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AN ASCII FORTRAN SUBROUTINE FOR COMPUTING THE ELECTROMAGNETIC R--ETC(U)
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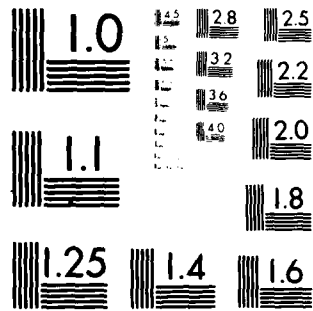
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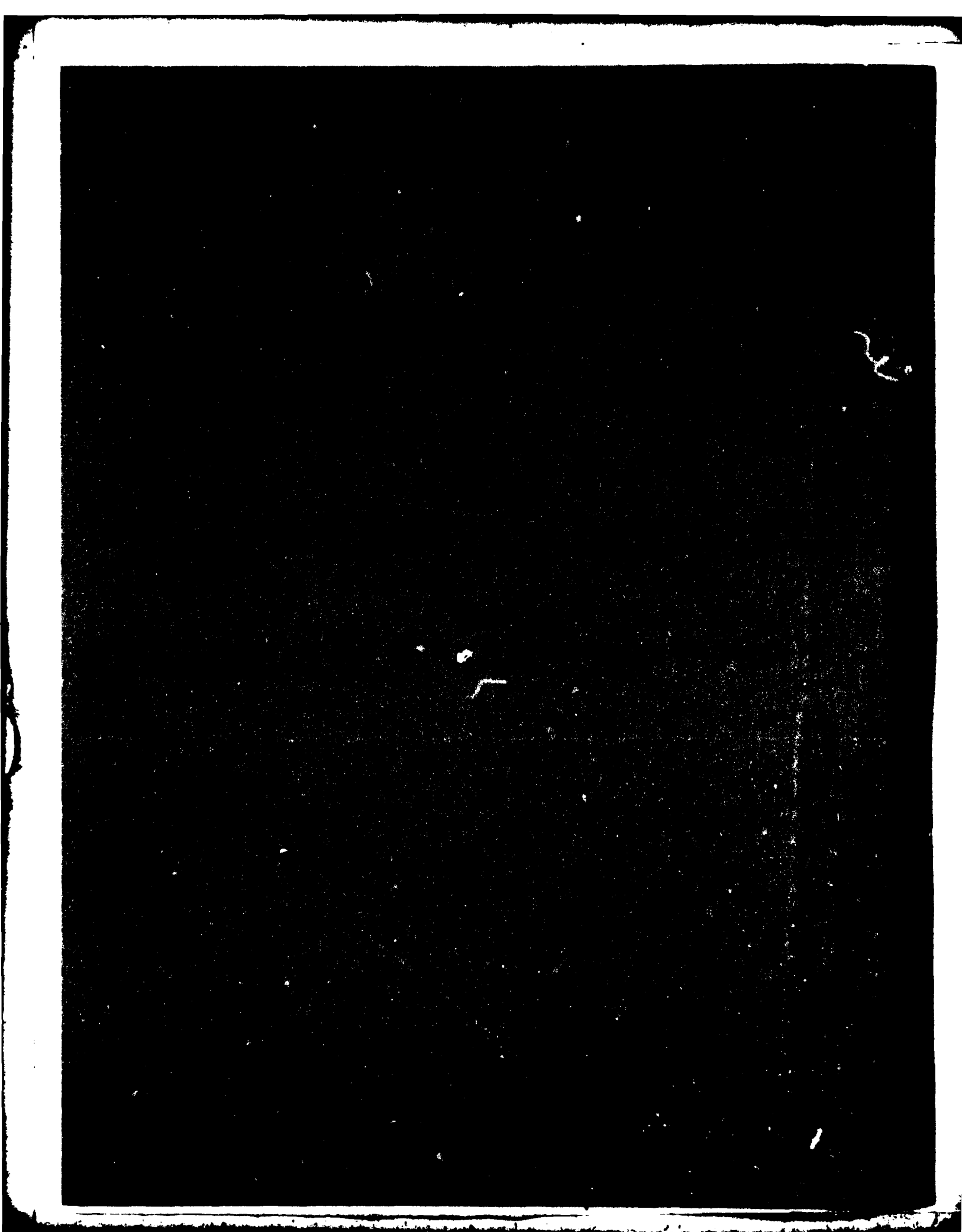
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report describes the ASCMIE subroutine for performing Mie scattering calculations by means of the downward recursion algorithm developed by J. V. Dave. ASCMIE is written in UNIVAC 1100 series ASCII FORTRAN language. The ASCII FORTRAN compiler is a modern, state-of-the-art compiler which implements the ANSI FORTRAN 77 standard; this compiler is intended as a future replacement for the UNIVAC 1100 series FORTRAN V compiler. Rather than carry out a straightforward conversion of the FORTRAN V Mie scattering		

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routine to ASCII FORTRAN, the code was completely rewritten in order to incorporate new ASCII FORTRAN language elements. The result is a more structured, modular, M1e scattering code which executes faster than the FORTRAN V code.

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PREFACE

The work described in this report was authorized under Project 1L162662A554, Smoke/Obscurant Technology. This work was started and completed in May 1980.

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CONTENTS

	Page
1 INTRODUCTION	7
2 SOFTWARE DESIGN AND CODING CONVENTIONS	7
3 RESULTS	9
3.1 Sample Problem	9
3.2 Timing Study	10
4 CONCLUSIONS	11
LITERATURE CITED	13
APPENDIXES	
A. FTN Compilation Listing of Subroutine ASCMIE	15
B. FTN Compilation Listing of Main Program MIECHK	31
C. MAP Listing of Absolute Element ASCMIE	37
D. Sample Output from Execution of Absolute Element ASCMIE	39
DISTRIBUTION LIST	43

AN ASCII FORTRAN SUBROUTINE FOR COMPUTING THE ELECTROMAGNETIC RADIATION SCATTERED BY A SPHERE

1 INTRODUCTION

The Lorenz-Mie formalism^{1,2,3} is the analytical solution for the far field radiation which results when plane electromagnetic waves are scattered by a homogeneous spherical particle. With the advent of modern high speed computers programmed to provide numerical results, the Lorenz-Mie formalism may be regarded as an idealized experimental tool which is capable of predicting with certainty the scattering produced by spherical particulates.³

The development and use of computer codes to perform Lorenz-Mie calculations are of prime importance for smoke/aerosol research. For example, the excellent and widely used FORTRAN subroutine DBMIE,⁴ which was developed by J. V. Dave,⁵ has been the mainstay for performing such calculations at Chemical Systems Laboratory (CSL). The DBMIE code was modified for use on the ARRADCOM UNIVAC 1108 computer as a FORTRAN V subroutine.⁶ The FORTRAN V compiler will be replaced in the near future by the UNIVAC 1100 series ASCII FORTRAN compiler.⁷ The ASCII compiler is a modern, state-of-the-art compiler which implements the ANSI FORTRAN 77 standard.⁸ Rather than carry out a straightforward conversion of the FORTRAN V Mie scattering subroutine, the code was completely rewritten to incorporate new ASCII FORTRAN language elements. The result was the ASCMIE subroutine which is a more structured, modular, Mie scattering code which executes faster than the FORTRAN V code.

2 SOFTWARE DESIGN AND CODING CONVENTIONS

A compilation listing of the ASCMIE subroutine is given in appendix A; the reader should become familiar with this listing before proceeding. This subroutine is an implementation of the downward recursion algorithm of Dave.⁵ A call to subroutine ASCMIE requires the specification of the following input arguments:

$X = \pi D/\lambda$, the size parameter for a sphere of diameter D illuminated by electromagnetic radiation of wavelength λ . An error condition is generated and the execution of ASCMIE is halted if $X \leq 0$. X is a double precision variable.

N = the real part of the complex refractive index, m . A printed warning is generated if $N \leq 1$ because the algorithm has been thoroughly tested for $N > 1$ only. N is a double precision variable.

K = imaginary part of the complex refractive index, m . An error condition is generated and the execution of ASCMIE is halted if $K < 0$. K is a double precision variable.

THETAD = a double precision array containing the scattering angles in degrees. The maximum number of scattering angles is set by the PARAMETER variable MXTHET at 100 angles. An error condition is generated and the execution of ASCMIE is halted if any value of the scattering angle exceeds 90 degrees.

NTHETA = the number of scattering angles at which the Lorenz-Mie solutions are sought. NTHETA should not exceed 100 unless ASCMIE is recompiled with MXTHET set larger. An error condition is generated and the execution of ASCMIE is halted if NTHETA > MXTHET. NTHETA is an integer variable.

All the input arguments specified above are checked for error and warning conditions before a decision is made to proceed or halt execution. Each error or warning is described by a printed message. Also, a check is made to determine if sufficient array storage is available to perform the calculations before the program is allowed to proceed.

The subroutine returns the following outputs:

QEXT = efficiency factor for total extinction. QEXT is a double precision variable.

QSCAT = efficiency factor for scattering. QSCAT is a double precision variable.

CTBRQS = product of the asymmetry factor and QSCAT. CTBRQS is a double precision variable.

FMX = elements of the transformation matrix. FMX (4,MXTHET,2) is a double precision array.

Definitions of the efficiency factors, asymmetry factor, and the transformation matrix can be found in any of several excellent treatises on the Lorenz-Mie Theory.^{1,2,3}

An attempt was made to make the ASCMIE code as structured as possible. The beginning of this program module is indicated by the SUBROUTINE statement and the program module ends with the END statement. All of the FORTRAN code which implements the algorithm between the SUBROUTINE and END statements was divided into blocks according to the following scheme:

- (a) BLOCK 0 contains all specifications statements.
- (b) BLOCKS 100 to 600 are blocks of FORTRAN code which implement algorithmic tasks.
- (c) Each BLOCK is divided into as many SUBBLOCKS as necessary for clarity and convenience.

Each BLOCK of the code was constructed according to the following style rules:

- (a) Each BLOCK starts with a statement labelled:

0, 100, 200, . . . , 600

- (b) Each SUBBLOCK starts with a statement labelled:

0, 10, 20, . . . , 90
 100, 110, 120, . . . , 190
 200, 210, 220, . . . , 290
 : : : : :
 : : : : :
 : : : : :
 600, 610, 620, . . . , 690

The smallest available label is used.

- (c) 9000 series labels are FORMAT statements. Each digit following the 9 serves to identify the BLOCK and SUBBLOCK in which the FORMAT statement occurs.

Using the conventions described above, the ASCMIE code is represented by the following skeleton:

START OF MODULE: SUBROUTINE ASCMIE (X, N, K,
 THETAD, NTHETA, QEXT, QSCAT, CTBRQS, FMX)

BLOCK 0: SPECIFICATIONS
 BLOCK 100: CHECK FOR INVALID OR
 OUT-OF-RANGE ARGUMENTS
 BLOCK 200: INITIALIZING CALCULATIONS
 BLOCK 300: SERIES SUMMATIONS
 BLOCK 400: CALCULATE FINAL RESULTS
 BLOCK 500: RETURN
 BLOCK 600: ERROR SECTION
 END OF MODULE: END

3 RESULTS

3.1 Sample Problem. A FORTRAN main program, MIECHK, was written to call the ASCMIE subroutine and produce numeric results for sample problems. MIECHK is essentially the same program as that used previously by Dave⁵ for the same purpose; a compilation listing of program MIECHK is given in appendix B. A MAP (Memory Allocation Processor) listing of the absolute element ASCMIE, which was produced by including MIECHK and ASCMIE, is given in appendix C. This absolute element was executed for Dave's sample problem $m = 1.342 - 0.1i$, $X = 1571.0.5$. The results produced by ASCMIE are given in appendix D and are in agreement with previous results.⁵

3.2 Timing Study. An important consideration in choosing a Mie scattering code is the computer time required to produce numeric results. The time required to execute ASCMIE for the sample problem described above (section 3.1) was compared as the size parameter was varied from 0.1 to 1571 with similar results for two FORTRAN V versions of the Dave subroutine - MEMIE* and MIE2.** The results of the timing study are presented in table 1, where the times shown are the central processing unit times as listed by the UNIVAC 1108 accounting algorithm.

Table 1. Comparison of Execution Times for Three Mie Scattering Subroutines

X	Time		
	ASCMIE	MEMIE	MIE2
	sec	sec	sec
0.1	.947	.979	.995
1.0	1.018	1.049	1.051
10.0	1.427	1.490	1.592
100.0	4.021	4.068	5.004
1000.0	27.758	28.952	34.671
1571.0	41.166	42.137	51.637

In every case ASCMIE took less time to compute the same results than the MEMIE and MIE2 subroutines. Independent of the value of X, we find that

$$T_A < T_{M1} < T_{M2} \quad (1)$$

where

T_A = time required when using the ASCMIE subroutine

T_{M1} = time required when using the MEMIE subroutine

T_{M2} = time required when using the MIE2 subroutine

Because of the uncertainties inherent in computer timing operations and the cursory nature of this timing study, these results should be regarded as suggestive but not definitive.

*Unpublished data by M. E. Milham.

**Unpublished data by J. H. Frickel.

4. CONCLUSIONS

The ASCMIE subroutine:

- (a) Is based on the downward recursion scheme of Dave.
- (b) Uses many of the FORTRAN 77 features available in the UNIVAC 1100 series ASCII FORTRAN language.
- (c) Is more modular and structured than the original Dave code.
- (d) Executes faster than FORTRAN V versions of the Dave code (MEMIE, MIE2).

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APPENDIX A

FTN COMPILATION LISTING OF SUBROUTINE ASCMIE

```

@FTN.DRSZ ASCM
FTN BR1 *02/12/81-09:42(0.)
1. C
2. C
3. C
4. C
5. C
6. C
7. C
8. C
9. C
10. C
11. C
12. C
13. C
14. C
15. C
16. C
17. C
18. C
19. C
20. C
21. C
22. C
23. C
24. C
25. C
26. C
27. C
28. C
29. C
30. C
31. C
32. C
33. C
34. C
35. C
36. C
37. C
38. C
39. C
40. C
41. C
42. C
43. C
44. C
45. C
46. C
47. C
48. C
49. C
50. C
51. C
52. C
53. C

SUBROUTINE ASCMIE(X,N,K,THETAD,NTHETA,QEXT,QSCAT,CTBROS,FMX)
** M. E. MILHAM 1980
C INPUTS:
X = SIZE PARAMETER,PI*D/WL
N = REAL PART OF REFRACTIVE INDEX
K = IMAGINARY PART OF REFRACTIVE INDEX
THETAD = SCATTERING ANGLES(DEGREES)
NTHETA = NUMBER OF SCATTERING ANGLES
C OUTPUTS:
QEXT = EFFICIENCY FACTOR FOR EXTINCTION
QSCAT = EFFICIENCY FACTOR FOR SCATTERING
CTBROS = ASYMMETRY FACTOR * QSCAT
FMX = ELEMENTS OF THE TRANSFORMATION MATRIX(F)

C BLOCK 0: ASCMIE SPECIFICATIONS
90
PARAMETER
+ MXTHET=100.
+ NMX0=7000.
+ AMAX=NMX0-1.
+ RAD=DATAN(1.000)/45.000
C
10
LOGICAL
+ STOP.
+ ENDSUM
C
REAL*8
+ X.
+ XI.
+ N.
+ K.
+ QEXT.
+ QSCAT.
+ T(5).
+ TA(4).
+ T3(2).
+ TC(2)
C
REAL*8
+ TD(2).
+ TE(2).
+ CTBROS.
+ FMX(4,NXTHET,2).
+ PI(3,NXTHET).

```

```

54.      +      TAU(3,MXTHET),
55.      +      CSTHET(MXTHET),
56.      +      SI2THT(MXTHET),
57.      +      THETAD(MXTHET)
58.      C
59.      30      COMPLEX*16
60.      +      M.
61.      +      MI.
62.      +      XMI.
63.      +      AN.
64.      +      BN.
65.      +      ANP.
66.      +      BNP.
67.      +      TC1.
68.      +      TC2.
69.      +      WM1.
70.      +      WN(2).
71.      +      A(NMX0)
72.      C
73.
74.
75.      40      EQUIVALENCE
76.      +      (WN(1),TA(1)),
77.      +      (AN,TB(1)),
78.      +      (BN,TC(1)),
79.      +      (ANP,TD(1)),
80.      +      (BNP,TE(1))
81.      C
82.      C END OF BLOCK 0: ASCMIE
83.      C
84.      C-----
85.      C BLOCK 100: ASCMIE CHECK FOR INVALID OR OUT OF RANGE ARGUMENTS
86.      C
87.      C CHECK FOR X>0
88.
89.      100      STOP=.FALSE.
90.      IF(X.GT.0.000) THEN
91.      CONTINUE
92.      C
93.      ELSE
94.      C
95.      WRITE(UNIT=6,FMT=9100) X
96.      FORMAT(' X = ',G15.7,' MUST BE GREATER THAN 0')
97.      C
98.      STOP=.TRUE.
99.      C
100.      END IF
101.      C
102.      C CHECK N>1
103.      110      IF(N.GT.1.D0) THEN
104.      CONTINUE
105.      C
106.      ELSE
107.      WRITE(UNIT=6,FMT=9110) N
108.      FORMAT(' N = ',G15.7,' SUBROUTINE NOT CHECKED FOR N<1')
109.      END IF
110.      C
111.

```

```

. ASCM0054
. ASCM0055
. ASCM0056
. ASCM0057
. ASCM0058
. ASCM0059
. ASCM0060
. ASCM0061
. ASCM0062
. ASCM0063
. ASCM0064
. ASCM0065
. ASCM0066
. ASCM0067
. ASCM0068
. ASCM0069
. ASCM0070
. ASCM0071
. ASCM0072
. ASCM0073
. ASCM0074
. ASCM0075
. ASCM0076
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. ASCM0095
. ASCM0096
. ASCM0097
. ASCM0098
. ASCM0099
. ASCM0100
. ASCM0101
. ASCM0102
. ASCM0103
. ASCM0104
. ASCM0105
. ASCM0106
. ASCM0107
. ASCM0108
. ASCM0109
. ASCM0110
. ASCM0111

```

```

112. C CHECK K
113.
114. 120 IF(K.LT.0.0D0) THEN
115.     WRITE(UNIT=6,FMT=9120) K
116. 9120 FORMAT(' K =',G15.7,' K MUST BE .GE.0')
117. C
118. STOP=.TRUE.
119. C
120. ELSE
121. CONTINUE
122. END IF
123. C CHECK NTHETA
124.
125. 130 IF(NTHETA.LE.MXTHET.AND.NTHETA.GT.0) THEN
126. CONTINUE
127. C
128. ELSE
129. I=MXTHET
130. WRITE(UNIT=6,FMT=9130) NTHETA,I
131. FORMAT(' CALCULATIONS REQUESTED FOR AN IMPROPER NUMBER OF'
132. + ' SCATTERING ANGLES. NTHETA =',I10/' MXTHET =',I10)
133. C
134. STOP=.TRUE.
135. C
136. END IF
137. C CHECK THETAD(J)
138.
139. 140 DO 141 J=1,NTHETA
141. C REMOVE ANY NEGATIVE ANGLES
142. THETAD(J)=DABS(THETAD(J))
143. C
144. IF(THETAD(J).GT.90.0D0) THEN
145.     WRITE(UNIT=6,FMT=9140) J,THETAD(J)
146. 9140 FORMAT(' THETAD(',I3,') =',G15.4,' DEGREES.THETAD MUST'
147. + ' BE .LE.90.')
148. C
149. STOP=.TRUE.
150. C
151. ELSE
152. CONTINUE
153. END IF
154. 141 CONTINUE
155. C SET NMX1,NMX2 AND CHECK "A" ARRAY STORAGE
156.
157. 150 T(1)=(X*X)*(N+N*K*K)
158. T(1)=DSORT(T(1))
159. NMX1=1.1D0*T(1)
160. NMX2=T(1)
161. C
162. IF(NMX1.LE.AMAX.AND.NMX1.GE.150) THEN
163. ELSE IF(NMX1.LT.150) THEN
164.     NMX1=150
165.     NMX2=135
166. C
167. ELSE
168.
169.

```

```

. ASCM0112
. ASCM0113
. ASCM0114
. ASCM0115
. ASCM0116
. ASCM0117
. ASCM0118
. ASCM0119
. ASCM0120
. ASCM0121
. ASCM0122
. ASCM0123
. ASCM0124
. ASCM0125
. ASCM0126
. ASCM0127
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. ASCM0166
. ASCM0167
. ASCM0168
. ASCM0169

```

```

170. 1 I=AMA\
171. 1 WRITE(UNIT=6,FMT=9150) NMX1,I
172. 1 FORMAT(' A(',15,') REQUIRED ONLY A(',15,') IS AVAILABLE')
173. 1 9150
174. 1 WRITE(UNIT=6,FMT=9151) X,N,K
175. 1 9151
176. 1 FORMAT(' X =',G15.7, ' N =',G15.7, ' K =',G15.7)
177. 1 C
178. 1 STOP=.TRUE.
179. 1 END IF
180. 1 C
181. 1 C STOP OR GO ???
182. 1 160 IF(STOP) THEN
183. 1 STOP
184. 1 C
185. 1 ELSE
186. 1 CONTINUE
187. 1 END IF
188. 1 C
189. 1 C END OF BLOCK 100: ASCMIE
190. 1 C
191. 1 C-----
192. 1 C BLOCK 200: ASCMIE INITIALIZING CALCULATIONS
193. 1 C SET: A
194. 1
195. 1 200 M=DCMPLX(N,-K)
196. 1 MI=1.000/M
197. 1 XI=1.000/X
198. 1 XMI=XI*MI
199. 1 C
200. 1 NN1=NMX1+1
201. 1 A(NN1)=(0.000,0.000)
202. 1 C
203. 1 DO 201 NN=NN1,2,-1
204. 1 A(NN-1)=NN*XMI-1.000/(NN*XMI+A(NN))
205. 1 201 CONTINUE
206. 1 C
207. 1 C SET PHASE FUNCTIONS(PI,TAU)
208. 1
209. 1 210 DO 211 J=1,NTHETA
210. 1 C
211. 1 IF(THETAD(J).EQ.0.000) THEN
212. 1 CSTHET(J)=1.000
213. 1 SI2TH(J)=0.000
214. 1 ELSE IF(THETAD(J).EQ.90.000) THEN
215. 1 CSTHET(J)=0.000
216. 1 SI2TH(J)=1.000
217. 1 C
218. 1 ELSE
219. 1 CSTHET(J)=DCOS(RAD*THETAD(J))
220. 1 SI2TH(J)=1.000-CSTHET(J)*CSTHET(J)
221. 1 END IF
222. 1 C
223. 1 211 CONTINUE
224. 1 C
225. 1 DO 212 J=1,NTHETA
226. 1 C
227. 1 PI(1,J)=0.000

```

```

1 228. C      PI(2,J)=1.0D0
1 229. C      TAU(1,J)=0.0D0
1 230. C      TAU(2,J)=CSTHET(J)
1 231. C
1 232. C      212 CONTINUE
1 233. C
1 234. C      C SET: W FUNCTION, AN, BN, ANP, BNP
1 235. C
1 236. C      220
1 237. C      T(1)=DCOS(X)
1 238. C      T(2)=DSIN(X)
1 239. C      WM1=DCPLX(T(1),-T(2))
1 240. C      WN(1)=DCPLX(T(2),T(1))
1 241. C      WN(2)=XI*WN(1)-WM1
1 242. C
1 243. C      TC1=A(1)*MI+XI
1 244. C      TC2=A(1)*M+XI
1 245. C      AN=(TC1*TA(3)-TA(1))/(TC1*WN(2))-N(1)
1 246. C      BN=(TC2*TA(3)-TA(1))/(TC2*WN(2))-N(1)
1 247. C      ANP=AN
1 248. C      BNP=BN
1 249. C
1 250. C      C SET: COMPLEX AMPLITUDES(S1,S2)
1 251. C      C FOR BLOCKS 200 - 300:
1 252. C      C FMX(1,J,K)=REAL PART OF S1
1 253. C      C FMX(2,J,K)=IMAGINARY PART OF S1
1 254. C      C FMX(3,J,K)=REAL PART OF S2
1 255. C      C FMX(4,J,K)=IMAGINARY PART OF S2
1 256. C      C KK=1: FOR THETAD(J), KK=2 FOR 180.0-THETAD(J)
1 257. C
1 258. C      230
1 259. C      T(1)=1.5000
1 260. C      TB(1)=T(1)*TB(1)
1 261. C      TR(2)=T(1)*TB(2)
1 262. C      TC(1)=T(1)*TC(1)
1 263. C      TC(2)=T(1)*TC(2)
1 264. C
1 265. C      DO 231 J=1,NTHETA
1 266. C      T(5)=TAU(2,J)
1 267. C
1 268. C      T(1)=TC(1)*T(5)
1 269. C      T(2)=TC(2)*T(5)
1 270. C      T(3)=TB(1)*T(5)
1 271. C      T(4)=TB(2)*T(5)
1 272. C
1 273. C      T(5)=PI(2,J)
1 274. C
1 275. C      FMX(1,J,1)=TB(1)*T(5)
1 276. C      FMX(1,J,2)=FMX(1,J,1)
1 277. C      FMX(1,J,1)=FMX(1,J,1)+T(1)
1 278. C      FMX(1,J,2)=FMX(1,J,2)-T(1)
1 279. C
1 280. C      FMX(2,J,1)=TB(2)*T(5)
1 281. C      FMX(2,J,2)=FMX(2,J,1)
1 282. C      FMX(2,J,1)=FMX(2,J,1)+T(2)
1 283. C      FMX(2,J,2)=FMX(2,J,2)-T(2)
1 284. C
1 285. C      FMX(3,J,1)=TC(1)*T(5)

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1 285. FMX(3,J,2)=FMX(3,J,1)
1 287. FMX(3,J,1)=FMX(3,J,1)+T(3)
1 288. FMX(3,J,2)=FMX(3,J,2)-T(3)
1 289.
1 290. FMX(4,J,1)=TC(2)*T(5)
1 291. FMX(4,J,2)=FMX(4,J,1)
1 292. FMX(4,J,1)=FMX(4,J,1)+T(4)
1 293. FMX(4,J,2)=FMX(4,J,2)-T(4)
1 294.
1 295.
1 296.
1 297.
1 298.
1 299.
1 300. QEXT=2.000*(TB(1)+TC(1))
1 301. QSCAT=(TB(1)**2+TB(2)**2+TC(1)**2+TC(2)**2)/0.7500
1 302. CTBROS=0.000
1 303.
1 304.
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1 341.
1 342.
1 343.

C 231 CONTINUE
C SET QEXT,QSCAT, AND CTBROS
240 QEXT=2.000*(TB(1)+TC(1))
    QSCAT=(TB(1)**2+TB(2)**2+TC(1)**2+TC(2)**2)/0.7500
    CTBROS=0.000
C END OF BLOCK 200: ASCMIE
C-----
C BLOCK 300: ASCMIE SERIES SUMMATIONS
300 DO 510 NN=2,NMX2
    * NOTE THIS DO LOOP TERMINATES IN BLOCK 500
    C
    T(1)=2*NN-1
    T(2)=NN-1
    T(3)=2*NN+1
    C
    DO 302 J=1,NTHETA
        PI(3,J)=(T(1)*PI(2,J)+CSTHET(J)-NN*PI(1,J))/T(2)
        TAU(3,J)=CSTHET(J)*(PI(3,J)-PI(1,J))-T(1)*SIZTHT(J)*PI(2,J)+
        + TAU(1,J)
    302 CONTINUE
    C
    C SET W'S,AN,BN
    310 WM1=WN(1)
        WN(1)=WN(2)
        WN(2)=T(1)*XI+WN(1)*WN(1)
    C
        TC1=A(NN)*MI+NN*XI
        TC2=A(NN)*M+NN*XI
        AN=(TC1*TA(3)-TA(1))/(TC1*WN(2)-N(1))
        BN=(TC2*TA(3)-TA(1))/(TC2*WN(2)-N(1))
    C
    C SET QEXT,QSCAT,CTBROS
    320 T(5)=NN
        T(4)=T(1)/(T(2)*T(5))
        T(2)=(T(2)*(T(5)+1.000))/T(5)
    C
        CTBROS=CTBROS+T(2)*(TD(1)*TB(1)+TD(2)*TB(2)+TE(1)*TC(1)+
        + TE(2)*TC(2))+T(4)*(TD(1)*TE(1)+TD(2)*TE(2))
        QEXT=QEXT+T(3)*(TB(1)+TC(1))
        T(4)=TB(1)**2+TB(2)**2+TC(1)**2+TC(2)**2
        QSCAT=QSCAT+T(3)*T(4)

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1 285. ASCM0286
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1 288. ASCM0288
1 289. ASCM0289
1 290. ASCM0290
1 291. ASCM0291
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1 293. ASCM0293
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1 295. ASCM0295
1 296. ASCM0296
1 297. ASCM0297
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1 299. ASCM0299
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1 330. ASCM0330
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1 336. ASCM0336
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1 339. ASCM0339
1 340. ASCM0340
1 341. ASCM0341
1 342. ASCM0342
1 343. ASCM0343

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1 344. C
1 345. C SET COMPLEX AMPLITUDES
1 346.
1 347. 330 T(2)=NN*(NN+1)
1 348. T(1)=T(3)/T(2)
1 349. KK=(NN/2)*2
1 350. C
1 351. DO 331 J=1,NTHETA
1 352. C
1 353. FMX(1,J,1)=FMX(1,J,1)+T(1)*(TB(1)*PI(3,J)+TC(1)*TAU(3,J))
2 354. FMX(2,J,1)=FMX(2,J,1)+T(1)*(TB(2)*PI(3,J)+TC(2)*TAU(3,J))
2 355. FMX(3,J,1)=FMX(3,J,1)+T(1)*(TC(1)*PI(3,J)+TB(1)*TAU(3,J))
2 356. FMX(4,J,1)=FMX(4,J,1)+T(1)*(TC(2)*PI(3,J)+TB(2)*TAU(3,J))
2 357. C
2 358. IF(KK.NE.NN) THEN
2 359. C
2 360. FMX(1,J,2)=FMX(1,J,2)+T(1)*(TB(1)*PI(3,J)-TC(1)*TAU(3,J))
3 361. FMX(2,J,2)=FMX(2,J,2)+T(1)*(TB(2)*PI(3,J)-TC(2)*TAU(3,J))
3 362. FMX(3,J,2)=FMX(3,J,2)+T(1)*(TC(1)*PI(3,J)-TB(1)*TAU(3,J))
3 363. FMX(4,J,2)=FMX(4,J,2)+T(1)*(TC(2)*PI(3,J)-TB(2)*TAU(3,J))
3 364. C
3 365. ELSE
3 366. C
3 367. FMX(1,J,2)=FMX(1,J,2)+T(1)*(-TB(1)*PI(3,J)+TC(1)*TAU(3,J))
3 368. FMX(2,J,2)=FMX(2,J,2)+T(1)*(-TB(2)*PI(3,J)+TC(2)*TAU(3,J))
3 369. FMX(3,J,2)=FMX(3,J,2)+T(1)*(-TC(1)*PI(3,J)+TB(1)*TAU(3,J))
3 370. FMX(4,J,2)=FMX(4,J,2)+T(1)*(-TC(2)*PI(3,J)+TB(2)*TAU(3,J))
3 371. C
3 372. END IF
3 373. C
3 374. 331 CONTINUE
2 375. C
2 376. C CHECK FOR CONVERGENCE
2 377. C
1 378. 340 ENDSUM=T(4).LT.1.0D-14
1 379. IF(.NOT.ENDSUM) THEN
1 380. * NOTE THIS IF THEN-ELSE ENDS IN BLOCK 500
1 381. C
1 382. C UPDATE PI.TAU.ANP.BNP FOR NEXT ITERATION
1 383. C
1 384. 350 DO 351 J=1,NTHETA
2 385. C
2 386. PI(1,J)=PI(2,J)
2 387. PI(2,J)=PI(3,J)
3 388. C
3 389. TAU(1,J)=TAU(2,J)
3 390. TAU(2,J)=TAU(3,J)
3 391. C
3 392. 351 CONTINUE
3 393. C
3 394. ANP=AN
2 395. BNP=BN
2 396. C
2 397. C END OF BLOCK 300: ASCMIE
2 398. C BLOCK 400: ASCMIE CALCULATE FINAL RESULTS
2 399. C-----
2 400. SUMMATION COMPLETE
2 401. C-----

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402. C
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C
C
ELSE
DO 402 J=1,NTHETA
DO 402 KK=1,2
DO 401 I=1,4
T(I)=FMX(I,J,KK)
401 CONTINUE
C
C SET F MATRIX ELEMENTS
C
FMX(1,J,KK)=T(3)**2+T(4)**2
FMX(2,J,KK)=T(1)**2+T(2)**2
FMX(3,J,KK)=T(1)*T(3)+T(2)*T(4)
FMX(4,J,KK)=T(2)*T(3)-T(4)*T(1)
C
402 CONTINUE
C
C SET QCAT,QCBROS,QCBROS
410 T(1)=2.0D0*XI**2
QEXT=QEXT+T(1)
QSCAT=QSCAT+T(1)
CTBROS=2.0D0*CTBROS+T(1)
C
C END OF BLOCK 400: ASCMIE
C
C BLOCK 500: ASCMIE RETURN
500 RETURN
C
C
END IF
C
510 CONTINUE
C
C END OF BLOCK 500: ASCMIE
C
C BLOCK 600: ASCMIE ERROR SECTION - CONVERGENCE NOT OBTAINED
600 WRITE(UNIT=6,FMT=9600) NMIX2
9600 FORMAT(' NMIX2 =',110,' IS TOO SMALL. CONVERGENCE'
+
STOP
C
C END OF BLOCK 600: ASCMIE
END

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F O R T R A N C R O S S R E F E R E N C E L I S T I N G

S U B R O U T I N E A S C I I Z

NAME	USE	LINE NUMBER
100	DEFINED	89
110	DEFINED	104
120	DEFINED	114
130	DEFINED	126
140	DEFINED	141
141	DEFINED	155
141	USED	141
150	DEFINED	159
160	DEFINED	181
200	DEFINED	195
201	DEFINED	205
201	USED	203
210	DEFINED	209
211	DEFINED	223
211	USED	209
212	DEFINED	233
212	USED	225
220	DEFINED	237
230	DEFINED	258
231	DEFINED	295
231	USED	264
240	DEFINED	299
300	DEFINED	309
302	DEFINED	320
302	USED	316
310	DEFINED	324
320	DEFINED	335
330	DEFINED	347
331	DEFINED	374
331	USED	351
340	DEFINED	378
350	DEFINED	384
351	DEFINED	392
351	USED	384
400	DEFINED	406
401	DEFINED	411
401	USED	409
402	DEFINED	420
402	USED	406
410	DEFINED	424
500	DEFINED	434
510	DEFINED	440
510	USED	309
600	DEFINED	446
9100	DEFINED	96
9100	USED	95
9110	DEFINED	109
9110	USED	108
9120	DEFINED	116
9120	USED	115
9130	DEFINED	132
9130	USED	131

407

K	SPEC	287	287	288	288	290	291	291	292
	USED	3	36						318
KK	SET	114	115	159	159	173	195		353
	USED	349	407	407					355
M	SPEC	358	410	415	416	417	418		360
	SET	60							362
	SET	195							367
MI	USED	196	244	329					369
	SPEC	60							386
	SET	196							410
MATHET	USED	198	243	328					415
	SET	24							
N	USED	48	48	48	48	48	48	126	130
	SPEC	3	36						
	USED	104	108	159	159	173	195		
NMX0	SET	24							
	USED	24	60						
NMX1	SET	161	166						
	USED	164	164	165	171	200			
NMX2	SET	162	167						
	USED	309	446						
NN	SET	203	203	309	309				
	USED	204	204	204	204	312	313	314	317
	USED	328	328	329	329	335	347	347	349
	USED	358							
NN1	SET	200	200	203					
	USED	201	201						
NTHETA	SPEC	3							
	USED	126	126	131	141	209	225	264	316
	USED	351	384	406					
PI	SPEC	48							
	SET	227	228	317	386	387			
	USED	273	317	317	318	318	318	353	354
	USED	355	356	360	361	362	363	367	368
	USED	369	370	386	387				
OEXT	SPEC	3	36						
	SET	299	341	425					
	USED	341	425						
QSCAT	SPEC	3	36	426					
	SET	300	343						
	USED	343	426						
RAD	SET	24							
	USED	219							
SI2THT	SPEC	48							
	SET	213	216	220					
	USED	318							
	SPEC	31							
STOP	SET	89	98	118	135	150	176		

26

I		USED SPEC SET	181 36 159 270 337 160 260 277 290 336 343 360 378 417 75	160 271 342 161 261 278 292 336 343 361 415 418	237 273 347 162 262 280 293 337 348 362 415 418	238 312 348 239 268 282 317 337 348 363 416 418	258 313 410 239 269 283 317 337 353 367 416 418	266 314 424 240 270 285 318 339 354 368 417 425	268 335 210 271 287 326 341 355 369 417 426	269 336 259 288 336 341 356 370 417 427
TA		EQUIV SPEC USED	75 36 245							
TAU		SPEC SET USED	48 230 266 362 75	245 231 318 363	246 318 353 367	246 389 354 368	330 390 355 369	330 330 356 370	331 360 389	331
TB		EQUIV SPEC SET USED	36 259 259 300 355 369 75	260 260 339 356 370						
TC		EQUIV SPEC SET USED	75 36 261 300 355 369	262 262 339 356 370	270 339 360	271 341 361	275 342 362	280 342 363	299 353 367	300 354 368
TC1		SPEC SET USED SPEC SET USED EQUIV	60 243 245 60 244 246 75	328 245 329 246						
TC2		SPEC SET USED SPEC SET USED EQUIV	48 339 75 48 339 339 48	339 339 339 339	339 339 331	339 339 331	362 342 362	290 342 363	299 353 367	300 354 368
TD		SPEC SET USED SPEC SET USED EQUIV	48 339 75 48 339 339 48	339 339 339 339	339 339 331	339 339 331	362 342 362	290 342 363	299 353 367	300 354 368
TE		SPEC SET USED SPEC SET USED EQUIV	48 339 75 48 339 339 48	339 339 339 339	339 339 331	339 339 331	362 342 362	290 342 363	299 353 367	300 354 368
THEYAD		SPEC SET USED SPEC SET USED EQUIV	3 143 143 60 239 241 75	48 145 324 326						
WM1		SPEC SET USED SPEC SET USED EQUIV	60 240 241 330	241 245 330	325 245 331	326 246 331	246 246 331	324 324 325	325 325 326	326
WN		SPEC SET USED SPEC SET USED EQUIV	60 240 241 330	241 245 330	325 245 331	326 246 331	246 246 331	324 324 325	325 325 326	326

X	SPEC	3	36	159	159	173	197	237	238
	USED	90	95						
XI	SPEC	36							
	SET	197							
	USED	198	241	243	244	326	328	329	424
XMI	SPEC	60							
	SET	198							
	USED	204	204						

F O R T R A N S T O R A G E M A P

NAME	TYPE	MODE	RELATIVE ADDRESS	LOC COUNT	ELEMENT LENGTH	NUMBER OF ELEMENTS	COMMON SIZE	PROGRAM UNIT
100L	USRDEFND	STMTNMBR	000042	1				SUBROUTINE ASCMIE
110L	USRDEFND	STMTNMBR	000054	1				SUBROUTINE ASCMIE
120L	USRDEFND	STMTNMBR	000063	1				SUBROUTINE ASCMIE
130L	USRDEFND	STMTNMBR	000073	1				SUBROUTINE ASCMIE
140L	USRDEFND	STMTNMBR	000107	1				SUBROUTINE ASCMIE
141L	USRDEFND	STMTNMBR	000134	1				SUBROUTINE ASCMIE
150L	USRDEFND	STMTNMBR	000141	1				SUBROUTINE ASCMIE
160L	USRDEFND	STMTNMBR	000223	1				SUBROUTINE ASCMIE
200L	USRDEFND	STMTNMBR	000227	1				SUBROUTINE ASCMIE
201L	USRDEFND	STMTNMBR	000350	1				SUBROUTINE ASCMIE
210L	USRDEFND	STMTNMBR	000354	1				SUBROUTINE ASCMIE
211L	USRDEFND	STMTNMBR	000417	1				SUBROUTINE ASCMIE
212L	USRDEFND	STMTNMBR	000440	1				SUBROUTINE ASCMIE
220L	USRDEFND	STMTNMBR	000441	1				SUBROUTINE ASCMIE
230L	USRDEFND	STMTNMBR	000664	1				SUBROUTINE ASCMIE
231L	USRDEFND	STMTNMBR	001001	1				SUBROUTINE ASCMIE
240L	USRDEFND	STMTNMBR	001002	1				SUBROUTINE ASCMIE
300L	USRDEFND	STMTNMBR	001025	1				SUBROUTINE ASCMIE
302L	USRDEFND	STMTNMBR	001134	1				SUBROUTINE ASCMIE
310L	USRDEFND	STMTNMBR	001135	1				SUBROUTINE ASCMIE
320L	USRDEFND	STMTNMBR	001311	1				SUBROUTINE ASCMIE
330L	USRDEFND	STMTNMBR	001403	1				SUBROUTINE ASCMIE
331L	USRDEFND	STMTNMBR	001574	1				SUBROUTINE ASCMIE
340L	USRDEFND	STMTNMBR	001577	1				SUBROUTINE ASCMIE
350L	USRDEFND	STMTNMBR	001606	1				SUBROUTINE ASCMIE
351L	USRDEFND	STMTNMBR	001620	1				SUBROUTINE ASCMIE
400L	USRDEFND	STMTNMBR	001632	1				SUBROUTINE ASCMIE
402L	USRDEFND	STMTNMBR	001720	1				SUBROUTINE ASCMIE
410L	USRDEFND	STMTNMBR	001722	1				SUBROUTINE ASCMIE
500L	USRDEFND	STMTNMBR	001740	1				SUBROUTINE ASCMIE
510L	USRDEFND	STMTNMBR	001741	1				SUBROUTINE ASCMIE
600L	USRDEFND	STMTNMBR	001761	1				SUBROUTINE ASCMIE
9100F	FORMAT	STMTNMBR	000052	4				SUBROUTINE ASCMIE
9110F	FORMAT	STMTNMBR	000064	4				SUBROUTINE ASCMIE
9120F	FORMAT	STMTNMBR	000100	4				SUBROUTINE ASCMIE
9130F	FORMAT	STMTNMBR	000110	4				SUBROUTINE ASCMIE
9140F	FORMAT	STMTNMBR	000142	4				SUBROUTINE ASCMIE
9150F	FORMAT	STMTNMBR	000161	4				SUBROUTINE ASCMIE
9151F	FORMAT	STMTNMBR	000176	4				SUBROUTINE ASCMIE
9600F	FORMAT	STMTNMBR	000206	4				SUBROUTINE ASCMIE
A	COMPLEX	ARRAY	000000	0	16	7000		SUBROUTINE ASCMIE
AN	COMPLEX	SCALAR	071731	0	16			SUBROUTINE ASCMIE
ANP	COMPLEX	SCALAR	071721	0	16			SUBROUTINE ASCMIE
BN	COMPLEX	SCALAR	071725	0	16			SUBROUTINE ASCMIE
BNP	COMPLEX	SCALAR	071715	0	16			SUBROUTINE ASCMIE
CSTHET	REAL	ARRAY	067722	0	8	100		SUBROUTINE ASCMIE
CTBROS	REAL	SCALAR	DUMMY	0	8			SUBROUTINE ASCMIE
ENDSUM	LOGICAL	SCALAR	066571	0	4			SUBROUTINE ASCMIE
FMX	REAL	ARRAY	DUMMY	0	8	800		SUBROUTINE ASCMIE
I	INTEGER	SCALAR	051540	0	4			SUBROUTINE ASCMIE
J	INTEGER	SCALAR	066541	0	4			SUBROUTINE ASCMIE
K	REAL	SCALAR	DUMMY	0	8			SUBROUTINE ASCMIE

NAME	TYPE	MODE	RELATIVE ADDRESS	LOC CUUNIT	ELEMENT LENGTH	NUMBER OF ELEMENTS	COMMON SIZE	PROGRAM UNIT	F2SESS	DSQRT	FSTOPS	FDCOV\$
KK	INTEGER	SCALAR	070552	0	4			SUBROUTINE ASCMIE				
M	COMPLEX	SCALAR	066543	0	16			SUBROUTINE ASCMIE				
MI	COMPLEX	SCALAR	070553	0	16			SUBROUTINE ASCMIE				
N	REAL	SCALAR	DUMMY		8			SUBROUTINE ASCMIE				
NMX1	INTEGER	SCALAR	071713	0	4			SUBROUTINE ASCMIE				
NMX2	INTEGER	SCALAR	071714	0	4			SUBROUTINE ASCMIE				
NN	INTEGER	SCALAR	070557	0	4			SUBROUTINE ASCMIE				
NN1	INTEGER	SCALAR	066542	0	4			SUBROUTINE ASCMIE				
NTHETA	INTEGER	SCALAR	DUMMY		4			SUBROUTINE ASCMIE				
PI	REAL	ARRAY	070560	0	8	300		SUBROUTINE ASCMIE				
QEXT	REAL	SCALAR	DUMMY		8			SUBROUTINE ASCMIE				
QSCAT	REAL	SCALAR	DUMMY		8			SUBROUTINE ASCMIE				
S12THT	REAL	ARRAY	070242	0	8	100		SUBROUTINE ASCMIE				
STOP	LOGICAL	SCALAR	071710	0	4			SUBROUTINE ASCMIE				
T	REAL	ARRAY	066547	0	8			SUBROUTINE ASCMIE				
TA	REAL	ARRAY	071735	0	8	5		SUBROUTINE ASCMIE				
TAU	REAL	ARRAY	071735	0	8	4		SUBROUTINE ASCMIE				
TB	REAL	ARRAY	066572	0	8	300		SUBROUTINE ASCMIE				
TC	REAL	ARRAY	071731	0	8	2		SUBROUTINE ASCMIE				
TC1	COMPLEX	SCALAR	071725	0	8	2		SUBROUTINE ASCMIE				
TC2	COMPLEX	SCALAR	066561	0	16			SUBROUTINE ASCMIE				
TD	REAL	SCALAR	066565	0	16			SUBROUTINE ASCMIE				
TE	REAL	ARRAY	071721	0	8	2		SUBROUTINE ASCMIE				
THETAD	REAL	ARRAY	071715	0	8	2		SUBROUTINE ASCMIE				
WM1	COMPLEX	SCALAR	DUMMY		8	100		SUBROUTINE ASCMIE				
WN	COMPLEX	SCALAR	070232	0	16			SUBROUTINE ASCMIE				
X	REAL	ARRAY	071735	0	16	2		SUBROUTINE ASCMIE				
X1	REAL	SCALAR	DUMMY		8			SUBROUTINE ASCMIE				
XMI	COMPLEX	SCALAR	071711	0	8			SUBROUTINE ASCMIE				
			070236	0	16			SUBROUTINE ASCMIE				

ENTRY POINTS
ASCMIE

ENTRY 000016

1

EXTERNAL REFERENCES
IBJ\$ BDICALL\$
DCOS D\$IN

BDIREF\$

ASCMIE

WTC\$

FMT\$

F2SE\$

DSQRT

FSTOPS

FDCOV\$

END FTN 1015 IBANK 29981 DBANK

@RESUME.H

APPENDIX B

FTN COMPILATION LISTING OF MAIN PROGRAM MIECHK

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@FTN.DRSZ CLASS.MIECHK
FTN 8R *11/24/80-12:51(B.)
1. DOUBLE PRECISION RFR,RFI,X,QEXT,QSCAT,QABS,THETD(100),AJX,
2. ELTRMX(4,100,2),ALAM,CTBROS,AVCSTH,
3. CON/3.1415926535897932D0/
4. REAL AIN(100,2),POLR(100,2)
5. 90 READ(5,10,END=1000) RFR,RFI,X,JX,AJX,MMM
6. READ(5,12) THETD(1)
7. IF( MMM.EQ.0 ) GO TO 95
8. IF MMM = 0, THE VALUE OF X REMAINS UNCHANGED, OTHERWISE, X IS
9. CHANGED TO ( 2.0 * PI * X ) / ( MMM * 1.0D-3 ).
10. ALAM = MMM * 1.0D-3
11. X = (2.0D0 * CON * X) / ALAM
12. DO 100 J = 2,JX
13. THETD(J) = (J - 1) * AJX + THETD(1)
14. CONTINUE
15. CALL ASCMIE( X,RFR,RFI,THETD,JX,QEXT,QSCAT,CTBROS,ELTRMX )
16. QABS = QEXT - QSCAT
17. AVCSTH = CTBROS / QSCAT
18. DO 150 K = 1,2
19. DO 150 J = 1,JX
20. AIN(J,K) = ELTRMX(1,J,K) + ELTRMX(2,J,K)
21. POLR(J,K) = ( ELTRMX(2,J,K) - ELTRMX(1,J,K) ) / AIN(J,K)
22. AIN(J,K) = 0.5 * AIN(J,K)
23. CONTINUE
24. WRITE(6,20)
25. WRITE(6,25) X
26. WRITE(6,30) RFR,RFI
27. WRITE(6,35)
28. WRITE(6,40) (THETD(J),(ELTRMX(I,J,1),I= 1,4),AIN(J,1),POLR(J,1),
29. 1J = 1,JX)
30. DO 200 J = 1,JX
31. THETD(J) = 180.0D0 - THETD(J)
32. CONTINUE
33. JMX = JX - 1
34. DO 210 J = 1,JMX
35. JJ = JX - J
36. WRITE(6,40) THETD(JJ),(ELTRMX(I,JJ,2),I = 1,4),
37. 1 AIN(JJ,2),POLR(JJ,2)
38. CONTINUE
39. WRITE(6,45) QEXT
40. WRITE(6,50) QSCAT
41. WRITE(6,55) QABS
42. WRITE(6,60) AVCSTH
43. WRITE(6,20)
44. GO TO 90
45. 1000 STOP
46. C
47. C
48. C
49. C
50. 10 FORMAT( )
51. 12 FORMAT(D15.5)
52. 20 FORMAT('1')
53. 25 FORMAT('10',10X,'ELEMENTS OF THE TRANSFORMATION MATRIX FOR A SPHERE
1 WITH SIZE PARAMETER = ',F15.5)

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54. 30 FORMAT('0'.10X,'REFRACTIVE INDEX. REAL = '.015.5. 0X,'IMAGINARY = '
55. 1015.5//)
56. 35 FORMAT('0'.2X,'ANGLE'.9X,'M SUB 2'.5X,'M SUB 1'.8X,'S SUB 21'.6X
57. 1,'0 SUB 21'.8X,'INTENSITY'.6X,'POLARIZATION'//)
58. 40 FORMAT(F10.4,5E15.6,F15.4)
59. 45 FORMAT('0'.9X,'EFFICIENCY FACTOR FOR EXTINCTION'.E15.6)
60. 50 FORMAT('0'.9X,'EFFICIENCY FACTOR FOR SCATTERING'.E15.6)
61. 55 FORMAT('0'.9X,'EFFICIENCY FACTOR FOR ABSORPTION'.E15.6)
62. 60 FORMAT('0'.9X,'ASYMMETRY FACTOR'.E15.6//)
63.      END

```

F O R T R A N C R O S S R E F E R E N C E L I S T I N G

MAIN PROGRAM

NAME	USE	LINE NUMBER
10	DEFINED	49
	USED	5
12	DEFINED	50
	USED	6
20	DEFINED	51
	USED	24
25	DEFINED	52
	USED	25
30	DEFINED	54
	USED	26
35	DEFINED	56
	USED	27
40	DEFINED	58
	USED	28
45	DEFINED	59
	USED	39
50	DEFINED	60
	USED	40
55	DEFINED	61
	USED	41
60	DEFINED	62
	USED	42
90	DEFINED	5
	USED	44
95	DEFINED	12
	USED	7
100	DEFINED	14
	USED	12
150	DEFINED	23
	USED	18
200	DEFINED	32
	USED	30
210	DEFINED	38
	USED	34
1000	DEFINED	45
	USED	5
AIN	SPEC	4
	SET	20
	USED	21
AUX	SPEC	1
	SET	5
	USED	13
ALAM	SPEC	1
	SET	10
	USED	11
ASCMIE	USED	15
AVCSTH	SPEC	1
	SET	17
	USED	42
CON	SPEC	1
	SET	1
	USED	11
		22
		22
		28
		36

[illegible]

NAME	TYPE	MODE	RELATIVE ADDRESS	LOC COUNT	ELEMENT LENGTH	NUMBER OF ELEMENTS	COMMON SIZE	PROGRAM UNIT
10F	FORMAT	STMTNMBR	000005	4				MAIN PROGRAM
12F	FORMAT	STMTNMBR	000006	4				MAIN PROGRAM
20F	FORMAT	STMTNMBR	000010	4				MAIN PROGRAM
25F	FORMAT	STMTNMBR	000012	4				MAIN PROGRAM
30F	FORMAT	STMTNMBR	000040	4				MAIN PROGRAM
35F	FORMAT	STMTNMBR	000057	4				MAIN PROGRAM
40F	FORMAT	STMTNMBR	000107	4				MAIN PROGRAM
45F	FORMAT	STMTNMBR	000113	4				MAIN PROGRAM
50F	FORMAT	STMTNMBR	000127	4				MAIN PROGRAM
55F	FORMAT	STMTNMBR	000143	4				MAIN PROGRAM
60F	FORMAT	STMTNMBR	000157	4				MAIN PROGRAM
90L	USRDEFND	STMTNMBR	000004	1				MAIN PROGRAM
95L	USRDEFND	STMTNMBR	000026	1				MAIN PROGRAM
100L	USRDEFND	STMTNMBR	000044	1				MAIN PROGRAM
150L	USRDEFND	STMTNMBR	000110	1				MAIN PROGRAM
200L	USRDEFND	STMTNMBR	000142	1				MAIN PROGRAM
210L	USRDEFND	STMTNMBR	000171	1				MAIN PROGRAM
1000L	USRDEFND	STMTNMBR	000215	1				MAIN PROGRAM
AIN	REAL	ARRAY	003745	0	4	200		MAIN PROGRAM
AJX	REAL	SCALAR	004255	0	8			MAIN PROGRAM
ALAM	REAL	SCALAR	000323	0	8			MAIN PROGRAM
AVGCSH	REAL	SCALAR	000311	0	8			MAIN PROGRAM
CON	REAL	SCALAR	004261	0	8			MAIN PROGRAM
CTBRQS	REAL	SCALAR	004263	0	8			MAIN PROGRAM
ELTRMX	REAL	ARRAY	000325	0	8	800		MAIN PROGRAM
I	INTEGER	SCALAR	000313	0	4			MAIN PROGRAM
J	INTEGER	SCALAR	000314	0	4			MAIN PROGRAM
JJ	INTEGER	SCALAR	003741	0	4			MAIN PROGRAM
JMX	INTEGER	SCALAR	000310	0	4			MAIN PROGRAM
K	INTEGER	SCALAR	003744	0	4			MAIN PROGRAM
KMM	INTEGER	SCALAR	000315	0	4			MAIN PROGRAM
POLR	REAL	ARRAY	000320	0	4			MAIN PROGRAM
QAES	REAL	SCALAR	003425	0	4	200		MAIN PROGRAM
QEXT	REAL	SCALAR	004257	0	8			MAIN PROGRAM
QSCAT	REAL	SCALAR	000316	0	8			MAIN PROGRAM
RFI	REAL	SCALAR	003742	0	8			MAIN PROGRAM
RFR	REAL	SCALAR	003735	0	8			MAIN PROGRAM
THETD	REAL	SCALAR	003737	0	8			MAIN PROGRAM
X	REAL	ARRAY	000000	0	8	100		MAIN PROGRAM
		SCALAR	000321	0	8			MAIN PROGRAM

ENTRY POINTS

ENTRY 000000

1

EXTERNAL REFERENCES

IBUS\$ BDICALL\$ BDIREFS FMAINS FINITS FMTES\$ F2SESS ASCMIE FMTCS\$ FSTOPS\$
FEXITS

END FTM 144 IBANK 2526 DBANK

@RESUME.H

APPENDIX C

MAP LISTING OF ABSOLUTE ELEMENT ASCMIE

OMAP.S .CLASS.ASCMIE
 MAP 30:11 574111 11/24/80 12:52:54
 1. IN CLASS.MIECHK
 2. IN CLASS.ASCMIE
 3. LIB FTN.
 4. END

AFCM STATUS OF OUTPUT ELEMENT=UNKNOWN
 QUARTER-WORD SENSITIVE

ADDRESS LIMITS 001000 004037 1568 IBANK WORDS DECIMAL
 STARTING ADDRESS 001631 040000 142845 34214 DBANK WORDS DECIMAL

SEGMENT	SMAINS	001000	004037	040000	142845				
ERUS/ENAFIX									
M3PKTS									
F2RTNS									
F2ACTIVS/FORFTN									
F2TABX									
F2FCA									
FORCOMS/FORFTN									
F2CLOSE									
CERUS									
PMDSCOM(COMMONBLOCK)									
F2CON									
F2FRT									
WEKINTERFACE									
F2SCT									
F2INIT									
F2CDOCS									
F2EXIT									
F2IDENT									
CDDIVS/MATH									
DSINCOSS/MATH									
MOEROS(COMMONBLOCK)									
DSORTS/MATH									
MIECHK									
ASCMIE									

S(6) 14257 142611
S(012) 142612 142645

COMMON BANKS REFERENCED

0400038 0400003 0400025 0400002 0400001
SYSS*RLIBS. LEVEL 74R1
END MAP. ERRORS: 0 TIME: 12.263 STORAGE: 13896/3/030777/073777

0RESUME.H

APPENDIX D

SAMPLE OUTPUT FROM EXECUTION OF ABSOLUTE ELEMENT ASCMIE

ELEMENTS OF THE TRANSFORMATION MATRIX FOR A SPHERE WITH SIZE PARAMETER = 1570.79600

REFRACTIVE INDEX. REAL = .13420+001 IMAGINARY = .10000+000

ANGLE	M SUB 2	M SUB 1	S SUB 21	D SUB 21	INTENSITY	POLARIZATION
.0000	.154427+013	.154427+013	.154427+013	.000000	.154427+013	.0000
1.0000	.191006+009	.191972+009	.191488+009	.210217+006	.191489+009	.0025
2.0000	.147108+008	.150618+008	.148905+008	-.376930+006	.148663+008	.0118
3.0000	.128131+007	.158655+007	.142506+007	-.455865+005	.143393+007	.1064
4.0000	.199123+007	.226270+007	.212165+007	.646080+005	.212696+007	.0638
5.0000	.200562+007	.222034+007	.211025+007	-.336779+004	.211298+007	.0508
6.0000	.104769+007	.122670+007	.113276+007	-.447543+005	.113720+007	.0787
7.0000	.533631+006	.705286+006	.613227+006	-.177689+005	.619459+006	.1386
8.0000	.550585+006	.719071+006	.629207+006	.298967+004	.634828+006	.1327
9.0000	.557855+006	.716762+006	.632268+006	-.929962+004	.637308+006	.1247
10.0000	.422135+006	.573725+006	.491758+006	-.190622+005	.497930+006	.1522
11.0000	.327684+006	.478442+006	.395779+006	-.116908+005	.403063+006	.1870
12.0000	.318546+006	.469143+006	.389519+006	-.688259+004	.393845+006	.1912
13.0000	.301075+006	.449385+006	.367652+006	-.114045+005	.375230+006	.1976
14.0000	.256418+006	.403351+006	.321327+006	-.132425+005	.320884+006	.2227
15.0000	.228798+006	.376102+006	.290154+006	-.103056+005	.302450+006	.2435
16.0000	.217879+006	.365087+006	.281859+006	-.100957+005	.291483+006	.2525
17.0000	.199721+006	.346162+006	.262675+006	-.117313+005	.272941+006	.2683
18.0000	.179548+006	.325751+006	.241581+006	-.112776+005	.252651+006	.2893
19.0000	.167236+006	.313355+006	.228681+006	-.104599+005	.240296+006	.3040
20.0000	.155008+006	.301334+006	.216399+006	-.110323+005	.228571+006	.3183
21.0000	.142512+006	.287390+006	.202072+006	-.111154+005	.214951+006	.3370
22.0000	.131931+006	.276225+006	.190606+006	-.106396+005	.204033+006	.3535
23.0000	.122759+006	.266202+006	.180452+006	-.107497+005	.194480+006	.3688
24.0000	.113108+006	.255539+006	.169669+006	-.107599+005	.184324+006	.3864
25.0000	.104690+006	.246070+006	.160163+006	-.104803+005	.175384+006	.4031
26.0000	.971025+005	.237257+006	.151423+006	-.104550+005	.167180+006	.4192
27.0000	.896129+005	.228419+006	.142700+006	-.103483+005	.159019+006	.4364
28.0000	.820251+005	.220303+006	.134706+006	-.101477+005	.151614+006	.4531
29.0000	.766734+005	.212432+006	.127245+006	-.100567+005	.144583+006	.4697
30.0000	.707459+005	.204929+006	.120001+006	-.988153+004	.137837+006	.4867
31.0000	.652480+005	.197310+006	.113002+006	-.971707+004	.131524+006	.5034
32.0000	.602428+005	.190914+006	.106813+006	-.956611+004	.125578+006	.5203
33.0000	.555177+005	.184330+006	.100728+006	-.937711+004	.119928+006	.5371
34.0000	.511189+005	.178027+006	.942507+005	-.921292+004	.114573+006	.5538
35.0000	.470063+005	.171957+006	.894524+005	-.902452+004	.109482+006	.5706
36.0000	.431974+005	.166150+006	.842556+005	-.884445+004	.104674+006	.5873
37.0000	.396351+005	.160957+006	.790025+005	-.866333+004	.100096+006	.6040
38.0000	.363254+005	.155193+006	.740154+005	-.846393+004	.957668+005	.6206
39.0000	.332576+005	.149041+006	.701529+005	-.828110+004	.916492+005	.6371
40.0000	.304033+005	.145093+006	.659224+005	-.809161+004	.877481+005	.6535
41.0000	.277480+005	.140333+006	.616991+005	-.790212+004	.840403+005	.6698
42.0000	.252864+005	.135761+006	.580811+005	-.771314+004	.801238+005	.6860
43.0000	.230011+005	.131564+006	.544509+005	-.752451+004	.771826+005	.7020
44.0000	.208047+005	.127130+006	.510040+005	-.733765+004	.740115+005	.7178
45.0000	.189241+005	.123074+006	.477277+005	-.715150+004	.700992+005	.7335
46.0000	.171109+005	.119166+006	.446150+005	-.695791+004	.681337+005	.7489

47.0000	154354+003	.115409+006	.416570+005	-6.3654+04	.253217+003	.7641
48.0000	.136899+003	.111792+06	.386462+005	-6.0582+04	.624061+05	.7790
49.0000	.124334+003	.108315+006	.361751+005	-6.4255+004	.604830+05	.7936
50.0000	.111511+005	.104968+006	.336363+005	-6.25375+004	.581597+005	.8079
51.0000	.994507+004	.101748+006	.312235+005	-6.603182+004	.558469+05	.8219
52.0000	.837859+004	.986499+005	.289304+005	-5.91273+004	.537442+05	.8355
53.0000	.782527+004	.956676+005	.267507+005	-5.74659+004	.517465+05	.8488
54.0000	.689925+004	.927976+005	.246790+005	-5.56353+004	.498481+05	.8616
55.0000	.605904+004	.900335+005	.227059+005	-5.1237+04	.486443+05	.8740
56.0000	.529735+004	.873728+005	.208381+005	-5.25710+004	.463301+05	.8859
57.0000	.459133+004	.848107+005	.190590+005	-5.11372+004	.447010+005	.8973
58.0000	.396239+004	.823433+005	.173671+005	-4.96365+004	.431528+05	.9082
59.0000	.339620+004	.799668+005	.157601+005	-4.81688+004	.410815+005	.9185
60.0000	.288872+004	.776775+005	.142319+005	-4.67344+004	.402831+005	.9283
61.0000	.243312+004	.754723+005	.127792+005	-4.53333+004	.390541+005	.9375
62.0000	.203486+004	.733469+005	.113982+005	-4.39354+004	.376909+05	.9460
63.0000	.168155+004	.712991+005	.100368+005	-4.26303+004	.364263+005	.9539
64.0000	.137304+004	.693254+005	.883776+004	-4.13286+004	.353492+005	.9612
65.0000	.110636+004	.674229+005	.765157+004	-4.00592+004	.342646+005	.9677
66.0000	.878718+003	.655888+005	.652400+004	-3.88220+004	.332338+005	.9736
67.0000	.687495+003	.638204+005	.545216+004	-3.76167+004	.322540+005	.9787
68.0000	.530226+003	.621152+005	.443331+004	-3.64429+004	.313227+005	.9831
69.0000	.404596+003	.604706+005	.345485+004	-3.53002+004	.304376+005	.9867
70.0000	.308429+003	.593843+005	.254430+004	-3.41879+004	.295963+005	.9896
71.0000	.239679+003	.573539+005	.166532+004	-3.31058+004	.287968+005	.9917
72.0000	.196425+003	.558774+005	.837678+003	-3.20532+004	.280369+005	.9935
73.0000	.176861+003	.544526+005	.472536+002	-3.10295+004	.273147+005	.9933
74.0000	.179288+003	.530776+005	.703969+003	-3.00343+004	.266284+005	.9922
75.0000	.202111+003	.517503+005	.141790+004	-2.90670+004	.259762+005	.9904
76.0000	.243832+003	.504690+005	.209337+004	-2.81269+004	.253564+05	.9878
77.0000	.303042+003	.492320+005	.274109+004	-2.72135+004	.247675+005	.9844
78.0000	.378416+003	.480374+005	.335371+004	-2.63263+004	.242079+005	.9802
79.0000	.458712+003	.468833+005	.393580+004	-2.54645+004	.236762+005	.9753
80.0000	.572761+003	.457695+005	.440884+004	-2.46277+004	.231711+005	.9696
81.0000	.689465+003	.446930+005	.501424+004	-2.38152+004	.226912+005	.9632
82.0000	.817792+003	.436530+005	.551334+004	-2.30265+004	.222354+005	.9561
83.0000	.956776+003	.426491+005	.598742+004	-2.22609+004	.218024+05	.9483
84.0000	.110351+004	.416769+005	.643769+004	-2.15175+004	.213912+005	.9399
85.0000	.126313+004	.407382+005	.695530+004	-2.07968+004	.210006+005	.9307
86.0000	.142884+004	.398308+005	.727136+004	-2.00971+004	.206298+005	.9210
87.0000	.160186+004	.389535+005	.765591+004	-1.94184+004	.202777+005	.9107
88.0000	.178156+004	.391053+005	.802293+004	-1.87599+004	.199434+005	.8978
89.0000	.275753+004	.342638+005	.959175+004	-1.57533+004	.185106+005	.8510
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97.0000	.359993+004	.316154+005	.105804+005	-1.36602+004	.176076+005	.7955
98.0000	.381536+004	.310055+005	.107964+005	-1.31764+004	.174104+005	.7809
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102.0000	.468632+004	.287538+005	.115522+005	-1.13850+004	.167201+005	.7197
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