DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

# PORTING THE EXCITATION-EMISSION-MATRIX 3-D PLOTTING PROGRAM FROM APPLESOFT BASIC TO IBM COMPATIBLE GW-BASIC

Arnold F. Theisen

U.S. Geological Survey

Denver Federal Center, MS-964

Denver, Colorado 80225

Open-File Report 89-312

# PORTING THE EXCITATION-EMISSION-MATRIX 3-D PLOTTING PROGRAM FROM APPLESOFT BASIC TO IBM COMPATIBLE GW-BASIC

Excitation-emission-matrix (EEM) room temperature fluorescence has been a major tool for the study of the fluorescence properties of materials by members of the Luminescence Studies Project of the U.S. Geological Survey. The display of EEM data as a three dimensional perspective plot has been a key factor in the successful interpretation of these data. The in-house developed software to produce these 3-D plots has been hardware specific until now.

EEM fluorescence data generated with a Perkin-Elmer MPF-series spectrometer was collected and stored using a Cyborg Corporation Integrated System for Automated Acquisition and Control (ISAAC). The ISAAC owned by this project, uses an Apple II for a central processing unit (CPU). Although other ISAAC-CPU combinations are now available, this was not originally the case. For details of this setup see Theisen and Hemphill, 1985.

The 3-D perspective software has evolved from Apple II machine language and a program called A2-3D2 from SubLogic to an AppleSoft BASIC program using a simple algorithm obtained from "Microcomputer Graphics" (Myers, 1982). Included in the same book is a hidden-line removal algorithm, a feature the A2-3D2 package did not provide.

With any program that requires extensive calculations, as this one does, speed is an absolute necessity. To achieve an acceptable level of speed on the Apple II, a 10 MHz Motorola MC68000-based coprocessor board (PDQ II) from Enhancement Technology was purchased and installed. Data for the mineral Barite was collected and plotted (figure 1) in approximately one hour.

Recent collaborative efforts between this project and the Remote Sensing group from the U.S. Army Engineer Topographic Laboratories (ETL) has created a requirement, by ETL, to make the same kinds of measurements using an SLM-Aminco fluorescence spectrometer. The CPU for the SLM is an IBM-PC and all the microcomputers the ETL Remote Sensing group uses are either IBM-PC's or PC clones. The 3-D plotting software has, therefore, been ported to IBM-PC compatible GW-BASIC.

The original Apple II program (listing I) reads previously stored binary format EEM data, transforms 3-D data into a 2-D representation, and checks for hidden lines as the information is being plotted. Listing II is the GW-BASIC port of this program developed on a GRID-3 laptop microcomputer. While the Apple II version was coupled to a Houston Instrument (HI) plotter and therefore used HI plotter commands, the GW-BASIC version is set up for Hewlett-Packard (HP) and compatible plotters and uses HP Graphics Language (HPGL). The other major difference with the GW-BASIC program is that it reads previously stored ASCII format EEM data. For both listings, more than two spaces in a print statement are numbered inside brackets (e.g. [3] represents 3 spaces).

## REFERENCES

Myers, R.E., 1982, Microcomputer Graphics: Addison-Wesley Publishing Company, Reading, Mass., 282 pages.

Theisen, A.F. and Hemphill, W.R., 1985, Microcomputers in the luminescence laboratory: A technique for automating spectrometers: American Laboratory, v. 17, no. 9, p. 166-171.

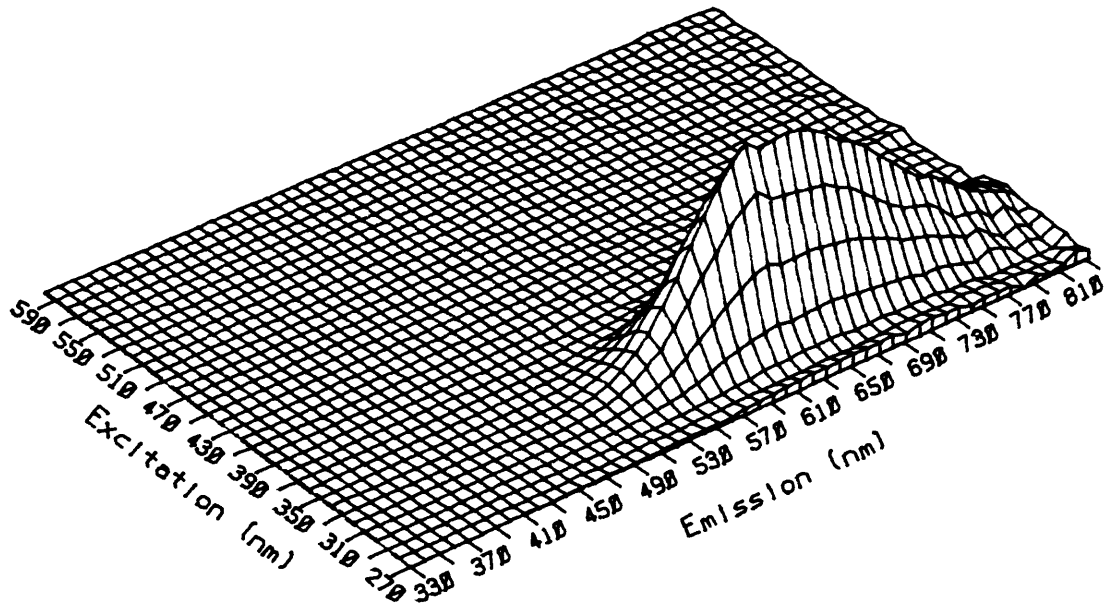


Figure 1. Excitation-emission-matrix plot example, the mineral Barite. Produced with an Enhancement Technology's PDQ II equipped Apple II on a Houston Instrument DMP-29.

Listing I (EEM 3-D PLOT)

```
  1   REM CHANGED 4/14/89
 10   GOTO 1000
 17   REM ***************************************************
 18   REM 3 - D  to  2 - D  translation routine
 19   REM ***************************************************
 20   TX =  - PX * S1 + PY * C1
 30   TY =  - PX * C1 * C2 - PY * S1 * C2 + PZ * S2
 40   TZ =  - PX * S2 * C1 - PY * S2 * S1 - PZ * C2 + RHO
 50   SX = (D * TX / TZ + 36.6050347) * 24.7680682 + 160
 60   SY = (D * TY / TZ + 25.2546018) * 23.4965782 + 1
 70   RETURN
 77   REM ***************************************************
 78   REM Houston Instrument line segment plot command
 79   REM ***************************************************
 80   SG$ = ";:A" +  STR$ (X + 280) + "," +  STR$ (Y + 75)
 90   PRINT SG$:
      SG$ = "":
      SG =  FRE (0)
100   RETURN
107   REM ***************************************************
108   REM Hidden line removal routine
109   REM ***************************************************
110   IF Y <  = MAX%#(X) THEN 140
120   IF QZ = 0 THEN  GOSUB 80:
      PRINT ";:D":
      QZ = 1
130   MAX%#(X) = Y:
      GOTO 180
140   IF Y >  = MIN%#(X) THEN 170
```

Listing I (EEM 3-D PLOT)

```
150   IF QZ = 0 THEN  GOSUB 80:
      PRINT ";:D":
      QZ = 1

160   MIN%#(X) = Y:
      GOTO 200

170   IF QZ = 1 THEN  GOSUB 80:
      QZ = 0:
      IF PU = 1 THEN  PRINT ";:U"

180   IF Y < MIN%#(X) THEN MIN%#(X) = Y

190   IF (PD = 0 AND X = X2) OR (PD = 1 AND Y = Y2) THEN 80

200   RETURN

210   PX = XA - .5:
      PY = YA - .5:
      PZ = ZA:
      GOSUB 20

220   XS =  INT (SX + .5):
      YS =  INT (SY + .5)

230   RETURN

240   PX = XB - .5:
      PY = YB - .5:
      PZ = ZB:
      GOSUB 20

250   XE =  INT (SX + .5):
      YE =  INT (SY + .5)

260   IF XS = XE THEN 360

270   SL = (YS - YE) / (XS - XE)

280   B = YS - SL * XS

290   X1 = XS:
      X2 = XE:
      Y1 = YS:
      IF XS > XE THEN X1 = XE:
      X2 = XS:
      Y1 = YE

300   PRINT ";:U":
      X = X1:
      Y = Y1:
      GOSUB 80:
      QZ = 0:
      PD = 0:
      IF PU = 0 THEN  PRINT ";:D"
```

Listing I (EEM 3-D PLOT)

```
310   FOR X = X1 TO X2

320   Y =  INT ((SL * X + B) + .5)

330   GOSUB 110

340   NEXT

350   GOTO 420

360   IF YS = YE THEN 420

370   Y1 = YS:
      Y2 = YE:
      X1 = XS:
      IF YS > YE THEN Y1 = YE:
      Y2 = YS:
      X1 = XE

380   PRINT ";:U":
      X = X1:
      Y = Y1:
      GOSUB 80:
      QZ = 0:
      PD = 1:
      IF PU = 0 THEN  PRINT ";:D"

390   FOR Y = Y1 TO Y2

400   GOSUB 110

410   NEXT

420   RETURN

427   REM ************************************************

428   REM Hidden line min/max array clearing routine

429   REM ************************************************

430   FOR XX = 1 TO 1969:
      MIN%#(XX) = 1757:
      MAX%#(XX) = 0:
      NEXT

440   RETURN

997   REM ************************************************

998   REM M A I N   P R O G R A M

999   REM ************************************************
```

Listing I (EEM 3-D PLOT)

```
1000    RHO = 10:
        THETA = .9:
        PHI = .9:
        D = 590:
        PU = 1:
        AF = 1

1020    S1 =  SIN (TH):
        C1 =  COS (TH):
        S2 =  SIN (PH):
        C2 =  COS (PH)

1040    TEXT :
        HOME :
        PRINT "E E M[3]3 - D[3]P L O T":
        PRINT :
        PRINT

1060    HIMEM: 33019

1080    DIM MAX%#(1969),MIN%#(1969):
        I$ =  CHR$ (1)

1100    GOSUB 430

1120    D$ =  CHR$ (13) +  CHR$ (4)

1140    PRINT "1st Filename= ";:
        CALL  - 657

1150    S$ = "":
        FOR WW = 512 TO 767:
        IF  PEEK (WW) <  > 141 THEN S$ = S$ +  CHR$ ( PEEK (WW) - 128)
        :
        NEXT

1160    DIM JP%(72,107)

1180    BA% =  PEEK (110) * 256 +  PEEK (109) - 15777

1200    PRINT D$"BLOAD"S$",A"BA%",D2"

1220    ML$ = "(x" +  STR$ ( INT ((1000 / JP%(13,0) + .05) * 10) / 10)
         + ")"

1240    INPUT "Do you want the time shown? (Y/N) ";TM$:
        PRINT :
        IF TM$ <  > "Y" AND TM$ <  > "N" THEN 1240

1260    INPUT "Do you want 180 rot.? (Y/N) ";PR$:
        PRINT :
        IF PR$ <  > "N" AND PR$ <  > "Y" THEN 1260

1280    INPUT "Ratio, Correction or Neither? (R/C/N) ";HC$:
        IF HC$ <  > "R" AND HC$ <  > "C" AND HC$ <  > "N" THEN 1280
```

Listing I (EEM 3-D PLOT)

```
1300    IF HC$ = "N" THEN 1880

1310    PRINT :
        PRINT "2nd Filename= ";:
        CALL  - 657

1320    S2$ = "":
        FOR WW = 512 TO 767:
        IF  PEEK (WW) <  > 141 THEN S2$ = S2$ +  CHR$ ( PEEK (WW) - 12
        8):
        NEXT

1340    DIM JP%#(72,107)

1350    FOR X = 0 TO 19:
        JP%#(X,0) = JP%(X,0):
        NEXT

1360    ST = 2:
        IF JP%(0,0) = 5 THEN ST = 1

1380    FOR X = 0 TO 72 STEP ST

1400    FOR M = 1 TO 107 STEP ST

1420    JP%#(X,M) = JP%(X,M)

1440    NEXT M:
        NEXT X

1450    BA% =  PEEK (110) * 256 +  PEEK (109) - 15777:
        PRINT D$"BLOAD"S2$",A"BA%",D2"

1460    IF HC$ = "R" THEN QL$ = "(x" +  STR$ ( INT ((1000 / JP%(13,0)
        + .05) * 10) / 10) + ")":
        GOTO 1500

1470    RX = JP%#(13,0):
        PRINT :
        PRINT "Select PEAK: A - (EX270,EM330)":
        PRINT "[13]B - (EX410,EM470)":
        PRINT "[13]C - (EX500,EM560)":
        PRINT "[13]D - yourEx,yourEm":
        GET PK$:
        ON ( ASC (PK$) - 64) GOTO 1480,1485,1490,1491

1475    IF  ASC (PK$) < 65 OR  ASC (PK$) > 67 THEN 1470

1480    XP = 6:
        MP = 7:
        GOTO 1495

1485    XP = 34:
        MP = 35:
        GOTO 1495
```

Listing I (EEM 3-D PLOT)

```
1490    XP = 52:
        MP = 53:
        GOTO 1495

1491    PRINT :
        INPUT "Enter Ex & Em WL ";XP,MP

1492    XP =  INT ((XP - 240) / 5):
        MP =  INT ((MP - 295) / 5)

1495    AF = JP%#(XP,MP) / JP%(XP,MP)

1500    MX = 0:
        MN = 100

1520    XS = JP%(1,0):
        IF JP%#(1,0) > XS THEN XS = JP%#(1,0)

1540    XS = (XS - 240) / 5

1560    XE = JP%(2,0):
        IF JP%#(2,0) < XE THEN XE = JP%#(2,0)

1580    XE = (XE - 240) / 5

1600    MS = JP%(3,0):
        IF JP%#(3,0) > MS THEN MS = JP%#(3,0)

1620    MS = (MS - 295) / 5

1640    ME = JP%(4,0):
        IF JP%#(4,0) < ME THEN ME = JP%#(4,0)

1660    ME = (ME - 295) / 5

1680    ST = 2:
        IF JP%(0,0) = 5 AND JP%#(0,0) = 5 THEN ST = 1

1700    FOR X = XS TO XE STEP ST

1720    FOR M = MS TO ME STEP ST

1740    IF JP%(X,M) = 0 AND HC$ = "R" THEN 1840

1760    IF HC$ = "R" THEN JP%(X,M) = (JP%#(X,M) / JP%#(13,0)) / (JP%(X
        ,M) / JP%(13,0)) * 1000 + .5

1780    IF HC$ = "C" THEN A = JP%#(X,M):
        B = JP%(X,M) * AF:
        JP%(X,M) = (A + 1000) / (B + 1000) * 1000 - 1000

1790    IF JP%(X,M) < 0 THEN JP%(X,M) = 0

1800    IF JP%(X,M) > MX THEN MX = JP%(X,M):
        JP%(14,0) = X:
        JP%(15,0) = M
```

Listing I (EEM 3-D PLOT)

```
1820    IF JP%(X,M) < MN THEN MN = JP%(X,M)

1840    NEXT M:
        NEXT X

1860    JP%(13,0) = MX:
        JP%(16,0) = MN:
        JP%(1,0) = XS * 5 + 240:
        JP%(2,0) = XE * 5 + 240:
        JP%(3,0) = MS * 5 + 295:
        JP%(4,0) = ME * 5 + 295

1880    MX = JP%(13,0):
        OV = JP%(16,0)

1890    IF HC$ = "C" THEN  PRINT :
        PRINT S$" original maximum was":
        PRINT RX / 10:
        JP%(5,0) = JP%#(5,0)

1900    PRINT :
        PRINT "Maximum Value (Default= "MX / 10")":
        PRINT "at Ex"5 * JP%(14,0) + 240"("JP%(14,0)"), Em"5 * JP%(15,
        0) + 295"("JP%(15,0)")";:
        INPUT "[4]";SS$:
        PRINT :
        IF SS$ <  > "" THEN MX =  VAL (SS$) * 10

1920    PRINT "Offset Value (Default= "OV / 10")";:
        INPUT " ";SS$:
        PRINT :
        IF SS$ <  > "" THEN OV =  VAL (SS$) * 10

1940    NF = 100 / (MX - OV)

1960    RL$ = "(x" +  LEFT$ ( STR$ (NF + .0005),4) + ")"

1980    PRINT :
        INPUT "Plot Small, Large or Cat. page (S/L/C) ";PLT$

2000    DT$ =  STR$ (JP%(9,0)) + "/" +  STR$ (JP%(10,0)) + "/" +  STR$
         (JP%(8,0))

2020    PRINT "Starting Ex (Default= "JP%(1,0);:
        INPUT ") ";SS$:
        PRINT :
        IF SS$ <  > "" AND  VAL (SS$) < JP%(1,0) THEN 2020

2040    IF SS$ <  > "" THEN JP%(1,0) =  VAL (SS$)

2060    PRINT "Ending Ex[3](Default= "JP%(2,0);:
        INPUT ") ";SS$:
        PRINT :
        IF SS$ <  > "" AND  VAL (SS$) > JP%(2,0) THEN 2060

2080    IF SS$ <  > "" THEN JP%(2,0) =  VAL (SS$)
```

Listing I (EEM 3-D PLOT)

```
2100    PRINT "Starting Em (Default= "JP%(3,0);:
        INPUT ") ";SS$:
        PRINT :
        IF SS$ < > "" AND VAL (SS$) < JP%(3,0) THEN 2100

2120    IF SS$ < > "" THEN JP%(3,0) = VAL (SS$)

2140    PRINT "Ending Em[3](Default= "JP%(4,0);:
        INPUT ") ";SS$:
        PRINT :
        IF SS$ < > "" AND VAL (SS$) > JP%(4,0) THEN 2140

2160    IF SS$ < > "" THEN JP%(4,0) = VAL (SS$)

2180    SS$ = "":
        ZZ = FRE (0)

2200    EL$ = "_"

2220    DQ% = (JP%(2,0) - JP%(1,0)) / 5

2240    DZ% = (JP%(4,0) - JP%(3,0)) / 5

2260    BL$ = ";:H A 100,10 S12+ "

2280    PRINT :
        PRINT "BE SURE PLOTTER IS SELECTED![2]THEN PRESS RETURN.":
        GET AZ$:
        PRINT

2300    PRINT D$"PR#1":
        PRINT I$"4D":
        PRINT I$"14B":
        PRINT ";:P1"

2320    IF PLT$ = "C" THEN PRINT ";:A W 0,75,2438,1825,0,970,1490,198
        0":
        GOTO 2500

2340    IF PLT$ = "S" THEN PRINT ";:EH":
        PRINT ";:ECM":
        PRINT ";:V40"

2350    IF PLT$ < > "S" THEN PRINT ";:V16"

2360    IF HC$ = "R" THEN PRINT BL$"("S$ML$" / "S2$QL$")";

2380    IF HC$ = "C" THEN PRINT BL$S$" (vs "S2$") ["PK$"][5]GAIN= " +
          STR$ (JP%(5,0) / 1000);

2400    IF HC$ = "N" THEN PRINT BL$S$"[5]"DT$"[5]GAIN= " + STR$ (JP%
        (5,0) / 1000);

2420    PRINT RL$EL$

2440    PRINT ";:HAD 0,1825 2438,1825 2438,0 0,0 U"
```

Listing I (EEM 3-D PLOT)

```
2460    IF TM$ = "Y" THEN  PRINT ";:H A 50,1750 S12+ "JP%(11,0)":" RIG
        HT$ ("00" +  STR$ (JP%(12,0)),2)EL$

2480    XA = 1:
        XB = XA

2500    ZA = 0:
        ZB = ZA

2520    BL$ = "":
        DT$ = "":
        ML$ = ""

2540    YA = 0

2560    YB = .7142857143

2580    GOSUB 210:
        GOSUB 240

2600    PRINT ";:U"

2620    XS$ =  STR$ ( INT ((XS + XE) / 2 + 32.5))

2640    YS$ =  STR$ ( INT ((YS + YE) / 2 + 95.5))

2660    BX$ = ";:A " + XS$ + "," + YS$ + " S(S5,NI,G0,X163,Y-130)"

2680    PRINT BX$"Excitation (nm)"EL$:
        BX$ = ""

2700    GOSUB 430

2720    XB = 1.025

2740    FOR I = 0 TO DQ% STEP 4

2760    YA = (DQ% - I) / DQ% * .7142857143

2780    YB = YA

2800    GOSUB 210:
        GOSUB 240

2820    PRINT ";:U"

2840    IF (I / 8 -  INT (I / 8)) > 1E - 5 THEN 2960

2860    SX$ =  STR$ (XE + 230):
        SY$ =  STR$ (YE + 70)

2880    N = JP%(1,0) + 5 * I:
        IF PR$ = "Y" THEN N = JP%(2,0) - 5 * I

2900    N$ =  STR$ (N)
```

Listing I (EEM 3-D PLOT)

```
2920    NX$ = ";:A " + SX$ + "," + SY$ + " S(S4,NI,G0,X163,Y-130)" + N
        $ + EL$

2940    PRINT NX$

2960    NEXT I:
        REM FOR AT 2740

2980    XB = 0

3000    YA = .7142857143:
        YB = YA

3020    GOSUB 210:
        GOSUB 240

3040    PRINT ";:U"

3060    XS$ =  STR$ ( INT ((XS + XE) / 2 + 175.5))

3080    YS$ =  STR$ ( INT ((YS + YE) / 2 - 149.5))

3100    BM$ = ";:A " + XS$ + "," + YS$ + " S(S5,NI,G0,X398,Y191)"

3120    PRINT BM$"Emission (nm)"EL$:
        BM$ = ""

3140    GOSUB 430

3160    YB = .7392857143

3180    FOR I = 0 TO DZ% STEP 4

3200    XA = (DZ% - I) / DZ%:
        XB = XA

3220    GOSUB 210:
        GOSUB 240

3240    PRINT ";:U"

3260    IF (I / 8 -  INT (I / 8)) > 1E - 5 THEN 3380

3280    SX$ =  STR$ (XE + 270):
        SY$ =  STR$ (YE + 30)

3300    N = JP%(3,0) + 5 * I:
        IF PR$ = "Y" THEN N = JP%(4,0) - 5 * I

3320    N$ =  STR$ (N)

3340    NX$ = ";:A " + SX$ + "," + SY$ + " S(S4,NI,G0,X398,Y191)" + N$
         + EL$

3360    PRINT NX$
```

Listing I (EEM 3-D PLOT)

```
3380    NEXT I:
        REM FOR AT 3180

3400    GOSUB 430

3420    DIM LP#((JP%(2,0) - JP%(1,0)) / JP%(0,0),1)

3440    IF PR$ = "Y" THEN  FOR I = JP%(4,0) TO JP%(3,0) STEP  - JP%(0,
        0):
        GOTO 3480

3460    FOR I = JP%(3,0) TO JP%(4,0) STEP JP%(0,0):
        REM Step X-Emission

3480    EM = (I - 295) / 5

3500    XB = (JP%(4,0) - I) / (JP%(4,0) - JP%(3,0))

3520    IF PR$ = "Y" THEN XB = (I - JP%(3,0)) / (JP%(4,0) - JP%(3,0))

3540    ZB = ZA

3560    XA = XB + JP%(0,0) / (JP%(4,0) - JP%(3,0)):
        IF (PR$ = "N" AND I = JP%(3,0)) OR (PR$ = "Y" AND I = JP%(4,0)
        ) THEN XA = XB

3580    YA = .7142857143:
        YB = YA

3600    GOSUB 210:
        GOSUB 240

3620    ZB = (JP%((JP%(1,0) - 240) / 5,EM) - OV) * NF / 320

3640    IF PR$ = "Y" THEN ZB = (JP%((JP%(2,0) - 240) / 5,EM) - OV) * N
        F / 320

3660    XA = XB:
        CJ = 0:
        PU = 0

3680    GOSUB 210:
        GOSUB 240

3700    PU = 1

3720    IF PR$ = "Y" THEN  FOR J = JP%(2,0) TO JP%(1,0) STEP  - JP%(0,
        0):
        GOTO 3760

3740    FOR J = JP%(1,0) TO JP%(2,0) STEP JP%(0,0):
        REM Step Y-Excitation

3760    EX = (J - 240) / 5

3780    YA = (JP%(2,0) - J) / (JP%(2,0) - JP%(1,0)) * .7142857143
```

Listing I (EEM 3-D PLOT)

```
3800    IF PR$ = "Y" THEN YA = (J - JP%(1,0)) / (JP%(2,0) - JP%(1,0))
        * .7142857143

3820    XS = LP#(CJ,0):
        YS = LP#(CJ,1)

3840    IF (PR$ = "N" AND I = JP%(3,0)) OR (PR$ = "Y" AND I = JP%(4,0)
        ) THEN  GOSUB 210

3860    YB = YA

3880    ZB = (JP%(EX,EM) - OV) * NF / 320

3900    GOSUB 240

3920    LP#(CJ,0) = XE:
        LP#(CJ,1) = YE:
        CJ = CJ + 1

3940    NEXT J:
        REM FOR AT 3740

3960    IF (PR$ = "N" AND I = JP%(3,0)) OR (PR$ = "Y" AND I = JP%(4,0)
        ) THEN ZB = ZA:
        YB = .7142857143:
        GOSUB 210:
        GOSUB 240

3980    FOR JJ = CJ - 2 TO 0 STEP  - 1

4000    XS = LP#(JJ,0):
        YS = LP#(JJ,1)

4020    XE = LP#(JJ + 1,0):
        YE = LP#(JJ + 1,1)

4040    GOSUB 260

4060    NEXT JJ:
        NEXT I:
        REM FOR AT 3980 (JJ) & 3460 (I)

4080    PRINT D$"PR#1":
        PRINT ";:EF":
        PRINT ";:HAU 3400,0":
        PRINT ";:@"

4100    PRINT  CHR$ (1)"R"

4120    PRINT D$"RUN MENU,S6,D1"
```

END Listing I (EEM 3-D PLOT)

Listing II (GW-BASIC EEM 3-D)

```
 997   REM ************************************************

 998   REM M A I N   P R O G R A M

 999   REM ************************************************

1000   RHO = 10:
       THETA = .9:
       PHI = .9:
       D = 590:
       PU = 1:
       AF = 1

1020   S1 =  SIN (THETA):
       C1 =  COS (THETA):
       S2 =  SIN (PHI):
       C2 =  COS (PHI)

1040       CLS:
        PRINT "E E M[3]3 - D[3]P L O T":
        PRINT :
        PRINT

1060   DIM MAX%(1969),MIN%(1969)

1080   GOSUB 7000

1100   INPUT "Filename= ";S$

1120   DIM EEM%(47,50)

1140       OPEN S$ FOR INPUT AS #1

1160   INPUT  #1, ;STRTEX,ENDEX,STRTEM,ENDEM,MAXIMUM,MINIMUM,MEAN,STD
       EV,DA,MO,YR,HR,MIN

1180   INPUT "Do you want the time shown? (Y/N) ";TM$:
       PRINT :
       IF TM$ <  > "Y" AND TM$ <  > "N" THEN 1180

1200   INPUT "Do you want 180 rot.? (Y/N) ";PR$:
       PRINT :
       IF PR$ <  > "N" AND PR$ <  > "Y" THEN 1200

1220   PRINT "Maximum Value (Default= "MAXIMUM")";:
       INPUT " ";SS$:
       PRINT :
       IF SS$ <  > "" THEN MAXIMUM =  VAL (SS$)

1240   PRINT "Minimum Value (Default= "MINIMUM")";:
       INPUT " ";SS$:
       PRINT :
       IF SS$ <  > "" THEN MINIMUM =  VAL (SS$)

1260   NF = 100 / (MAXIMUM - MINIMUM)
```

Listing II (GW-BASIC EEM 3-D)

```
1280    FOR XX = 0 TO 47

1300    FOR MM = 0 TO 50

1320    INPUT  #1, ;EEM:
        EEM%(XX,MM) =  INT ((EEM - MINIMUM) * NF + .5)

1340    IF EEM%(XX,MM) > 100 THEN EEM%(XX,MM) = 100

1360    IF EEM%(XX,MM) < 0 THEN EEM%(XX,MM) = 0

1380    NEXT MM

1400    NEXT XX

1420        CLOSE#1

1440    RL$ = "(x" +  STR$ (NF) + ")"

1460    DT$ =  STR$ (MO) + "/" +  STR$ (DA) + "/" +  STR$ (YR)

1480    PRINT "Starting Ex (Default= "STRTEX;:
        INPUT ")";SS$:
        PRINT :
        IF SS$ <  > "" AND  VAL (SS$) < STRTEX THEN 2020

1500    IF SS$ <  > "" THEN STRTEX =  VAL (SS$)

1520    PRINT "Ending Ex[3](Default= "ENDEX;:
        INPUT ") ";SS$:
        PRINT :
        IF SS$ <  > "" AND  VAL (SS$) > ENDEX THEN 1520

1540    IF SS$ <  > "" THEN ENDEX =  VAL (SS$)

1560    PRINT "Starting Em (Default= "STRTEM;:
        INPUT ") ";SS$:
        PRINT :
        IF SS$ <  > "" AND  VAL (SS$) < STRTEM THEN 1560

1580    IF SS$ <  > "" THEN STRTEM =  VAL (SS$)

1600    PRINT "Ending Em[3](Default= "ENDEM;:
        INPUT ") ";SS$:
        PRINT :
        IF SS$ <  > "" AND  VAL (SS$) > ENDEM THEN 1600

1620    IF SS$ <  > "" THEN ENDEM =  VAL (SS$)

1640    EL$ =  CHR$ (3)

1660    DQ% = (ENDEX - STRTEX) / 10

1680    DZ% = (ENDEM - STRTEM) / 10

1700    BL$ = "PA 720,560 SI .25,.35 LB"
```

```
1720    PRINT :
        PRINT "BE SURE PLOTTER IS SELECTED![2]THEN PRESS RETURN."

1740    AZ$ = INKEY$:
        IF  LEN (AZ$) = 0 THEN 1740

1760        OPEN"COM1:1200,E,7,1"AS#1

1780    PRINT  #1, "IN SP1 DI;"

1800    PRINT  #1, BL$S$"[5]"DT$"[5]"RL$EL$

1820    PRINT  #1, "PU PA 320,520 PD PA 320,7820 10072,7820 10072,520
        320,520 PU;"

1840    IF TM$ = "Y" THEN  PRINT  #1, "PA 520,7520 LB" STR$ (HR)":" RI
        GHT$ ("00" +  STR$ (MIN),2)EL$

1860    XA = 1:
        XB = XA

1880    ZA = 0:
        ZB = ZA

1900    BL$ = "":
        DT$ = "":
        ML$ = ""

1920    YA = 0:
        YB = .7142857143

1940    GOSUB 5000:
        GOSUB 6000

1960    PRINT  #1, "PU;"

1980    XS$ =  STR$ ( INT ((XS + XE) * 2 + 130))

2000    YS$ =  STR$ ( INT ((YS + YE) * 2 + 382))

2020    BX$ = "PA " + XS$ + "," + YS$ + " DI .7772,-.6293 LB"

2040    PRINT  #1, BX$"Excitation (nm)"EL$

2060    GOSUB 7000

2080    XB = 1.025

2100    FOR I = 0 TO DQ% STEP 2

2120    YA = (DQ% - I) / DQ% * .7142857143

2140    YB = YA

2160    GOSUB 5000:
        GOSUB 6000
```

Listing II (GW-BASIC EEM 3-D)

```
2180    PRINT  #1, "PU;"

2200    IF (I / 8 -  INT (I / 8)) > 1E - 5 THEN 2320

2220    SX$ =  STR$ (4 * XE + 780):
        SY$ =  STR$ (4 * YE + 320)

2240    N = STRTEX + 10 * I:
        IF PR$ = "Y" THEN N = ENDEX - 10 * I

2260    N$ =  STR$ (N)

2280    NX$ = "PA " + SX$ + "," + SY$ + "SI .25,.35 DI .9032,.429 LB"
        + N$ + EL$

2300    PRINT  #1, NX$"PU;"

2320    NEXT I

2340    XB = 0

2360    YA = .7142857143:
        YB = YA

2380    GOSUB 5000:
        GOSUB 6000

2400    PRINT  #1, "PU;"

2420    XS$ =  STR$ ( INT ((XS + XE) * 2 + 702))

2440    YS$ =  STR$ ( INT ((YS + YE) * 2 - 598))

2460    BM$ = "PA " + XS$ + "," + YS$ + "SI .25,.35 DI .9032,.429 LB"

2480    PRINT  #1, BM$"Emission (nm)"EL$

2500    GOSUB 7000

2520    YB = .7392857143

2540    FOR I = 0 TO DZ% STEP 2

2560    XA = (DZ% - I) / DZ%:
        XB = XA

2580    GOSUB 5000:
        GOSUB 6000

2600    PRINT  #1, "PU;"

2620    IF (I / 8 -  INT (I / 8)) > 1E - 5 THEN 2740

2640    SX$ =  STR$ (4 * XE + 1000):
        SY$ =  STR$ (4 * YE + 20)
```

Listing II (GW-BASIC EEM 3-D)

```
2660    N = STRTEM + 10 * I:
        IF PR$ = "Y" THEN N = ENDEM - 10 * I

2680    N$ =  STR$ (N)

2700    NX$ = "PA " + SX$ + "," + SY$ + "SI .2,.3 DI .9032,.429 LB" +
        N$ + EL$

2720    PRINT  #1, NX$"PU;"

2740    NEXT I

2760    GOSUB 7000

2780    DIM LP((ENDEX - STRTEX) / 10,1)

2800    IF PR$ = "Y" THEN 2900

2820    FOR I = STRTEM TO ENDEM STEP 10

2840    GOSUB 9000

2860    NEXT I

2880    GOTO 2960

2900    FOR I = ENDEM TO STRTEM STEP  - 10

2920    GOSUB 9000

2940    NEXT I

2960    PRINT  #1, "SP0"

2980    REM CLOSE #1

2990    END

2997    REM ************************************************

2998    REM 3 - D  to  2 - d   translation routine

2999    REM ************************************************

3000    TX =  - PX * S1 + PY * C1

3010    TY =  - PX * C1 * C2 - PY * S1 * C2 + PZ * S2

3020    TZ =  - PX * S2 * C1 - PY * S2 * S1 - PZ * C2 + RHO

3030    SX = (D * TX / TZ + 36.6050347) * 24.7680682 + 240

3040    SY = (D * TY / TZ + 25.2546018) * 23.4965782 + 131

3050    RETURN
```

Listing II (GW-BASIC EEM 3-D)

```
3497    REM ***************************************************
3498    REM Hewlett Packard line segment plot command
3499    REM ***************************************************
3500    PRINT  #1 ,"PA",(X + 280) * 4,",",(Y + 75) * 4,";"
3510    RETURN
3997    REM ***************************************************
3998    REM Hidden line removal routine
3999    REM ***************************************************
4000    IF Y <  = MAX%(X) THEN 4030
4010    IF QZ = 0 THEN  GOSUB 3500:
        PRINT  #1, "PD;":
        QZ = 1
4020    MAX%(X) = Y:
        GOTO 4070
4030    IF Y >  = MIN%(X) THEN 4060
4040    IF QZ = 0 THEN  GOSUB 3500:
        PRINT  #1, "PD;":
        QZ = 1
4050    MIN%(X) = Y:
        GOTO 4090
4060    IF QZ = 1 THEN  GOSUB 3500:
        QZ = 0:
        IF PU = 1 THEN  PRINT  #1, "PU;"
4070    IF Y < MIN%(X) THEN MIN%(X) = Y
4080    IF (PD = 0 AND X = X2) OR (PD = 1 AND Y = Y2) THEN 3500
4090    RETURN
5000    PX = XA - .5:
        PY = YA - .5:
        PZ = ZA:
        GOSUB 3000
5010    XS =  INT (SX + .5):
        YS =  INT (SY + .5)
5020    RETURN
```

```
 6000    PX = XB - .5:
         PY = YB - .5:
         PZ = ZB:
         GOSUB 3000

 6010    XE =  INT (SX + .5):
         YE =  INT (SY + .5)

 6020    IF XS = XE THEN 6120

 6030    SL = (YS - YE) / (XS - XE)

 6040    B = YS - SL * XS

 6050    X1 = XS:
         X2 = XE:
         Y1 = YS:
         IF XS > XE THEN X1 = XE:
         X2 = XS:
         Y1 = YE

 6060    PRINT  #1, "PU;":
         X = X1:
         Y = Y1:
         GOSUB 3500:
         QZ = 0:
         PD = 0:
         IF PU = 0 THEN  PRINT  #1, "PD;"

 6070    FOR X = X1 TO X2

 6080    Y =  INT ((SL * X + B) + .5)

 6090    GOSUB 4000

 6100    NEXT

 6110    GOTO 6180

 6120    IF YS = YE THEN 6180

 6130    Y1 = YS:
         Y2 = YE:
         X1 = XS:
         IF YS > YE THEN Y1 = YE:
         Y2 = YS:
         X1 = XE

 6140    PRINT  #1, "PU;":
         X = X1:
         Y = Y1:
         GOSUB 3500:
         QZ = 0:
         PD = 1:
         IF PU = 0 THEN  PRINT  #1, "PD;"
```

Listing II (GW-BASIC EEM 3-D)

```
6150    FOR Y = Y1 TO Y2

6160    GOSUB 4000

6170    NEXT

6180    RETURN

6997    REM ************************************************

6998    REM Hidden line min/max array clearing routine

6999    REM ************************************************

7000    FOR XX = 1 TO 1969:
        MIN%(XX) = 1757:
        MAX%(XX) = 0:
        NEXT

7010    RETURN

7997    REM ************************************************

7998    REM Excitation spectra loop routine

7999    REM ************************************************

8000    XX = (J - 230) / 10

8010    YA = (ENDEX - J) / (ENDEX - STRTEX) * .7142857143

8020    IF PR$ = "Y" THEN YA = (J - STRTEX) / (ENDEX - STRTEX) * .7142
        857143

8030    XS = LP(CJ,0):
        YS = LP(CJ,1)

8040    IF (PR$ = "N" AND I = STRTEM) OR (PR$ = "Y" AND I = ENDEM) THE
        N  GOSUB 5000

8050    YB = YA

8060    ZB = EEM%(XX,MM) / 320

8070    GOSUB 6000

8080    LP(CJ,0) = XE:
        LP(CJ,1) = YE:
        CJ = CJ + 1

8090    RETURN

8997    REM ************************************************

8998    REM Emission spectra loop routine
```

Listing II (GW-BASIC EEM 3-D)

```
8999    REM ************************************************

9000    MM = (I - 300) / 10

9010    XB = (ENDEM - I) / (ENDEM - STRTEM)

9020    IF PR$ = "Y" THEN XB = (I - STRTEM) / (ENDEM - STRTEM)

9030    ZB = ZA

9040    XA = XB + 10 / (ENDEM - STRTEM)

9050    YA = .7142857143:
        YB = YA

9060    GOSUB 5000:
        GOSUB 6000

9070    PX = (STRTEX - 230) / 10:
        QX = (ENDEX - 230) / 10

9080    ZB = EEM%(PX,MM) / 320

9090    IF PR$ = "Y" THEN ZB = EEM%(QX,MM) / 320

9100    XA = XB:
        CJ = 0:
        PU = 0

9110    GOSUB 5000:
        GOSUB 6000

9120    PU = 1

9130    IF PR$ = "Y" THEN 9180

9140    FOR J = STRTEX TO ENDEX STEP 10

9150    GOSUB 8000

9160    NEXT J

9170    GOTO 9210

9180    FOR J = ENDEX TO STRTEX STEP  - 10

9190    GOSUB 8000

9200    NEXT J

9210    IF (PR$ = "N" AND I = STRTEM) OR (PR$ = "Y" AND I = ENDEM) THE
        N ZB = ZA:
        YB = .7142857143:
        GOSUB 5000:
        GOSUB 6000
```

Listing II (GW-BASIC EEM 3-D)

```
 9220    FOR JJ = CJ - 2 TO 0 STEP  - 1

 9230    XS = LP(JJ,0):
         YS = LP(JJ,1)

 9240    XE = LP(JJ + 1,0):
         YE = LP(JJ + 1,1)

 9250    GOSUB 6020

 9260    NEXT JJ

 9270    RETURN
```

END Listing II (GW-BASIC EEM 3-D)