::bitset<>` in Gnu standard C++ library.
- class [glucat::index_set< LO, HI >::reference](#)
Index set member reference.

Namespaces

- [glucat](#)

Functions

- `template<const index_t LO, const index_t HI>`
`const index_set< LO, HI > glucat::operator^ (const index_set< LO, HI > &lhs, const index_set< LO, HI > &rhs)`
Symmetric set difference: exclusive or.
- `template<const index_t LO, const index_t HI>`
`const index_set< LO, HI > glucat::operator& (const index_set< LO, HI > &lhs, const index_set< LO, HI > &rhs)`
Set intersection: and.
- `template<const index_t LO, const index_t HI>`
`const index_set< LO, HI > glucat::operator| (const index_set< LO, HI > &lhs, const index_set< LO, HI > &rhs)`

Set union: or.

- `template<const index_t LO, const index_t HI>`
`int glucat::compare (const index_set< LO, HI > &a, const index_set< LO, HI > &b)`

"lexicographic compare" eg. {3,4,5} is less than {3,7,8}

- `glucat::GLUCAT_CTAssert (sizeof(set_value_t) >=sizeof(std::bitset< DEFAULT_HI-DEFAULT_LO >),`
`Default_index_set_too_big_for_value) template< const index_t LO`

Size of `set_value_t` should be enough to contain `bitset<DEFAULT_HI-DEFAULT_LO>`

- `const index_t HI std::ostream & glucat::operator<< (std::ostream &os, const index_set< LO, HI > &ist)`

Write out index set.

- `template<const index_t LO, const index_t HI>`
`std::istream & glucat::operator>> (std::istream &s, index_set< LO, HI > &ist)`

Read in index set.

- `int glucat::sign_of_square (index_t j)`

Square of generator [j].

- `template<const index_t LO, const index_t HI>`
`index_t glucat::min_neg (const index_set< LO, HI > &ist)`

Minimum negative index, or 0 if none.

- `template<const index_t LO, const index_t HI>`
`index_t glucat::max_pos (const index_set< LO, HI > &ist)`

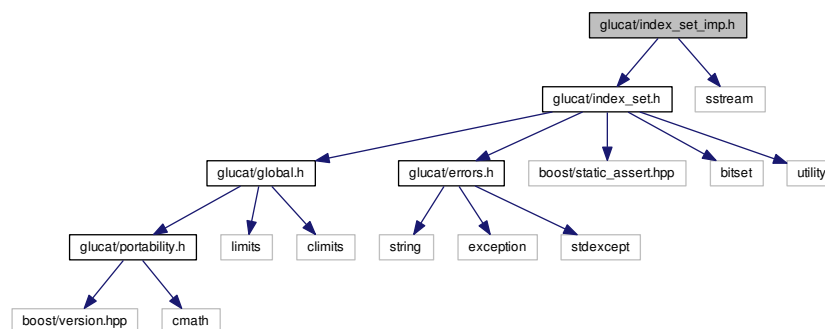
Maximum positive index, or 0 if none.

7.14 glucat/index_set_imp.h File Reference

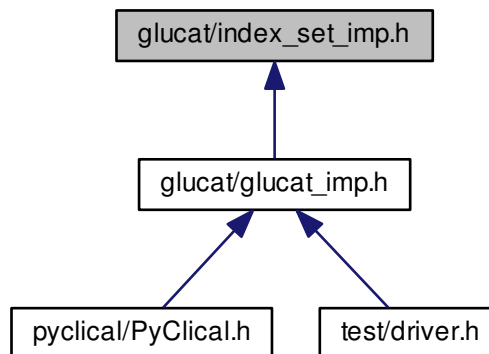
```
#include "glucat/index_set.h"
```

```
#include <sstream>
```

Include dependency graph for `index_set_imp.h`:



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



Namespaces

- [glucat](#)

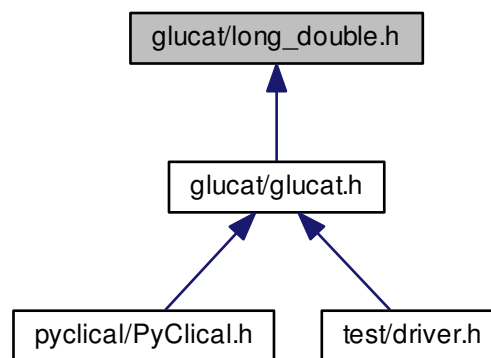
Functions

- `template<const index_t LO, const index_t HI>`
`const index_set< LO, HI > glucat::operator^ (const index_set< LO, HI > &lhs, const index_set< LO, HI > &rhs)`
Symmetric set difference: exclusive or.
- `template<const index_t LO, const index_t HI>`
`const index_set< LO, HI > glucat::operator& (const index_set< LO, HI > &lhs, const index_set< LO, HI > &rhs)`
Set intersection: and.
- `template<const index_t LO, const index_t HI>`
`const index_set< LO, HI > glucat::operator| (const index_set< LO, HI > &lhs, const index_set< LO, HI > &rhs)`
Set union: or.
- `template<const index_t LO, const index_t HI>`
`int glucat::compare (const index_set< LO, HI > &a, const index_set< LO, HI > &b)`
"lexicographic compare" eg. {3,4,5} is less than {3,7,8}
- `const index_t HI std::ostream & glucat::operator<< (std::ostream &os, const index_set< LO, HI > &ist)`
Write out index set.
- `template<const index_t LO, const index_t HI>`
`std::istream & glucat::operator>> (std::istream &s, index_set< LO, HI > &ist)`
Read in index set.
- `static unsigned long glucat::inverse\_reversed\_gray (unsigned long x)`
Inverse reversed Gray code.
- `static unsigned long glucat::inverse\_gray (unsigned long x)`
Inverse Gray code.
- `int glucat::sign\_of\_square (index_t j)`
Square of generator {j}.

- template<const index_t LO, const index_t HI>
index_t [glucat::min_neg](#) (const index_set< LO, HI > &ist)
Minimum negative index, or 0 if none.
- template<const index_t LO, const index_t HI>
index_t [glucat::max_pos](#) (const index_set< LO, HI > &ist)
Maximum positive index, or 0 if none.

7.15 glucat/long_double.h File Reference

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



Classes

- struct [glucat::numeric_traits< Scalar_T >::demoted<>](#)
Demoted type for long double.

Namespaces

- [glucat](#)

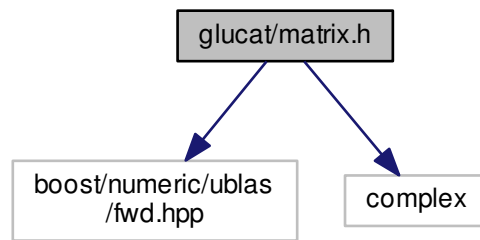
Variables

- static const long double [glucat::l_pi](#) = 3.1415926535897932384626433832795029L
- static const long double [glucat::l_ln2](#) = 0.6931471805599453094172321214581766L

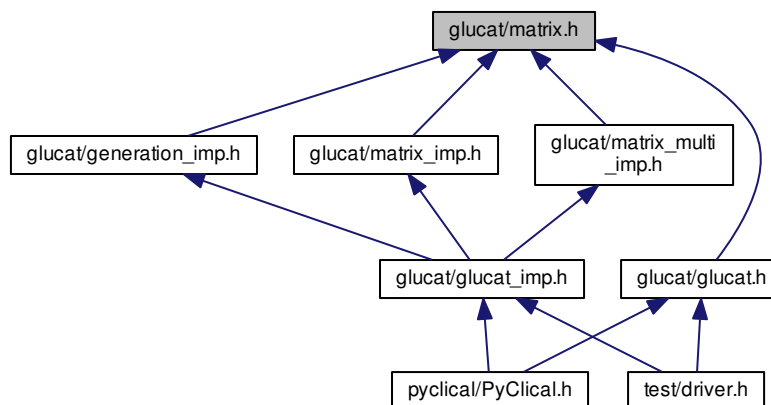
7.16 glucat/matrix.h File Reference

```
#include <boost/numeric/ublas/fwd.hpp>
#include <complex>
```

Include dependency graph for `matrix.h`:



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



Classes

- struct `glucat::matrix::eig_genus< Matrix_T >`
Structure containing classification of eigenvalues.

Namespaces

- `glucat`
- `glucat::matrix`

Enumerations

- enum `glucat::matrix::eig_case_t` { `glucat::matrix::safe_eig_case`, `glucat::matrix::negative_eig_case`, `glucat::matrix::both_eig_case` }
Classification of eigenvalues of a matrix.

Functions

- template<typename LHS_T, typename RHS_T >
const RHS_T [glucat::matrix::kron](#) (const LHS_T &lhs, const RHS_T &rhs)
Kronecker tensor product of matrices - as per Matlab kron.
- template<typename LHS_T, typename RHS_T >
const RHS_T [glucat::matrix::mono_kron](#) (const LHS_T &lhs, const RHS_T &rhs)
Sparse Kronecker tensor product of monomial matrices.
- template<typename LHS_T, typename RHS_T >
const RHS_T [glucat::matrix::nork](#) (const LHS_T &lhs, const RHS_T &rhs, const bool mono=true)
Left inverse of Kronecker product.
- template<typename LHS_T, typename RHS_T >
const RHS_T [glucat::matrix::signed_perm_nork](#) (const LHS_T &lhs, const RHS_T &rhs)
Left inverse of Kronecker product where lhs is a signed permutation matrix.
- template<typename Matrix_T >
Matrix_T::size_type [glucat::matrix::nnz](#) (const Matrix_T &m)
Number of non-zeros.
- template<typename Matrix_T >
bool [glucat::matrix::isnan](#) (const Matrix_T &m)
Not a Number.
- template<typename Matrix_T >
const Matrix_T [glucat::matrix::unit](#) (const typename Matrix_T::size_type n)
Unit matrix - as per Matlab eye.
- template<typename LHS_T, typename RHS_T >
const RHS_T::expression_type [glucat::matrix::mono_prod](#) (const ublas::matrix_expression< LHS_T > &lhs, const ublas::matrix_expression< RHS_T > &rhs)
Product of monomial matrices.
- template<typename LHS_T, typename RHS_T >
const RHS_T::expression_type [glucat::matrix::sparse_prod](#) (const ublas::matrix_expression< LHS_T > &lhs, const ublas::matrix_expression< RHS_T > &rhs)
Product of sparse matrices.
- template<typename LHS_T, typename RHS_T >
const RHS_T::expression_type [glucat::matrix::prod](#) (const ublas::matrix_expression< LHS_T > &lhs, const ublas::matrix_expression< RHS_T > &rhs)
Product of matrices.
- template<typename Scalar_T, typename LHS_T, typename RHS_T >
Scalar_T [glucat::matrix::inner](#) (const LHS_T &lhs, const RHS_T &rhs)
*Inner product: $\sum(x(i,j)*y(i,j))/x.nrows()$*
- template<typename Matrix_T >
Matrix_T::value_type [glucat::matrix::norm_frob2](#) (const Matrix_T &val)
Square of Frobenius norm.
- template<typename Matrix_T >
Matrix_T::value_type [glucat::matrix::trace](#) (const Matrix_T &val)
Matrix trace.
- template<typename Matrix_T >
ublas::vector< std::complex
< double > > [glucat::matrix::eigenvalues](#) (const Matrix_T &val)
Eigenvalues of a matrix.
- template<typename Matrix_T >
eig_genus< Matrix_T > [glucat::matrix::classify_eigenvalues](#) (const Matrix_T &val)
Classify the eigenvalues of a matrix.

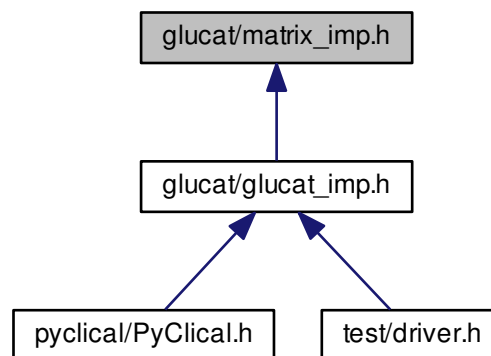
7.17 glucat/matrix_imp.h File Reference

```
#include "glucat/matrix.h"
#include <boost/numeric/ublas/vector.hpp>
#include <boost/numeric/ublas/vector_proxy.hpp>
#include <boost/numeric/ublas/matrix.hpp>
#include <boost/numeric/ublas/matrix_expression.hpp>
#include <boost/numeric/ublas/matrix_proxy.hpp>
#include <boost/numeric/ublas/matrix_sparse.hpp>
#include <boost/numeric/ublas/operation.hpp>
#include <boost/numeric/ublas/operation_sparse.hpp>
#include <boost/numeric/bindings/lapack/driver/gees.hpp>
#include <boost/numeric/bindings/ublas.hpp>
#include <set>
```

Include dependency graph for matrix_imp.h:



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



Namespaces

- [glucat](#)
- [glucat::matrix](#)

Functions

- `template<typename LHS_T, typename RHS_T >`
`const RHS_T glucat::matrix::kron (const LHS_T &lhs, const RHS_T &rhs)`
Kronecker tensor product of matrices - as per Matlab kron.
- `template<typename LHS_T, typename RHS_T >`
`const RHS_T glucat::matrix::mono\_kron (const LHS_T &lhs, const RHS_T &rhs)`

Sparse Kronecker tensor product of monomial matrices.

- template<typename LHS_T , typename RHS_T >
void [glucat::matrix::nork_range](#) (RHS_T &result, const typename LHS_T::const_iterator2 lhs_it2, const RHS_T &rhs, const typename RHS_T::size_type res_s1, const typename RHS_T::size_type res_s2)

Utility routine for nork: calculate result for a range of indices.

- template<typename LHS_T , typename RHS_T >
const RHS_T [glucat::matrix::nork](#) (const LHS_T &lhs, const RHS_T &rhs, const bool mono=true)

Left inverse of Kronecker product.

- template<typename LHS_T , typename RHS_T >
const RHS_T [glucat::matrix::signed_perm_nork](#) (const LHS_T &lhs, const RHS_T &rhs)

Left inverse of Kronecker product where lhs is a signed permutation matrix.

- template<typename Matrix_T >
Matrix_T::size_type [glucat::matrix::nnz](#) (const Matrix_T &m)

Number of non-zeros.

- template<typename Matrix_T >
bool [glucat::matrix::isnan](#) (const Matrix_T &m)

Not a Number.

- template<typename Matrix_T >
const Matrix_T [glucat::matrix::unit](#) (const typename Matrix_T::size_type n)

Unit matrix - as per Matlab eye.

- template<typename LHS_T , typename RHS_T >
const RHS_T::expression_type [glucat::matrix::mono_prod](#) (const ublas::matrix_expression< LHS_T > &lhs, const ublas::matrix_expression< RHS_T > &rhs)

Product of monomial matrices.

- template<typename LHS_T , typename RHS_T >
const RHS_T::expression_type [glucat::matrix::sparse_prod](#) (const ublas::matrix_expression< LHS_T > &lhs, const ublas::matrix_expression< RHS_T > &rhs)

Product of sparse matrices.

- template<typename LHS_T , typename RHS_T >
const RHS_T::expression_type [glucat::matrix::prod](#) (const ublas::matrix_expression< LHS_T > &lhs, const ublas::matrix_expression< RHS_T > &rhs)

Product of matrices.

- template<typename Scalar_T , typename LHS_T , typename RHS_T >
Scalar_T [glucat::matrix::inner](#) (const LHS_T &lhs, const RHS_T &rhs)

*Inner product: $\sum(x(i,j)*y(i,j))/x.nrows()$*

- template<typename Matrix_T >
Matrix_T::value_type [glucat::matrix::norm_frob2](#) (const Matrix_T &val)

Square of Frobenius norm.

- template<typename Matrix_T >
Matrix_T::value_type [glucat::matrix::trace](#) (const Matrix_T &val)

Matrix trace.

- template<typename Matrix_T >
static ublas::matrix< double,
ublas::column_major > [glucat::matrix::to_lapack](#) (const Matrix_T &val)

Convert matrix to LAPACK format.

- template<typename Matrix_T >
ublas::vector< std::complex
< double > > [glucat::matrix::eigenvalues](#) (const Matrix_T &val)

Eigenvalues of a matrix.

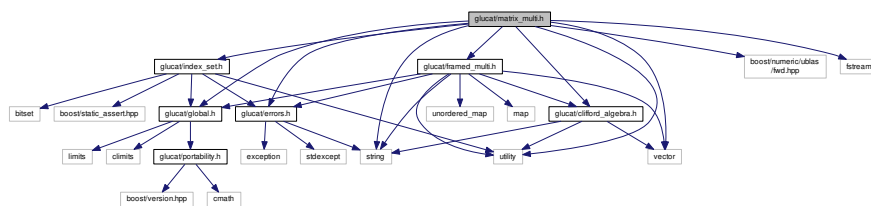
- template<typename Matrix_T >
eig_genus< Matrix_T > [glucat::matrix::classify_eigenvalues](#) (const Matrix_T &val)

Classify the eigenvalues of a matrix.

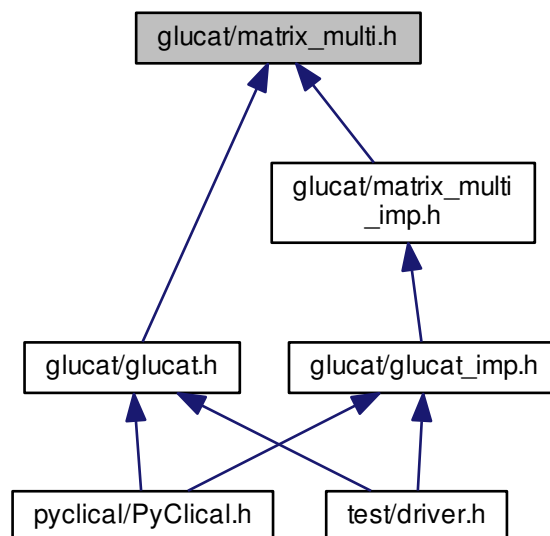
7.18 glucat/matrix_multi.h File Reference

```
#include "glucat/global.h"
#include "glucat/errors.h"
#include "glucat/index_set.h"
#include "glucat/clifford_algebra.h"
#include "glucat/framed_multi.h"
#include <boost/numeric/ublas/fwd.hpp>
#include <fstream>
#include <string>
#include <utility>
#include <vector>
```

Include dependency graph for matrix_multi.h:



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



Classes

- class [glucat::framed_multi](#)< [Scalar_T](#), [LO](#), [HI](#) >
A *framed_multi*<*Scalar_T*,*LO*,*HI*> is a framed approximation to a multivector.
- class [glucat::matrix_multi](#)< [Scalar_T](#), [LO](#), [HI](#) >

- *A `matrix_multi<Scalar_T,LO,HI>` is a matrix approximation to a multivector.*
- class `glucat::matrix_multi< Scalar_T, LO, HI >`
A `matrix_multi<Scalar_T,LO,HI>` is a matrix approximation to a multivector.
- struct `std::numeric_limits< glucat::matrix_multi< Scalar_T, LO, HI > >`
Numeric limits for `matrix_multi` inherit limits for the corresponding scalar type.

Namespaces

- `glucat`
- `std`

Functions

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::operator*` (`const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO,`
`HI > &rhs`)
Geometric product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::operator^` (`const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO,`
`HI > &rhs`)
Outer product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::operator&` (`const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO,`
`HI > &rhs`)
Inner product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::operator%` (`const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO,`
`HI > &rhs`)
Left contraction.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`Scalar_T glucat::star` (`const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO, HI >`
`&rhs`)
Hestenes scalar product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::operator/` (`const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO,`
`HI > &rhs`)
Geometric quotient.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::operator|` (`const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO,`
`HI > &rhs`)
Transformation via twisted adjoint action.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`std::istream & glucat::operator>>` (`std::istream &s, matrix_multi< Scalar_T, LO, HI > &val`)
Read multivector from input.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`std::ostream & glucat::operator<<` (`std::ostream &os, const matrix_multi< Scalar_T, LO, HI > &val`)
Write multivector to output.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const index_set< LO, HI > glucat::reframe (const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO, HI > &rhs, matrix_multi< Scalar_T, LO, HI > &lhs_reframed, matrix_multi< Scalar_T, LO, HI > &rhs_reframed)`

Find a common frame for operands of a binary operator.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::sqrt (const matrix_multi< Scalar_T, LO, HI > &val, const matrix_multi< Scalar_T, LO, HI >`
`&i, bool prechecked)`

Square root of multivector with specified complexifier.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::matrix\_sqrt (const matrix_multi< Scalar_T, LO, HI > &val, const matrix_multi< Scalar_T,`
`LO, HI > &i)`

Square root of multivector with specified complexifier.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::log (const matrix_multi< Scalar_T, LO, HI > &val, const matrix_multi< Scalar_T, LO, HI >`
`&i, bool prechecked)`

Natural logarithm of multivector with specified complexifier.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::matrix\_log (const matrix_multi< Scalar_T, LO, HI > &val, const matrix_multi< Scalar_T, LO,`
`HI > &i)`

Natural logarithm of multivector with specified complexifier.

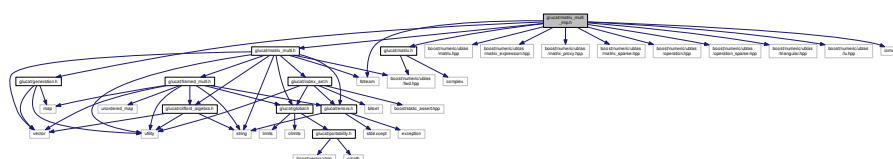
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::exp (const matrix_multi< Scalar_T, LO, HI > &val)`

Exponential of multivector.

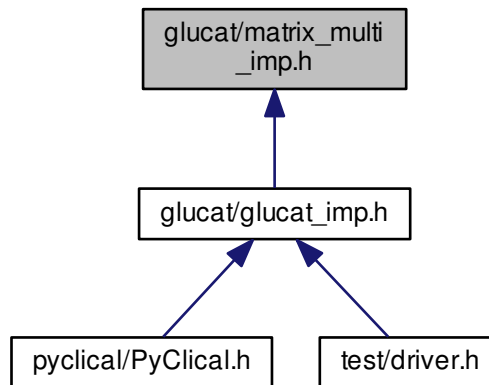
7.19 glucat/matrix_multi_imp.h File Reference

```
#include "glucat/matrix_multi.h"
#include "glucat/matrix.h"
#include "glucat/generation.h"
#include <boost/numeric/ublas/matrix.hpp>
#include <boost/numeric/ublas/matrix_expression.hpp>
#include <boost/numeric/ublas/matrix_proxy.hpp>
#include <boost/numeric/ublas/matrix_sparse.hpp>
#include <boost/numeric/ublas/operation.hpp>
#include <boost/numeric/ublas/operation_sparse.hpp>
#include <boost/numeric/ublas/triangular.hpp>
#include <boost/numeric/ublas/lu.hpp>
#include <fstream>
#include <iomanip>
```

Include dependency graph for matrix_multi_imp.h:



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



Classes

- class [glucat::basis_table< Scalar_T, LO, HI, Matrix_T >](#)
Table of basis elements used as a cache by basis_element()

Namespaces

- [glucat](#)

Functions

- index_t [glucat::offset_level](#) (const index_t p, const index_t q)
Determine the log2 dim corresponding to signature p, q.
- template<typename Matrix_Index_T, const index_t LO, const index_t HI>
static Matrix_Index_T [glucat::folded_dim](#) (const index_set< LO, HI > &sub)
Determine the matrix dimension of the fold of a subalgebra.
- template<typename Scalar_T, const index_t LO, const index_t HI>
const index_set< LO, HI > [glucat::reframe](#) (const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO, HI > &rhs, matrix_multi< Scalar_T, LO, HI > &lhs_reframed, matrix_multi< Scalar_T, LO, HI > &rhs_reframed)
Find a common frame for operands of a binary operator.
- template<typename Scalar_T, const index_t LO, const index_t HI>
const matrix_multi< Scalar_T, LO, HI > [glucat::operator*](#) (const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO, HI > &rhs)
Geometric product.
- template<typename Scalar_T, const index_t LO, const index_t HI>
const matrix_multi< Scalar_T, LO, HI > [glucat::operator^](#) (const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO, HI > &rhs)
Outer product.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::operator& (const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO,`
`HI > &rhs)`
Inner product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::operator% (const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO,`
`HI > &rhs)`
Left contraction.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`Scalar_T glucat::star (const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO, HI >`
`&rhs)`
Hestenes scalar product.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::operator/ (const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO,`
`HI > &rhs)`
Geometric quotient.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::operator| (const matrix_multi< Scalar_T, LO, HI > &lhs, const matrix_multi< Scalar_T, LO,`
`HI > &rhs)`
Transformation via twisted adjoint action.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`std::ostream & glucat::operator<< (std::ostream &os, const matrix_multi< Scalar_T, LO, HI > &val)`
Write multivector to output.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`std::istream & glucat::operator>> (std::istream &s, matrix_multi< Scalar_T, LO, HI > &val)`
Read multivector from input.
- `template<typename Multivector_T , typename Matrix_T , typename Basis_Matrix_T >`
`static Multivector_T glucat::fast (const Matrix_T &X, index_t level)`
Inverse generalized Fast Fourier Transform.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`static const matrix_multi`
`< Scalar_T, LO, HI > glucat::pade\_approx (const int array_size, const Scalar_T a[], const Scalar_T b[], const`
`matrix_multi< Scalar_T, LO, HI > &X)`
Pade' approximation.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`static void glucat::db\_step (matrix_multi< Scalar_T, LO, HI > &M, matrix_multi< Scalar_T, LO, HI > &Y)`
Single step of product form of Denman-Beavers square root iteration.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`static const matrix_multi`
`< Scalar_T, LO, HI > glucat::db\_sqrt (const matrix_multi< Scalar_T, LO, HI > &val)`
Product form of Denman-Beavers square root iteration.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::sqrt (const matrix_multi< Scalar_T, LO, HI > &val, const matrix_multi< Scalar_T, LO, HI >`
`&i, bool prechecked)`
Square root of multivector with specified complexifier.
- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::matrix\_sqrt (const matrix_multi< Scalar_T, LO, HI > &val, const matrix_multi< Scalar_T,`
`LO, HI > &i)`
Square root of multivector with specified complexifier.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`static const matrix_multi`
`< Scalar_T, LO, HI > glucat::pade_log (const matrix_multi< Scalar_T, LO, HI > &val)`

Pade' approximation of log.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`static const matrix_multi`
`< Scalar_T, LO, HI > glucat::cascade_log (const matrix_multi< Scalar_T, LO, HI > &val)`

Incomplete square root cascade and Pade' approximation of log.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::log (const matrix_multi< Scalar_T, LO, HI > &val, const matrix_multi< Scalar_T, LO, HI >`
`&i, bool prechecked)`

Natural logarithm of multivector with specified complexifier.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::matrix_log (const matrix_multi< Scalar_T, LO, HI > &val, const matrix_multi< Scalar_T, LO,`
`HI > &i)`

Natural logarithm of multivector with specified complexifier.

- `template<typename Scalar_T , const index_t LO, const index_t HI>`
`const matrix_multi< Scalar_T,`
`LO, HI > glucat::exp (const matrix_multi< Scalar_T, LO, HI > &val)`

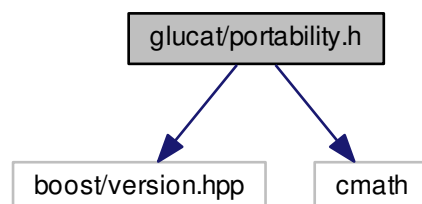
Exponential of multivector.

7.20 glucat/portability.h File Reference

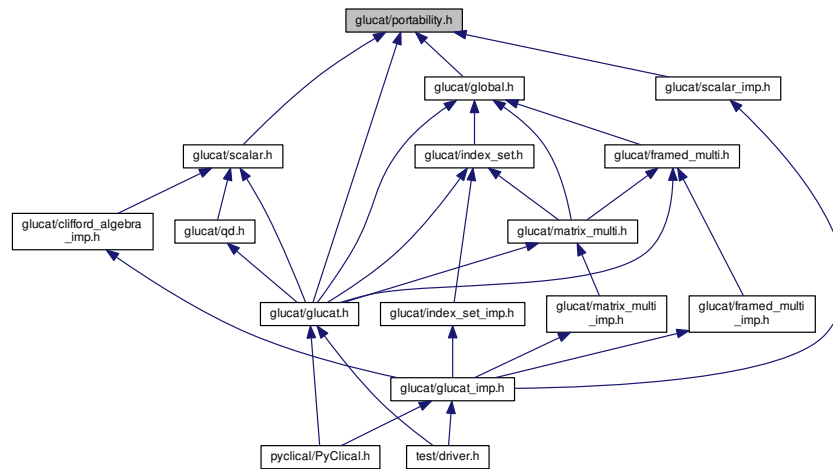
```
#include <boost/version.hpp>
```

```
#include <cmath>
```

Include dependency graph for portability.h:



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



Macros

- `#define _GLUCAT_ISNAN(x) (x != x)`
- `#define _GLUCAT_ISINF(x) (!_GLUCAT_ISNAN(x) && _GLUCAT_ISNAN(x-x))`
- `#define UBLAS_ABS abs`
- `#define UBLAS_SQRT sqrt`

7.20.1 Macro Definition Documentation

7.20.1.1 `#define _GLUCAT_ISINF( x )(!_GLUCAT_ISNAN(x) && _GLUCAT_ISNAN(x-x))`

Definition at line 48 of file portability.h.

Referenced by `glucat::numeric_traits< Scalar_T >::isInf()`.

7.20.1.2 `#define _GLUCAT_ISNAN( x ) (x != x)`

Definition at line 47 of file portability.h.

Referenced by `glucat::numeric_traits< Scalar_T >::isNaN()`.

7.20.1.3 `#define UBLAS_ABS abs`

Definition at line 56 of file portability.h.

Referenced by `glucat::numeric_traits< Scalar_T >::abs()`.

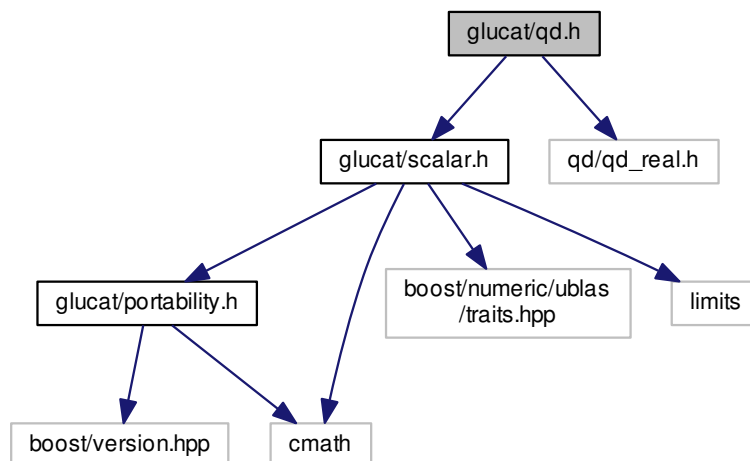
7.20.1.4 `#define UBLAS_SQRT sqrt`

Definition at line 57 of file portability.h.

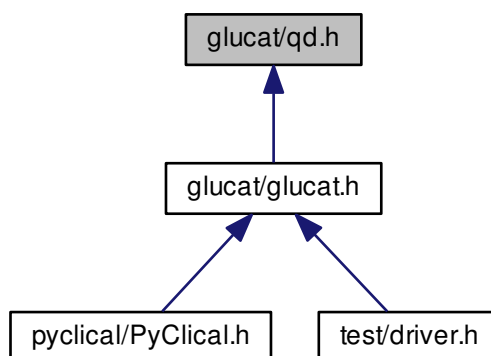
Referenced by `glucat::numeric_traits< Scalar_T >::sqrt()`.

7.21 glucat/qd.h File Reference

```
#include "glucat/scalar.h"  
#include <qd/qd_real.h>  
Include dependency graph for qd.h:
```



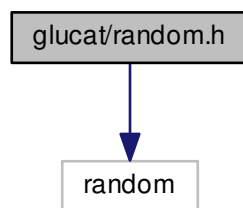
This graph shows which files directly or indirectly include this file:



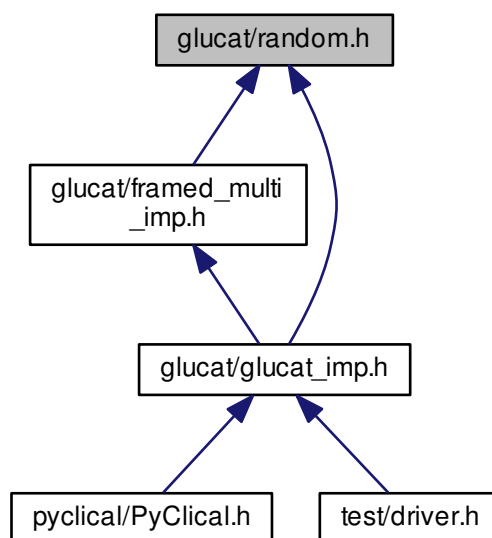
7.22 glucat/random.h File Reference

```
#include <random>
```

Include dependency graph for random.h:



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



Classes

- class `glucat::random_generator< Scalar_T >`
Random number generator with single instance per `Scalar_T`.

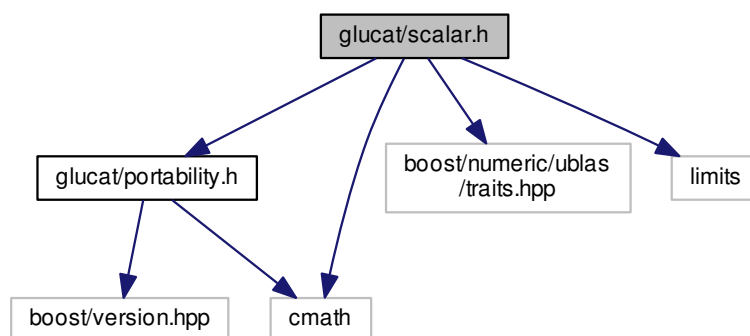
Namespaces

- `glucat`

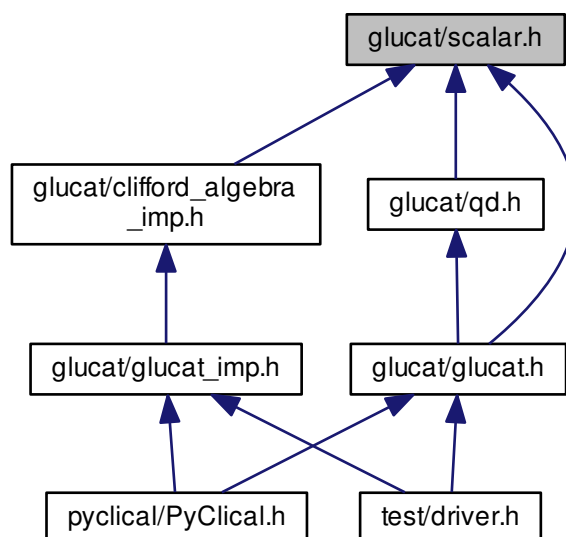
7.23 glucat/scalar.h File Reference

```
#include "glucat/portability.h"
#include <boost/numeric/ublas/traits.hpp>
#include <cmath>
#include <limits>
```

Include dependency graph for scalar.h:



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



Classes

- class `glucat::numeric_traits< Scalar_T >`

Extra traits which extend numeric limits.

- struct `glucat::numeric_traits< Scalar_T >::promoted`

Promoted type.

- struct `glucat::numeric_traits< Scalar_T >::demoted<>`

Demoted type for long double.

Namespaces

- `glucat`

Functions

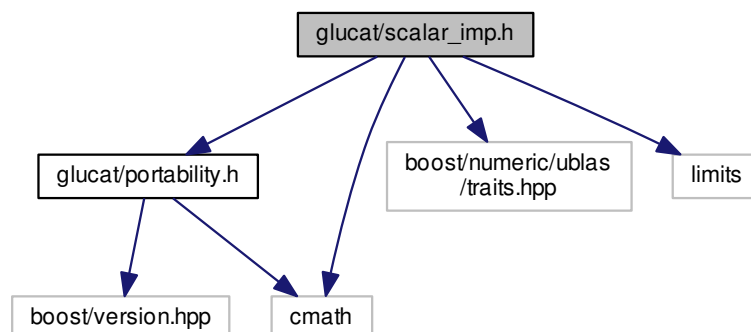
- template<typename Scalar_T >
Scalar_T `glucat::log2` (const Scalar_T &x)

Log base 2 of scalar.

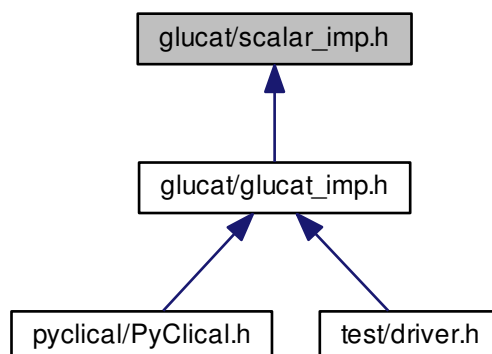
7.24 glucat/scalar_imp.h File Reference

```
#include "glucat/portability.h"
#include <boost/numeric/ublas/traits.hpp>
#include <cmath>
#include <limits>
```

Include dependency graph for scalar_imp.h:



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



Namespaces

- [glucat](#)

Functions

- `template<typename Scalar_T >`
`numeric_traits< Scalar_T >`
`::promoted::type glucat::to\_promote (const Scalar_T &val)`
Cast to promote.
- `template<typename Scalar_T >`
`numeric_traits< Scalar_T >`
`::demoted::type glucat::to\_demote (const Scalar_T &val)`
Cast to demote.

7.25 pyclical/glucat.pxd File Reference

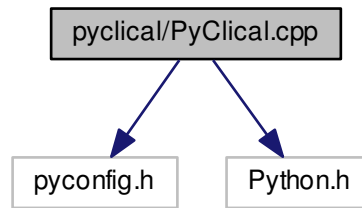
Namespaces

- [glucat](#)

7.26 pyclical/PyClical.cpp File Reference

```
#include "pyconfig.h"
#include "Python.h"
```

Include dependency graph for PyClical.cpp:



Macros

- `#define PY_SSIZE_T_CLEAN`
- `#define CYTHON_USE_PYLONG_INTERNALS 0`

7.26.1 Macro Definition Documentation

7.26.1.1 `#define CYTHON_USE_PYLONG_INTERNALS 0`

Definition at line 12 of file PyClical.cpp.

7.26.1.2 `#define PY_SSIZE_T_CLEAN`

Definition at line 3 of file PyClical.cpp.

7.27 pyclical/PyClical.h File Reference

```

#include "glucat/glucat.h"
#include "glucat/glucat_imp.h"
#include <iostream>
#include <sstream>
#include <iomanip>

```

Include dependency graph for PyClical.h:



Namespaces

- `cga3`
Definitions for 3D Conformal Geometric Algebra [DL].

Typedefs

- typedef [glucat::tuning](#)
< [glucat::DEFAULT_Mult_Matrix_Threshold](#),
[glucat::DEFAULT_Div_Max_Steps](#),
[glucat::DEFAULT_Sqrt_Max_Steps](#),
[glucat::DEFAULT_Log_Max_Outer_Steps](#),
[glucat::DEFAULT_Log_Max_Inner_Steps](#),
[glucat::DEFAULT_Basis_Max_Count](#),
[glucat::DEFAULT_Fast_Size_Threshold](#),
[glucat::DEFAULT_Inv_Fast_Dim_Threshold](#),
[glucat::DEFAULT_Products_Size_Threshold](#),
[glucat::precision_promoted](#) > [Tune_P](#)
- typedef std::string [String](#)
- typedef [index_set](#)< [lo_ndx](#), [hi_ndx](#) > [IndexSet](#)
- typedef double [scalar_t](#)
- typedef [matrix_multi](#)< [scalar_t](#) > [Clifford](#)

Functions

- template<typename [Scalar_T](#) >
[PyObject](#) * [PyFloat_FromDouble](#) ([Scalar_T](#) v)
- template<typename [Index_Set_T](#) >
[String](#) [index_set_to_repr](#) (const [Index_Set_T](#) &ist)
The "official" string representation of [Index_Set_T](#) ist.
- template<typename [Index_Set_T](#) >
[String](#) [index_set_to_str](#) (const [Index_Set_T](#) &ist)
The "informal" string representation of [Index_Set_T](#) ist.
- template<typename [Multivector_T](#) >
[String](#) [clifford_to_repr](#) (const [Multivector_T](#) &mv)
The "official" string representation of [Multivector_T](#) mv.
- template<typename [Multivector_T](#) >
[String](#) [clifford_to_str](#) (const [Multivector_T](#) &mv)
The "informal" string representation of [Multivector_T](#) mv.
- template<typename [Multivector_T](#) >
[Multivector_T](#) [cga3::cga3](#) (const [Multivector_T](#) &x)
Convert Euclidean 3D vector to Conformal Geometric Algebra null vector [DL (10.50)].
- template<typename [Multivector_T](#) >
[Multivector_T](#) [cga3::cga3std](#) (const [Multivector_T](#) &X)
Convert CGA3 null vector to standard Conformal Geometric Algebra null vector [DL (10.52)].
- template<typename [Multivector_T](#) >
[Multivector_T](#) [cga3::agc3](#) (const [Multivector_T](#) &X)
Convert CGA3 null vector to Euclidean 3D vector [DL (10.50)].

Variables

- const [index_t](#) [lo_ndx](#) = [DEFAULT_LO](#)
- const [index_t](#) [hi_ndx](#) = [DEFAULT_HI](#)

7.27.1 Typedef Documentation

7.27.1.1 typedef [matrix_multi](#)<[scalar_t](#)> [Clifford](#)

Definition at line 160 of file [PyClical.h](#).

7.27.1.2 `typedef index_set<lo_ndx,hi_ndx> IndexSet`

Definition at line 157 of file PyClical.h.

7.27.1.3 `typedef double scalar_t`

Definition at line 159 of file PyClical.h.

7.27.1.4 `typedef std::string String`

Definition at line 65 of file PyClical.h.

7.27.1.5 `typedef glucat::tuning< glucat::DEFAULT_Mult_Matrix_Threshold, glucat::DEFAULT_Div_Max_Steps, glucat::DEFAULT_Sqrt_Max_Steps, glucat::DEFAULT_Log_Max_Outer_Steps, glucat::DEFAULT_Log_Max_Inner_Steps, glucat::DEFAULT_Basis_Max_Count, glucat::DEFAULT_Fast_Size_Threshold, glucat::DEFAULT_Inv_Fast_Dim_Threshold, glucat::DEFAULT_Products_Size_Threshold, glucat::precision_promoted > Tune_P`

Definition at line 49 of file PyClical.h.

7.27.2 Function Documentation

7.27.2.1 `template<typename Multivector_T > String clifford_to_repr ( const Multivector_T & mv ) [inline]`

The "official" string representation of Multivector_T mv.

Definition at line 87 of file PyClical.h.

Referenced by PyClical.clifford::__repr__().

7.27.2.2 `template<typename Multivector_T > String clifford_to_str ( const Multivector_T & mv ) [inline]`

The "informal" string representation of Multivector_T mv.

Definition at line 98 of file PyClical.h.

References glucat::abs(), and PyClical::e().

Referenced by PyClical.clifford::__str__().

7.27.2.3 `template<typename Index_Set_T > String index_set_to_repr ( const Index_Set_T & ist ) [inline]`

The "official" string representation of Index_Set_T ist.

Definition at line 69 of file PyClical.h.

Referenced by PyClical.index_set::__repr__().

7.27.2.4 `template<typename Index_Set_T > String index_set_to_str ( const Index_Set_T & ist ) [inline]`

The "informal" string representation of Index_Set_T ist.

Definition at line 78 of file PyClical.h.

References PyClical::ist.

Referenced by PyClical.index_set::__str__().

7.27.2.5 `template<typename Scalar_T > PyObject* PyFloat_FromDouble ( Scalar_T v ) [inline]`

Create a PyFloatObject object from Scalar_T v. Needed because Scalar_T might not be the same as double.

Definition at line 59 of file PyClical.h.

7.27.3 Variable Documentation

7.27.3.1 `const index_t hi_ndx = DEFAULT_HI`

Definition at line 156 of file PyClical.h.

7.27.3.2 `const index_t lo_ndx = DEFAULT_LO`

Definition at line 155 of file PyClical.h.

7.28 pyclical/PyClical.pxd File Reference

Namespaces

- [PyClical](#)

7.29 pyclical/PyClical.pyx File Reference

Classes

- class [PyClical.index_set](#)
- class [PyClical.index_set](#)
- class [PyClical.clifford](#)
- class [PyClical.clifford](#)

Namespaces

- [PyClical](#)

Functions

- def [PyClical.index_set_hidden_doctests](#)
- def [PyClical.clifford_hidden_doctests](#)
- def [PyClical.e](#)
- def [PyClical.istpq](#)
- def [PyClical._test](#)

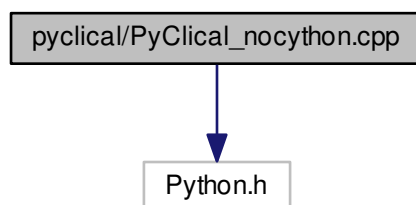
Variables

- string [PyClical.__version__](#) = "0.8.2"
- tuple [PyClical.tau](#) = atan(clifford(1.0))
- float [PyClical.pi](#) = tau/2.0
- [PyClical.cl](#) = clifford
- [PyClical.ist](#) = index_set
- tuple [PyClical.ninf3](#) = e(4)
- tuple [PyClical.nbar3](#) = e(4)

7.30 pyclical/PyClical_nocython.cpp File Reference

```
#include "Python.h"
```

Include dependency graph for PyClical_nocython.cpp:



Macros

- `#define PY_SSIZE_T_CLEAN`

7.30.1 Macro Definition Documentation

7.30.1.1 `#define PY_SSIZE_T_CLEAN`

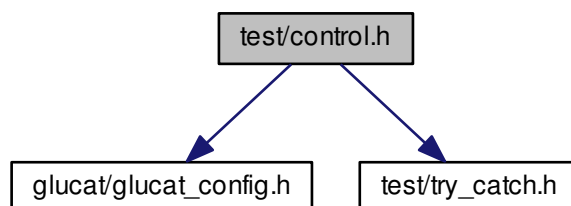
Definition at line 52 of file PyClical_nocython.cpp.

7.31 test/control.h File Reference

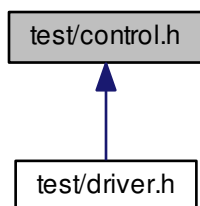
```
#include "glucat/glucat_config.h"
```

```
#include "test/try_catch.h"
```

Include dependency graph for control.h:



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



Classes

- class [glucat::control_t](#)
Parameters to control tests.

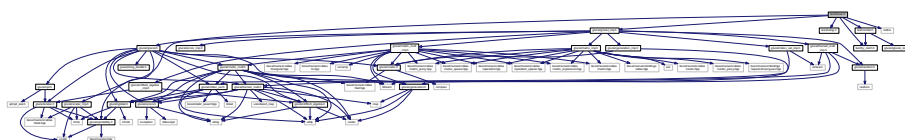
Namespaces

- [glucat](#)

7.32 test/driver.h File Reference

```
#include "glucat/glucat.h"
#include "test/tuning.h"
#include "glucat/glucat_imp.h"
#include "test/try_catch.h"
#include "test/control.h"
#include <cstdio>
```

Include dependency graph for driver.h:



7.33 test/timing.h File Reference

Namespaces

- [glucat](#)
- [glucat::timing](#)

Functions

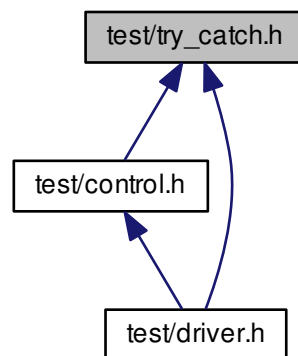
- static double `glucat::timing::elapsed` (clock_t cpu_time)
Elapsed time in milliseconds.

Variables

- const double `glucat::timing::MS_PER_SEC` = 1000.0
Timing constant: milliseconds per second.
- const double `glucat::timing::MS_PER_CLOCK` = MS_PER_SEC / double(CLOCKS_PER_SEC)
Timing constant: milliseconds per clock.
- const int `glucat::timing::EXTRA_TRIALS` = 2
Timing constant: trial expansion factor.

7.34 test/try_catch.h File Reference

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



Namespaces

- `glucat`

Typedefs

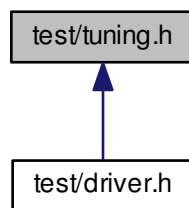
- typedef int(* `glucat::intfn`)()
For exception catching: pointer to function returning int.
- typedef int(* `glucat::intintfn`)(int)
For exception catching: pointer to function of int returning int.

Functions

- int [glucat::try_catch](#) (intfn f)
Exception catching for functions returning int.
- int [glucat::try_catch](#) (intintfn f, int arg)
Exception catching for functions of int returning int.

7.35 test/tuning.h File Reference

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



Macros

- `#define \_\_TEST\_TUNING\_DEFAULT\_CONSTANT(SUFFIX) const unsigned int Test_Tuning_##SUFFIX = glucat::DEFAULT_##SUFFIX`

Typedefs

- typedef [glucat::precision_t](#) [precision_t](#)
- typedef [glucat::tuning](#)
`< Test_Tuning_Mult_Matrix_Threshold,
Test_Tuning_Div_Max_Steps,
Test_Tuning_Sqrt_Max_Steps,
Test_Tuning_Log_Max_Outer_Steps,
Test_Tuning_Log_Max_Inner_Steps,
Test_Tuning_Basis_Max_Count,
Test_Tuning_Fast_Size_Threshold,
Test_Tuning_Inv_Fast_Dim_Threshold,
Test_Tuning_Products_Size_Threshold,
Test_Tuning_Function_Precision > Tune_P`
Tuning policy.

Functions

- [__TEST_TUNING_DEFAULT_CONSTANT](#) (Mult_Matrix_Threshold)
- [__TEST_TUNING_DEFAULT_CONSTANT](#) (Div_Max_Steps)
- [__TEST_TUNING_DEFAULT_CONSTANT](#) (Sqrt_Max_Steps)
- [__TEST_TUNING_DEFAULT_CONSTANT](#) (Log_Max_Outer_Steps)

- [__TEST_TUNING_DEFAULT_CONSTANT](#) (Log_Max_Inner_Steps)
- [__TEST_TUNING_DEFAULT_CONSTANT](#) (Basis_Max_Count)
- [__TEST_TUNING_DEFAULT_CONSTANT](#) (Fast_Size_Threshold)
- [__TEST_TUNING_DEFAULT_CONSTANT](#) (Inv_Fast_Dim_Threshold)
- [__TEST_TUNING_DEFAULT_CONSTANT](#) (Products_Size_Threshold)

Variables

- const unsigned int [Test_Tuning_Int_Digits](#) = std::numeric_limits<int>::digits
- const unsigned int [Test_Tuning_Max_Threshold](#) = 1 << [Test_Tuning_Int_Digits](#)
- const [precision_t](#) [Test_Tuning_Function_Precision](#) = [glucat::DEFAULT_Function_Precision](#)

7.35.1 Macro Definition Documentation

7.35.1.1 `#define __TEST_TUNING_DEFAULT_CONSTANT( SUFFIX ) const unsigned int Test_Tuning_##SUFFIX = glucat::DEFAULT_##SUFFIX`

Definition at line 41 of file tuning.h.

7.35.2 Typedef Documentation

7.35.2.1 `typedef glucat::precision_t precision_t`

Definition at line 39 of file tuning.h.

7.35.2.2 `typedef glucat::tuning< Test_Tuning_Mult_Matrix_Threshold, Test_Tuning_Div_Max_Steps, Test_Tuning_Sqrt_Max_Steps, Test_Tuning_Log_Max_Outer_Steps, Test_Tuning_Log_Max_Inner_Steps, Test_Tuning_Basis_Max_Count, Test_Tuning_Fast_Size_Threshold, Test_Tuning_Inv_Fast_Dim_Threshold, Test_Tuning_Products_Size_Threshold, Test_Tuning_Function_Precision > Tune_P`

Tuning policy.

Definition at line 126 of file tuning.h.

7.35.3 Function Documentation

7.35.3.1 `__TEST_TUNING_DEFAULT_CONSTANT ( Mult_Matrix_Threshold )`

7.35.3.2 `__TEST_TUNING_DEFAULT_CONSTANT ( Div_Max_Steps )`

7.35.3.3 `__TEST_TUNING_DEFAULT_CONSTANT ( Sqrt_Max_Steps )`

7.35.3.4 `__TEST_TUNING_DEFAULT_CONSTANT ( Log_Max_Outer_Steps )`

7.35.3.5 `__TEST_TUNING_DEFAULT_CONSTANT ( Log_Max_Inner_Steps )`

7.35.3.6 `__TEST_TUNING_DEFAULT_CONSTANT ( Basis_Max_Count )`

7.35.3.7 `__TEST_TUNING_DEFAULT_CONSTANT ( Fast_Size_Threshold )`

7.35.3.8 `__TEST_TUNING_DEFAULT_CONSTANT ( Inv_Fast_Dim_Threshold )`

7.35.3.9 `__TEST_TUNING_DEFAULT_CONSTANT ( Products_Size_Threshold )`

7.35.4 Variable Documentation

7.35.4.1 `const precision_t Test_Tuning_Function_Precision = glucat::DEFAULT_Function_Precision`

Definition at line 110 of file tuning.h.

7.35.4.2 `const unsigned int Test_Tuning_Int_Digits = std::numeric_limits<int>::digits`

Definition at line 36 of file tuning.h.

7.35.4.3 `const unsigned int Test_Tuning_Max_Threshold = 1 << Test_Tuning_Int_Digits`

Definition at line 37 of file tuning.h.

7.36 test/undefine.h File Reference

Index

- ~basis_table
 - glucat::basis_table, [58](#)
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- ~control_t
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