NAG Toolbox for MATLAB

c02ah

1 Purpose

c02ah determines the roots of a quadratic equation with complex coefficients.

2 Syntax

```
[zsm, zlg, ifail] = c02ah(ar, ai, br, bi, cr, ci)
```

3 Description

c02ah attempts to find the roots of the quadratic equation $az^2 + bz + c = 0$ (where a, b and c are complex coefficients), by carefully evaluating the 'standard' closed formula

$$z = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}.$$

It is based on the function CQDRTC from Smith 1967.

Note: it is not necessary to scale the coefficients prior to calling the function.

4 References

Smith B T 1967 ZERPOL: A zero finding algorithm for polynomials using Laguerre's method *Technical Report* Department of Computer Science, University of Toronto, Canada

5 Parameters

5.1 Compulsory Input Parameters

1: **ar – double scalar**
2: **ai – double scalar**

ar and **ai** must contain the real and imaginary parts respectively of a, the coefficient of z^2.

3: **br – double scalar**
4: **bi – double scalar**

br and **bi** must contain the real and imaginary parts respectively of b, the coefficient of z.

5: **cr – double scalar**
6: **ci – double scalar**

cr and **ci** must contain the real and imaginary parts respectively of c, the constant coefficient.

5.2 Optional Input Parameters

None.

5.3 Input Parameters Omitted from the MATLAB Interface

None.

5.4 Output Parameters

1: **zsm(2) – double array**

The real and imaginary parts of the smallest root in magnitude are stored in **zsm**(1) and **zsm**(2) respectively.

2: **zlg(2) – double array**

The real and imaginary parts of the largest root in magnitude are stored in **zlg**(1) and **zlg**(2) respectively.

3: **ifail – int32 scalar**

0 unless the function detects an error (see Section 6).

6 Error Indicators and Warnings

Errors or warnings detected by the function:

ifail $= 1$

On entry, $(\mathbf{ar}, \mathbf{ai}) = (0, 0)$. In this case, **zsm**$(1)$ and **zsm**(2) contain the real and imaginary parts respectively of the root $-c/b$.

ifail $= 2$

On entry, $(\mathbf{ar}, \mathbf{ai}) = (0, 0)$ and $(\mathbf{br}, \mathbf{bi}) = (0, 0)$. In this case, **zsm**$(1)$ contains the largest machine representable number (see x02al) and **zsm**(2) contains zero.

ifail $= 3$

On entry, $(\mathbf{ar}, \mathbf{ai}) = (0, 0)$ and the root $-c/b$ overflows. In this case, **zsm**(1) contains the largest machine representable number (see x02al) and **zsm**(2) contains zero.

ifail $= 4$

On entry, $(\mathbf{cr}, \mathbf{ci}) = (0, 0)$ and the root $-b/a$ overflows. In this case, both **zsm**(1) and **zsm**(2) contain zero.

ifail $= 5$

On entry, $\tilde{b}$ is so large that $\tilde{b}^2$ is indistinguishable from $\tilde{b}^2 - 4\tilde{a}\tilde{c}$ and the root $-b/a$ overflows, where $\tilde{b} = \max(|\mathbf{br}|, |\mathbf{bi}|)$, $\tilde{a} = \max(|\mathbf{ar}|, |\mathbf{ai}|)$ and $\tilde{c} = \max(|\mathbf{cr}|, |\mathbf{ci}|)$. In this case, **zsm**$(1)$ and **zsm**(2) contain the real and imaginary parts respectively of the root $-c/b$.

If **ifail** > 0 on exit, then **zlg**(1) contains the largest machine representable number (see x02al) and **zlg**(2) contains zero.

7 Accuracy

If **ifail** $= 0$ on exit, then the computed roots should be accurate to within a small multiple of the ***machine precision*** except when underflow (or overflow) occurs, in which case the true roots are within a small multiple of the underflow (or overflow) threshold of the machine.

8 Further Comments

None.

9 Example

```
ar = 1;
ai = 0;
br = -3;
bi = 1;
cr = 8;
ci = 1;
[zsm, zlg, ifail] = c02ah(ar, ai, br, bi, cr, ci)
```

```
zsm =
    1.0000
    2.0000
zlg =
    2.0000
   -3.0000
ifail =
           0
```