

# NAG Library Routine Document

## S14AHF

**Note:** before using this routine, please read the Users' Note for your implementation to check the interpretation of *bold italicised* terms and other implementation-dependent details.

### 1 Purpose

S14AHF returns the value of  $\ln G(x)$ , the scaled logarithm of the gamma function  $\Gamma(x)$ , via the function name.

### 2 Specification

```
FUNCTION S14AHF (X, IFAIL)
REAL (KIND=nag_wp) S14AHF
INTEGER          IFAIL
REAL (KIND=nag_wp) X
```

### 3 Description

S14AHF calculates an approximate value for  $\ln G(x)$ , where  $G(x) = \Gamma(x+1)/\left(\frac{x}{e}\right)^x$ . This is a variant of the  $\ln \Gamma(x)$  function (see also S14ABF), which avoids rounding problems for very large arguments by computing  $\ln \Gamma(x)$  with the Stirling approximation factored out.

For  $0 < x < 15$ ,  $\ln G(x) = \ln \Gamma(x+1) - x \ln x + x$ ;

and for  $15 \leq x$ ,  $\ln G(x) = \frac{1}{2} \ln x + \ln(\sqrt{2\pi}) + \frac{1}{x}R(1/x^2)$ , where  $R$  is a suitable Remez approximation.

For  $x \leq 0.0$ , the value  $\ln G(x)$  is undefined; S14AHF returns zero and exits with  $IFAIL = 1$ .

### 4 References

Abramowitz M and Stegun I A (1972) *Handbook of Mathematical Functions* (3rd Edition) Dover Publications

### 5 Arguments

1: X – REAL (KIND=nag\_wp) *Input*

*On entry:* the argument  $x$  of the function.

*Constraint:*  $X > 0.0$ .

2: IFAIL – INTEGER *Input/Output*

*On entry:* IFAIL must be set to 0, -1 or 1. If you are unfamiliar with this argument you should refer to Section 3.4 in How to Use the NAG Library and its Documentation for details.

For environments where it might be inappropriate to halt program execution when an error is detected, the value -1 or 1 is recommended. If the output of error messages is undesirable, then the value 1 is recommended. Otherwise, if you are not familiar with this argument, the recommended value is 0. **When the value -1 or 1 is used it is essential to test the value of IFAIL on exit.**

*On exit:* IFAIL = 0 unless the routine detects an error or a warning has been flagged (see Section 6).

## 6 Error Indicators and Warnings

If on entry  $IFAIL = 0$  or  $-1$ , explanatory error messages are output on the current error message unit (as defined by X04AAF).

Errors or warnings detected by the routine:

$IFAIL = 1$

On entry,  $X \leq 0.0$ . On softfailure, the function value returned is zero.

$IFAIL = -99$

An unexpected error has been triggered by this routine. Please contact NAG.

See Section 3.9 in *How to Use the NAG Library and its Documentation* for further information.

$IFAIL = -399$

Your licence key may have expired or may not have been installed correctly.

See Section 3.8 in *How to Use the NAG Library and its Documentation* for further information.

$IFAIL = -999$

Dynamic memory allocation failed.

See Section 3.7 in *How to Use the NAG Library and its Documentation* for further information.

## 7 Accuracy

S14AHF has been designed to produce full relative accuracy for all input arguments. Empirical results obtained by comparing with multiprecision software confirm this.

## 8 Parallelism and Performance

S14AHF is not threaded in any implementation.

## 9 Further Comments

None.

## 10 Example

This example reads values of the argument  $x$  from a file, evaluates the function at each value of  $x$  and prints the results.

### 10.1 Program Text

```

Program s14ahfe

!      S14AHF Example Program Text
!      Mark 26 Release. NAG Copyright 2016.

!      .. Use Statements ..
!      Use nag_library, Only: nag_wp, s14ahf
!      .. Implicit None Statement ..
!      Implicit None
!      .. Parameters ..
!      Integer, Parameter          :: nin = 5, nout = 6
!      .. Local Scalars ..
!      Real (Kind=nag_wp)         :: x, y
!      Integer                    :: ifail, ioerr
!      .. Executable Statements ..
!      Write (nout,*) 'S14AHF Example Program Results'

```

```

!      Skip heading in data file
      Read (nin,*)

      Write (nout,*)
      Write (nout,*) '      X      Y'
      Write (nout,*)

data: Do
      Read (nin,*,Iostat=ioerr) x

      If (ioerr<0) Then
        Exit data
      End If

      ifail = -1
      y = s14ahf(x,ifail)

      If (ifail<0) Then
        Exit data
      End If

      Write (nout,99999) x, y
    End Do data

99999 Format (1X,1P,2E12.3)
      End Program s14ahfe

```

## 10.2 Program Data

```

S14AHF Example Program Data
      1.0
      1.25
      1.5
      1.75
      2.0
      5.0
      10.0
      20.0
      1000.0

```

## 10.3 Program Results

S14AHF Example Program Results

| X         | Y         |
|-----------|-----------|
| 1.000E+00 | 1.000E+00 |
| 1.250E+00 | 1.096E+00 |
| 1.500E+00 | 1.176E+00 |
| 1.750E+00 | 1.246E+00 |
| 2.000E+00 | 1.307E+00 |
| 5.000E+00 | 1.740E+00 |
| 1.000E+01 | 2.079E+00 |
| 2.000E+01 | 2.421E+00 |
| 1.000E+03 | 4.373E+00 |

**Example Program**  
Returns the Value of  $\ln G(x)$ , the Scaled Logarithm of the Gamma Function  $\Gamma(x)$

