

qpp
0.1

Generated by Doxygen 1.8.7

Wed Oct 22 2014 17:36:13

Contents

1	Namespace Index	1
1.1	Namespace List	1
2	Hierarchical Index	3
2.1	Class Hierarchy	3
3	Class Index	5
3.1	Class List	5
4	File Index	7
4.1	File List	7
5	Namespace Documentation	9
5.1	qpp Namespace Reference	9
5.1.1	Function Documentation	14
5.1.1.1	absm	14
5.1.1.2	adjoint	15
5.1.1.3	anticomm	15
5.1.1.4	channel	16
5.1.1.5	channel	17
5.1.1.6	choi	17
5.1.1.7	choi2kraus	18
5.1.1.8	comm	18
5.1.1.9	compperm	19
5.1.1.10	conjugate	20
5.1.1.11	cosm	20
5.1.1.12	cwise	21
5.1.1.13	det	21
5.1.1.14	disp	22
5.1.1.15	disp	22
5.1.1.16	disp	22
5.1.1.17	disp	22
5.1.1.18	displn	23

5.1.1.19	displn	23
5.1.1.20	displn	23
5.1.1.21	displn	24
5.1.1.22	entanglement	24
5.1.1.23	evals	24
5.1.1.24	evects	25
5.1.1.25	expandout	25
5.1.1.26	expm	26
5.1.1.27	funm	27
5.1.1.28	gconcurrency	28
5.1.1.29	grams	28
5.1.1.30	grams	28
5.1.1.31	grams	29
5.1.1.32	hevals	29
5.1.1.33	hevects	30
5.1.1.34	inverse	30
5.1.1.35	invperm	31
5.1.1.36	kron	31
5.1.1.37	kron	32
5.1.1.38	kron	33
5.1.1.39	kron	33
5.1.1.40	kronpow	34
5.1.1.41	load	34
5.1.1.42	loadMATLABmatrix	35
5.1.1.43	loadMATLABmatrix	35
5.1.1.44	loadMATLABmatrix	35
5.1.1.45	logdet	35
5.1.1.46	logm	35
5.1.1.47	mket	36
5.1.1.48	mket	36
5.1.1.49	mket	37
5.1.1.50	multiidx2n	37
5.1.1.51	n2multiidx	38
5.1.1.52	norm	38
5.1.1.53	operator""_i	39
5.1.1.54	operator""_i	39
5.1.1.55	powm	39
5.1.1.56	prj	40
5.1.1.57	ptrace	40
5.1.1.58	ptrace1	41

5.1.1.59	ptrace2	42
5.1.1.60	ptranspose	43
5.1.1.61	qmutualinfo	45
5.1.1.62	rand	45
5.1.1.63	rand	45
5.1.1.64	rand	46
5.1.1.65	rand	46
5.1.1.66	randH	46
5.1.1.67	randint	46
5.1.1.68	randket	47
5.1.1.69	randkraus	47
5.1.1.70	randn	47
5.1.1.71	randn	47
5.1.1.72	randn	48
5.1.1.73	randn	48
5.1.1.74	randperm	48
5.1.1.75	randrho	49
5.1.1.76	randU	49
5.1.1.77	randV	49
5.1.1.78	renyi	49
5.1.1.79	renyi_inf	50
5.1.1.80	reshape	50
5.1.1.81	save	50
5.1.1.82	saveMATLABmatrix	50
5.1.1.83	saveMATLABmatrix	51
5.1.1.84	saveMATLABmatrix	51
5.1.1.85	schmidtcoeff	51
5.1.1.86	schmidtprob	52
5.1.1.87	schmidtU	52
5.1.1.88	schmidtV	53
5.1.1.89	shannon	53
5.1.1.90	sinm	53
5.1.1.91	spectralpowm	54
5.1.1.92	sqrtm	55
5.1.1.93	sum	56
5.1.1.94	super	57
5.1.1.95	syspermute	57
5.1.1.96	trace	58
5.1.1.97	transpose	59
5.1.1.98	tsallis	60

5.1.2	Variable Documentation	60
5.1.2.1	gt	60
5.1.2.2	rdevs	60
5.1.2.3	st	60
5.2	qpp::ct Namespace Reference	60
5.2.1	Function Documentation	60
5.2.1.1	omega	60
5.2.2	Variable Documentation	60
5.2.2.1	chop	60
5.2.2.2	ee	60
5.2.2.3	eps	60
5.2.2.4	maxn	61
5.2.2.5	pi	61
5.3	qpp::internal Namespace Reference	61
5.3.1	Function Documentation	61
5.3.1.1	_check_col_vector	61
5.3.1.2	_check_dims	61
5.3.1.3	_check_dims_match_cvect	61
5.3.1.4	_check_dims_match_mat	61
5.3.1.5	_check_dims_match_rvect	62
5.3.1.6	_check_eq_dims	62
5.3.1.7	_check_nonzero_size	62
5.3.1.8	_check_perm	62
5.3.1.9	_check_row_vector	62
5.3.1.10	_check_square_mat	62
5.3.1.11	_check_subsys_match_dims	62
5.3.1.12	_check_vector	62
5.3.1.13	_kron2	62
5.3.1.14	_multiidx2n	62
5.3.1.15	_n2multiidx	62
5.3.1.16	variadic_vector_emplace	62
5.3.1.17	variadic_vector_emplace	62
5.4	qpp::types Namespace Reference	63
5.4.1	Typedef Documentation	63
5.4.1.1	bra	63
5.4.1.2	cmat	63
5.4.1.3	cplx	63
5.4.1.4	dmat	63
5.4.1.5	DynMat	63
5.4.1.6	ket	63

6	Class Documentation	65
6.1	qpp::DiscreteDistribution Class Reference	65
6.1.1	Constructor & Destructor Documentation	65
6.1.1.1	DiscreteDistribution	65
6.1.1.2	DiscreteDistribution	65
6.1.1.3	DiscreteDistribution	65
6.1.2	Member Function Documentation	65
6.1.2.1	probabilities	65
6.1.2.2	sample	66
6.1.3	Member Data Documentation	66
6.1.3.1	_d	66
6.2	qpp::DiscreteDistributionAbsSquare Class Reference	66
6.2.1	Constructor & Destructor Documentation	67
6.2.1.1	DiscreteDistributionAbsSquare	67
6.2.1.2	DiscreteDistributionAbsSquare	67
6.2.1.3	DiscreteDistributionAbsSquare	67
6.2.1.4	DiscreteDistributionAbsSquare	67
6.2.2	Member Function Documentation	67
6.2.2.1	cplx2weights	67
6.2.2.2	probabilities	67
6.2.2.3	sample	67
6.2.3	Member Data Documentation	67
6.2.3.1	_d	67
6.3	qpp::Exception Class Reference	67
6.3.1	Member Enumeration Documentation	69
6.3.1.1	Type	69
6.3.2	Constructor & Destructor Documentation	70
6.3.2.1	Exception	70
6.3.2.2	Exception	70
6.3.3	Member Function Documentation	70
6.3.3.1	_construct_exception_msg	70
6.3.3.2	what	70
6.3.4	Member Data Documentation	70
6.3.4.1	_custom	70
6.3.4.2	_msg	70
6.3.4.3	_type	70
6.3.4.4	_where	70
6.4	qpp::Gates Class Reference	70
6.4.1	Constructor & Destructor Documentation	72
6.4.1.1	Gates	72

6.4.2	Member Function Documentation	72
6.4.2.1	apply	73
6.4.2.2	applyCTRL	73
6.4.2.3	CTRL	74
6.4.2.4	Fd	74
6.4.2.5	Id	74
6.4.2.6	Rn	74
6.4.2.7	Xd	75
6.4.2.8	Zd	75
6.4.3	Friends And Related Function Documentation	75
6.4.3.1	Singleton< const Gates >	75
6.4.4	Member Data Documentation	75
6.4.4.1	CNOTab	75
6.4.4.2	CNOTba	75
6.4.4.3	CZ	75
6.4.4.4	FRED	75
6.4.4.5	H	75
6.4.4.6	Id2	75
6.4.4.7	S	75
6.4.4.8	SWAP	75
6.4.4.9	T	75
6.4.4.10	TOF	76
6.4.4.11	X	76
6.4.4.12	Y	76
6.4.4.13	Z	76
6.5	qpp::NormalDistribution Class Reference	76
6.5.1	Constructor & Destructor Documentation	76
6.5.1.1	NormalDistribution	76
6.5.2	Member Function Documentation	76
6.5.2.1	sample	76
6.5.3	Member Data Documentation	76
6.5.3.1	_d	76
6.6	qpp::Qudit Class Reference	77
6.6.1	Constructor & Destructor Documentation	77
6.6.1.1	Qudit	77
6.6.2	Member Function Documentation	77
6.6.2.1	getD	77
6.6.2.2	getRho	77
6.6.2.3	measure	78
6.6.2.4	measure	78

6.6.3	Member Data Documentation	78
6.6.3.1	_D	78
6.6.3.2	_rho	78
6.7	qpp::RandomDevices Class Reference	79
6.7.1	Constructor & Destructor Documentation	80
6.7.1.1	RandomDevices	80
6.7.2	Friends And Related Function Documentation	80
6.7.2.1	Singleton< const RandomDevices >	80
6.7.3	Member Data Documentation	80
6.7.3.1	_rd	80
6.7.3.2	_rng	80
6.8	qpp::Singleton< T > Class Template Reference	80
6.8.1	Constructor & Destructor Documentation	80
6.8.1.1	Singleton	80
6.8.1.2	~Singleton	81
6.8.1.3	Singleton	81
6.8.2	Member Function Documentation	81
6.8.2.1	get_instance	81
6.8.2.2	operator=	81
6.9	qpp::States Class Reference	81
6.9.1	Constructor & Destructor Documentation	82
6.9.1.1	States	82
6.9.2	Friends And Related Function Documentation	82
6.9.2.1	Singleton< const States >	82
6.9.3	Member Data Documentation	82
6.9.3.1	b00	82
6.9.3.2	b01	82
6.9.3.3	b10	82
6.9.3.4	b11	83
6.9.3.5	GHZ	83
6.9.3.6	pb00	83
6.9.3.7	pb01	83
6.9.3.8	pb10	83
6.9.3.9	pb11	83
6.9.3.10	pGHZ	83
6.9.3.11	pW	83
6.9.3.12	px0	83
6.9.3.13	px1	83
6.9.3.14	py0	83
6.9.3.15	py1	83

6.9.3.16	pz0	83
6.9.3.17	pz1	83
6.9.3.18	W	83
6.9.3.19	x0	83
6.9.3.20	x1	83
6.9.3.21	y0	83
6.9.3.22	y1	83
6.9.3.23	z0	83
6.9.3.24	z1	83
6.10	qpp::Timer Class Reference	83
6.10.1	Constructor & Destructor Documentation	84
6.10.1.1	Timer	84
6.10.2	Member Function Documentation	84
6.10.2.1	seconds	84
6.10.2.2	tic	84
6.10.2.3	toc	84
6.10.3	Friends And Related Function Documentation	84
6.10.3.1	operator<<	84
6.10.4	Member Data Documentation	84
6.10.4.1	_end	84
6.10.4.2	_start	84
6.11	qpp::UniformIntDistribution Class Reference	84
6.11.1	Constructor & Destructor Documentation	85
6.11.1.1	UniformIntDistribution	85
6.11.2	Member Function Documentation	85
6.11.2.1	sample	85
6.11.3	Member Data Documentation	85
6.11.3.1	_d	85
6.12	qpp::UniformRealDistribution Class Reference	85
6.12.1	Constructor & Destructor Documentation	85
6.12.1.1	UniformRealDistribution	85
6.12.2	Member Function Documentation	85
6.12.2.1	sample	86
6.12.3	Member Data Documentation	86
6.12.3.1	_d	86
7	File Documentation	87
7.1	include/channels.h File Reference	87
7.2	include/classes/exception.h File Reference	88
7.3	include/classes/gates.h File Reference	88

7.4	include/classes/qudit.h File Reference	89
7.5	include/classes/randevs.h File Reference	89
7.6	include/classes/singleton.h File Reference	90
7.6.1	Macro Definition Documentation	90
7.6.1.1	CLASS_CONST_SINGLETON	90
7.6.1.2	CLASS_SINGLETON	90
7.7	include/classes/stat.h File Reference	91
7.8	include/classes/states.h File Reference	91
7.9	include/classes/timer.h File Reference	92
7.10	include/constants.h File Reference	92
7.11	include/entanglement.h File Reference	93
7.12	include/entropies.h File Reference	94
7.13	include/functions.h File Reference	95
7.14	include/internal.h File Reference	98
7.15	include/io.h File Reference	100
7.16	include/matlab.h File Reference	100
7.17	include/qpp.h File Reference	102
7.18	include/random.h File Reference	103
7.19	include/types.h File Reference	104
	Index	105

Chapter 1

Namespace Index

1.1 Namespace List

Here is a list of all namespaces with brief descriptions:

qpp	9
qpp::ct	60
qpp::internal	61
qpp::types	63

Chapter 2

Hierarchical Index

2.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

qpp::DiscreteDistribution	65
qpp::DiscreteDistributionAbsSquare	66
exception	
qpp::Exception	67
qpp::NormalDistribution	76
qpp::Qudit	77
qpp::Singleton< T >	80
qpp::Gates	70
qpp::RandomDevices	79
qpp::Singleton< const Gates >	80
qpp::Singleton< const RandomDevices >	80
qpp::Singleton< const States >	80
qpp::States	81
qpp::Timer	83
qpp::UniformIntDistribution	84
qpp::UniformRealDistribution	85

Chapter 3

Class Index

3.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

qpp::DiscreteDistribution	65
qpp::DiscreteDistributionAbsSquare	66
qpp::Exception	67
qpp::Gates	70
qpp::NormalDistribution	76
qpp::Qudit	77
qpp::RandomDevices	79
qpp::Singleton< T >	80
qpp::States	81
qpp::Timer	83
qpp::UniformIntDistribution	84
qpp::UniformRealDistribution	85

Chapter 4

File Index

4.1 File List

Here is a list of all files with brief descriptions:

include/channels.h	87
include/constants.h	92
include/entanglement.h	93
include/entropies.h	94
include/functions.h	95
include/internal.h	98
include/io.h	100
include/matlab.h	100
include/qpp.h	102
include/random.h	103
include/types.h	104
include/classes/exception.h	88
include/classes/gates.h	88
include/classes/qudit.h	89
include/classes/randevs.h	89
include/classes/singleton.h	90
include/classes/stat.h	91
include/classes/states.h	91
include/classes/timer.h	92

Chapter 5

Namespace Documentation

5.1 qpp Namespace Reference

Namespaces

- [ct](#)
- [internal](#)
- [types](#)

Classes

- class [DiscreteDistribution](#)
- class [DiscreteDistributionAbsSquare](#)
- class [Exception](#)
- class [Gates](#)
- class [NormalDistribution](#)
- class [Qudit](#)
- class [RandomDevices](#)
- class [Singleton](#)
- class [States](#)
- class [Timer](#)
- class [UniformIntDistribution](#)
- class [UniformRealDistribution](#)

Functions

- [types::cmat super](#) (const std::vector< [types::cmat](#) > &Ks)
- [types::cmat choi](#) (const std::vector< [types::cmat](#) > &Ks)
- std::vector< [types::cmat](#) > [choi2kraus](#) (const [types::cmat](#) &A)
- template<typename Derived >
[types::cmat channel](#) (const Eigen::MatrixBase< Derived > &rho, const std::vector< [types::cmat](#) > &Ks)
- template<typename Derived >
[types::cmat channel](#) (const Eigen::MatrixBase< Derived > &rho, const std::vector< [types::cmat](#) > &Ks,
const std::vector< std::size_t > &subsys, const std::vector< std::size_t > &dims)
- constexpr std::complex< double > [operator""_i](#) (unsigned long long int x)
- constexpr std::complex< double > [operator""_i](#) (long double x)
- template<typename Derived >
[types::cmat schmidtcoeff](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)

- `template<typename Derived >`
`types::cmat schmidtU` (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)
- `template<typename Derived >`
`types::cmat schmidtV` (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)
- `template<typename Derived >`
`types::cmat schmidtprob` (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)
- `template<typename Derived >`
`double entanglement` (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)
- `template<typename Derived >`
`double gconcurrency` (const Eigen::MatrixBase< Derived > &A)
- `template<typename Derived >`
`double shannon` (const Eigen::MatrixBase< Derived > &A)
- `template<typename Derived >`
`double renyi` (const double alpha, const Eigen::MatrixBase< Derived > &A)
- `template<typename Derived >`
`double renyi_inf` (const Eigen::MatrixBase< Derived > &A)
- `template<typename Derived >`
`double tsallis` (const double alpha, const Eigen::MatrixBase< Derived > &A)
- `template<typename Derived >`
`double qmutualinfo` (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &subsys, const std::vector< std::size_t > &dims)
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > transpose` (const Eigen::MatrixBase< Derived > &A)
Transpose.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > conjugate` (const Eigen::MatrixBase< Derived > &A)
Complex conjugate.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > adjoint` (const Eigen::MatrixBase< Derived > &A)
Adjoint.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > inverse` (const Eigen::MatrixBase< Derived > &A)
Inverse.
- `template<typename Derived >`
`Derived::Scalar trace` (const Eigen::MatrixBase< Derived > &A)
Trace.
- `template<typename Derived >`
`Derived::Scalar det` (const Eigen::MatrixBase< Derived > &A)
Determinant.
- `template<typename Derived >`
`Derived::Scalar logdet` (const Eigen::MatrixBase< Derived > &A)
Logarithm of the determinant.
- `template<typename Derived >`
`Derived::Scalar sum` (const Eigen::MatrixBase< Derived > &A)
Element-wise sum.
- `template<typename Derived >`
`double norm` (const Eigen::MatrixBase< Derived > &A)
Trace norm.
- `template<typename Derived >`
`types::cmat evals` (const Eigen::MatrixBase< Derived > &A)
Eigenvalues.

- `template<typename Derived >`
`types::cmat evecs` (const Eigen::MatrixBase< Derived > &A)
Eigenvectors.
- `template<typename Derived >`
`types::cmat hevals` (const Eigen::MatrixBase< Derived > &A)
Hermitian eigenvalues.
- `template<typename Derived >`
`types::cmat hevects` (const Eigen::MatrixBase< Derived > &A)
Hermitian eigenvectors.
- `template<typename Derived >`
`types::cmat funm` (const Eigen::MatrixBase< Derived > &A, `types::cplx`(*)f)(const `types::cplx` &))
Functional calculus $f(A)$
- `template<typename Derived >`
`types::cmat sqrtm` (const Eigen::MatrixBase< Derived > &A)
Matrix square root.
- `template<typename Derived >`
`types::cmat absm` (const Eigen::MatrixBase< Derived > &A)
Matrix absolut value.
- `template<typename Derived >`
`types::cmat expm` (const Eigen::MatrixBase< Derived > &A)
Matrix exponential.
- `template<typename Derived >`
`types::cmat logm` (const Eigen::MatrixBase< Derived > &A)
Matrix logarithm.
- `template<typename Derived >`
`types::cmat sinm` (const Eigen::MatrixBase< Derived > &A)
Matrix sin.
- `template<typename Derived >`
`types::cmat cosm` (const Eigen::MatrixBase< Derived > &A)
Matrix cos.
- `template<typename Derived >`
`types::cmat spectralpowm` (const Eigen::MatrixBase< Derived > &A, const `types::cplx` z)
Matrix power.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > powm` (const Eigen::MatrixBase< Derived > &A, std::size_t n)
Matrix power.
- `template<typename OutputScalar , typename Derived >`
`types::DynMat< OutputScalar > cwise` (const Eigen::MatrixBase< Derived > &A, OutputScalar(*)f)(const
`typename Derived::Scalar &))`
Functor.
- `template<typename T >`
`types::DynMat< typename T::Scalar > kron` (const T &head)
Kronecker product (variadic overload)
- `template<typename T , typename... Args>`
`types::DynMat< typename T::Scalar > kron` (const T &head, const Args &...tail)
Kronecker product (variadic overload)
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > kron` (const std::vector< Derived > &As)
Kronecker product (std::vector overload)
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > kron` (const std::initializer_list< Derived > &As)

Kronecker product (std::initializer_list overload)

- template<typename Derived >
types::DynMat< typename
Derived::Scalar > [kronpow](#) (const Eigen::MatrixBase< Derived > &A, std::size_t n)

Kronecker power.

- template<typename Derived >
types::DynMat< typename
Derived::Scalar > [reshape](#) (const Eigen::MatrixBase< Derived > &A, std::size_t rows, std::size_t cols)

Reshape.

- template<typename Derived >
types::DynMat< typename
Derived::Scalar > [syspermute](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &perm, const std::vector< std::size_t > &dims)

System permutation.

- template<typename Derived >
types::DynMat< typename
Derived::Scalar > [ptrace1](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)

Partial trace.

- template<typename Derived >
types::DynMat< typename
Derived::Scalar > [ptrace2](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)

Partial trace.

- template<typename Derived >
types::DynMat< typename
Derived::Scalar > [ptrace](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &subsys, const std::vector< std::size_t > &dims)

Partial trace.

- template<typename Derived >
types::DynMat< typename
Derived::Scalar > [ptranspose](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &subsys, const std::vector< std::size_t > &dims)

Partial transpose.

- template<typename Derived1 , typename Derived2 >
types::DynMat< typename
Derived1::Scalar > [comm](#) (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< Derived2 > &B)

Commutator.

- template<typename Derived1 , typename Derived2 >
types::DynMat< typename
Derived1::Scalar > [anticomm](#) (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< Derived2 > &B)

Anti-commutator.

- template<typename Derived >
types::DynMat< typename
Derived::Scalar > [prj](#) (const Eigen::MatrixBase< Derived > &V)

Projector.

- template<typename Derived >
types::DynMat< typename
Derived::Scalar > [expandout](#) (const Eigen::MatrixBase< Derived > &A, std::size_t pos, const std::vector< std::size_t > &dims)

Expand out.

- template<typename Derived >
types::DynMat< typename
Derived::Scalar > [grams](#) (const std::vector< Derived > &Vs)

Gram-Schmidt orthogonalization.

- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > grams` (const std::initializer_list< Derived > &Vs)
Gram-Schmidt orthogonalization.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > grams` (const Eigen::MatrixBase< Derived > &A)
Gram-Schmidt orthogonalization.
- `std::vector< std::size_t > n2multiidx` (std::size_t n, const std::vector< std::size_t > &dims)
Non-negative integer index to multi-index.
- `std::size_t multiidx2n` (const std::vector< std::size_t > &midx, const std::vector< std::size_t > &dims)
Multi-index to non-negative integer index.
- `types::ket mket` (const std::vector< std::size_t > &mask)
Constructs multi-partite qubit ket.
- `types::ket mket` (const std::vector< std::size_t > &mask, const std::vector< std::size_t > &dims)
Constructs multi-partite qudit ket.
- `types::ket mket` (const std::vector< std::size_t > &mask, std::size_t d)
Constructs multi-partite qudit ket.
- `std::vector< std::size_t > invperm` (const std::vector< std::size_t > &perm)
Inverse permutation.
- `std::vector< std::size_t > compperm` (const std::vector< std::size_t > &perm, const std::vector< std::size_t > &sigma)
Compose permutations.
- `template<typename T >`
`void disp` (const T &x, const std::string &separator, const std::string &start="[" , const std::string &end="]",
std::ostream &os=std::cout)
- `template<typename T >`
`void displn` (const T &x, const std::string &separator, const std::string &start="[" , const std::string &end="]",
std::ostream &os=std::cout)
- `template<typename T >`
`void disp` (const T *x, const std::size_t n, const std::string &separator, const std::string &start="[" , const std::string &end="]",
std::ostream &os=std::cout)
- `template<typename T >`
`void displn` (const T *x, const std::size_t n, const std::string &separator, const std::string &start="[" , const
std::string &end="]", std::ostream &os=std::cout)
- `template<typename Derived >`
`void disp` (const Eigen::MatrixBase< Derived > &A, double chop=ct::chop, std::ostream &os=std::cout)
- `template<typename Derived >`
`void displn` (const Eigen::MatrixBase< Derived > &A, double chop=ct::chop, std::ostream &os=std::cout)
- `void disp` (const types::cplx c, double chop=ct::chop, std::ostream &os=std::cout)
- `void displn` (const types::cplx c, double chop=ct::chop, std::ostream &os=std::cout)
- `template<typename Derived >`
`void save` (const Eigen::MatrixBase< Derived > &A, const std::string &fname)
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > load` (const std::string &fname)
- `template<typename Derived >`
`Derived loadMATLABmatrix` (const std::string &mat_file, const std::string &var_name)
- `template<>`
`types::dmat loadMATLABmatrix` (const std::string &mat_file, const std::string &var_name)
- `template<>`
`types::cmat loadMATLABmatrix` (const std::string &mat_file, const std::string &var_name)
- `template<typename Derived >`
`void saveMATLABmatrix` (const Eigen::MatrixBase< Derived > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)

- `template<>`
void `saveMATLABmatrix` (const Eigen::MatrixBase< `types::dmat` > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)
- `template<>`
void `saveMATLABmatrix` (const Eigen::MatrixBase< typename `types::cmat` > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)
- `template<typename Derived >`
Derived `rand` (std::size_t rows, std::size_t cols, double a=0, double b=1)
- `template<>`
`types::dmat rand` (std::size_t rows, std::size_t cols, double a, double b)
- `template<>`
`types::cmat rand` (std::size_t rows, std::size_t cols, double a, double b)
- double `rand` (double a=0, double b=1)
- long long `randint` (long long a, long long b)
- `template<typename Derived >`
Derived `randn` (std::size_t rows, std::size_t cols, double mean=0, double sigma=1)
- `template<>`
`types::dmat randn` (std::size_t rows, std::size_t cols, double mean, double sigma)
- `template<>`
`types::cmat randn` (std::size_t rows, std::size_t cols, double mean, double sigma)
- double `randn` (double mean=0, double sigma=1)
- `types::cmat randU` (std::size_t D)
- `types::cmat randV` (std::size_t Din, std::size_t Dout)
- std::vector< `types::cmat` > `randkraus` (std::size_t n, std::size_t D)
- `types::cmat randH` (std::size_t D)
- `types::ket randket` (std::size_t D)
- `types::cmat randrho` (std::size_t D)
- std::vector< std::size_t > `randperm` (std::size_t n)

Variables

- const `RandomDevices` & `rdevs` = `RandomDevices::get_instance()`
- const `Gates` & `gt` = `Gates::get_instance()`
- const `States` & `st` = `States::get_instance()`

5.1.1 Function Documentation

5.1.1.1 `template<typename Derived > types::cmat qpp::absm (const Eigen::MatrixBase< Derived > & A)`

Matrix absolut value.

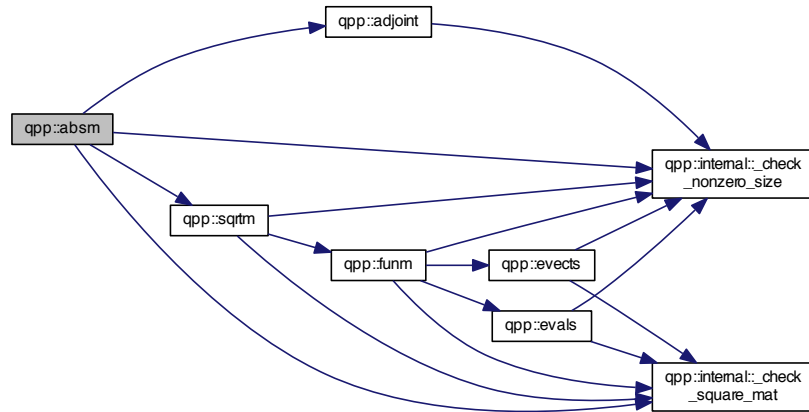
Parameters

<code>A</code>	Eigen expression
----------------	------------------

Returns

Matrix absolut value of A , as a dynamic matrix over the complex field

Here is the call graph for this function:



5.1.1.2 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::adjoint (const Eigen::MatrixBase< Derived > & A)`

Adjoint.

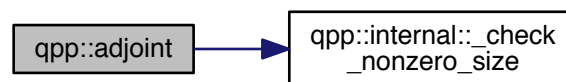
Parameters

A	Eigen expression
-----	------------------

Returns

Adjoint (Hermitian conjugate) of A , as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.3 `template<typename Derived1 , typename Derived2 > types::DynMat<typename Derived1::Scalar> qpp::anticomm (const Eigen::MatrixBase< Derived1 > & A, const Eigen::MatrixBase< Derived2 > & B)`

Anti-commutator.

Anti-commutator $\{A, B\} = AB + BA$

Both A and B must be expressions over the same scalar field

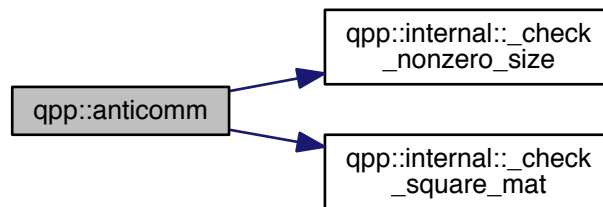
Parameters

A	Eigen expression
B	Eigen expression

Returns

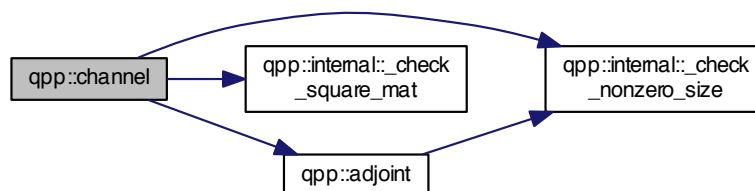
Anti-commutator $AB + BA$, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



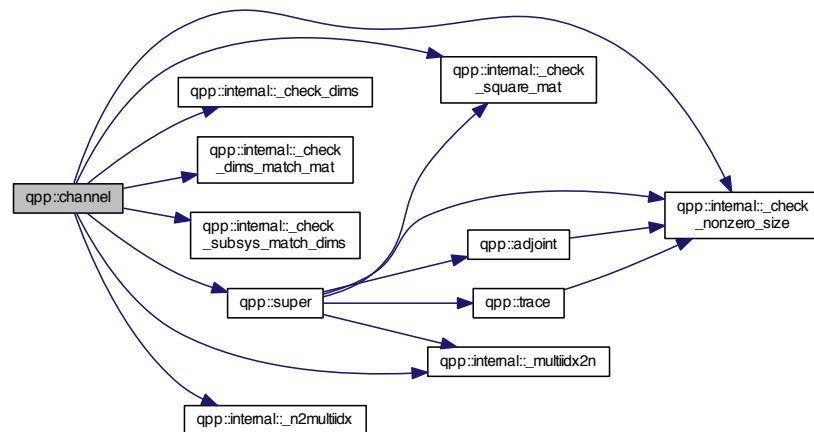
5.1.1.4 `template<typename Derived> types::cmat qpp::channel (const Eigen::MatrixBase< Derived> & rho, const std::vector< types::cmat> & Ks)`

Here is the call graph for this function:



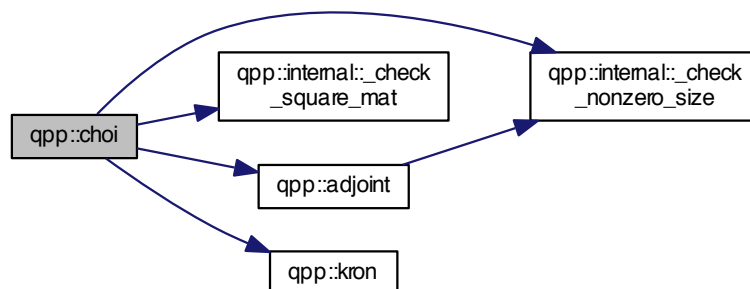
5.1.1.5 `template<typename Derived > types::cmat qpp::channel (const Eigen::MatrixBase< Derived > & rho, const std::vector< types::cmat > & Ks, const std::vector< std::size_t > & subsys, const std::vector< std::size_t > & dims)`

Here is the call graph for this function:



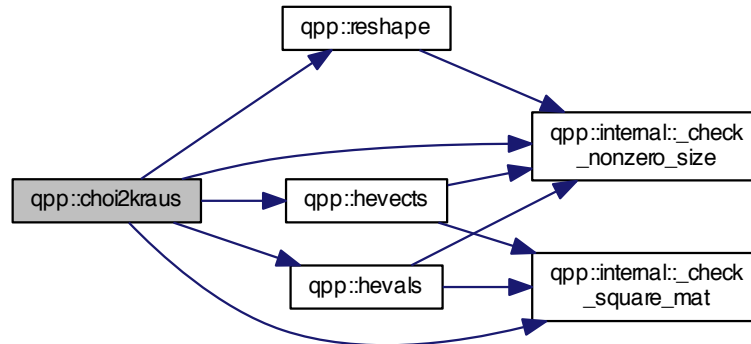
5.1.1.6 `types::cmat qpp::choi (const std::vector< types::cmat > & Ks)`

Here is the call graph for this function:



5.1.1.7 `std::vector<types::cmat> qpp::choi2kraus (const types::cmat & A)`

Here is the call graph for this function:



5.1.1.8 `template<typename Derived1 , typename Derived2 > types::DynMat<typename Derived1::Scalar> qpp::comm (const Eigen::MatrixBase< Derived1 > & A, const Eigen::MatrixBase< Derived2 > & B)`

Commutator.

Commutator $[A, B] = AB - BA$

Both A and B must be expressions over the same scalar field

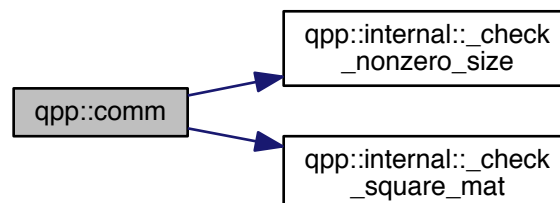
Parameters

A	Eigen expression
B	Eigen expression

Returns

Commutator $AB - BA$, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.9 `std::vector<std::size_t> qpp::compperm (const std::vector< std::size_t > & perm, const std::vector< std::size_t > & sigma)`

Compose permutations.

Parameters

<i>perm</i>	Permutation
<i>sigma</i>	Permutation

Returns

The composition $perm \circ sigma$

Here is the call graph for this function:



5.1.1.10 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::conjugate (const Eigen::MatrixBase< Derived > & A)`

Complex conjugate.

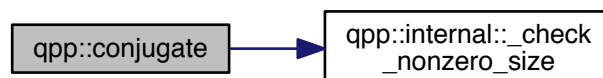
Parameters

<i>A</i>	Eigen expression
----------	------------------

Returns

Complex conjugate of *A*, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.11 `template<typename Derived > types::cmat qpp::cosm (const Eigen::MatrixBase< Derived > & A)`

Matrix cos.

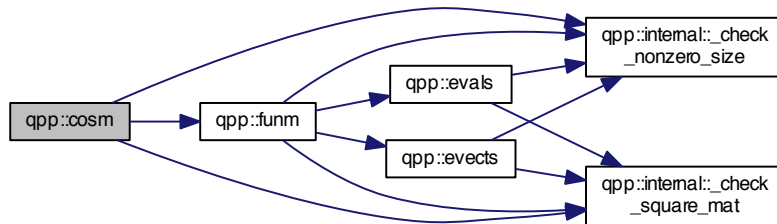
Parameters

A	Eigen expression
-----	------------------

Returns

Matrix cosine of A , as a dynamic matrix over the complex field

Here is the call graph for this function:



5.1.1.12 `template<typename OutputScalar , typename Derived > types::DynMat<OutputScalar> qpp::cwise (const Eigen::MatrixBase< Derived > & A, OutputScalar*)(const typename Derived::Scalar &) f)`

Functor.

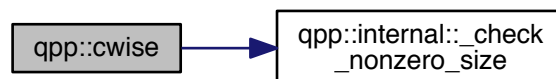
Parameters

A	Eigen expression
f	Pointer-to-function from scalars of A to <i>OutputScalar</i>

Returns

Component-wise $f(A)$, as a dynamic matrix over *OutputScalar* scalar field

Here is the call graph for this function:



5.1.1.13 `template<typename Derived > Derived::Scalar qpp::det (const Eigen::MatrixBase< Derived > & A)`

Determinant.

Parameters

A	Eigen expression
-----	------------------

Returns

Determinant of A , as a dynamic matrix over the same scalar field
 Returns $\pm\infty$ when determinant overflows/underflows

Here is the call graph for this function:



5.1.1.14 `template<typename T> void qpp::disp (const T & x, const std::string & separator, const std::string & start = " [", const std::string & end = "] ", std::ostream & os = std::cout)`

5.1.1.15 `template<typename T> void qpp::disp (const T * x, const std::size_t n, const std::string & separator, const std::string & start = " [", const std::string & end = "] ", std::ostream & os = std::cout)`

5.1.1.16 `template<typename Derived> void qpp::disp (const Eigen::MatrixBase< Derived > & A, double chop = ct::chop, std::ostream & os = std::cout)`

5.1.1.17 `void qpp::disp (const types::cplx c, double chop = ct::chop, std::ostream & os = std::cout)`

Here is the call graph for this function:



5.1.1.18 `template<typename T> void qpp::displn (const T & x, const std::string & separator, const std::string & start = " [", const std::string & end = "] ", std::ostream & os = std::cout)`

Here is the call graph for this function:



5.1.1.19 `template<typename T> void qpp::displn (const T * x, const std::size_t n, const std::string & separator, const std::string & start = " [", const std::string & end = "] ", std::ostream & os = std::cout)`

Here is the call graph for this function:



5.1.1.20 `template<typename Derived> void qpp::displn (const Eigen::MatrixBase< Derived > & A, double chop = ct::chop, std::ostream & os = std::cout)`

Here is the call graph for this function:



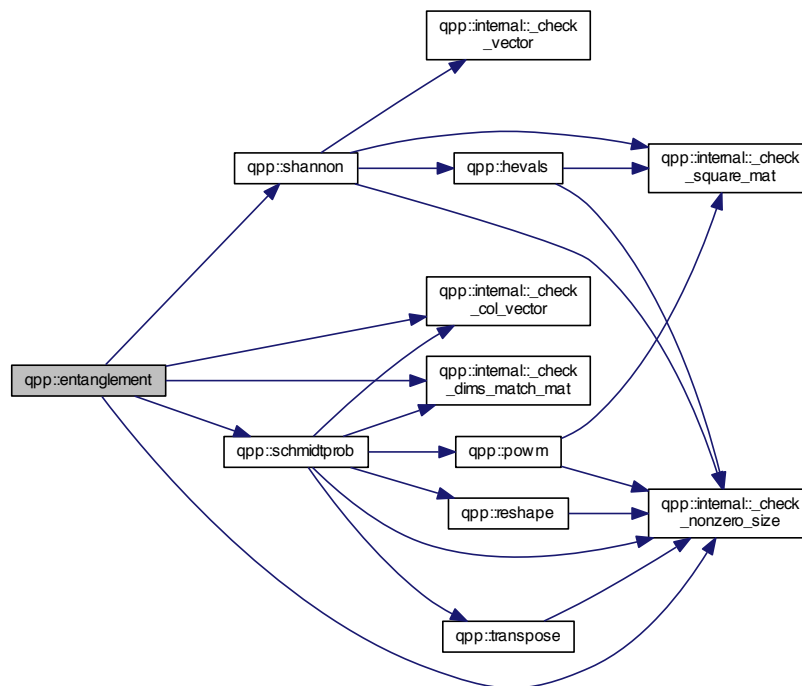
5.1.1.21 `void qpp::displn (const types::cplx c, double chop = ct:::chop, std::ostream & os = std:::cout)`

Here is the call graph for this function:



5.1.1.22 `template<typename Derived> double qpp::entanglement (const Eigen::MatrixBase< Derived> & A, const std::vector< std::size_t> & dims)`

Here is the call graph for this function:



5.1.1.23 `template<typename Derived> types::cmat qpp::evals (const Eigen::MatrixBase< Derived> & A)`

Eigenvalues.

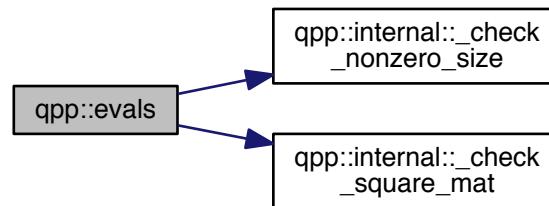
Parameters

A	Eigen expression
-----	------------------

Returns

Eigenvalues of A , as a dynamic matrix over the complex field

Here is the call graph for this function:



5.1.1.24 `template<typename Derived> types::cmat qpp::evecs (const Eigen::MatrixBase< Derived> & A)`

Eigenvectors.

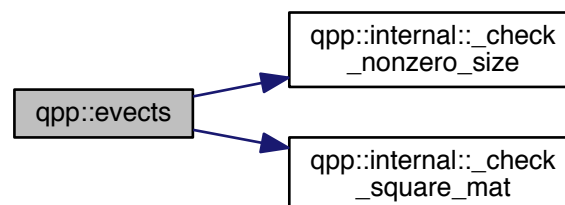
Parameters

A	Eigen expression
-----	------------------

Returns

Eigenvectors of A , as a dynamic matrix over the complex field

Here is the call graph for this function:



5.1.1.25 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::expandout (const Eigen::MatrixBase< Derived> & A, std::size_t pos, const std::vector< std::size_t> & dims)`

Expand out.

Expand out A as a matrix in a multi-partite system
 Faster than using $\text{kron}(I, I, \dots, I, A, I, \dots, I)$

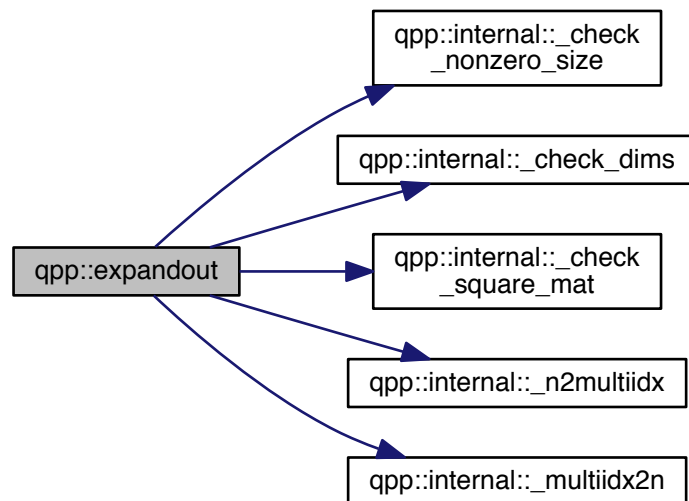
Parameters

A	Eigen expression
pos	Position
$dims$	Dimensions of multi-partite system

Returns

Tensor product $I \otimes \dots \otimes I \otimes A \otimes I \otimes \dots \otimes I$, with A on position pos , as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.26 `template<typename Derived> types::cmat qpp::expm (const Eigen::MatrixBase< Derived> & A)`

Matrix exponential.

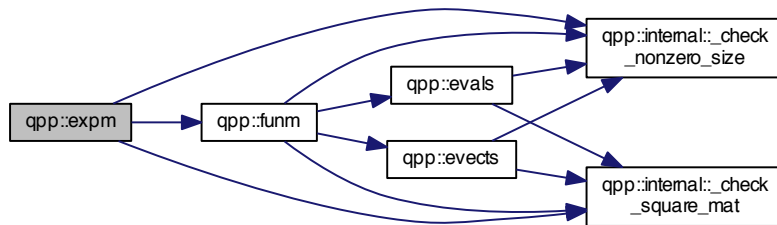
Parameters

A	Eigen expression
-----	------------------

Returns

Matrix exponential of A , as a dynamic matrix over the complex field

Here is the call graph for this function:



5.1.1.27 `template<typename Derived > types::cmat qpp::funm (const Eigen::MatrixBase< Derived > & A,
types::cplx*)(const types::cplx &) f)`

Functional calculus $f(A)$

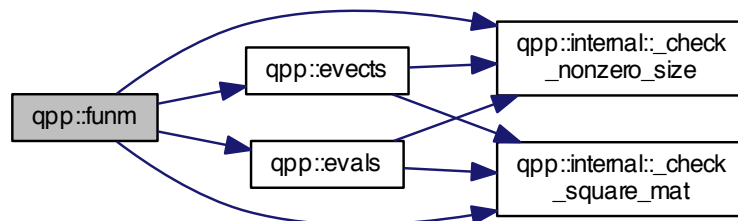
Parameters

A	Eigen expression
f	Pointer-to-function from complex to complex

Returns

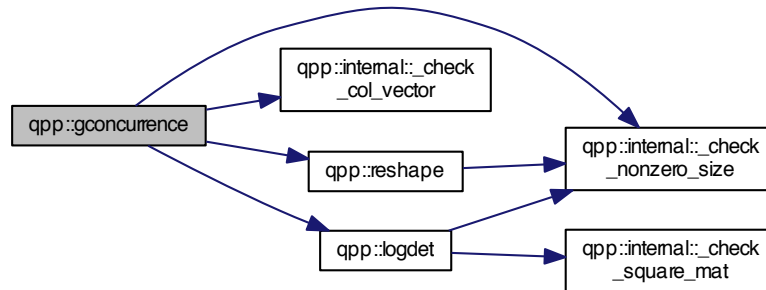
$f(A)$, as a dynamic matrix over the complex field

Here is the call graph for this function:



5.1.1.28 `template<typename Derived> double qpp::gconcurrency (const Eigen::MatrixBase< Derived> & A)`

Here is the call graph for this function:



5.1.1.29 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::grams (const std::vector< Derived> & Vs)`

Gram-Schmidt orthogonalization.

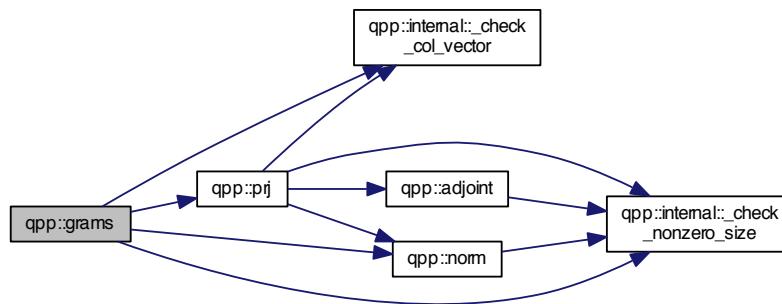
Parameters

<code>Vs</code>	<code>std::vector</code> of Eigen expressions as column vectors
-----------------	---

Returns

Gram-Schmidt vectors of `Vs` as columns of dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.30 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::grams (const std::initializer_list< Derived> & Vs)`

Gram-Schmidt orthogonalization.

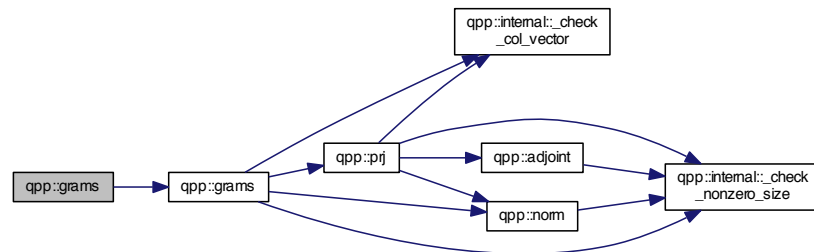
Parameters

<i>Vs</i>	std::initializer_list of Eigen expressions as column vectors
-----------	--

Returns

Gram-Schmidt vectors of *Vs* as columns of dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.31 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::grams (const Eigen::MatrixBase< Derived> & A)`

Gram-Schmidt orthogonalization.

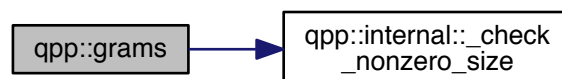
Parameters

<i>A</i>	Eigen expression, input vectors as columns of <i>A</i>
----------	--

Returns

Gram-Schmidt vectors of columns of *A*, as columns of dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.32 `template<typename Derived> types::dmat qpp::hevals (const Eigen::MatrixBase< Derived> & A)`

Hermitian eigenvalues.

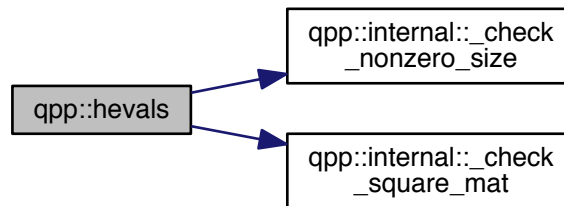
Parameters

A	Eigen expression
-----	------------------

Returns

Eigenvalues of Hermitian A , as a dynamic matrix over the real field

Here is the call graph for this function:



5.1.1.33 `template<typename Derived> types::cmat qpp::hevects (const Eigen::MatrixBase< Derived> & A)`

Hermitian eigenvectors.

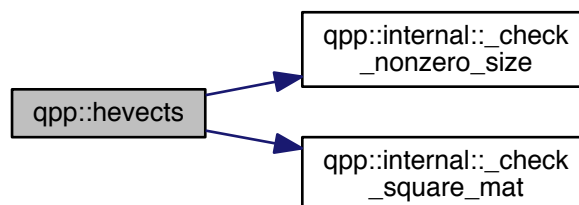
Parameters

A	Eigen expression
-----	------------------

Returns

Eigenvectors of Hermitian A , as a dynamic matrix over the complex field

Here is the call graph for this function:



5.1.1.34 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::inverse (const Eigen::MatrixBase< Derived> & A)`

Inverse.

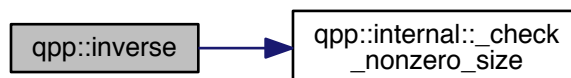
Parameters

A	Eigen expression
-----	------------------

Returns

Inverse of A , as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.35 `std::vector<std::size_t> qpp::invperm (const std::vector< std::size_t > & perm)`

Inverse permutation.

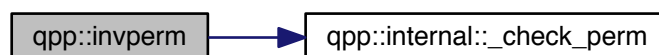
Parameters

<i>perm</i>	Permutation
-------------	-------------

Returns

Inverse of permutation *perm*

Here is the call graph for this function:



5.1.1.36 `template<typename T> types::DynMat<typename T::Scalar> qpp::kron (const T & head)`

Kronecker product (variadic overload)

Parameters

<i>head</i>	Eigen expression
-------------	------------------

Returns

Its argument *head*, used to stop the recursion for the variadic template version of [qpp::kron\(...\)](#)

5.1.1.37 `template<typename T , typename... Args> types::DynMat<typename T::Scalar> qpp::kron (const T & head,
const Args &... tail)`

Kronecker product (variadic overload)

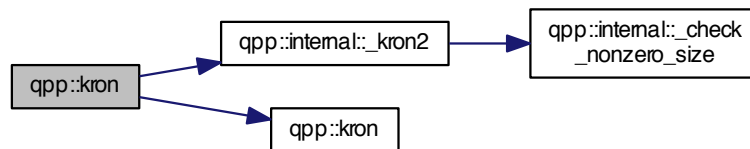
Parameters

<i>head</i>	Eigen expression
<i>tail</i>	Variadic Eigen expression (zero or more parameters)

Returns

Kronecker product of all input parameters, evaluated from left to right, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.138 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::kron (const std::vector< Derived > & As)`

Kronecker product (std::vector overload)

Parameters

<i>As</i>	std::vector of Eigen expressions
-----------	----------------------------------

Returns

Kronecker product of all elements in *As*, evaluated from left to right, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.139 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::kron (const std::initializer_list< Derived > & As)`

Kronecker product (std::initializer_list overload)

Parameters

<i>As</i>	std::initializer_list of Eigen expressions, such as { <i>A1</i> , <i>A2</i> , ... , <i>Ak</i> }
-----------	---

Returns

Kronecker product of all elements in *As*, evaluated from left to right, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.40 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::kronpow (const Eigen::MatrixBase< Derived > & A, std::size_t n)`

Kronecker power.

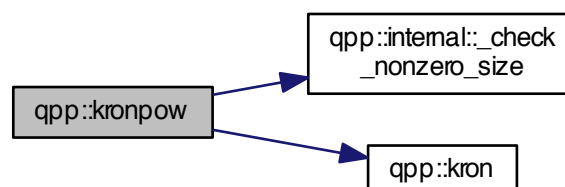
Parameters

<i>A</i>	Eigen expression
<i>n</i>	Non-negative integer

Returns

Kronecker product of *A* with itself *n* times, i.e. $A^{\otimes n}$, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.41 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::load (const std::string & fname)`

5.1.1.42 `template<typename Derived > Derived qpp::loadMATLABmatrix (const std::string & mat_file, const std::string & var_name)`

5.1.1.43 `template<> types::dmat qpp::loadMATLABmatrix (const std::string & mat_file, const std::string & var_name)`

5.1.1.44 `template<> types::cmat qpp::loadMATLABmatrix (const std::string & mat_file, const std::string & var_name)`

5.1.1.45 `template<typename Derived > Derived::Scalar qpp::logdet (const Eigen::MatrixBase< Derived > & A)`

Logarithm of the determinant.

Especially useful when determinant overflows/underflows

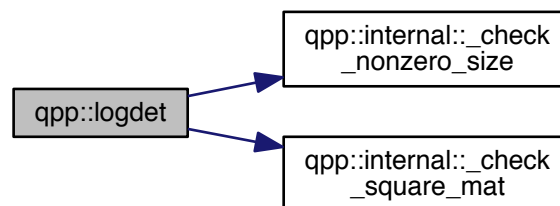
Parameters

<i>A</i>	Eigen expression
----------	------------------

Returns

Logarithm of the determinant of *A*, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.46 `template<typename Derived > types::cmat qpp::logm (const Eigen::MatrixBase< Derived > & A)`

Matrix logarithm.

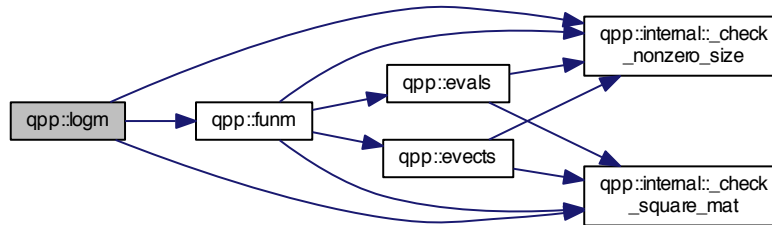
Parameters

<i>A</i>	Eigen expression
----------	------------------

Returns

Matrix logarithm of A , as a dynamic matrix over the complex field

Here is the call graph for this function:



5.1.1.47 `types::ket qpp::mket (const std::vector< std::size_t > & mask)`

Constructs multi-partite qubit ket.

Constructs the multi-partite qubit ket $|mask\rangle$, where $mask$ is a `std::vector` of 0's and 1's

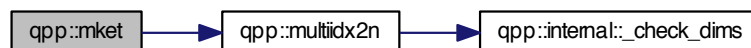
Parameters

<i>mask</i>	<code>std::vector</code> of 0's and 1's
-------------	---

Returns

Multi-partite qubit state vector, as dynamic column vector over the complex field

Here is the call graph for this function:



5.1.1.48 `types::ket qpp::mket (const std::vector< std::size_t > & mask, const std::vector< std::size_t > & dims)`

Constructs multi-partite qudit ket.

Constructs the multi-partite qudit ket $|mask\rangle$, where $mask$ is a `std::vector` of non-negative integers
Each element in $mask$ has to be smaller than the corresponding element in $dims$

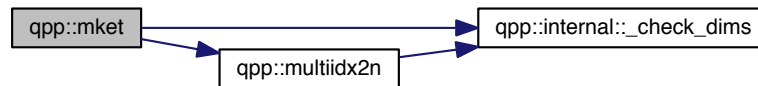
Parameters

<i>mask</i>	std::vector of non-negative integers
-------------	--------------------------------------

Returns

Multi-partite qudit state vector, as dynamic column vector over the complex field

Here is the call graph for this function:



5.1.1.49 types::ket qpp::mket (const std::vector< std::size_t > & *mask*, std::size_t *d*)

Constructs multi-partite qudit ket.

Constructs the multi-partite qudit ket $|\text{mask}\rangle$ in a multi-partite system, each subsystem of equal dimension d *mask* is a std::vector of non-negative integers, where each element in *mask* has to be strictly smaller than d

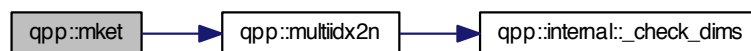
Parameters

<i>mask</i>	std::vector of non-negative integers
<i>d</i>	Subsystems' dimension

Returns

Multi-partite qudit state vector, as dynamic column vector over the complex field

Here is the call graph for this function:



5.1.1.50 std::size_t qpp::multiidx2n (const std::vector< std::size_t > & *midx*, const std::vector< std::size_t > & *dims*)

Multi-index to non-negative integer index.

Uses standard lexicographical order, e.e. 00...0, 00...1 etc.

Parameters

<i>midx</i>	Multi-index
<i>dims</i>	Dimensions of multi-partite system

Returns

Non-negative integer index

Here is the call graph for this function:



5.1.1.51 `std::vector<std::size_t> qpp::n2multiidx (std::size_t n, const std::vector< std::size_t > & dims)`

Non-negative integer index to multi-index.

Uses standard lexicographical order, e.e. 00...0, 00...1 etc.

Parameters

<i>n</i>	Non-negative integer index
<i>dims</i>	Dimensions of multi-partite system

Returns

Multi-index of same size as *dims*

Here is the call graph for this function:



5.1.1.52 `template<typename Derived > double qpp::norm (const Eigen::MatrixBase< Derived > & A)`

Trace norm.

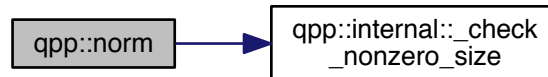
Parameters

A	Eigen expression
-----	------------------

Returns

Trace norm (Frobenius norm) of A , as a real number

Here is the call graph for this function:



5.1.1.53 `constexpr std::complex<double> qpp::operator""_i (unsigned long long int x)`

5.1.1.54 `constexpr std::complex<double> qpp::operator""_i (long double x)`

5.1.1.55 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::powm (const Eigen::MatrixBase< Derived > & A, std::size_t n)`

Matrix power.

Defines $A^0 = I$

Explicitly multiplies the matrix A with itself n times

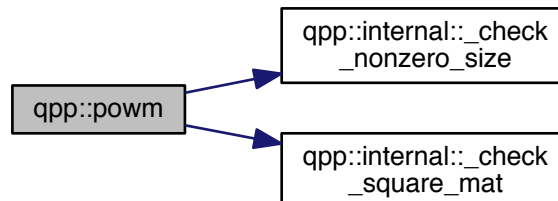
Parameters

A	Eigen expression
n	Non-negative integer

Returns

Matrix power A^n , as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.56 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::prj (const Eigen::MatrixBase<Derived> & V)`

Projector.

Normalized projector onto state vector

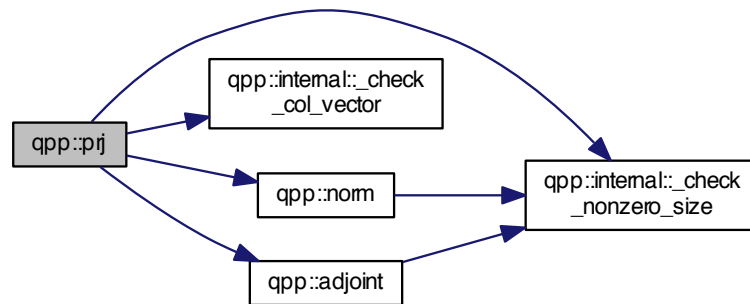
Parameters

<i>V</i>	Eigen expression
----------	------------------

Returns

Projector onto the state vector *V*, or the matrix *Zero* if *V* has norm zero (i.e. smaller than [qpp::ct::eps](#)), as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.57 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::ptrace (const Eigen::MatrixBase<Derived> & A, const std::vector<std::size_t> & subsys, const std::vector<std::size_t> & dims)`

Partial trace.

Partial trace of multi-partite density matrix over a list of subsystems

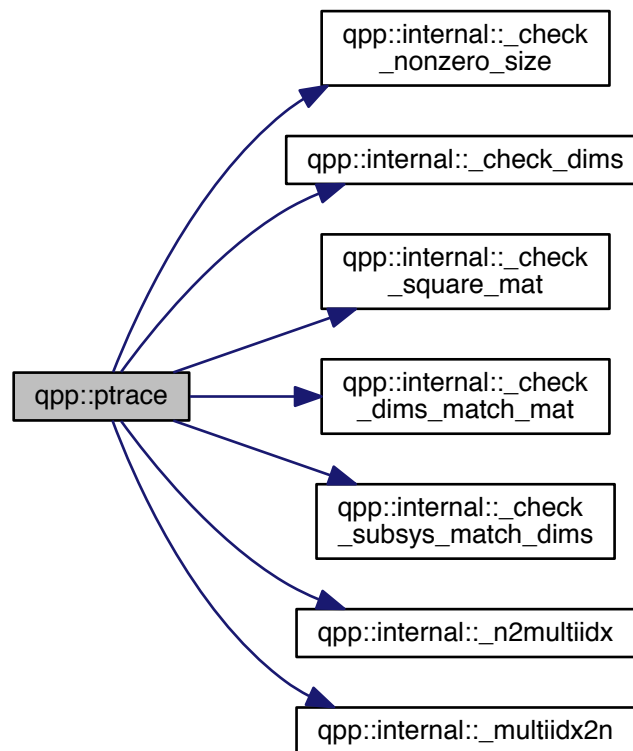
Parameters

<i>A</i>	Eigen expression
<i>subsys</i>	Subsystems' indexes
<i>dims</i>	Dimensions of multi-partite system

Returns

Partial trace $Tr_{subsys}(\cdot)$ over the subsystems *subsys* in a multi-partite system, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.58 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::ptrace1 (const Eigen::MatrixBase< Derived> & A, const std::vector< std::size_t> & dims)`

Partial trace.

Partial trace of density matrix over the first subsystem in a bi-partite system

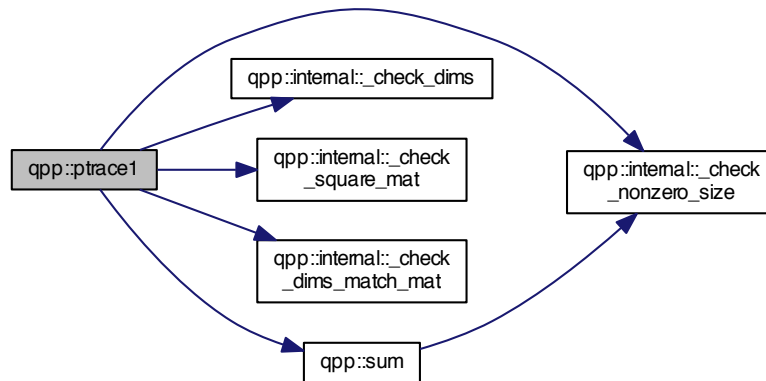
Parameters

<i>A</i>	Eigen expression
<i>dims</i>	Dimensions of bi-partite system (must be a <code>std::vector</code> with 2 elements)

Returns

Partial trace $Tr_A(\cdot)$ over the first subsystem A in a bi-partite system $A \otimes B$, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.59 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::ptrace2 (const Eigen::MatrixBase< Derived> & A, const std::vector< std::size_t> & dims)`

Partial trace.

Partial trace of density matrix over the second subsystem in a bi-partite system

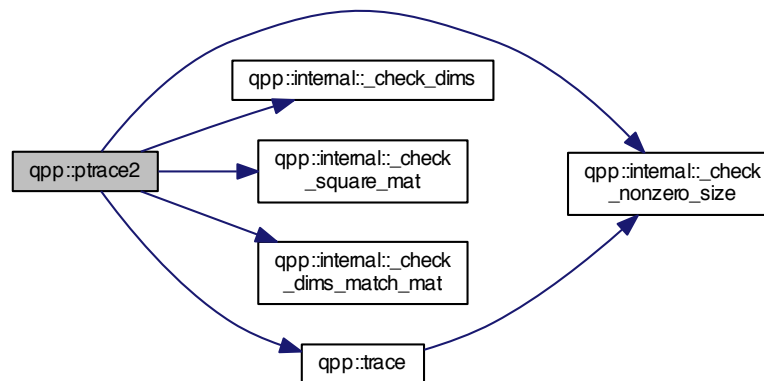
Parameters

<i>A</i>	Eigen expression
<i>dims</i>	Dimensions of bi-partite system (must be a std::vector with 2 elements)

Returns

Partial trace $Tr_B(\cdot)$ over the second subsystem B in a bi-partite system $A \otimes B$, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.60 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::ptranspose (const Eigen::MatrixBase< Derived> & A, const std::vector< std::size_t> & subsys, const std::vector< std::size_t> & dims)`

Partial transpose.

Partial transpose of multi-partite density matrix over a list of subsystems

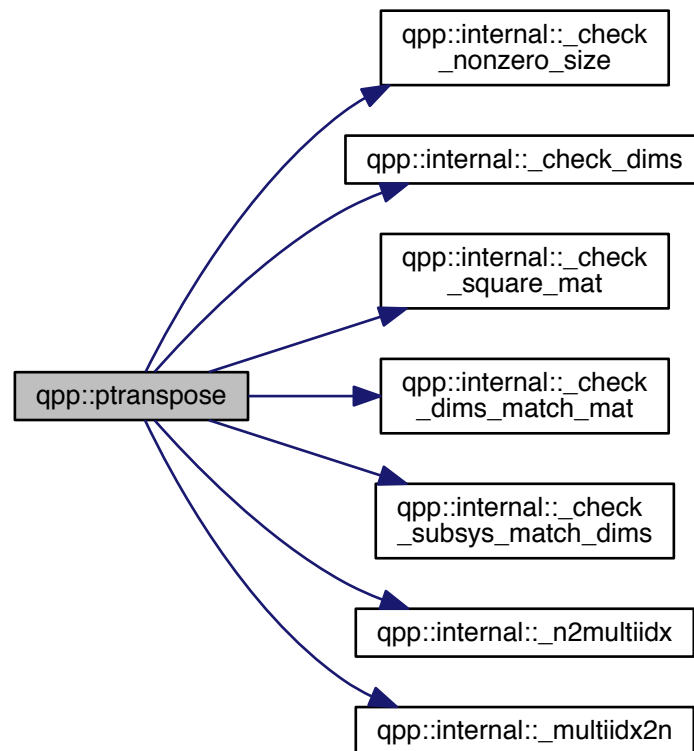
Parameters

<i>A</i>	Eigen expression
<i>subsys</i>	Subsystems' indexes
<i>dims</i>	Dimensions of multi-partite system

Returns

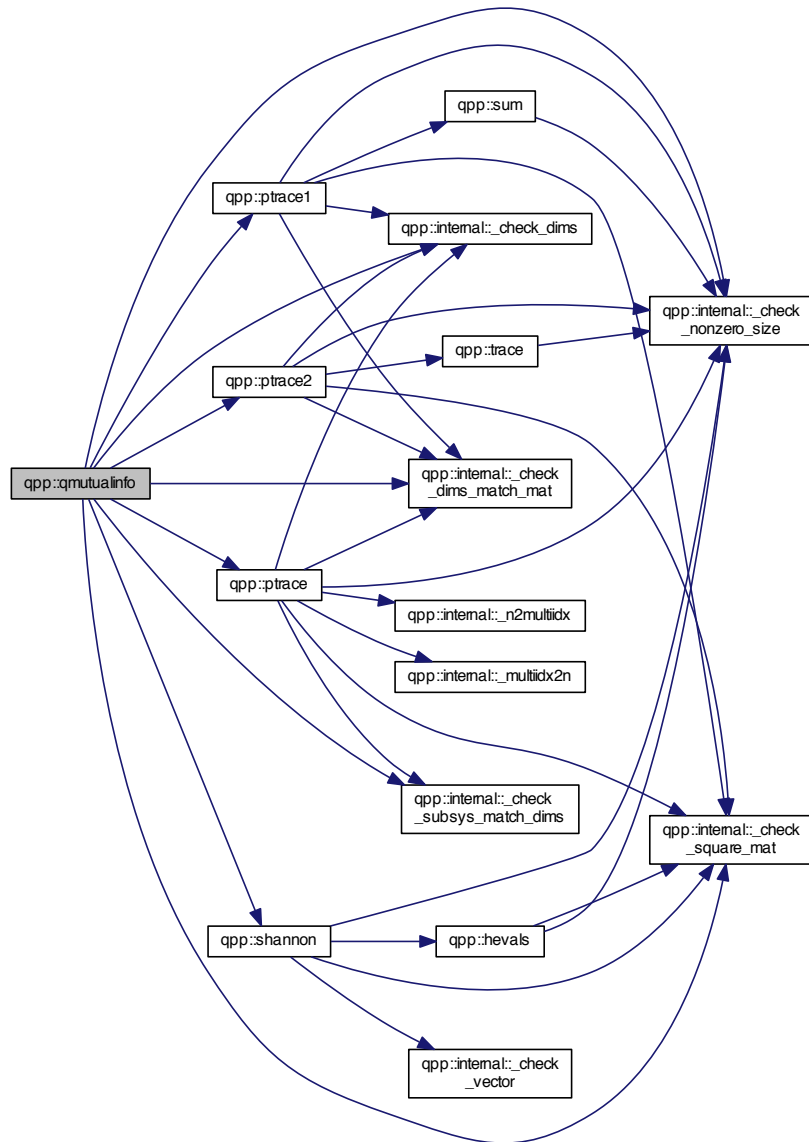
Partial transpose $(\cdot)^{T_{\text{subsys}}}$ over the subsystems *subsys* in a multi-partite system, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.61 `template<typename Derived> double qpp::qmutualinfo (const Eigen::MatrixBase< Derived> & A, const std::vector< std::size_t> & subsys, const std::vector< std::size_t> & dims)`

Here is the call graph for this function:



5.1.1.62 `template<typename Derived> Derived qpp::rand (std::size_t rows, std::size_t cols, double a = 0, double b = 1)`

5.1.1.63 `template<> types::dmat qpp::rand (std::size_t rows, std::size_t cols, double a, double b)`

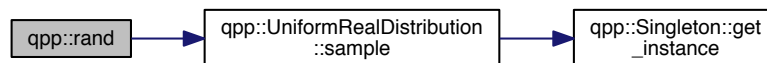
5.1.1.64 `template<> types::cmat qpp::rand (std::size_t rows, std::size_t cols, double a, double b)`

Here is the call graph for this function:



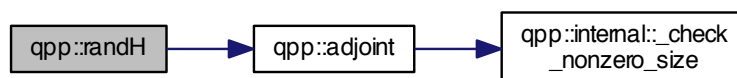
5.1.1.65 `double qpp::rand (double a = 0, double b = 1)`

Here is the call graph for this function:



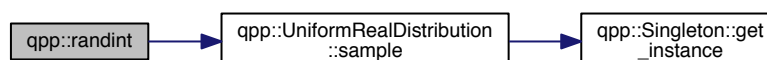
5.1.1.66 `types::cmat qpp::randH (std::size_t D)`

Here is the call graph for this function:



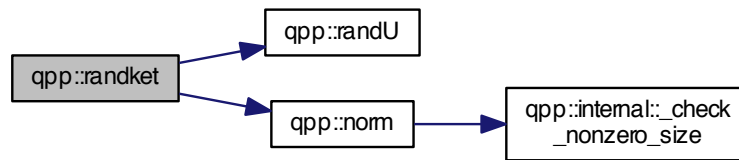
5.1.1.67 `long long qpp::randint (long long a, long long b)`

Here is the call graph for this function:

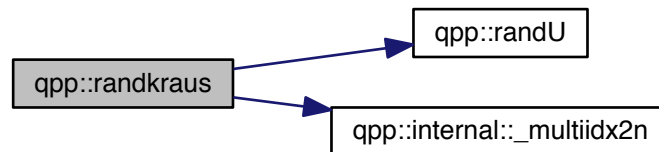


5.1.1.68 `types::ket qpp::randket (std::size_t D)`

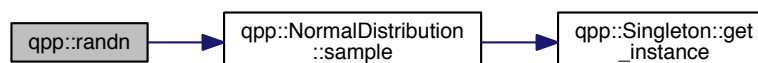
Here is the call graph for this function:

5.1.1.69 `std::vector<types::cmat> qpp::randkraus (std::size_t n, std::size_t D)`

Here is the call graph for this function:

5.1.1.70 `template<typename Derived> Derived qpp::randn (std::size_t rows, std::size_t cols, double mean = 0, double sigma = 1)`5.1.1.71 `template<> types::dmat qpp::randn (std::size_t rows, std::size_t cols, double mean, double sigma)`

Here is the call graph for this function:



5.1.1.72 `template<> types::cmat qpp::randn (std::size_t rows, std::size_t cols, double mean, double sigma)`

Here is the call graph for this function:



5.1.1.73 `double qpp::randn (double mean = 0, double sigma = 1)`

Here is the call graph for this function:



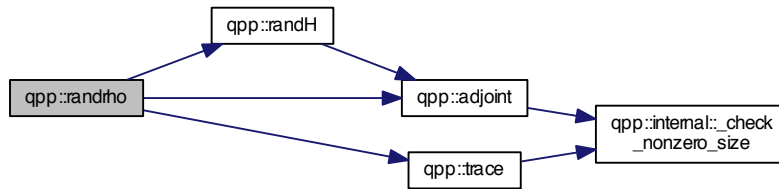
5.1.1.74 `std::vector<std::size_t> qpp::randperm (std::size_t n)`

Here is the call graph for this function:



5.1.1.75 `types::cmat qpp::randrho (std::size_t D)`

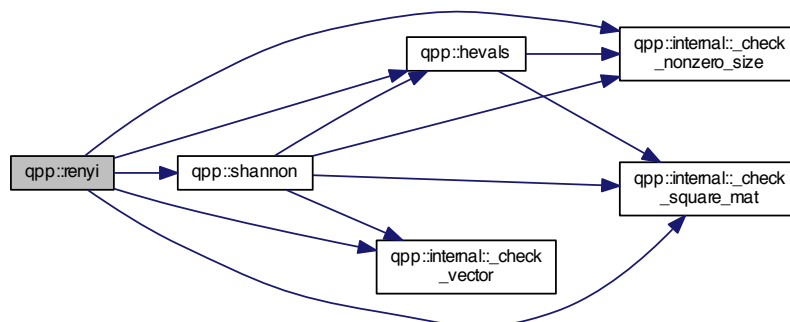
Here is the call graph for this function:

5.1.1.76 `types::cmat qpp::randU (std::size_t D)`5.1.1.77 `types::cmat qpp::randV (std::size_t Din, std::size_t Dout)`

Here is the call graph for this function:

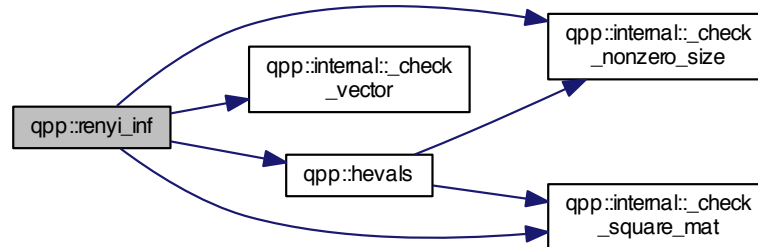
5.1.1.78 `template<typename Derived> double qpp::renyi (const double alpha, const Eigen::MatrixBase< Derived > & A)`

Here is the call graph for this function:



5.1.1.79 `template<typename Derived> double qpp::renyi_inf (const Eigen::MatrixBase< Derived> & A)`

Here is the call graph for this function:



5.1.1.80 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::reshape (const Eigen::MatrixBase< Derived> & A, std::size_t rows, std::size_t cols)`

Reshape.

Uses column-major order when reshaping (same as MATLAB)

Parameters

<i>A</i>	Eigen expression
<i>rows</i>	Number of rows of the reshaped matrix
<i>cols</i>	Number of columns of the reshaped matrix

Returns

Reshaped matrix with *rows* rows and *cols* columns, as a dynamic matrix over the same scalar field

Here is the call graph for this function:

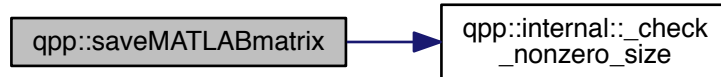


5.1.1.81 `template<typename Derived> void qpp::save (const Eigen::MatrixBase< Derived> & A, const std::string & fname)`

5.1.1.82 `template<typename Derived> void qpp::saveMATLABmatrix (const Eigen::MatrixBase< Derived> & A, const std::string & mat_file, const std::string & var_name, const std::string & mode)`

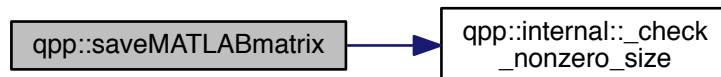
5.1.1.83 `template<> void qpp::saveMATLABmatrix (const Eigen::MatrixBase< types::dmat > & A, const std::string & mat_file, const std::string & var_name, const std::string & mode)`

Here is the call graph for this function:



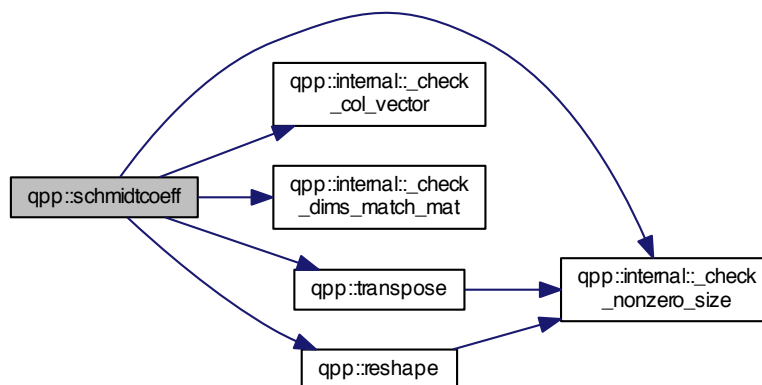
5.1.1.84 `template<> void qpp::saveMATLABmatrix (const Eigen::MatrixBase< typename types::cmat > & A, const std::string & mat_file, const std::string & var_name, const std::string & mode)`

Here is the call graph for this function:



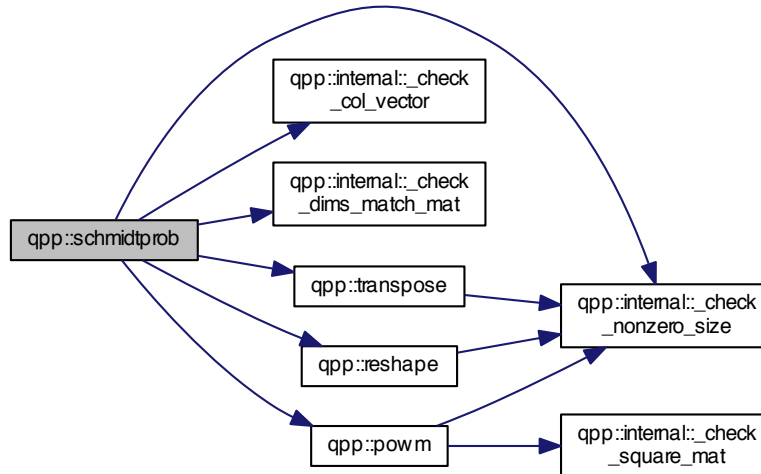
5.1.1.85 `template<typename Derived> types::cmat qpp::schmidtcoeff (const Eigen::MatrixBase< Derived > & A, const std::vector< std::size_t > & dims)`

Here is the call graph for this function:



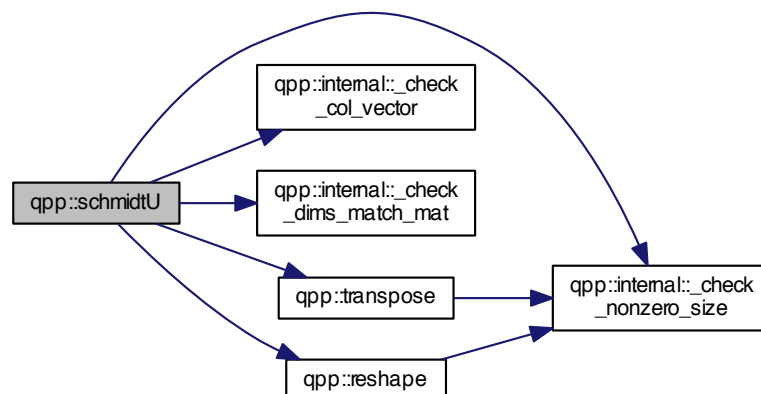
5.1.1.86 `template<typename Derived> types::cmat qpp::schmidtprob (const Eigen::MatrixBase< Derived> & A, const std::vector< std::size_t> & dims)`

Here is the call graph for this function:



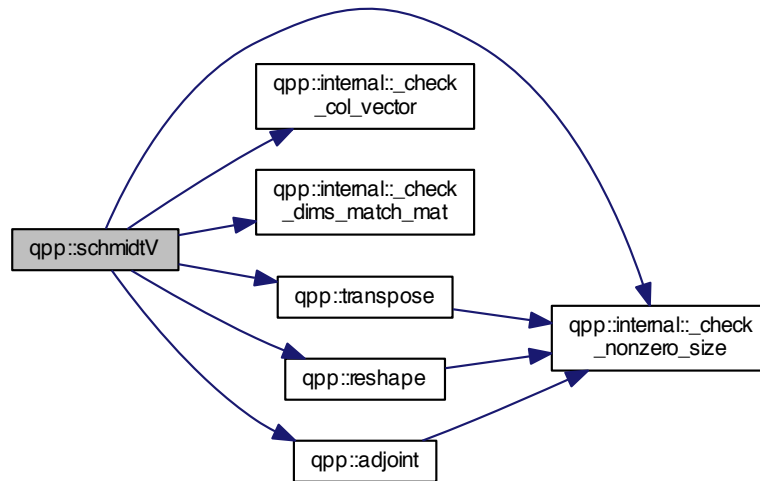
5.1.1.87 `template<typename Derived> types::cmat qpp::schmidtU (const Eigen::MatrixBase< Derived> & A, const std::vector< std::size_t> & dims)`

Here is the call graph for this function:



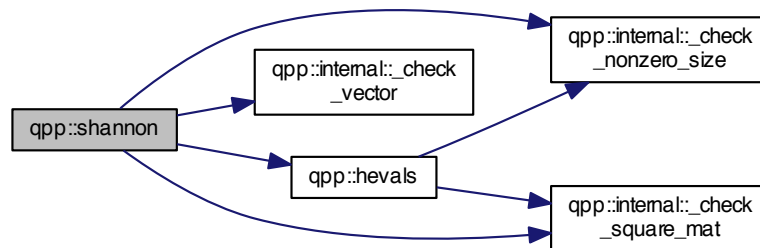
5.1.1.88 `template<typename Derived> types::cmat qpp::schmidtV (const Eigen::MatrixBase< Derived> & A, const std::vector< std::size_t> & dims)`

Here is the call graph for this function:



5.1.1.89 `template<typename Derived> double qpp::shannon (const Eigen::MatrixBase< Derived> & A)`

Here is the call graph for this function:



5.1.1.90 `template<typename Derived> types::cmat qpp::sinm (const Eigen::MatrixBase< Derived> & A)`

Matrix sin.

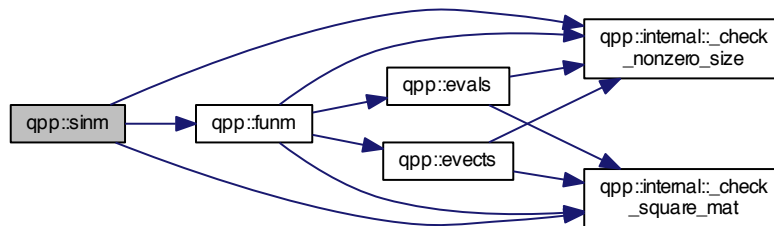
Parameters

A	Eigen expression
-----	------------------

Returns

Matrix sine of A , as a dynamic matrix over the complex field

Here is the call graph for this function:



5.1.1.91 `template<typename Derived> types::cmat qpp::spectralpowm (const Eigen::MatrixBase< Derived> & A, const types::cplx z)`

Matrix power.

Defines $A^0 = I$

Uses the spectral decomposition of A to compute the matrix power

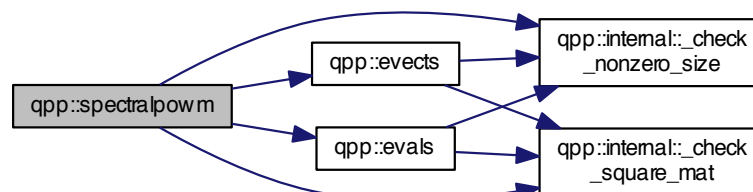
Parameters

A	Eigen expression
z	complex number

Returns

Matrix power A^z , as a dynamic matrix over the complex field

Here is the call graph for this function:



5.1.1.92 `template<typename Derived> types::cmat qpp::sqrtm (const Eigen::MatrixBase< Derived > & A)`

Matrix square root.

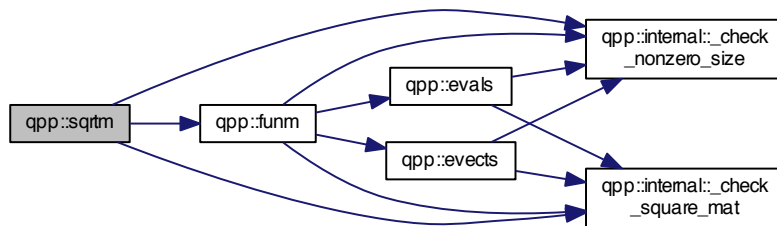
Parameters

A	Eigen expression
-----	------------------

Returns

Matrix square root of A , as a dynamic matrix over the complex field

Here is the call graph for this function:



5.1.1.93 `template<typename Derived> Derived::Scalar qpp::sum (const Eigen::MatrixBase< Derived > & A)`

Element-wise sum.

Parameters

A	Eigen expression
-----	------------------

Returns

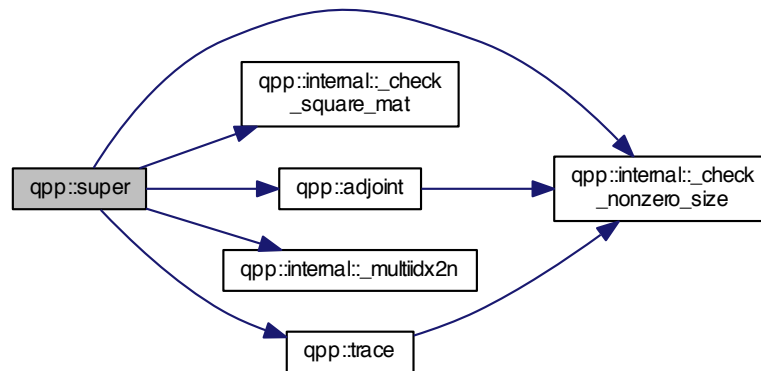
Element-wise sum of A , as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.94 `types::cmat qpp::super (const std::vector< types::cmat > & Ks)`

Here is the call graph for this function:

5.1.1.95 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::syspermute (const Eigen::MatrixBase< Derived > & A, const std::vector< std::size_t > & perm, const std::vector< std::size_t > & dims)`

System permutation.

Permutes the subsystems in a state vector or density matrix

The qubit `perm[i]` is permuted to the location `i`

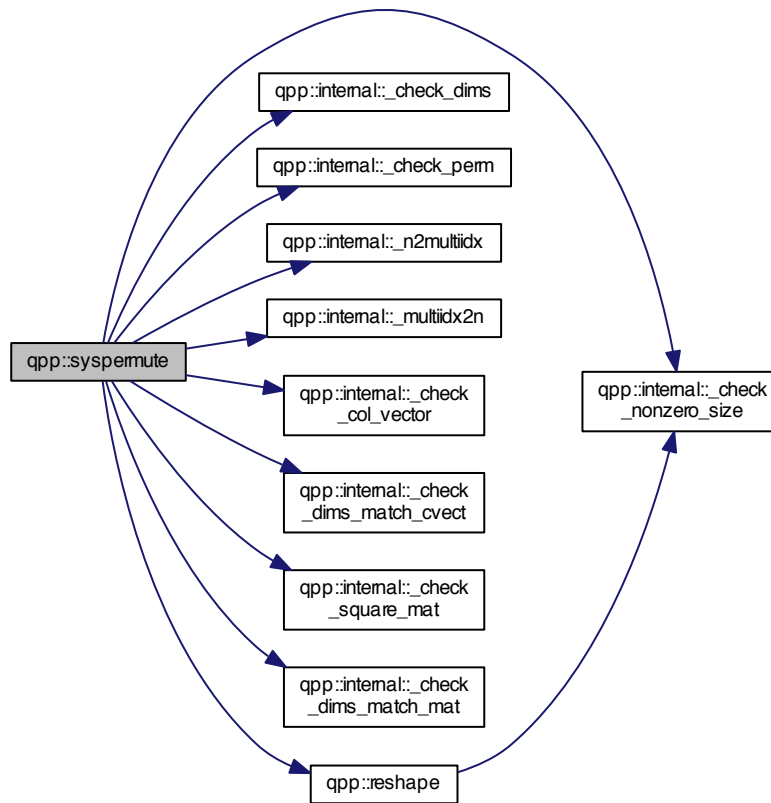
Parameters

<code>A</code>	Eigen expression
<code>perm</code>	Permutation
<code>dims</code>	Subsystems' dimensions

Returns

Permuted system, as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.96 `template<typename Derived> Derived::Scalar qpp::trace (const Eigen::MatrixBase< Derived> & A)`

Trace.

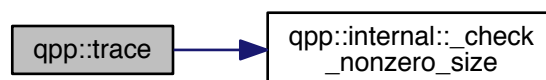
Parameters

A	Eigen expression
---	------------------

Returns

Trace of A , as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.97 `template<typename Derived> types::DynMat<typename Derived::Scalar> qpp::transpose (const Eigen::MatrixBase< Derived> & A)`

Transpose.

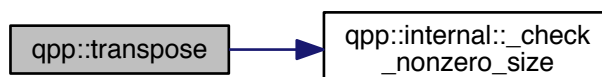
Parameters

A	Eigen expression
-----	------------------

Returns

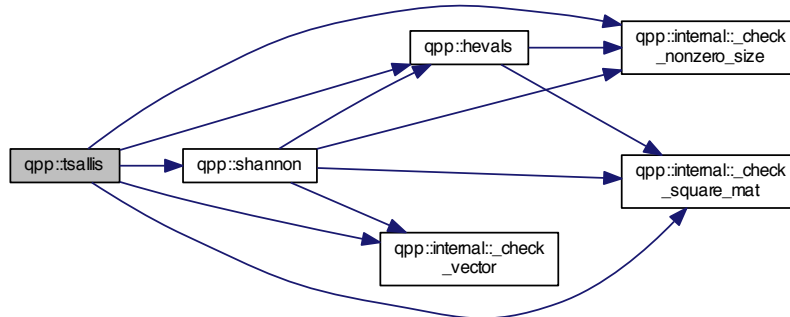
Transpose of A , as a dynamic matrix over the same scalar field

Here is the call graph for this function:



5.1.1.98 `template<typename Derived> double qpp::tsallis (const double alpha, const Eigen::MatrixBase< Derived> & A)`

Here is the call graph for this function:



5.1.2 Variable Documentation

5.1.2.1 `const Gates& qpp::gt = Gates::get_instance()`

5.1.2.2 `const RandomDevices& qpp::rdevs = RandomDevices::get_instance()`

5.1.2.3 `const States& qpp::st = States::get_instance()`

5.2 qpp::ct Namespace Reference

Functions

- `std::complex< double> omega (std::size_t D)`

Variables

- `constexpr double chop = 1e-10`
- `constexpr double eps = 1e-12`
- `constexpr std::size_t maxn = 64`
- `constexpr double pi = 3.141592653589793238462643383279502884`
- `constexpr double ee = 2.718281828459045235360287471352662497`

5.2.1 Function Documentation

5.2.1.1 `std::complex<double> qpp::ct::omega (std::size_t D)`

5.2.2 Variable Documentation

5.2.2.1 `constexpr double qpp::ct::chop = 1e-10`

5.2.2.2 `constexpr double qpp::ct::ee = 2.718281828459045235360287471352662497`

5.2.2.3 `constexpr double qpp::ct::eps = 1e-12`

5.2.2.4 constexpr std::size_t qpp::ct::maxn = 64

5.2.2.5 constexpr double qpp::ct::pi = 3.141592653589793238462643383279502884

5.3 qpp::internal Namespace Reference

Functions

- void [_n2multiidx](#) (std::size_t n, std::size_t numdims, const std::size_t *dims, std::size_t *result)
- std::size_t [_multiidx2n](#) (const std::size_t *midx, std::size_t numdims, const std::size_t *dims)
- template<typename Derived >
bool [_check_square_mat](#) (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
bool [_check_vector](#) (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
bool [_check_row_vector](#) (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
bool [_check_col_vector](#) (const Eigen::MatrixBase< Derived > &A)
- template<typename T >
bool [_check_nonzero_size](#) (const T &x)
- bool [_check_dims](#) (const std::vector< std::size_t > &dims)
- template<typename Derived >
bool [_check_dims_match_mat](#) (const std::vector< std::size_t > &dims, const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
bool [_check_dims_match_cvect](#) (const std::vector< std::size_t > &dims, const Eigen::MatrixBase< Derived > &V)
- template<typename Derived >
bool [_check_dims_match_rvect](#) (const std::vector< std::size_t > &dims, const Eigen::MatrixBase< Derived > &V)
- bool [_check_eq_dims](#) (const std::vector< std::size_t > &dims, std::size_t dim)
- bool [_check_subsys_match_dims](#) (const std::vector< std::size_t > &subsys, const std::vector< std::size_t > &dims)
- bool [_check_perm](#) (const std::vector< std::size_t > &perm)
- template<typename Derived1 , typename Derived2 >
[types::DynMat](#)< typename
Derived1::Scalar > [_kron2](#) (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< Derived2 > &B)
- template<typename T >
void [variadic_vector_emplace](#) (std::vector< T > &)
- template<typename T , typename First , typename... Args>
void [variadic_vector_emplace](#) (std::vector< T > &v, First &&first, Args &&...args)

5.3.1 Function Documentation

5.3.1.1 template<typename Derived > bool qpp::internal::_check_col_vector (const Eigen::MatrixBase< Derived > & A)

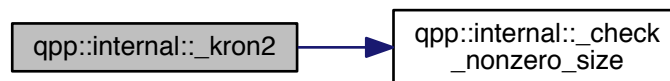
5.3.1.2 bool qpp::internal::_check_dims (const std::vector< std::size_t > & dims)

5.3.1.3 template<typename Derived > bool qpp::internal::_check_dims_match_cvect (const std::vector< std::size_t > & dims, const Eigen::MatrixBase< Derived > & V)

5.3.1.4 template<typename Derived > bool qpp::internal::_check_dims_match_mat (const std::vector< std::size_t > & dims, const Eigen::MatrixBase< Derived > & A)

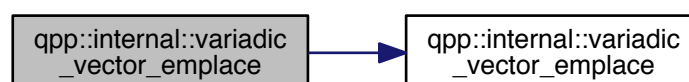
- 5.3.1.5 `template<typename Derived > bool qpp::internal::_check_dims_match_rvect (const std::vector< std::size_t > & dims, const Eigen::MatrixBase< Derived > & V)`
- 5.3.1.6 `bool qpp::internal::_check_eq_dims (const std::vector< std::size_t > & dims, std::size_t dim)`
- 5.3.1.7 `template<typename T > bool qpp::internal::_check_nonzero_size (const T & x)`
- 5.3.1.8 `bool qpp::internal::_check_perm (const std::vector< std::size_t > & perm)`
- 5.3.1.9 `template<typename Derived > bool qpp::internal::_check_row_vector (const Eigen::MatrixBase< Derived > & A)`
- 5.3.1.10 `template<typename Derived > bool qpp::internal::_check_square_mat (const Eigen::MatrixBase< Derived > & A)`
- 5.3.1.11 `bool qpp::internal::_check_subsys_match_dims (const std::vector< std::size_t > & subsys, const std::vector< std::size_t > & dims)`
- 5.3.1.12 `template<typename Derived > bool qpp::internal::_check_vector (const Eigen::MatrixBase< Derived > & A)`
- 5.3.1.13 `template<typename Derived1 , typename Derived2 > types::DynMat<typename Derived1::Scalar>
qpp::internal::_kron2 (const Eigen::MatrixBase< Derived1 > & A, const Eigen::MatrixBase< Derived2 > & B)`

Here is the call graph for this function:



- 5.3.1.14 `std::size_t qpp::internal::_multiidx2n (const std::size_t * midx, std::size_t numdims, const std::size_t * dims)`
- 5.3.1.15 `void qpp::internal::_n2multiidx (std::size_t n, std::size_t numdims, const std::size_t * dims, std::size_t * result)`
- 5.3.1.16 `template<typename T > void qpp::internal::variadic_vector_emplace (std::vector< T > &)`
- 5.3.1.17 `template<typename T , typename First , typename... Args> void qpp::internal::variadic_vector_emplace (std::vector< T > & v, First && first, Args &&... args)`

Here is the call graph for this function:



5.4 qpp::types Namespace Reference

Typedefs

- using `cplx` = `std::complex< double >`
- using `cmat` = `Eigen::MatrixXcd`
- using `dmat` = `Eigen::MatrixXd`
- using `ket` = `Eigen::Matrix< cplx, Eigen::Dynamic, 1 >`
- using `bra` = `Eigen::Matrix< cplx, 1, Eigen::Dynamic >`
- `template<typename Scalar >`
using `DynMat` = `Eigen::Matrix< Scalar, Eigen::Dynamic, Eigen::Dynamic >`

5.4.1 Typedef Documentation

5.4.1.1 using `qpp::types::bra` = `typedef Eigen::Matrix<cplx, 1, Eigen::Dynamic>`

5.4.1.2 using `qpp::types::cmat` = `typedef Eigen::MatrixXcd`

5.4.1.3 using `qpp::types::cplx` = `typedef std::complex<double>`

5.4.1.4 using `qpp::types::dmat` = `typedef Eigen::MatrixXd`

5.4.1.5 `template<typename Scalar > using qpp::types::DynMat` = `typedef Eigen::Matrix<Scalar, Eigen::Dynamic, Eigen::Dynamic>`

5.4.1.6 using `qpp::types::ket` = `typedef Eigen::Matrix<cplx, Eigen::Dynamic, 1>`

Chapter 6

Class Documentation

6.1 qpp::DiscreteDistribution Class Reference

```
#include <stat.h>
```

Public Member Functions

- `template<typename InputIterator >`
`DiscreteDistribution` (InputIterator first, InputIterator last)
- `DiscreteDistribution` (std::initializer_list< double > weights)
- `DiscreteDistribution` (std::vector< double > weights)
- `std::size_t sample` ()
- `std::vector< double > probabilities` () const

Protected Attributes

- `std::discrete_distribution`
< std::size_t > `_d`

6.1.1 Constructor & Destructor Documentation

6.1.1.1 `template<typename InputIterator > qpp::DiscreteDistribution::DiscreteDistribution (InputIterator first, InputIterator last)` [inline]

6.1.1.2 `qpp::DiscreteDistribution::DiscreteDistribution (std::initializer_list< double > weights)` [inline]

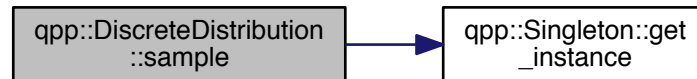
6.1.1.3 `qpp::DiscreteDistribution::DiscreteDistribution (std::vector< double > weights)` [inline]

6.1.2 Member Function Documentation

6.1.2.1 `std::vector<double> qpp::DiscreteDistribution::probabilities () const` [inline]

6.1.2.2 `std::size_t qpp::DiscreteDistribution::sample ()` `[inline]`

Here is the call graph for this function:



6.1.3 Member Data Documentation

6.1.3.1 `std::discrete_distribution<std::size_t> qpp::DiscreteDistribution::_d` `[protected]`

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

- [include/classes/stat.h](#)

6.2 `qpp::DiscreteDistributionAbsSquare` Class Reference

```
#include <stat.h>
```

Public Member Functions

- `template<typename InputIterator >`
[DiscreteDistributionAbsSquare](#) (InputIterator first, InputIterator last)
- [DiscreteDistributionAbsSquare](#) (std::initializer_list< [types::cplx](#) > amplitudes)
- [DiscreteDistributionAbsSquare](#) (std::vector< [types::cplx](#) > amplitudes)
- `template<typename Derived >`
[DiscreteDistributionAbsSquare](#) (const Eigen::MatrixBase< Derived > &V)
- `std::size_t sample ()`
- `std::vector< double > probabilities () const`

Protected Member Functions

- `template<typename InputIterator >`
`std::vector< double > cplx2weights (InputIterator first, InputIterator last) const`

Protected Attributes

- `std::discrete_distribution`
`< std::size_t > _d`

6.2.1 Constructor & Destructor Documentation

6.2.1.1 `template<typename InputIterator > qpp::DiscreteDistributionAbsSquare::DiscreteDistributionAbsSquare (InputIterator first, InputIterator last) [inline]`

6.2.1.2 `qpp::DiscreteDistributionAbsSquare::DiscreteDistributionAbsSquare (std::initializer_list< types::cplx > amplitudes) [inline]`

6.2.1.3 `qpp::DiscreteDistributionAbsSquare::DiscreteDistributionAbsSquare (std::vector< types::cplx > amplitudes) [inline]`

6.2.1.4 `template<typename Derived > qpp::DiscreteDistributionAbsSquare::DiscreteDistributionAbsSquare (const Eigen::MatrixBase< Derived > & V) [inline]`

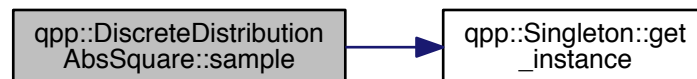
6.2.2 Member Function Documentation

6.2.2.1 `template<typename InputIterator > std::vector<double> qpp::DiscreteDistributionAbsSquare::cplx2weights (InputIterator first, InputIterator last) const [inline], [protected]`

6.2.2.2 `std::vector<double> qpp::DiscreteDistributionAbsSquare::probabilities () const [inline]`

6.2.2.3 `std::size_t qpp::DiscreteDistributionAbsSquare::sample () [inline]`

Here is the call graph for this function:



6.2.3 Member Data Documentation

6.2.3.1 `std::discrete_distribution<std::size_t> qpp::DiscreteDistributionAbsSquare::_d [protected]`

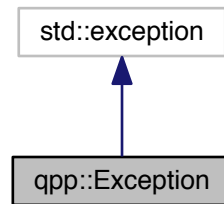
The documentation for this class was generated from the following file:

- [include/classes/stat.h](#)

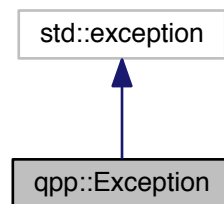
6.3 qpp::Exception Class Reference

```
#include <exception.h>
```

Inheritance diagram for qpp::Exception:



Collaboration diagram for qpp::Exception:



Public Types

- enum `Type` {
`Type::UNKNOWN_EXCEPTION = 1`, `Type::ZERO_SIZE`, `Type::MATRIX_NOT_SQUARE`, `Type::MATRIX_NOT_CVECTOR`,
`Type::MATRIX_NOT_RVECTOR`, `Type::MATRIX_NOT_VECTOR`, `Type::MATRIX_NOT_SQUARE_OR_CVECTOR`,
`Type::MATRIX_NOT_SQUARE_OR_RVECTOR`, `Type::MATRIX_NOT_SQUARE_OR_VECTOR`, `Type::DIMS_INVALID`, `Type::DIMS_NOT_EQUAL`, `Type::DIMS_MISMATCH_MATRIX`,
`Type::DIMS_MISMATCH_CVECTOR`, `Type::DIMS_MISMATCH_RVECTOR`, `Type::DIMS_MISMATCH_VECTOR`,
`Type::SUBSYS_MISMATCH_DIMS`, `Type::PERM_INVALID`, `Type::NOT_QUBIT_GATE`, `Type::NOT_QUBIT_SUBSYS`, `Type::NOT_BIPARTITE`,
`Type::OUT_OF_RANGE`, `Type::TYPE_MISMATCH`, `Type::UNDEFINED_TYPE`, `Type::CUSTOM_EXCEPTION` }

Public Member Functions

- `Exception` (const std::string &where, const `Type` &type)
- `Exception` (const std::string &where, const std::string &custom)
- virtual const char * `what` () const noexcept override

Private Member Functions

- `std::string _construct_exception_msg ()`

Private Attributes

- `std::string _where`
- `std::string _msg`
- `Type _type`
- `std::string _custom`

6.3.1 Member Enumeration Documentation

6.3.1.1 `enum qpp::Exception::Type` [strong]

Enumerator

UNKNOWN_EXCEPTION
ZERO_SIZE
MATRIX_NOT_SQUARE
MATRIX_NOT_CVECTOR
MATRIX_NOT_RVECTOR
MATRIX_NOT_VECTOR
MATRIX_NOT_SQUARE_OR_CVECTOR
MATRIX_NOT_SQUARE_OR_RVECTOR
MATRIX_NOT_SQUARE_OR_VECTOR
DIMS_INVALID
DIMS_NOT_EQUAL
DIMS_MISMATCH_MATRIX
DIMS_MISMATCH_CVECTOR
DIMS_MISMATCH_RVECTOR
DIMS_MISMATCH_VECTOR
SUBSYS_MISMATCH_DIMS
PERM_INVALID
NOT_QUBIT_GATE
NOT_QUBIT_SUBSYS
NOT_BIPARTITE
OUT_OF_RANGE
TYPE_MISMATCH
UNDEFINED_TYPE
CUSTOM_EXCEPTION

6.3.2 Constructor & Destructor Documentation

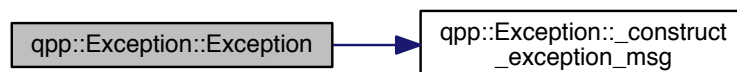
6.3.2.1 `qpp::Exception::Exception (const std::string & where, const Type & type)` `[inline]`

Here is the call graph for this function:



6.3.2.2 `qpp::Exception::Exception (const std::string & where, const std::string & custom)` `[inline]`

Here is the call graph for this function:



6.3.3 Member Function Documentation

6.3.3.1 `std::string qpp::Exception::_construct_exception_msg ()` `[inline]`, `[private]`

6.3.3.2 `virtual const char* qpp::Exception::what () const` `[inline]`, `[override]`, `[virtual]`, `[noexcept]`

6.3.4 Member Data Documentation

6.3.4.1 `std::string qpp::Exception::_custom` `[private]`

6.3.4.2 `std::string qpp::Exception::_msg` `[private]`

6.3.4.3 `Type qpp::Exception::_type` `[private]`

6.3.4.4 `std::string qpp::Exception::_where` `[private]`

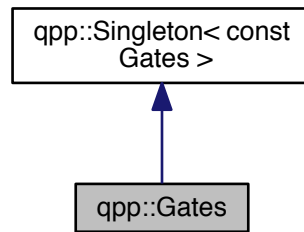
The documentation for this class was generated from the following file:

- [include/classes/exception.h](#)

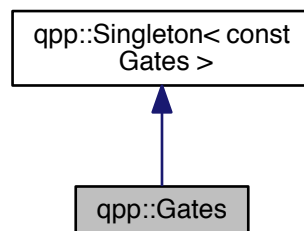
6.4 qpp::Gates Class Reference

```
#include <gates.h>
```

Inheritance diagram for qpp::Gates:



Collaboration diagram for qpp::Gates:



Public Member Functions

- [types::cmat Rn](#) (double theta, std::vector< double > n) const
- [types::cmat Zd](#) (std::size_t D) const
- [types::cmat Fd](#) (std::size_t D) const
- [types::cmat Xd](#) (std::size_t D) const
- template<typename Derived = Eigen::MatrixXcd>
Derived [ld](#) (std::size_t D) const
- template<typename Derived1 , typename Derived2 >
[types::DynMat](#)< typename
Derived1::Scalar > [applyCTRL](#) (const Eigen::MatrixBase< Derived1 > &state, const Eigen::MatrixBase<
Derived2 > &A, const std::vector< std::size_t > &ctrl, const std::vector< std::size_t > &subsys, std::size_t
n, std::size_t d=2) const
- template<typename Derived1 , typename Derived2 >
[types::DynMat](#)< typename
Derived1::Scalar > [apply](#) (const Eigen::MatrixBase< Derived1 > &state, const Eigen::MatrixBase< De-
rived2 > &A, const std::vector< std::size_t > &subsys, const std::vector< std::size_t > &dims) const
- template<typename Derived >
[types::DynMat](#)< typename
Derived::Scalar > [CTRL](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &ctrl,
const std::vector< std::size_t > &subsys, std::size_t n, std::size_t d=2) const

Public Attributes

- [types::cmat Id2](#) { types::cmat::Identity(2, 2) }
- [types::cmat H](#) { types::cmat::Zero(2, 2) }
- [types::cmat X](#) { types::cmat::Zero(2, 2) }
- [types::cmat Y](#) { types::cmat::Zero(2, 2) }
- [types::cmat Z](#) { types::cmat::Zero(2, 2) }
- [types::cmat S](#) { types::cmat::Zero(2, 2) }
- [types::cmat T](#) { types::cmat::Zero(2, 2) }
- [types::cmat CNOTab](#) { types::cmat::Identity(4, 4) }
- [types::cmat CZ](#) { types::cmat::Identity(4, 4) }
- [types::cmat CNOTba](#) { types::cmat::Zero(4, 4) }
- [types::cmat SWAP](#) { types::cmat::Identity(4, 4) }
- [types::cmat TOF](#) { types::cmat::Identity(8, 8) }
- [types::cmat FRED](#) { types::cmat::Identity(8, 8) }

Private Member Functions

- [Gates](#) ()

Friends

- class [Singleton< const Gates >](#)

Additional Inherited Members

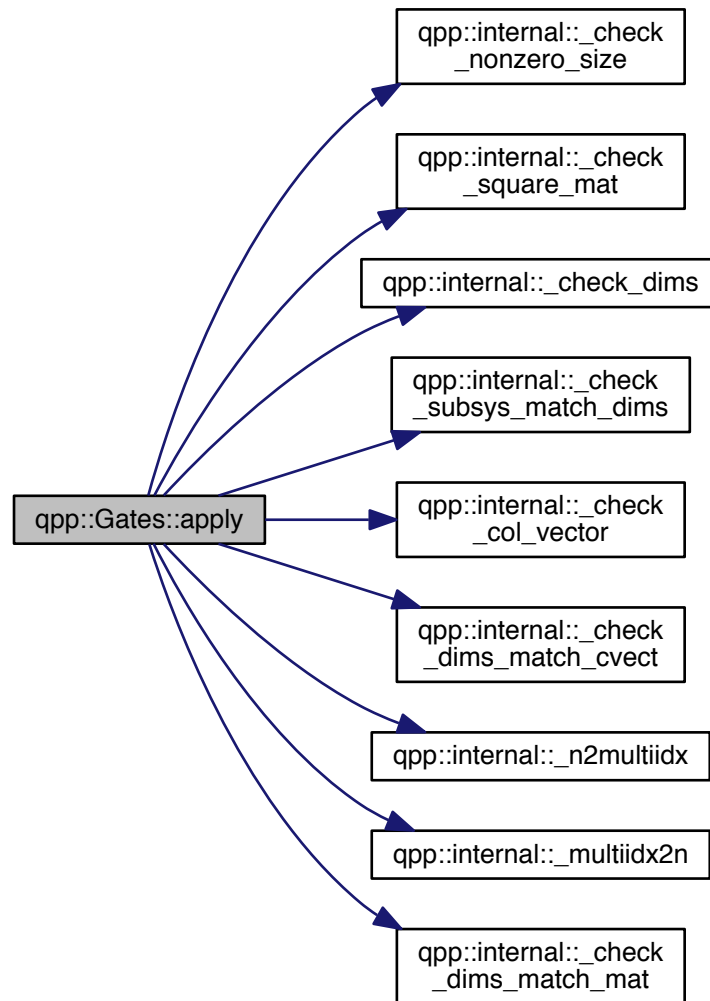
6.4.1 Constructor & Destructor Documentation

6.4.1.1 `qpp::Gates::Gates ()` `[inline]`, `[private]`

6.4.2 Member Function Documentation

```
6.4.2.1 template<typename Derived1 , typename Derived2 > types::DynMat<typename Derived1::Scalar>
qpp::Gates::apply ( const Eigen::MatrixBase< Derived1 > & state, const Eigen::MatrixBase< Derived2 > & A, const
std::vector< std::size_t > & subsys, const std::vector< std::size_t > & dims ) const [inline]
```

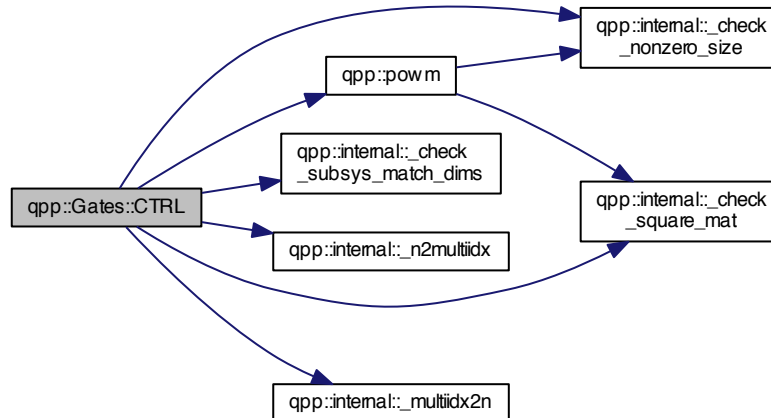
Here is the call graph for this function:



```
6.4.2.2 template<typename Derived1 , typename Derived2 > types::DynMat<typename Derived1::Scalar>
qpp::Gates::applyCTRL ( const Eigen::MatrixBase< Derived1 > & state, const Eigen::MatrixBase< Derived2 > & A,
const std::vector< std::size_t > & ctrl, const std::vector< std::size_t > & subsys, std::size_t n, std::size_t d = 2 )
const [inline]
```

6.4.2.3 `template<typename Derived > types::DynMat<typename Derived::Scalar> qpp::Gates::CTRL (const Eigen::MatrixBase< Derived > & A, const std::vector< std::size_t > & ctrl, const std::vector< std::size_t > & subsys, std::size_t n, std::size_t d = 2) const [inline]`

Here is the call graph for this function:



6.4.2.4 `types::cmat qpp::Gates::Fd (std::size_t D) const [inline]`

Here is the call graph for this function:

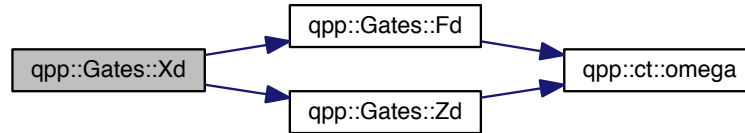


6.4.2.5 `template<typename Derived = Eigen::MatrixXcd> Derived qpp::Gates::Id (std::size_t D) const [inline]`

6.4.2.6 `types::cmat qpp::Gates::Rn (double theta, std::vector< double > n) const [inline]`

6.4.2.7 `types::cmat qpp::Gates::Xd (std::size_t D) const [inline]`

Here is the call graph for this function:



6.4.2.8 `types::cmat qpp::Gates::Zd (std::size_t D) const [inline]`

Here is the call graph for this function:



6.4.3 Friends And Related Function Documentation

6.4.3.1 `friend class Singleton< const Gates > [friend]`

6.4.4 Member Data Documentation

6.4.4.1 `types::cmat qpp::Gates::CNOTab { types::cmat::Identity(4, 4) }`

6.4.4.2 `types::cmat qpp::Gates::CNOTba { types::cmat::Zero(4, 4) }`

6.4.4.3 `types::cmat qpp::Gates::CZ { types::cmat::Identity(4, 4) }`

6.4.4.4 `types::cmat qpp::Gates::FRED { types::cmat::Identity(8, 8) }`

6.4.4.5 `types::cmat qpp::Gates::H { types::cmat::Zero(2, 2) }`

6.4.4.6 `types::cmat qpp::Gates::Id2 { types::cmat::Identity(2, 2) }`

6.4.4.7 `types::cmat qpp::Gates::S { types::cmat::Zero(2, 2) }`

6.4.4.8 `types::cmat qpp::Gates::SWAP { types::cmat::Identity(4, 4) }`

6.4.4.9 `types::cmat qpp::Gates::T { types::cmat::Zero(2, 2) }`

6.4.4.10 `types::cmat qpp::Gates::TOF { types::cmat::Identity(8, 8) }`

6.4.4.11 `types::cmat qpp::Gates::X { types::cmat::Zero(2, 2) }`

6.4.4.12 `types::cmat qpp::Gates::Y { types::cmat::Zero(2, 2) }`

6.4.4.13 `types::cmat qpp::Gates::Z { types::cmat::Zero(2, 2) }`

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

- [include/classes/gates.h](#)

6.5 qpp::NormalDistribution Class Reference

```
#include <stat.h>
```

Public Member Functions

- [NormalDistribution](#) (double mean=0, double sigma=1)
- double [sample](#) ()

Protected Attributes

- `std::normal_distribution _d`

6.5.1 Constructor & Destructor Documentation

6.5.1.1 `qpp::NormalDistribution::NormalDistribution (double mean = 0, double sigma = 1)` `[inline]`

6.5.2 Member Function Documentation

6.5.2.1 `double qpp::NormalDistribution::sample ()` `[inline]`

Here is the call graph for this function:



6.5.3 Member Data Documentation

6.5.3.1 `std::normal_distribution qpp::NormalDistribution::_d` `[protected]`

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

- [include/classes/stat.h](#)

6.6 qpp::Qudit Class Reference

```
#include <qudit.h>
```

Public Member Functions

- [Qudit](#) (const [types::cmat](#) &rho=[States::get_instance\(\)](#).pz0)
- [std::size_t measure](#) (const [types::cmat](#) &U, bool destructive=false)
- [std::size_t measure](#) (bool destructive=false)
- [types::cmat getRho](#) () const
- [std::size_t getD](#) () const

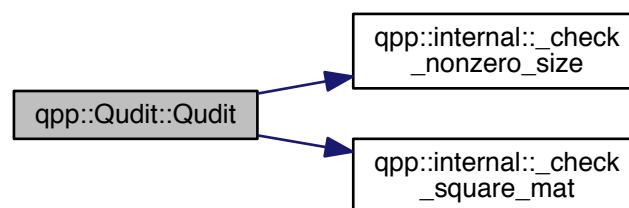
Private Attributes

- [types::cmat_rho](#)
- [std::size_t _D](#)

6.6.1 Constructor & Destructor Documentation

6.6.1.1 `qpp::Qudit::Qudit (const types::cmat & rho = States::get_instance\(\) .pz0) [inline]`

Here is the call graph for this function:



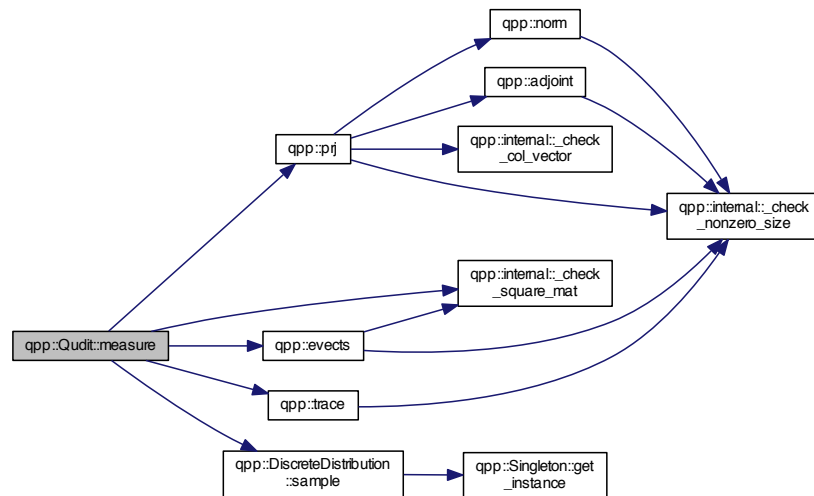
6.6.2 Member Function Documentation

6.6.2.1 `std::size_t qpp::Qudit::getD () const [inline]`

6.6.2.2 `types::cmat qpp::Qudit::getRho () const [inline]`

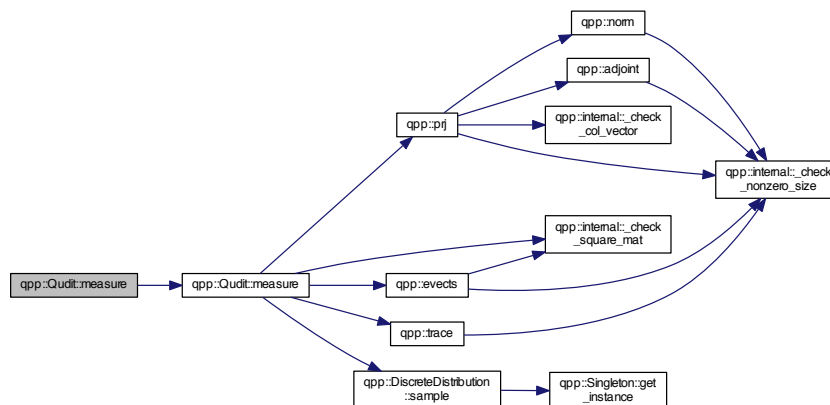
6.6.2.3 `std::size_t qpp::Qudit::measure (const types::cmat & U, bool destructive = false) [inline]`

Here is the call graph for this function:



6.6.2.4 `std::size_t qpp::Qudit::measure (bool destructive = false) [inline]`

Here is the call graph for this function:



6.6.3 Member Data Documentation

6.6.3.1 `std::size_t qpp::Qudit::_D [private]`

6.6.3.2 `types::cmat qpp::Qudit::_rho [private]`

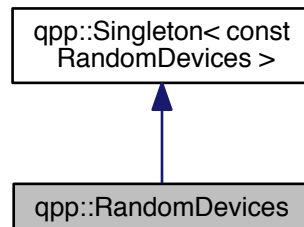
The documentation for this class was generated from the following file:

- [include/classes/qudit.h](#)

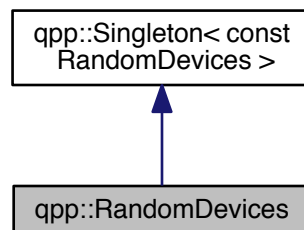
6.7 qpp::RandomDevices Class Reference

```
#include <randevs.h>
```

Inheritance diagram for qpp::RandomDevices:



Collaboration diagram for qpp::RandomDevices:



Public Attributes

- `std::random_device _rd`
- `std::mt19937 _rng`

Private Member Functions

- `RandomDevices ()`

Friends

- class `Singleton< const RandomDevices >`

Additional Inherited Members

6.7.1 Constructor & Destructor Documentation

6.7.1.1 `qpp::RandomDevices::RandomDevices ()` `[inline]`, `[private]`

6.7.2 Friends And Related Function Documentation

6.7.2.1 `friend class Singleton< const RandomDevices >` `[friend]`

6.7.3 Member Data Documentation

6.7.3.1 `std::random_device qpp::RandomDevices::_rd`

6.7.3.2 `std::mt19937 qpp::RandomDevices::_rng` `[mutable]`

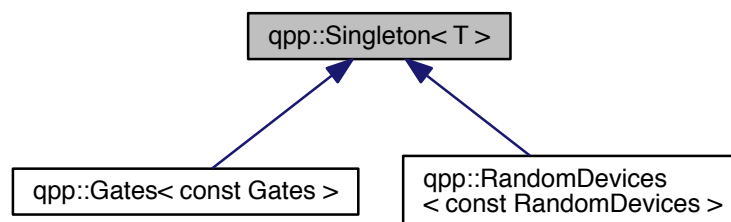
The documentation for this class was generated from the following file:

- [include/classes/randevs.h](#)

6.8 `qpp::Singleton< T >` Class Template Reference

```
#include <singleton.h>
```

Inheritance diagram for `qpp::Singleton< T >`:



Static Public Member Functions

- static `T & get_instance ()`

Protected Member Functions

- `Singleton ()=default`
- virtual `~Singleton ()`
- `Singleton (const Singleton &)=delete`
- `Singleton & operator= (const Singleton &)=delete`

6.8.1 Constructor & Destructor Documentation

6.8.1.1 `template<typename T> qpp::Singleton< T >::Singleton ()` `[protected]`, `[default]`

6.8.1.2 `template<typename T> virtual qpp::Singleton< T >::~~Singleton ()` `[inline]`, `[protected]`, `[virtual]`

6.8.1.3 `template<typename T> qpp::Singleton< T >::Singleton (const Singleton< T > &)` `[protected]`, `[delete]`

6.8.2 Member Function Documentation

6.8.2.1 `template<typename T> static T& qpp::Singleton< T >::get_instance ()` `[inline]`, `[static]`

6.8.2.2 `template<typename T> Singleton& qpp::Singleton< T >::operator= (const Singleton< T > &)` `[protected]`, `[delete]`

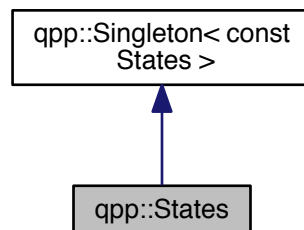
The documentation for this class was generated from the following file:

- `include/classes/singleton.h`

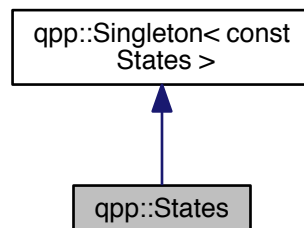
6.9 qpp::States Class Reference

```
#include <states.h>
```

Inheritance diagram for qpp::States:



Collaboration diagram for qpp::States:



Public Attributes

- [types::ket x0](#) { [types::ket::Zero\(2\)](#) }
- [types::ket x1](#) { [types::ket::Zero\(2\)](#) }
- [types::ket y0](#) { [types::ket::Zero\(2\)](#) }
- [types::ket y1](#) { [types::ket::Zero\(2\)](#) }
- [types::ket z0](#) { [types::ket::Zero\(2\)](#) }
- [types::ket z1](#) { [types::ket::Zero\(2\)](#) }
- [types::cmat px0](#) { [types::cmat::Zero\(2, 2\)](#) }
- [types::cmat px1](#) { [types::cmat::Zero\(2, 2\)](#) }
- [types::cmat py0](#) { [types::cmat::Zero\(2, 2\)](#) }
- [types::cmat py1](#) { [types::cmat::Zero\(2, 2\)](#) }
- [types::cmat pz0](#) { [types::cmat::Zero\(2, 2\)](#) }
- [types::cmat pz1](#) { [types::cmat::Zero\(2, 2\)](#) }
- [types::ket b00](#) { [types::ket::Zero\(4\)](#) }
- [types::ket b01](#) { [types::ket::Zero\(4\)](#) }
- [types::ket b10](#) { [types::ket::Zero\(4\)](#) }
- [types::ket b11](#) { [types::ket::Zero\(4\)](#) }
- [types::cmat pb00](#) { [types::cmat::Zero\(4, 4\)](#) }
- [types::cmat pb01](#) { [types::cmat::Zero\(4, 4\)](#) }
- [types::cmat pb10](#) { [types::cmat::Zero\(4, 4\)](#) }
- [types::cmat pb11](#) { [types::cmat::Zero\(4, 4\)](#) }
- [types::ket GHZ](#) { [types::ket::Zero\(8\)](#) }
- [types::ket W](#) { [types::ket::Zero\(8\)](#) }
- [types::cmat pGHZ](#) { [types::cmat::Zero\(8, 8\)](#) }
- [types::cmat pW](#) { [types::cmat::Zero\(8, 8\)](#) }

Private Member Functions

- [States](#) ()

Friends

- class [Singleton< const States >](#)

Additional Inherited Members

6.9.1 Constructor & Destructor Documentation

6.9.1.1 [qpp::States::States \(\)](#) [[inline](#)], [[private](#)]

6.9.2 Friends And Related Function Documentation

6.9.2.1 [friend class Singleton< const States >](#) [[friend](#)]

6.9.3 Member Data Documentation

6.9.3.1 [types::ket qpp::States::b00](#) { [types::ket::Zero\(4\)](#) }

6.9.3.2 [types::ket qpp::States::b01](#) { [types::ket::Zero\(4\)](#) }

6.9.3.3 [types::ket qpp::States::b10](#) { [types::ket::Zero\(4\)](#) }

```

6.9.3.4  types::ket qpp::States::b11 { types::ket::Zero(4) }
6.9.3.5  types::ket qpp::States::GHZ { types::ket::Zero(8) }
6.9.3.6  types::cmat qpp::States::pb00 { types::cmat::Zero(4, 4) }
6.9.3.7  types::cmat qpp::States::pb01 { types::cmat::Zero(4, 4) }
6.9.3.8  types::cmat qpp::States::pb10 { types::cmat::Zero(4, 4) }
6.9.3.9  types::cmat qpp::States::pb11 { types::cmat::Zero(4, 4) }
6.9.3.10 types::cmat qpp::States::pGHZ { types::cmat::Zero(8, 8) }
6.9.3.11 types::cmat qpp::States::pW { types::cmat::Zero(8, 8) }
6.9.3.12 types::cmat qpp::States::px0 { types::cmat::Zero(2, 2) }
6.9.3.13 types::cmat qpp::States::px1 { types::cmat::Zero(2, 2) }
6.9.3.14 types::cmat qpp::States::py0 { types::cmat::Zero(2, 2) }
6.9.3.15 types::cmat qpp::States::py1 { types::cmat::Zero(2, 2) }
6.9.3.16 types::cmat qpp::States::pz0 { types::cmat::Zero(2, 2) }
6.9.3.17 types::cmat qpp::States::pz1 { types::cmat::Zero(2, 2) }
6.9.3.18 types::ket qpp::States::W { types::ket::Zero(8) }
6.9.3.19 types::ket qpp::States::x0 { types::ket::Zero(2) }
6.9.3.20 types::ket qpp::States::x1 { types::ket::Zero(2) }
6.9.3.21 types::ket qpp::States::y0 { types::ket::Zero(2) }
6.9.3.22 types::ket qpp::States::y1 { types::ket::Zero(2) }
6.9.3.23 types::ket qpp::States::z0 { types::ket::Zero(2) }
6.9.3.24 types::ket qpp::States::z1 { types::ket::Zero(2) }

```

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

- [include/classes/states.h](#)

6.10 qpp::Timer Class Reference

```
#include <timer.h>
```

Public Member Functions

- [Timer](#) ()
- void [tic](#) ()

- void [toc](#) ()
- double [seconds](#) () const

Protected Attributes

- std::chrono::steady_clock::time_point [_start](#)
- std::chrono::steady_clock::time_point [_end](#)

Friends

- std::ostream & [operator<<](#) (std::ostream &os, const [Timer](#) &rhs)

6.10.1 Constructor & Destructor Documentation

6.10.1.1 `qpp::Timer::Timer ()` [[inline](#)]

6.10.2 Member Function Documentation

6.10.2.1 `double qpp::Timer::seconds ()` const [[inline](#)]

6.10.2.2 `void qpp::Timer::tic ()` [[inline](#)]

6.10.2.3 `void qpp::Timer::toc ()` [[inline](#)]

6.10.3 Friends And Related Function Documentation

6.10.3.1 `std::ostream& operator<< (std::ostream & os, const Timer & rhs)` [[friend](#)]

6.10.4 Member Data Documentation

6.10.4.1 `std::chrono::steady_clock::time_point qpp::Timer::_end` [[protected](#)]

6.10.4.2 `std::chrono::steady_clock::time_point qpp::Timer::_start` [[protected](#)]

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

- include/classes/[timer.h](#)

6.11 qpp::UniformIntDistribution Class Reference

```
#include <stat.h>
```

Public Member Functions

- [UniformIntDistribution](#) (int a=0, int b=1)
- int [sample](#) ()

Protected Attributes

- std::uniform_int_distribution [_d](#)

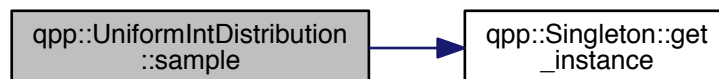
6.11.1 Constructor & Destructor Documentation

6.11.1.1 `qpp::UniformIntDistribution::UniformIntDistribution (int a = 0, int b = 1)` `[inline]`

6.11.2 Member Function Documentation

6.11.2.1 `int qpp::UniformIntDistribution::sample ()` `[inline]`

Here is the call graph for this function:



6.11.3 Member Data Documentation

6.11.3.1 `std::uniform_int_distribution qpp::UniformIntDistribution::_d` `[protected]`

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

- [include/classes/stat.h](#)

6.12 qpp::UniformRealDistribution Class Reference

```
#include <stat.h>
```

Public Member Functions

- [UniformRealDistribution](#) (double *a*=0, double *b*=1)
- double [sample](#) ()

Protected Attributes

- `std::uniform_real_distribution _d`

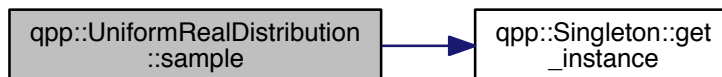
6.12.1 Constructor & Destructor Documentation

6.12.1.1 `qpp::UniformRealDistribution::UniformRealDistribution (double a = 0, double b = 1)` `[inline]`

6.12.2 Member Function Documentation

6.12.2.1 `double qpp::UniformRealDistribution::sample ()` `[inline]`

Here is the call graph for this function:



6.12.3 Member Data Documentation

6.12.3.1 `std::uniform_real_distribution qpp::UniformRealDistribution::_d` `[protected]`

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

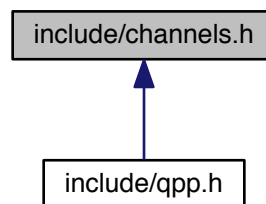
- `include/classes/stat.h`

Chapter 7

File Documentation

7.1 include/channels.h File Reference

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



Namespaces

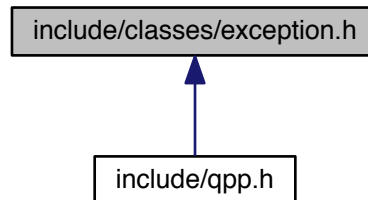
- [qpp](#)

Functions

- `types::cmat qpp::super (const std::vector< types::cmat > &Ks)`
- `types::cmat qpp::choi (const std::vector< types::cmat > &Ks)`
- `std::vector< types::cmat > qpp::choi2kraus (const types::cmat &A)`
- `template<typename Derived >
types::cmat qpp::channel (const Eigen::MatrixBase< Derived > &rho, const std::vector< types::cmat > &Ks)`
- `template<typename Derived >
types::cmat qpp::channel (const Eigen::MatrixBase< Derived > &rho, const std::vector< types::cmat > &Ks,
const std::vector< std::size_t > &subsys, const std::vector< std::size_t > &dims)`

7.2 include/classes/exception.h File Reference

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



Classes

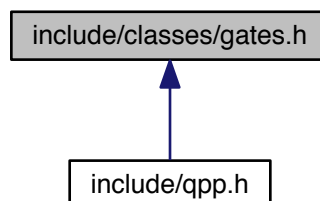
- class [qpp::Exception](#)

Namespaces

- [qpp](#)

7.3 include/classes/gates.h File Reference

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



Classes

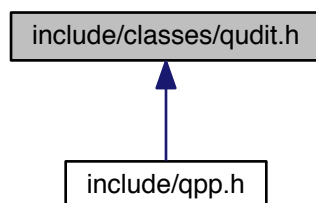
- class [qpp::Gates](#)

Namespaces

- [qpp](#)

7.4 include/classes/qudit.h File Reference

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



Classes

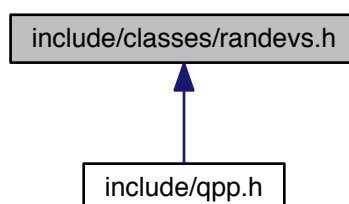
- class [qpp::Qudit](#)

Namespaces

- [qpp](#)

7.5 include/classes/randevs.h File Reference

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



Classes

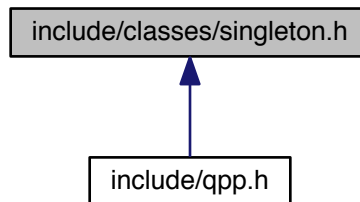
- class [qpp::RandomDevices](#)

Namespaces

- [qpp](#)

7.6 include/classes/singleton.h File Reference

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



Classes

- class [qpp::Singleton< T >](#)

Namespaces

- [qpp](#)

Macros

- [#define CLASS_SINGLETON\(Foo\)](#)
- [#define CLASS_CONST_SINGLETON\(Foo\)](#)

7.6.1 Macro Definition Documentation

7.6.1.1 [#define CLASS_CONST_SINGLETON\(Foo \)](#)

Value:

```

class Foo: public Singleton<const Foo>\
{
    friend class Singleton<const Foo>;
}
  
```

7.6.1.2 [#define CLASS_SINGLETON\(Foo \)](#)

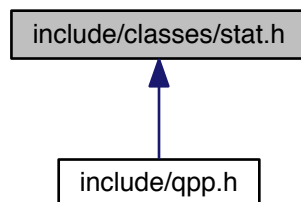
Value:

```

class Foo: public Singleton<Foo>\
{
    friend class Singleton<Foo>;
}
  
```

7.7 include/classes/stat.h File Reference

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



Classes

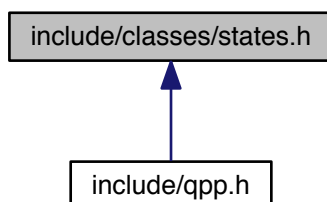
- class [qpp::NormalDistribution](#)
- class [qpp::UniformRealDistribution](#)
- class [qpp::UniformIntDistribution](#)
- class [qpp::DiscreteDistribution](#)
- class [qpp::DiscreteDistributionAbsSquare](#)

Namespaces

- [qpp](#)

7.8 include/classes/states.h File Reference

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



Classes

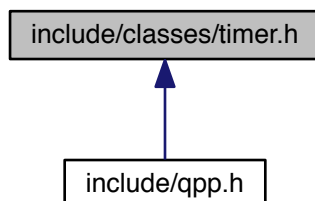
- class [qpp::States](#)

Namespaces

- [qpp](#)

7.9 include/classes/timer.h File Reference

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



Classes

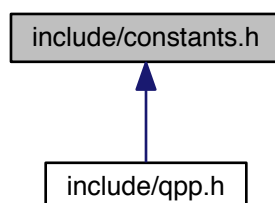
- class [qpp::Timer](#)

Namespaces

- [qpp](#)

7.10 include/constants.h File Reference

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



Namespaces

- [qpp](#)

- [qpp::ct](#)

Functions

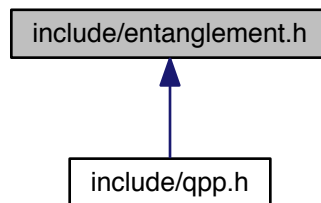
- constexpr std::complex< double > [qpp::operator""_i](#) (unsigned long long int x)
- constexpr std::complex< double > [qpp::operator""_i](#) (long double x)
- std::complex< double > [qpp::ct::omega](#) (std::size_t D)

Variables

- constexpr double [qpp::ct::chop](#) = 1e-10
- constexpr double [qpp::ct::eps](#) = 1e-12
- constexpr std::size_t [qpp::ct::maxn](#) = 64
- constexpr double [qpp::ct::pi](#) = 3.141592653589793238462643383279502884
- constexpr double [qpp::ct::ee](#) = 2.718281828459045235360287471352662497

7.11 include/entanglement.h File Reference

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



Namespaces

- [qpp](#)

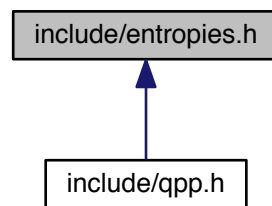
Functions

- template<typename Derived >
types::cmat [qpp::schmidtcoeff](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)
- template<typename Derived >
types::cmat [qpp::schmidtU](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)
- template<typename Derived >
types::cmat [qpp::schmidtV](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)
- template<typename Derived >
types::cmat [qpp::schmidtprob](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)
- template<typename Derived >
double [qpp::entanglement](#) (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &dims)

- `template<typename Derived >`
`double qpp::gconcurrency (const Eigen::MatrixBase< Derived > &A)`

7.12 include/entropies.h File Reference

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



Namespaces

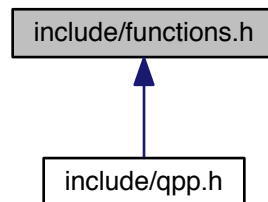
- [qpp](#)

Functions

- `template<typename Derived >`
`double qpp::shannon (const Eigen::MatrixBase< Derived > &A)`
- `template<typename Derived >`
`double qpp::renyi (const double alpha, const Eigen::MatrixBase< Derived > &A)`
- `template<typename Derived >`
`double qpp::renyi_inf (const Eigen::MatrixBase< Derived > &A)`
- `template<typename Derived >`
`double qpp::tsallis (const double alpha, const Eigen::MatrixBase< Derived > &A)`
- `template<typename Derived >`
`double qpp::qmutualinfo (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t > &subsys, const std::vector< std::size_t > &dims)`

7.13 include/functions.h File Reference

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



Namespaces

- [qpp](#)

Functions

- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::transpose (const Eigen::MatrixBase< Derived > &A)`
Transpose.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::conjugate (const Eigen::MatrixBase< Derived > &A)`
Complex conjugate.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::adjoint (const Eigen::MatrixBase< Derived > &A)`
Adjoint.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::inverse (const Eigen::MatrixBase< Derived > &A)`
Inverse.
- `template<typename Derived >`
`Derived::Scalar qpp::trace (const Eigen::MatrixBase< Derived > &A)`
Trace.
- `template<typename Derived >`
`Derived::Scalar qpp::det (const Eigen::MatrixBase< Derived > &A)`
Determinant.
- `template<typename Derived >`
`Derived::Scalar qpp::logdet (const Eigen::MatrixBase< Derived > &A)`
Logarithm of the determinant.
- `template<typename Derived >`
`Derived::Scalar qpp::sum (const Eigen::MatrixBase< Derived > &A)`
Element-wise sum.

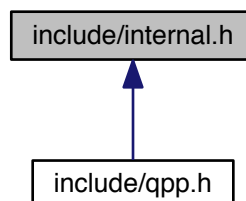
- `template<typename Derived >`
`double qpp::norm (const Eigen::MatrixBase< Derived > &A)`
Trace norm.
- `template<typename Derived >`
`types::cmat qpp::evals (const Eigen::MatrixBase< Derived > &A)`
Eigenvalues.
- `template<typename Derived >`
`types::cmat qpp::evecs (const Eigen::MatrixBase< Derived > &A)`
Eigenvectors.
- `template<typename Derived >`
`types::dmat qpp::hevals (const Eigen::MatrixBase< Derived > &A)`
Hermitian eigenvalues.
- `template<typename Derived >`
`types::cmat qpp::hevecs (const Eigen::MatrixBase< Derived > &A)`
Hermitian eigenvectors.
- `template<typename Derived >`
`types::cmat qpp::funm (const Eigen::MatrixBase< Derived > &A, types::cplx(*f)(const types::cplx &))`
Functional calculus $f(A)$
- `template<typename Derived >`
`types::cmat qpp::sqrtn (const Eigen::MatrixBase< Derived > &A)`
Matrix square root.
- `template<typename Derived >`
`types::cmat qpp::absm (const Eigen::MatrixBase< Derived > &A)`
Matrix absolut value.
- `template<typename Derived >`
`types::cmat qpp::expm (const Eigen::MatrixBase< Derived > &A)`
Matrix exponential.
- `template<typename Derived >`
`types::cmat qpp::logm (const Eigen::MatrixBase< Derived > &A)`
Matrix logarithm.
- `template<typename Derived >`
`types::cmat qpp::sinm (const Eigen::MatrixBase< Derived > &A)`
Matrix sin.
- `template<typename Derived >`
`types::cmat qpp::cosm (const Eigen::MatrixBase< Derived > &A)`
Matrix cos.
- `template<typename Derived >`
`types::cmat qpp::spectralpwm (const Eigen::MatrixBase< Derived > &A, const types::cplx z)`
Matrix power.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::pwm (const Eigen::MatrixBase< Derived > &A, std::size_t n)`
Matrix power.
- `template<typename OutputScalar , typename Derived >`
`types::DynMat< OutputScalar > qpp::cwise (const Eigen::MatrixBase< Derived > &A, OutputScalar(*f)(const typename Derived::Scalar &))`
Functor.
- `template<typename T >`
`types::DynMat< typename T::Scalar > qpp::kron (const T &head)`
Kronecker product (variadic overload)
- `template<typename T , typename... Args>`
`types::DynMat< typename T::Scalar > qpp::kron (const T &head, const Args &...tail)`
Kronecker product (variadic overload)

- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::kron (const std::vector< Derived > &As)`
Kronecker product (std::vector overload)
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::kron (const std::initializer_list< Derived > &As)`
Kronecker product (std::initializer_list overload)
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::kronpow (const Eigen::MatrixBase< Derived > &A, std::size_t n)`
Kronecker power.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::reshape (const Eigen::MatrixBase< Derived > &A, std::size_t rows, std::size_t cols)`
Reshape.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::syspermute (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t`
`> &perm, const std::vector< std::size_t > &dims)`
System permutation.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::ptrace1 (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t >`
`&dims)`
Partial trace.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::ptrace2 (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t >`
`&dims)`
Partial trace.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::ptrace (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t >`
`&subsys, const std::vector< std::size_t > &dims)`
Partial trace.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::ptranspose (const Eigen::MatrixBase< Derived > &A, const std::vector< std::size_t`
`> &subsys, const std::vector< std::size_t > &dims)`
Partial transpose.
- `template<typename Derived1 , typename Derived2 >`
`types::DynMat< typename`
`Derived1::Scalar > qpp::comm (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase< De-`
`rived2 > &B)`
Commutator.
- `template<typename Derived1 , typename Derived2 >`
`types::DynMat< typename`
`Derived1::Scalar > qpp::anticomm (const Eigen::MatrixBase< Derived1 > &A, const Eigen::MatrixBase<`
`Derived2 > &B)`
Anti-commutator.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::prj (const Eigen::MatrixBase< Derived > &V)`
Projector.

- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::expandout (const Eigen::MatrixBase< Derived > &A, std::size_t pos, const std::vector< std::size_t > &dims)`
Expand out.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::grams (const std::vector< Derived > &Vs)`
Gram-Schmidt orthogonalization.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::grams (const std::initializer_list< Derived > &Vs)`
Gram-Schmidt orthogonalization.
- `template<typename Derived >`
`types::DynMat< typename`
`Derived::Scalar > qpp::grams (const Eigen::MatrixBase< Derived > &A)`
Gram-Schmidt orthogonalization.
- `std::vector< std::size_t > qpp::n2multiidx (std::size_t n, const std::vector< std::size_t > &dims)`
Non-negative integer index to multi-index.
- `std::size_t qpp::multiidx2n (const std::vector< std::size_t > &midx, const std::vector< std::size_t > &dims)`
Multi-index to non-negative integer index.
- `types::ket qpp::mket (const std::vector< std::size_t > &mask)`
Constructs multi-partite qubit ket.
- `types::ket qpp::mket (const std::vector< std::size_t > &mask, const std::vector< std::size_t > &dims)`
Constructs multi-partite qudit ket.
- `types::ket qpp::mket (const std::vector< std::size_t > &mask, std::size_t d)`
Constructs multi-partite qudit ket.
- `std::vector< std::size_t > qpp::invperm (const std::vector< std::size_t > &perm)`
Inverse permutation.
- `std::vector< std::size_t > qpp::compperm (const std::vector< std::size_t > &perm, const std::vector< std::size_t > &sigma)`
Compose permutations.

7.14 include/internal.h File Reference

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



Namespaces

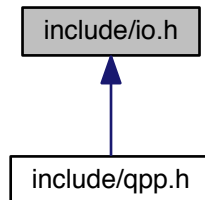
- [qpp](#)
- [qpp::internal](#)

Functions

- void [qpp::internal::_n2multiidx](#) (std::size_t n, std::size_t numdims, const std::size_t *dims, std::size_t *result)
- std::size_t [qpp::internal::_multiidx2n](#) (const std::size_t *midx, std::size_t numdims, const std::size_t *dims)
- template<typename Derived >
bool [qpp::internal::_check_square_mat](#) (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
bool [qpp::internal::_check_vector](#) (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
bool [qpp::internal::_check_row_vector](#) (const Eigen::MatrixBase< Derived > &A)
- template<typename Derived >
bool [qpp::internal::_check_col_vector](#) (const Eigen::MatrixBase< Derived > &A)
- template<typename T >
bool [qpp::internal::_check_nonzero_size](#) (const T &x)
- bool [qpp::internal::_check_dims](#) (const std::vector< std::size_t > &dims)
- template<typename Derived >
bool [qpp::internal::_check_dims_match_mat](#) (const std::vector< std::size_t > &dims, const Eigen::Matrix↵
Base< Derived > &A)
- template<typename Derived >
bool [qpp::internal::_check_dims_match_cvect](#) (const std::vector< std::size_t > &dims, const Eigen::Matrix↵
Base< Derived > &V)
- template<typename Derived >
bool [qpp::internal::_check_dims_match_rvect](#) (const std::vector< std::size_t > &dims, const Eigen::Matrix↵
Base< Derived > &V)
- bool [qpp::internal::_check_eq_dims](#) (const std::vector< std::size_t > &dims, std::size_t dim)
- bool [qpp::internal::_check_subsys_match_dims](#) (const std::vector< std::size_t > &subsys, const std↵
::vector< std::size_t > &dims)
- bool [qpp::internal::_check_perm](#) (const std::vector< std::size_t > &perm)
- template<typename Derived1 , typename Derived2 >
types::DynMat< typename
Derived1::Scalar > [qpp::internal::_kron2](#) (const Eigen::MatrixBase< Derived1 > &A, const Eigen::Matrix↵
Base< Derived2 > &B)
- template<typename T >
void [qpp::internal::variadic_vector_emplace](#) (std::vector< T > &)
- template<typename T , typename First , typename... Args>
void [qpp::internal::variadic_vector_emplace](#) (std::vector< T > &v, First &&first, Args &&...args)

7.15 include/io.h File Reference

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



Namespaces

- [qpp](#)

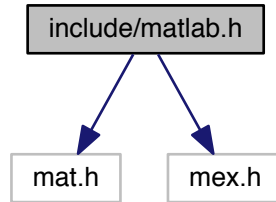
Functions

- `template<typename T >`
`void qpp::disp (const T &x, const std::string &separator, const std::string &start="[" , const std::string &end="]", std::ostream &os=std::cout)`
- `template<typename T >`
`void qpp::displn (const T &x, const std::string &separator, const std::string &start="[" , const std::string &end="]", std::ostream &os=std::cout)`
- `template<typename T >`
`void qpp::disp (const T *x, const std::size_t n, const std::string &separator, const std::string &start="[" , const std::string &end="]", std::ostream &os=std::cout)`
- `template<typename T >`
`void qpp::displn (const T *x, const std::size_t n, const std::string &separator, const std::string &start="[" , const std::string &end="]", std::ostream &os=std::cout)`
- `template<typename Derived >`
`void qpp::disp (const Eigen::MatrixBase< Derived > &A, double chop=ct::chop, std::ostream &os=std::cout)`
- `template<typename Derived >`
`void qpp::displn (const Eigen::MatrixBase< Derived > &A, double chop=ct::chop, std::ostream &os=std::cout)`
- `void qpp::disp (const types::cplx c, double chop=ct::chop, std::ostream &os=std::cout)`
- `void qpp::displn (const types::cplx c, double chop=ct::chop, std::ostream &os=std::cout)`
- `template<typename Derived >`
`void qpp::save (const Eigen::MatrixBase< Derived > &A, const std::string &fname)`
- `template<typename Derived >`
`types::DynMat< typename Derived::Scalar > qpp::load (const std::string &fname)`

7.16 include/matlab.h File Reference

```
#include "mat.h"
#include "mex.h"
```


Include dependency graph for matlab.h:



Namespaces

- [qpp](#)

Functions

- `template<typename Derived >`
`Derived qpp::loadMATLABmatrix (const std::string &mat_file, const std::string &var_name)`
- `template<>`
`types::dmat qpp::loadMATLABmatrix (const std::string &mat_file, const std::string &var_name)`
- `template<>`
`types::cmat qpp::loadMATLABmatrix (const std::string &mat_file, const std::string &var_name)`
- `template<typename Derived >`
`void qpp::saveMATLABmatrix (const Eigen::MatrixBase< Derived > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)`
- `template<>`
`void qpp::saveMATLABmatrix (const Eigen::MatrixBase< types::dmat > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)`
- `template<>`
`void qpp::saveMATLABmatrix (const Eigen::MatrixBase< typename types::cmat > &A, const std::string &mat_file, const std::string &var_name, const std::string &mode)`

7.17 include/qpp.h File Reference

```
#include <algorithm>
#include <chrono>
#include <cmath>
#include <complex>
#include <cstdlib>
#include <cstring>
#include <exception>
#include <fstream>
#include <functional>
#include <iomanip>
#include <iostream>
#include <iterator>
#include <numeric>
#include <ostream>
#include <random>
#include <stdexcept>
#include <string>
#include <type_traits>
#include <utility>
#include <vector>
#include <Eigen/Dense>
#include <Eigen/SVD>
#include "constants.h"
#include "types.h"
#include "classes/exception.h"
#include "classes/singleton.h"
#include "classes/states.h"
#include "classes/randevs.h"
#include "internal.h"
#include "functions.h"
#include "classes/gates.h"
#include "classes/stat.h"
#include "entropies.h"
#include "entanglement.h"
#include "channels.h"
#include "io.h"
#include "random.h"
#include "classes/qudit.h"
#include "classes/timer.h"
```

Include dependency graph for qpp.h:



Namespaces

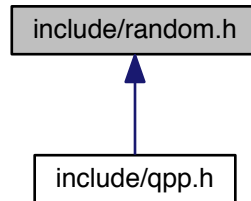
- [qpp](#)

Variables

- const RandomDevices & [qpp::rdevs](#) = RandomDevices::get_instance()
- const Gates & [qpp::gt](#) = Gates::get_instance()
- const States & [qpp::st](#) = States::get_instance()

7.18 include/random.h File Reference

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



Namespaces

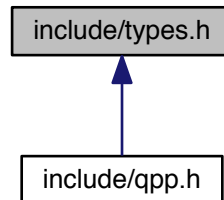
- [qpp](#)

Functions

- `template<typename Derived >`
Derived [qpp::rand](#) (std::size_t rows, std::size_t cols, double a=0, double b=1)
- `template<>`
types::dmat [qpp::rand](#) (std::size_t rows, std::size_t cols, double a, double b)
- `template<>`
types::cmat [qpp::rand](#) (std::size_t rows, std::size_t cols, double a, double b)
- double [qpp::rand](#) (double a=0, double b=1)
- long long [qpp::randint](#) (long long a, long long b)
- `template<typename Derived >`
Derived [qpp::randn](#) (std::size_t rows, std::size_t cols, double mean=0, double sigma=1)
- `template<>`
types::dmat [qpp::randn](#) (std::size_t rows, std::size_t cols, double mean, double sigma)
- `template<>`
types::cmat [qpp::randn](#) (std::size_t rows, std::size_t cols, double mean, double sigma)
- double [qpp::randn](#) (double mean=0, double sigma=1)
- types::cmat [qpp::randU](#) (std::size_t D)
- types::cmat [qpp::randV](#) (std::size_t Din, std::size_t Dout)
- std::vector< types::cmat > [qpp::randkraus](#) (std::size_t n, std::size_t D)
- types::cmat [qpp::randH](#) (std::size_t D)
- types::ket [qpp::randket](#) (std::size_t D)
- types::cmat [qpp::randrho](#) (std::size_t D)
- std::vector< std::size_t > [qpp::randperm](#) (std::size_t n)

7.19 include/types.h File Reference

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



Namespaces

- [qpp](#)
- [qpp::types](#)

Typedefs

- using [qpp::types::cplx](#) = `std::complex< double >`
- using [qpp::types::cmat](#) = `Eigen::MatrixXcd`
- using [qpp::types::dmat](#) = `Eigen::MatrixXd`
- using [qpp::types::ket](#) = `Eigen::Matrix< cplx, Eigen::Dynamic, 1 >`
- using [qpp::types::bra](#) = `Eigen::Matrix< cplx, 1, Eigen::Dynamic >`
- `template<typename Scalar >`
using [qpp::types::DynMat](#) = `Eigen::Matrix< Scalar, Eigen::Dynamic, Eigen::Dynamic >`

Index

- absm
 - qpp, [14](#)
- adjoint
 - qpp, [15](#)
- anticomm
 - qpp, [15](#)
- CUSTOM_EXCEPTION
 - qpp::Exception, [69](#)
- channel
 - qpp, [16](#)
- choi
 - qpp, [17](#)
- choi2kraus
 - qpp, [17](#)
- comm
 - qpp, [18](#)
- compperm
 - qpp, [18](#)
- conjugate
 - qpp, [20](#)
- cosm
 - qpp, [20](#)
- cwise
 - qpp, [21](#)
- DIMS_INVALID
 - qpp::Exception, [69](#)
- DIMS_MISMATCH_CVECTOR
 - qpp::Exception, [69](#)
- DIMS_MISMATCH_MATRIX
 - qpp::Exception, [69](#)
- DIMS_MISMATCH_RVECTOR
 - qpp::Exception, [69](#)
- DIMS_MISMATCH_VECTOR
 - qpp::Exception, [69](#)
- DIMS_NOT_EQUAL
 - qpp::Exception, [69](#)
- det
 - qpp, [21](#)
- disp
 - qpp, [22](#)
- displn
 - qpp, [22](#), [23](#)
- entanglement
 - qpp, [24](#)
- evals
 - qpp, [24](#)
- evects
 - qpp, [25](#)
- expandout
 - qpp, [25](#)
- expm
 - qpp, [26](#)
- funm
 - qpp, [27](#)
- gconcurrency
 - qpp, [27](#)
- grams
 - qpp, [28](#), [29](#)
- gt
 - qpp, [60](#)
- hevals
 - qpp, [29](#)
- hevects
 - qpp, [30](#)
- inverse
 - qpp, [30](#)
- invperm
 - qpp, [31](#)
- kron
 - qpp, [31](#), [33](#)
- kronpow
 - qpp, [34](#)
- load
 - qpp, [34](#)
- logdet
 - qpp, [35](#)
- logm
 - qpp, [35](#)
- MATRIX_NOT_CVECTOR
 - qpp::Exception, [69](#)
- MATRIX_NOT_RVECTOR
 - qpp::Exception, [69](#)
- MATRIX_NOT_SQUARE
 - qpp::Exception, [69](#)
- MATRIX_NOT_SQUARE_OR_CVECTOR
 - qpp::Exception, [69](#)
- MATRIX_NOT_SQUARE_OR_RVECTOR
 - qpp::Exception, [69](#)
- MATRIX_NOT_SQUARE_OR_VECTOR
 - qpp::Exception, [69](#)
- MATRIX_NOT_VECTOR
 - qpp::Exception, [69](#)

- qpp::Exception, 69
- mket
 - qpp, 36, 37
- multiidx2n
 - qpp, 37
- n2multiidx
 - qpp, 38
- NOT_BIPARTITE
 - qpp::Exception, 69
- NOT_QUBIT_GATE
 - qpp::Exception, 69
- NOT_QUBIT_SUBSYS
 - qpp::Exception, 69
- norm
 - qpp, 38
- OUT_OF_RANGE
 - qpp::Exception, 69
- PERM_INVALID
 - qpp::Exception, 69
- powm
 - qpp, 39
- prj
 - qpp, 39
- ptrace
 - qpp, 40
- ptrace1
 - qpp, 41
- ptrace2
 - qpp, 42
- ptranspose
 - qpp, 43
- qmutualinfo
 - qpp, 44
- qpp, 9
 - absm, 14
 - adjoint, 15
 - anticomm, 15
 - channel, 16
 - choi, 17
 - choi2kraus, 17
 - comm, 18
 - compperm, 18
 - conjugate, 20
 - cosm, 20
 - cwise, 21
 - det, 21
 - disp, 22
 - displn, 22, 23
 - entanglement, 24
 - evals, 24
 - evects, 25
 - expandout, 25
 - expm, 26
 - funm, 27
 - gconcurrency, 27
 - grams, 28, 29
 - gt, 60
 - hevals, 29
 - hevects, 30
 - inverse, 30
 - invperm, 31
 - kron, 31, 33
 - kronpow, 34
 - load, 34
 - logdet, 35
 - logm, 35
 - mket, 36, 37
 - multiidx2n, 37
 - n2multiidx, 38
 - norm, 38
 - powm, 39
 - prj, 39
 - ptrace, 40
 - ptrace1, 41
 - ptrace2, 42
 - ptranspose, 43
 - qmutualinfo, 44
 - rand, 45, 46
 - randint, 46
 - randket, 46
 - randkraus, 47
 - randn, 47, 48
 - randperm, 48
 - randrho, 48
 - rdevs, 60
 - renyi, 49
 - reshape, 50
 - save, 50
 - schmidtcoeff, 51
 - schmidtprob, 52
 - shannon, 53
 - sinm, 53
 - spectralpowm, 54
 - sqrtn, 54
 - st, 60
 - sum, 56
 - super, 56
 - syspermute, 57
 - trace, 58
 - transpose, 59
 - tsallis, 59
- qpp::Exception
 - CUSTOM_EXCEPTION, 69
 - DIMS_INVALID, 69
 - DIMS_MISMATCH_CVECTOR, 69
 - DIMS_MISMATCH_MATRIX, 69
 - DIMS_MISMATCH_RVECTOR, 69
 - DIMS_MISMATCH_VECTOR, 69
 - DIMS_NOT_EQUAL, 69
 - MATRIX_NOT_CVECTOR, 69
 - MATRIX_NOT_RVECTOR, 69
 - MATRIX_NOT_SQUARE, 69
 - MATRIX_NOT_SQUARE_OR_CVECTOR, 69

MATRIX_NOT_SQUARE_OR_RVECTOR, 69
MATRIX_NOT_SQUARE_OR_VECTOR, 69
MATRIX_NOT_VECTOR, 69
NOT_BIPARTITE, 69
NOT_QUBIT_GATE, 69
NOT_QUBIT_SUBSYS, 69
OUT_OF_RANGE, 69
PERM_INVALID, 69
SUBSYS_MISMATCH_DIMS, 69
TYPE_MISMATCH, 69
UNDEFINED_TYPE, 69
UNKNOWN_EXCEPTION, 69
ZERO_SIZE, 69

rand
 qpp, 45, 46
randint
 qpp, 46
randket
 qpp, 46
randkraus
 qpp, 47
randn
 qpp, 47, 48
randperm
 qpp, 48
randrho
 qpp, 48
rdevs
 qpp, 60
renyi
 qpp, 49
reshape
 qpp, 50

SUBSYS_MISMATCH_DIMS
 qpp::Exception, 69
save
 qpp, 50
schmidtcoeff
 qpp, 51
schmidtprob
 qpp, 52
shannon
 qpp, 53
sinm
 qpp, 53
spectralpowm
 qpp, 54
sqrtm
 qpp, 54
st
 qpp, 60
sum
 qpp, 56
super
 qpp, 56
syspermute
 qpp, 57

TYPE_MISMATCH
 qpp::Exception, 69
trace
 qpp, 58
transpose
 qpp, 59
tsallis
 qpp, 59

UNDEFINED_TYPE
 qpp::Exception, 69
UNKNOWN_EXCEPTION
 qpp::Exception, 69

ZERO_SIZE
 qpp::Exception, 69