

Contents

Foreword	1
1 Introduction	3
1.1 General remarks on MAGMA MIC	3
1.2 Remarks on installation and compilation	4
1.2.1 MAGMA MIC	4
1.2.2 MKL	5
1.2.3 Random matrix generation	5
2 Measuring Xeon Phi performance	6
2.1 Linpack benchmark for Xeon Phi	6
2.2 Linpack benchmark results	6
2.3 MAGMA MIC benchmark	8
3 Matrix-vector multiplication	9
3.1 <code>magma_sgmv</code> - matrix-vector multiplication, real, single precision .	9
3.2 <code>mkl_sgmv</code> - matrix-vector multiplication, real, single precision .	11
3.3 <code>magma_dgemv</code> - matrix-vector multiplication, real, double precision	12
3.4 <code>mkl_dgemv</code> - matrix-vector multiplication, real, double precision .	14
3.5 <code>magma_cgenv</code> - matrix-vector multiplication, complex, single pre- cision	15
3.6 <code>mkl_cgenv</code> - matrix-vector multiplication, complex, single precision	17
3.7 <code>magma_zgemv</code> - matrix-vector multiplication, complex, double pre- cision	18
3.8 <code>mkl_zgemv</code> - matrix-vector multiplication, complex, double precision	20
3.9 <code>magma_ssymv</code> - symmetric matrix-vector multiplication, real, single prec.	22
3.10 <code>mkl_ssymv</code> - symmetric matrix-vector multiplication, real, single precision	23
3.11 <code>magma_dsymv</code> - symmetric matrix-vector multiplication, real, dou- ble prec.	25
3.12 <code>mkl_dsymv</code> - symmetric matrix-vector multiplication, real, double prec.	26
3.13 <code>magma_csymv</code> - symmetric matrix-vector multiplication, complex, single precision	28
3.14 <code>mkl_csymv</code> - symmetric matrix-vector multiplication, complex, sin- gle prec.	30

3.15 <code>magma_zsymv</code> - symmetric matrix-vector multiplication, complex, double precision	31
3.16 <code>mkl_zsymv</code> - symmetric matrix-vector multiplication, complex, double prec.	33
3.17 <code>magma_strmv</code> - triangular matrix-vector multiplication, real, single prec.	34
3.18 <code>mkl_strmv</code> - triangular matrix-vector multiplication, real, single precision	36
3.19 <code>magma_dtrmv</code> - triangular matrix-vector multiplication, real, double prec.	37
3.20 <code>mkl_dtrmv</code> - triangular matrix-vector multiplication, real, double precision	39
3.21 <code>magma_ctrmv</code> - triangular matrix-vector multiplication, complex, single prec.	40
3.22 <code>mkl_ctrmv</code> - triangular matrix-vector multiplication, complex, single prec.	42
3.23 <code>magma_ztrmv</code> - triangular matrix-vector multiplication, complex, double precision	44
3.24 <code>mkl_ztrmv</code> - triangular matrix-vector multiplication, complex, double prec.	45
4 Matrix-matrix multiplication	48
4.1 <code>magma_sgemm</code> - matrix-matrix multiplication, real, single precision, example with matrices of ones	48
4.2 <code>mkl_sgemm</code> - matrix-matrix multiplication, real, single precision, example with matrices of ones	50
4.3 <code>magma_sgemm</code> - matrix-matrix multiplication, real, single precision, example with random matrices	52
4.4 <code>mkl_sgemm</code> - matrix-matrix multiplication, real, single precision, example with random matrices	54
4.5 <code>magma_dgemm</code> - matrix-matrix multiplication, real, double precision, example with matrices of ones	56
4.6 <code>mkl_dgemm</code> - matrix-matrix multiplication, real, single precision, example with matrices of ones	58
4.7 <code>magma_dgemm</code> - matrix-matrix multiplication, real, double precision, example with random matrices	60
4.8 <code>mkl_dgemm</code> - matrix-matrix multiplication, real, single precision, example with random matrices	63
4.9 <code>magma_cgemm</code> - matrix-matrix multiplication, complex, single precision, example with matrices of ones	65
4.10 <code>mkl_cgemm</code> - matrix-matrix multiplication, complex, single precision, example with matrices of ones	67
4.11 <code>magma_cgemm</code> - matrix-matrix multiplication, complex, single precision, example with random matrices	69
4.12 <code>mkl_cgemm</code> - matrix-matrix multiplication, complex, single precision, example with random matrices	72

4.13 <code>magma_zgemm</code> - matrix-matrix multiplication, complex, double precision, example with matrices of ones	74
4.14 <code>mkl_zgemm</code> - matrix-matrix multiplication, complex, double precision, example with matrices of ones	77
4.15 <code>magma_zgemm</code> - matrix-matrix multiplication, complex, double precision, example with random matrices	79
4.16 <code>mkl_zgemm</code> - matrix-matrix multiplication, complex, double precision, example with random matrices	82
4.17 <code>magma_strmm</code> - triangular matrix-matrix multiplication, real, single prec.	84
4.18 <code>mkl_strmm</code> - triangular matrix-matrix multiplication, real, single precision	86
4.19 <code>magma_dtrmm</code> - triangular matrix-matrix multiplication, real, double prec.	88
4.20 <code>mkl_dtrmm</code> - triangular matrix-matrix multiplication, real, double prec.	90
4.21 <code>magma_ctrmm</code> - triangular matrix-matrix multiplication, complex, single precision	92
4.22 <code>mkl_ctrmm</code> - triangular matrix-matrix multiplication, complex, single prec.	94
4.23 <code>magma_ztrmm</code> - triangular matrix-matrix multiplication, complex, double precision	96
4.24 <code>mkl_ztrmm</code> - triangular matrix-matrix multiplication, complex, double prec.	99
4.25 <code>magma_ssyrk</code> - symmetric rank-k update, real, single precision	100
4.26 <code>mkl_ssyrk</code> - symmetric rank-k update, real, single precision	102
4.27 <code>magma_dssyrk</code> - symmetric rank-k update, real, double precision	104
4.28 <code>mkl_dssyrk</code> - symmetric rank-k update, real, double precision	106
4.29 <code>magma_cherk</code> - Hermitian rank-k update, complex, single precision	107
4.30 <code>mkl_cherk</code> - Hermitian rank-k update, complex, single precision	109
4.31 <code>magma_zherk</code> - Hermitian rank-k update, complex, double precision	111
4.32 <code>mkl_zherk</code> - Hermitian rank-k update, complex, double precision	113
4.33 <code>magma_ssyrk_mmic</code> - symmetric rank-k update, real, single precision, multimic version	114
4.34 <code>magma_dssyrk_mmic</code> - symmetric rank-k update, real, double precision, multimic version	117
4.35 <code>magma_cherk_mmic</code> - Hermitian rank-k update, complex, single precision, multimic version	119
4.36 <code>magma_zherk_mmic</code> - Hermitian rank-k update, complex, double precision, multimic version	121
5 Solving triangular systems	125
5.1 <code>magma_strsv</code> - solve a triangular linear system, real, single precision	125
5.2 <code>mkl_strsv</code> - solve a triangular linear system, real, single precision	127
5.3 <code>magma_dtrsv</code> - solve a triangular linear system, real, double prec.	128
5.4 <code>mkl_dtrsv</code> - solve a triangular linear system, real, double prec.	130

5.5	<code>magma_ctrsv</code> - solve a triangular linear system, complex, single prec.	131
5.6	<code>mkl_ctrsv</code> - solve a triangular linear system, complex, single prec.	133
5.7	<code>magma_ztrsuv</code> - solve a triangular linear system, complex, double prec.	134
5.8	<code>mkl_ztrsuv</code> - solve a triangular linear system, complex, double prec.	136
5.9	<code>magma_strsm</code> - solve a triangular linear system with matrix rhs, real, single precision	137
5.10	<code>mkl_strsm</code> - solve a triangular linear system with matrix rhs, real, single precision	139
5.11	<code>magma_dtrsm</code> - solve a triangular linear system with matrix rhs, real, double precision	141
5.12	<code>mkl_dtrsm</code> - solve a triangular linear system with matrix rhs, real, double precision	143
5.13	<code>magma_ctrsm</code> - solve a triangular linear system with matrix rhs, complex, single precision	145
5.14	<code>mkl_ctrsm</code> - solve a triangular linear system with matrix rhs, complex, single precision	147
5.15	<code>magma_ztrsm</code> - solve a triangular linear system with matrix rhs, complex, double precision	149
5.16	<code>mkl_ztrsm</code> - solve a triangular linear system with matrix rhs, complex, double precision	151
6	LU decomposition and solving general linear systems	154
6.1	<code>magma_sgesv</code> - solve a general real linear system in single precision, CPU interface	154
6.2	<code>mkl_sgesv</code> - solve a general real linear system in single precision	156
6.3	<code>magma_dgesv</code> - solve a general real linear system in double precision, CPU interface	157
6.4	<code>mkl_dgesv</code> - solve a general real linear system in double precision	159
6.5	<code>magma_cgesv</code> - solve a general complex linear system in single precision, CPU interface	161
6.6	<code>mkl_cgesv</code> - solve a general complex linear system in single prec.	163
6.7	<code>magma_zgesv</code> - solve a general complex linear system in double precision, CPU interface	165
6.8	<code>mkl_zgesv</code> - solve a general complex linear system in double prec.	167
6.9	<code>magma_sgesv_mic</code> - solve a general real linear system in single precision, MIC interface	169
6.10	<code>magma_dgesv_mic</code> - solve a general real linear system in double precision, MIC interface	171
6.11	<code>magma_cgesv_mic</code> - solve a general complex linear system in single precision, MIC interface	173
6.12	<code>magma_zgesv_mic</code> - solve a general complex linear system in double precision, MIC interface	175
6.13	<code>magma_sgetrf</code> - LU factorization of a general real matrix in single precision, CPU interface	177

6.14 <code>mkl_sgetrf</code> - LU factorization of a general real matrix in single prec.	179
6.15 <code>magma_dgetrf</code> - LU factorization of a general real matrix in double precision, CPU interface	181
6.16 <code>mkl_dgetrf</code> - LU factorization of a general real matrix in double prec.	183
6.17 <code>magma_cgetrf</code> - LU factorization of a general complex matrix in single precision, CPU interface	184
6.18 <code>mkl_cgetrf</code> - LU factorization of a general complex matrix in single prec.	186
6.19 <code>magma_zgetrf</code> - LU factorization of a general complex matrix in double precision, CPU interface	188
6.20 <code>mkl_zgetrf</code> - LU factorization of a general complex matrix in double prec.	190
6.21 <code>magma_sgetrf_mic</code> - LU factorization of a general real matrix in single precision, MIC interface	191
6.22 <code>magma_dgetrf_mic</code> - LU factorization of a general real matrix in double precision, MIC interface	193
6.23 <code>magma_cgetrf_mic</code> - LU factorization of a general complex matrix in single precision, MIC interface	195
6.24 <code>magma_zgetrf_mic</code> - LU factorization of a general complex matrix in double precision, MIC interface	196
6.25 <code>magma_sgetrf_mmic</code> - LU factorization of a general real matrix in single precision, multi-mic version	198
6.26 <code>magma_dgetrf_mmic</code> - LU factorization of a general real matrix in double precision, multi-mic version	201
6.27 <code>magma_cgetrf_mmic</code> - LU factorization of a general complex matrix in single precision, multi-mic version	203
6.28 <code>magma_zgetrf_mmic</code> - LU factorization of a general complex matrix in double precision, multi-mic version	206
6.29 <code>magma_sgetri_mic</code> - inverse matrix in single precision, MIC interf.	208
6.30 <code>mkl_sgetri</code> - inverse matrix in single precision	210
6.31 <code>magma_dgetri_mic</code> - inverse matrix in double precision, MIC interf.	212
6.32 <code>mkl_dgetri</code> - inverse matrix in double precision	214
6.33 <code>magma_cgetri_mic</code> - inverse of a complex matrix in single precision, MIC interface	216
6.34 <code>mkl_cgetri</code> - inverse of a complex matrix in single precision	218
6.35 <code>magma_zgetri_mic</code> - inverse of a complex matrix in double precision, MIC interface	220
6.36 <code>mkl_zgetri</code> - inverse of a complex matrix in double precision	222
7 Cholesky decomposition and solving systems with positive definite matrices	225
7.1 <code>magma_sposv</code> - solve a system with a positive definite real matrix in single precision, CPU interface	225

7.2	<code>mkl sposv</code> - solve a system with a positive definite real matrix in sin. prec.	227
7.3	<code>magma_dposv</code> - solve a system with a positive definite real matrix in double precision, CPU interface	229
7.4	<code>mkl dposv</code> - solve a system with a positive definite real matrix in double precision	231
7.5	<code>magma_cposv</code> - solve a system with a positive definite complex matrix in single precision, CPU interface	232
7.6	<code>mkl cposv</code> - solve a system with a positive definite complex matrix in single precision	235
7.7	<code>magma_zposv</code> - solve a system with a positive definite complex matrix in double precision, CPU interface	237
7.8	<code>mkl zposv</code> - solve a system with a positive definite complex matrix in double precision	239
7.9	<code>magma_sposv_mic</code> - solve a system with a positive definite real matrix in single precision, MIC interface	241
7.10	<code>magma_dposv_mic</code> - solve a system with a positive definite real matrix in doble precision, MIC interface	243
7.11	<code>magma_cposv_mic</code> - solve a system with a positive definite complex matrix in single precision, MIC interface	245
7.12	<code>magma_zposv_mic</code> - solve a system with a positive definite complex matrix in double precision, MIC interface	248
7.13	<code>magma_spotrf</code> - Cholesky decomposition with a positive definite matrix in single precision, CPU interface	250
7.14	<code>mkl spotrf</code> - Cholesky decomposition with a positive definite matrix in single precision	252
7.15	<code>magma_dpotrf</code> - Cholesky decomposition with a positive definite matrix in double precision, CPU interface	254
7.16	<code>mkl dpotrf</code> - Cholesky decomposition with a positive definite matrix in double precision	255
7.17	<code>magma_cpotrf</code> - Cholesky decomposition with a positive definite complex matrix in single precision, CPU interface	257
7.18	<code>mkl cpotrf</code> - Cholesky decomposition with a positive definite complex matrix in single precision	259
7.19	<code>magma_zpotrf</code> - Cholesky decomposition with a positive definite complex matrix in double precision, CPU interface	261
7.20	<code>mkl zpotrf</code> - Cholesky decomposition with a positive definite complex matrix in double precision	263
7.21	<code>magma_spotrf_mic</code> - Cholesky decomposition with a positive definite matrix in single precision, MIC interface	265
7.22	<code>magma_dpotrf_mic</code> - Cholesky decomposition with a positive definite matrix in double precision, MIC interface	267
7.23	<code>magma_cpotrf_mic</code> - Cholesky decomposition with a positive definite complex matrix in single precision, MIC interface	268
7.24	<code>magma_zpotrf_mic</code> - Cholesky decomposition with a positive definite complex matrix in double precision, MIC interface	270

7.25 <code>magma_spotrf_mmic</code> - Cholesky decomposition with a positive definite matrix in single precision, multi-mic interface	272
7.26 <code>magma_dpotrf_mmic</code> - Cholesky decomposition with a positive definite matrix in double precision, multi-mic interface	275
7.27 <code>magma_cpotrf_mmic</code> - Cholesky decomposition with a positive definite complex matrix in single precision, multi-mic interface	277
7.28 <code>magma_zpotrf_mmic</code> - Cholesky decomposition with a positive definite complex matrix in double precision, multi-mic interface	280
8 QR decomposition and the least squares solution of general linear systems	283
8.1 <code>magma_cgels_mic</code> - the least squares solution of a complex linear system using QR decomposition in single precision, MIC interface .	283
8.2 <code>mkl_cgels</code> - the least squares solution of a complex linear system using QR decomposition in single precision	285
8.3 <code>magma_zgels_mic</code> - the least squares solution of a complex linear system using QR decomposition in double precision, MIC interface	288
8.4 <code>mkl_zgels</code> - the least squares solution of a complex linear system using QR decomposition in double precision	290
8.5 <code>magma_sgeqrf</code> - QR decomposition in single precision, CPU interf.	292
8.6 <code>mkl_sgeqrf</code> - QR decomposition in single precision	294
8.7 <code>magma_dgeqrf</code> - QR decomposition in double precision, CPU interf.	296
8.8 <code>mkl_dgeqrf</code> - QR decomposition in double precision	298
8.9 <code>magma_cgeqrf</code> - complex QR decomposition in single precision, CPU interf.	299
8.10 <code>mkl_cgeqrf</code> - complex QR decomposition in single precision	302
8.11 <code>magma_zgeqrf</code> - complex QR decomposition in double prec., CPU interf.	303
8.12 <code>mkl_zgeqrf</code> - complex QR decomposition in double precision	305
8.13 <code>magma_sgeqrf_mic</code> - QR decomposition in single precision, MIC interf.	307
8.14 <code>magma_dgeqrf_mic</code> - QR decomposition in double precision, MIC interf.	309
8.15 <code>magma_cgeqrf_mic</code> - complex QR decomposition in single precision, MIC interface	311
8.16 <code>magma_zgeqrf_mic</code> - complex QR decomposition in double precision, MIC interface	313
8.17 <code>magma_sgeqrf_mmic</code> - QR decomposition in single prec., multi-mic interf.	315
8.18 <code>magma_dgeqrf_mmic</code> - QR decomposition in double precision, multi-mic interface	318
8.19 <code>magma_cgeqrf_mmic</code> - complex QR decomposition in single precision, multi-mic interface	320
8.20 <code>magma_zgeqrf_mmic</code> - complex QR decomposition in double precision, multi-mic interface	323

9 Eigenvalues and eigenvectors for symmetric matrices	327
9.1 <code>magma_ssyevd</code> - compute the eigenvalues and optionally eigenvectors of a symmetric real matrix in single precision, CPU interface	327
9.2 <code>mkl ssyevd</code> - compute the eigenvalues and optionally eigenvectors of a symmetric real matrix in single precision	329
9.3 <code>magma_dsyevd</code> - compute the eigenvalues and optionally eigenvectors of a symmetric real matrix in double precision, CPU interface	330
9.4 <code>mkl dsyevd</code> - compute the eigenvalues and optionally eigenvectors of a symmetric real matrix in double precision	332
9.5 <code>magma_cheevd</code> - compute the eigenvalues and optionally eigenvectors of a Hermitian complex matrix in single precision, CPU interface	334
9.6 <code>mkl cheevd</code> - compute the eigenvalues and optionally eigenvectors of a Hermitian complex matrix in single precision	336
9.7 <code>magma_zheevd</code> - compute the eigenvalues and optionally eigenvectors of a Hermitian complex matrix in double precision, CPU interface	338
9.8 <code>mkl zheevd</code> - compute the eigenvalues and optionally eigenvectors of a Hermitian complex matrix in double precision	340
10 Reduction to tridiagonal form	342
10.1 <code>magma_ssyrtd</code> - reduce a real symmetric matrix to symmetric tridiagonal form by an orthogonal transformation in single precision	342
10.2 <code>mkl ssytrd</code> - reduce a real symmetric matrix to symmetric tridiagonal form by an orthogonal transformation in single precision	344
10.3 <code>magma_dsytrd</code> - reduce a real symmetric matrix to symmetric tridiagonal form by an orthogonal transformation in double precision	345
10.4 <code>mkl dsytrd</code> - reduce a real symmetric matrix to symmetric tridiagonal form by an orthogonal transformation in double precision	347
10.5 <code>magma_chetrd</code> - reduce a complex Hermitian matrix to symmetric tridiag. form by an unitary transf. in single precision	348
10.6 <code>mkl chetrd</code> - reduce a complex Hermitian matrix to symmetric tridiagonal form by an unitary transformation in single precision	350
10.7 <code>magma_zhetrd</code> - reduce a complex Hermitian matrix to symmetric tridiag. form by an unitary transf. in double precision	352
10.8 <code>mkl zhetrd</code> - reduce a complex Hermitian matrix to symmetric tridiagonal form by an unitary transformation in double precision	354
11 Eigenvalues and eigenvectors for general matrices	357
11.1 <code>magma_sggev</code> - compute the eigenvalues and optionally eigenvectors of a general real matrix in single precision, CPU interface	357
11.2 <code>mkl sggev</code> - compute the eigenvalues and optionally eigenvectors of a general real matrix in single precision	359
11.3 <code>magma_dggev</code> - compute the eigenvalues and optionally eigenvectors of a general real matrix in double precision, CPU interface	360
11.4 <code>mkl dggev</code> - compute the eigenvalues and optionally eigenvectors of a general real matrix in double precision	362

11.5 <code>magma_cggeev</code> - compute the eigenvalues and optionally eigenvectors of a general complex matrix in single precision, CPU interface	364
11.6 <code>mkl_cggeev</code> - compute the eigenvalues and optionally eigenvectors of a general complex matrix in single precision	366
11.7 <code>magma_zggeev</code> - compute the eigenvalues and optionally eigenvectors of a general complex matrix in double precision, CPU interface	368
11.8 <code>mkl_zggeev</code> - compute the eigenvalues and optionally eigenvectors of a general complex matrix in double precision	370
12 Singular value decomposition	373
12.1 <code>magma_sgesvd</code> - compute the singular value decomposition of a general real matrix in single precision, CPU interface	373
12.2 <code>mkl_sgesvd</code> - compute the singular value decomposition of a general real matrix in single precision	375
12.3 <code>magma_dgesvd</code> - compute the singular value decomposition of a general real matrix in double precision	376
12.4 <code>mkl_dgesvd</code> - compute the singular value decomposition of a general real matrix in double precision	378
12.5 <code>magma_cggesvd</code> - compute the singular value decomposition of a general complex matrix in single precision, CPU interface	380
12.6 <code>mkl_cggesvd</code> - compute the singular value decomposition of a general complex matrix in single precision	382
12.7 <code>magma_zggesvd</code> - compute the singular value decomposition of a general complex matrix in double precision, CPU interface	384
12.8 <code>mkl_zggesvd</code> - compute the singular value decomposition of a general complex matrix in double precision	386
13 Reduction to the Hessenberg form	389
13.1 <code>magma_sgehrd</code> - reduce a general matrix to the upper Hessenberg form in single precision, CPU interface	389
13.2 <code>mkl_sgehrd</code> - reduce a general matrix to the upper Hessenberg form in single precision	391
13.3 <code>magma_dgehrd</code> - reduce a general matrix to the upper Hessenberg form in double precision, CPU interface	392
13.4 <code>mkl_dgehrd</code> - reduce a general matrix to the upper Hessenberg form in double precision	394
13.5 <code>magma_cgehrd</code> - reduce a general complex matrix to the upper Hessenberg form in single precision, CPU interface	396
13.6 <code>mkl_cgehrd</code> - reduce a general complex matrix to the upper Hessenberg form in single precision	398
13.7 <code>magma_zgehrd</code> - reduce a general complex matrix to the upper Hessenberg form in double precision, CPU interface	400
13.8 <code>mkl_zgehrd</code> - reduce a general complex matrix to the upper Hessenberg form in double precision	402

14 Reduction to bidiagonal form	405
14.1 <code>magma_sgebrd</code> - reduce a real matrix to bidiagonal form by orthogonal transformations in single precision, CPU interface	405
14.2 <code>mkl_sgebrd</code> - reduce a real matrix to bidiagonal form by orthogonal transformations in single precision	407
14.3 <code>magma_dgebrd</code> - reduce a real matrix to bidiagonal form by orthogonal transformations in double precision, CPU interface	408
14.4 <code>mkl_dgebrd</code> - reduce a real matrix to bidiagonal form by orthogonal transformations in double precision	410
14.5 <code>magma_cgebrd</code> - reduce a complex matrix to bidiagonal form by unitary transformations in single precision, CPU interface	412
14.6 <code>mkl_cgebrd</code> - reduce a complex matrix to bidiagonal form by unitary transformations in single precision	414
14.7 <code>magma_zgebrd</code> - reduce a complex matrix to bidiagonal form by unitary transformations in double precision, CPU interface	416
14.8 <code>mkl_zgebrd</code> - reduce a complex matrix to bidiagonal form by unitary transformations in double precision	418
Appendices	421
A Generating random matrices	422
B MAGMA Licence	423
Bibliography	424