

nag_hermitian_eigenvalues (f02awc)

1. Purpose

nag_hermitian_eigenvalues (f02awc) calculates all the eigenvalues of a complex Hermitian matrix.

2. Specification

```
#include <nag.h>
#include <nagf02.h>

void nag_hermitian_eigenvalues(Integer n, Complex a[], Integer tda,
                               double r[], NagError *fail)
```

3. Description

The complex Hermitian matrix A is first reduced to a real tridiagonal matrix by $n - 2$ unitary transformations, and a subsequent diagonal transformation. The eigenvalues are then derived using the QL algorithm, an adaptation of the QR algorithm.

4. Parameters

n

Input: n , the order of the matrix A .
Constraint: $n \geq 1$.

a[n][tda]

Input: the elements of the lower triangle of the n by n complex Hermitian matrix A . Elements of the array above the diagonal need not be set.
Output: the array is overwritten.

tda

Input: the last dimension of the array **a** as declared in the function from which **nag_hermitian_eigenvalues** is called.
Constraint: **tda** $\geq n$.

r[n]

Output: the eigenvalues in ascending order.

fail

The NAG error parameter, see the Essential Introduction to the NAG C Library.

5. Error Indications and Warnings

NE_INT_ARG_LT

On entry, **n** must not be less than 1: **n** = $\langle value \rangle$.

NE_2_INT_ARG_LT

On entry **tda** = $\langle value \rangle$ while **n** = $\langle value \rangle$. These parameters must satisfy **tda** $\geq n$.

NE_ALLOC_FAIL

Memory allocation failed.

NE_TOO_MANY_ITERATIONS

More than $\langle value \rangle$ iterations are required to isolate all the eigenvalues.

6. Further Comments

The time taken by the function is approximately proportional to n^3 .

6.1. Accuracy

For a detailed error analysis see Wilkinson and Reinsch (1971), page 235.

6.2. References

Wilkinson J H and Reinsch C (1971) *Handbook for Automatic Computation (Vol. II, Linear Algebra)*
Springer-Verlag pp 227–240.

7. See Also

None.

8. Example

To calculate all the eigenvalues of the complex Hermitian matrix:

$$\begin{pmatrix} 0.50 & 0.00 & 1.84 + 1.38i & 2.08 - 1.56i \\ 0.00 & 0.50 & 1.12 + 0.84i & -0.56 + 0.42i \\ 1.84 - 1.38i & 1.12 - 0.84i & 0.50 & 0.00 \\ 2.08 + 1.56i & -0.56 - 0.42i & 0.00 & 0.50 \end{pmatrix}.$$

8.1. Program Text

```
/* nag_hermitian_eigenvalues(f02awc) Example Program
 *
 * Copyright 1991 Numerical Algorithms Group.
 *
 * Mark 2, 1991.
 */

#include <nag.h>
#include <stdio.h>
#include <nag_stdlib.h>
#include <nagf02.h>

#define NMAX 4
#define TDA NMAX

main()
{
    Integer i, j, n;
    Complex a[NMAX][TDA];
    double r[NMAX];

    Vprintf("f02awc Example Program Results\n");
    Vscanf("%*[^\\n]"); /* Skip heading in data file */
    Vscanf("%ld", &n);
    if (n>=1 || n<=NMAX)
    {
        for (i=0; i<n; i++)
            for (j=0; j<n; j++)
                Vscanf(" ( %lf , %lf ) ", &a[i][j].re,&a[i][j].im);
        f02awc(n, (Complex *)a, (Integer)TDA, r, NAGERR_DEFAULT);
        Vprintf("Eigenvalues\n");
        for (i=0; i<n; i++)
            Vprintf("%9.4f", r[i]);
        Vprintf("\\n");
        exit(EXIT_SUCCESS);
    }
    else
    {
        Vfprintf(stderr,"n is out of range: n = %4ld,\\n",n);
        exit(EXIT_FAILURE);
    }
}
```

8.2. Program Data

f02awc Example Program Data

4
(0.50, 0.00) (0.00, 0.00) (1.84,1.38) (2.08,-1.56)
(0.00, 0.00) (0.50, 0.00) (1.12,0.84) (-0.56, 0.42)
(1.84,-1.38) (1.12,-0.84) (0.50,0.00) (0.00, 0.00)
(2.08, 1.56) (-0.56,-0.42) (0.00,0.00) (0.50, 0.00)

8.3. Program Results

f02awc Example Program Results

Eigenvalues
-3.0000 -1.0000 2.0000 4.0000
