NAG C Library Function Document

nag_zunmqr (f08auc)

1 Purpose

nag_zunmqr (f08auc) multiplies an arbitrary complex matrix C by the complex unitary matrix Q from a QR factorization computed by nag_zgeqrf (f08asc) or nag_zgeqpf (f08bsc).

2 Specification

```
void nag_zunmqr (Nag_OrderType order, Nag_SideType side, Nag_TransType trans,
      Integer m, Integer n, Integer k, const Complex a[], Integer pda,
      const Complex tau[], Complex c[], Integer pdc, NagError *fail)
```

3 Description

nag_zunmqr (f08auc) is intended to be used after a call to nag_zgeqrf (f08asc) or nag_zgeqpf (f08bsc), which perform a QR factorization of a complex matrix A. The unitary matrix Q is represented as a product of elementary reflectors.

This function may be used to form one of the matrix products

$$QC, \; Q^HC, \; CQ \text{ or } CQ^H,$$

overwriting the result on C (which may be any complex rectangular matrix).

A common application of this function is in solving linear least-squares problems, as described in the f08 Chapter Introduction, and illustrated in Section 9 of the document for nag_zgeqrf (f08asc).

4 References

Golub G H and Van Loan C F (1996) *Matrix Computations* (3rd Edition) Johns Hopkins University Press, Baltimore

5 Parameters

1: **order** – Nag_OrderType *Input*

On entry: the **order** parameter specifies the two-dimensional storage scheme being used, i.e., row-major ordering or column-major ordering. C language defined storage is specified by **order** = **Nag_RowMajor**. See Section 2.2.1.4 of the Essential Introduction for a more detailed explanation of the use of this parameter.

Constraint: **order** = **Nag_RowMajor** or **Nag_ColMajor**.

2: **side** – Nag_SideType *Input*

On entry: indicates how Q or Q^H is to be applied to C as follows:

if **side** = **Nag_LeftSide**, Q or Q^H is applied to C from the left;

if **side** = **Nag_RightSide**, Q or Q^H is applied to C from the right.

Constraint: **side** = **Nag_LeftSide** or **Nag_RightSide**.

3: **trans** – Nag_TransType *Input*

On entry: indicates whether Q or Q^H is to be applied to C as follows:

if **trans** = **Nag_NoTrans**, Q is applied to C;

if **trans** = **Nag_ConjTrans**, Q^H is applied to C.

Constraint: **trans** = **Nag_NoTrans** or **Nag_ConjTrans**.

4: **m** – Integer *Input*

On entry: m, the number of rows of the matrix C.

Constraint: **m** ≥ 0.

5: **n** – Integer *Input*

On entry: n, the number of columns of the matrix C.

Constraint: **n** ≥ 0.

6: **k** – Integer *Input*

On entry: k, the number of elementary reflectors whose product defines the matrix Q.

Constraints:

if **side** = **Nag_LeftSide**, **m** $\geq$ **k** ≥ 0;
if **side** = **Nag_RightSide**, **n** $\geq$ **k** ≥ 0.

7: **a**[dim] – Complex *Input/Output*

Note: the dimension, dim, of the array **a** must be at least
max(1, **pda** × **k**) when **order** = **Nag_ColMajor**;
max(1, **pda** × **m**) when **order** = **Nag_RowMajor** and **side** = **Nag_LeftSide**;
max(1, **pda** × **n**) when **order** = **Nag_RowMajor** and **side** = **Nag_RightSide**.

If **order** = **Nag_ColMajor**, the (i, j)th element of the matrix A is stored in **a**$[(j-1) \times$ **pda** $+ i - 1]$ and if **order** = **Nag_RowMajor**, the (i, j)th element of the matrix A is stored in **a**$[(i-1) \times$ **pda** $+ j - 1]$.

On entry: details of the vectors which define the elementary reflectors, as returned by nag_zgeqrf (f08asc) or nag_zgeqpf (f08bsc).

On exit: used as internal workspace prior to being restored and hence is unchanged.

8: **pda** – Integer *Input*

On entry: the stride separating matrix row or column elements (depending on the value of **order**) in the array **a**.

Constraints:

if **order** = **Nag_ColMajor**,
if **side** = **Nag_LeftSide**, **pda** $\geq$ max(1, **m**);
if **side** = **Nag_RightSide**, **pda** $\geq$ max(1, **n**);

if **order** = **Nag_RowMajor**, **pda** $\geq$ max(1, **k**).

9: **tau**[dim] – const Complex *Input*

Note: the dimension, dim, of the array **tau** must be at least max(1, **k**).

On entry: further details of the elementary reflectors, as returned by nag_zgeqrf (f08asc) or nag_zgeqpf (f08bsc).

10: **c**[dim] – Complex *Input/Output*

Note: the dimension, dim, of the array **c** must be at least max(1, **pdc** × **n**) when **order** = **Nag_ColMajor** and at least max(1, **pdc** × **m**) when **order** = **Nag_RowMajor**.

If **order** = **Nag_ColMajor**, the (i, j)th element of the matrix C is stored in **c**$[(j-1) \times$ **pdc** $+ i - 1]$ and if **order** = **Nag_RowMajor**, the (i, j)th element of the matrix C is stored in **c**$[(i-1) \times$ **pdc** $+ j - 1]$.

On entry: the m by n matrix C.

On exit: **c** is overwritten by QC or Q^HC or CQ or CQ^H as specified by **side** and **trans**.

11: **pdc** – Integer *Input*

On entry: the stride separating matrix row or column elements (depending on the value of **order**) in the array **c**.

Constraints:

if **order** = **Nag_ColMajor**, **pdc** $\geq \max(1, \mathbf{m})$;
if **order** = **Nag_RowMajor**, **pdc** $\geq \max(1, \mathbf{n})$.

12: **fail** – NagError * *Output*

The NAG error parameter (see the Essential Introduction).

6 Error Indicators and Warnings

NE_INT

On entry, **m** = ⟨*value*⟩.
Constraint: **m** ≥ 0.

On entry, **n** = ⟨*value*⟩.
Constraint: **n** ≥ 0.

On entry, **pda** = ⟨*value*⟩.
Constraint: **pda** > 0.

On entry, **pdc** = ⟨*value*⟩.
Constraint: **pdc** > 0.

NE_INT_2

On entry, **pda** = ⟨*value*⟩, **k** = ⟨*value*⟩.
Constraint: **pda** $\geq \max(1, \mathbf{k})$.

On entry, **pdc** = ⟨*value*⟩, **m** = ⟨*value*⟩.
Constraint: **pdc** $\geq \max(1, \mathbf{m})$.

On entry, **pdc** = ⟨*value*⟩, **n** = ⟨*value*⟩.
Constraint: **pdc** $\geq \max(1, \mathbf{n})$.

NE_ENUM_INT_3

On entry, **side** = ⟨*value*⟩, **m** = ⟨*value*⟩, **n** = ⟨*value*⟩, **k** = ⟨*value*⟩.
Constraint: if **side** = **Nag_LeftSide**, **m** $\geq$ **k** ≥ 0;
if **side** = **Nag_RightSide**, **n** $\geq$ **k** ≥ 0.

On entry, **side** = ⟨*value*⟩, **m** = ⟨*value*⟩, **n** = ⟨*value*⟩, **pda** = ⟨*value*⟩.
Constraint: if **side** = **Nag_LeftSide**, **pda** $\geq \max(1, \mathbf{m})$;
if **side** = **Nag_RightSide**, **pda** $\geq \max(1, \mathbf{n})$.

NE_ALLOC_FAIL

Memory allocation failed.

NE_BAD_PARAM

On entry, parameter ⟨*value*⟩ had an illegal value.

NE_INTERNAL_ERROR

An internal error has occurred in this function. Check the function call and any array sizes. If the call is correct then please consult NAG for assistance.

7 Accuracy

The computed result differs from the exact result by a matrix E such that

$$\|E\|_2 = O(\epsilon)\|C\|_2,$$

where ϵ is the ***machine precision***.

8 Further Comments

The total number of real floating-point operations is approximately $8nk(2m - k)$ if **side** $=$ **Nag_LeftSide** and $8mk(2n - k)$ if **side** $=$ **Nag_RightSide**.

The real analogue of this function is nag_dormqr (f08agc).

9 Example

See Section 9 of the document for nag_zgeqrf (f08asc).
