Ralph

To: Space Plasma Group

From: Matt Richter(User name: mjr)

Date: 5/26/87

## MAG - A PROGRAM DEALING WITH THE VARIANCE MATRIX

MAG is a program which takes magnetic field data supplied by a data file and computes the variance matrix. MAG then finds eigenvectors and eigenvalues for the matrix using JACOBI, a program copied from NUMERICAL RECIPES. The output from MAG is written to a file specified by the user and is easy to plot using MONGO.

Originally, I had planned to tie MAG in with NXTMAG. This proved difficult because the summary tapes which NXTMAG must read, are far too long to leave up on disk for days at a time. Instead MAG reads data from a file specified by the user which contains only the magnetic data desired. In other words, MAG reads from a file which is basically a summary tape stripped of all unnecessary data. This file is smaller than a summary tape and can be edited to eliminate wildshots.

When running MAG, the program prompts the user for the name of a preparatory file. This 'prep' file, made by the user, contains, in order:

(1) the number of minutes MAG should sum over (iavtim)

(2) the name of the input file which contains the data (infile)

(3) the name of the output file where the data will be dumped (outfil)

(4) the start time in the form of YR, DOY, HR, MIN, SEC, MSEC (jtb)

(5) the end time in the same format (ite)

See the example of a 'prep' file on the next page.

MAG can work on either the 1.92, 9.6, or 48 second averages depending on what is read from the summary tape to the input file. It forms an array called 'BSUM' which has nine active components, one for each of the six $B_iB_j$ and three for the $B_i$'s. In five minutes, 156 data points are used. The eigenvectors and eigenvalues are usually consistent to less than .1% and at most 3.0%. Next, EIGSRT, another program copied from NUMERICAL RECIPES, arranges the eigenvalues in order from largest to smallest. The eigenvectors are sorted corresponding to their respective eigenvalue. This means that $e_1$ is the eigenvector associated with the largest eigenvalue. The output from MAG is as follows:

(1) the time in decimal hours

(2) the square root of the trace of the variance matrix

(3) the ratio of the largest eigenvalue to the smallest eigenvalue, $\frac{\lambda_3}{\lambda_1}$

(4) the ratio of $\frac{\lambda_2}{\lambda_1}$

(5) and $\frac{\lambda_3}{\lambda_2}$

(6) the cosine of the angle between the eigenvector associated with the principal eigenvalue and the average B-field, cosine $\theta_1$

(7) cosine $\theta_2$

(8) and cosine $\theta_3$

Output is written to the file specified in the 'prep' file. Then the time is compared with the end time. If the end time is greater, i.e. the run is not over yet, MAG starts crunching the next 'iavtim' minutes of data. The output columns are easily plotted using MONGO (see the documentation for MONGO). MAG can take a long time to run because it is dealing with large amounts of data. My suggestion is to try a short run first, say a half hour, to convince yourself it is working and then a full run. MAG has not been designed to run across a day boundary.

There are several programs which are used in conjunction with MAG. The first is GETDAT which reads the summary tape and writes the data needed by MAG, the time in decimal hours and the magnetic data, to a file. GETDAT uses NXTMOD to read the summary file and is a fairly simple program. GETDAT prompts the user interactively for such things as the output file name, the start time and the end time. It is here that the user selects the desired data (48, 9.6, or 1.92 seconds). GETDAT is presently hardwired for the component averages, a comment indicates where to make the change for rms values. A second program used in conjunction with MAG is WILDFIRE. This program reads the same data as MAG. WILDFIRE compares each data point to the one immediately preceding it and if the difference is greater then 25%, writes the timetag to a file. The purpose of this is to find any bad points. These points can then be edited from the original data file. Points where there is only fill data '999.9999', can be edited out of the data file easily by using the search command. The data files are usually huge so editting is always a time consumming process.

My Makefile contains instructions to run MAG and GETDAT. The location of the summary tape in the Makefile must be correct for GETDAT to function. To run WILDFIRE, it is easiest to use the f77 command and the '<' and '>' commands to feed in the data and write out the times associated with questionable data.

## EXAMPLE OF A 'PREP' FILE

Here is an example of the input file MAG needs to run. The comments on the right explain what each line does. The 'prep' file is really this straightforward.

```
3.5                 the number of minutes MAG should sum over
day64.data          file with mag data read off summary tape by GETDAT
temp.data           output file which will be used by MONGO for plotting
1979                start time array  YR
64                                    DOY
4                                     HR
0                                     MIN
0                                     SEC
0                                     MSEC
1979                end time array    YR
64                                    DOY
7                                     HR
30                                    MIN
0                                     SEC
0                                     MSEC
```

This example goes from 4 AM on day 64 to 7:30 AM.

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Center for Space Research
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Room 37-695 617-253-4285

# OIT SOFTWARE MEMORANDUM No. 36

To: Plasma Group

From: John Belcher and Pam Milligan

Subject: Reading 1.92, 9.6, and 48 sec Field Averages from a Summary Tape

Date: May 14, 1986

To read magnetic field averages from a Summary Tape, we use NXTMAG instead of NXTSUM. The calling argument of NXTMAG is identical to that of NXTSUM, with the field averages appearing in the ANS array as described below. The user only obtains one type of field average at a time, either 48 sec, 9.6 sec, or 1.92 sec averages. The kind of average is determined by calling SETBFL(I) before the first call to NXTMAG, with I = 1,2,3 corresponding to 48, 9.6, or 1.92 sec averages.

The variables returned in ANS are:

| WORD | MNEMONIC | DESCRIPTION |
|---|---|---|
| 1 a) | | number of words in ANS array |
| 1 b) | | tally of the calls to NXTMAG |
| 2 | F1 | averages of detail point magnitudes in gammas |
| 3 | | $((RMS_R)^2 + (RMS_T)^2 + (RMS_N)^2)^{1/2}$ |
| 4 | BR | R component of the B field |
| 5 | BT | T component of the B field |
| 6 | BN | N component of the B field |
| 7-9 | RMS | rms vector in gammas |
| 10 | RATEB | time period of field average (i.e., 48, 9.6 or 1.92 sec.) |
| 11 | N | number of samples in this average |

Fill values are 999.

To use NXTMAG with HITIME, we have created routines called DTMAG and QAMAG, which are of the generic type DATTIM abd QUATST as described in the HITIME documentation. These routines call NXTMAG, and are stored in a common file called DTMAG. In addition to the above quantities, QAFAKE checks for fill, computes ATAN2(BT,BN) (-180° to 180°), ATAN2(BN, $\sqrt{BT^2 + BR^2}$) (-90° to 90°), and $\sqrt{BR^2 + BT^2 + BN^2}$, and stores them in ANS(140, 141, 142). DTMAG returns these values to HITIME with JTLMOD=1. SETBFL should be called from the main routine, before the call to HITIME. In CMS, load NXTMAG. At present, there is a bug on CMS such that the second execution over the same time period

will not find that time period (but can find subsequent time periods). IPL CMS will enable you to go back to the same period.

To create a file that NXTMAG will read, one must copy a Summary tape to a disk file by using CPYTPD (found in PLS). This creates a FORTRAN-readable tape image that is read by RDFTPDM instead of BAT7. Because Summary tapes are IBM labeled, the following is currently the best method for putting one up on disk:

```
.
.
.
//LKED.SYSIN DD *
       INCLUDE SYSLIB(CPYTPD)
       INCLUDE SYSLIB(BAT7)
       ENTRY MAIN
/*
//GO.FT01F001 DD LABEL=(,BLP),UNIT=T6250,
//     VOL=SER=(Summary Tape Input)
//GO.FT02F001 DD DISP=OLD,DSN=CSR.$380340.YOUR.FILE
//GO.FT02F002 DD DISP=MOD,DSN=CSR.$380340.YOUR FILE
//GO.FT02F003 DD DISP=MOD,DSN=CSR.$380340.YOUR.FILE
//GO.FT02F004 DD DUMMY
```

Writing to FT02F001 puts the IBM label into the disk file; writing to FT02F002 (using the MOD option) appends the data records to this same file. The IBM trailer is appended to the file by writing to FT02F003. One prevents the generation of a non-fatal error message by dummying out FT02F004.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Center for Space Research
April 5, 1984

*LIBRARY PLS*

MEMORANDUM

**TO:** MJS Internal

**FROM:** George S. Gordon, Jr.

**SUBJECT:** $DATE

**PURPOSE**

To provide a listing of all routines that are loaded from the PLASMA GROUP libraries, along with the library name ad load date.

**METHOD**

$DATE is a Fortran callable subroutine written in assembler. It is called by the statement, '  CALL $DATE '. $DATE scans through core from the lowest location it can find using a trace back, (this implies that it is a good idea to have either your MAIN program or $date as the first program loaded) to the highest loction it can find, seignified by the common block $$$$h$. Within this area of core, $DATE look for the words '$$DATE$$', that sre inserted by the macro DATE XEDIT which is called by UPDAT EXEC. When found, $DATE calls $WRR, a Fortran subroutine, to write out the subroutine name, library name, date and time associated with this version of the routine.

AREAMN
LIBRARY: MJS

**FUNCTION:** AREAMN

**DATE:** April 6, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To set up the area table for the main sensor

"AREAMN" is a function used by "SETART" or "ARGEN" to set up the area table for the main sensor (for use in "PMODEL"). This function uses "OAREA" to compute the area overlap.

```
FUNCTION AREAMN(X,Y)
11/4/78   VMV
OBTAINS AREA OF VOYAGER MAIN SENSOR AS FUNCTION
OF X=VX/VZ,Y=VY/VZ
CUP COORDINATES
VZ.GT.0  PARTICLE MOVES INTO CUP
VY.GT.0  PARTICLE MOVES TOWARD SYMMETRY AXIS
```

ARGEN
LIBRARY: MJS

**PROGRAM:** ARGEN

**DATE:** April 6, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To generate the area table for the sensors

This main routine generates the area tables for the main sensor and side sensor, writing them out to units 21 and 22, respectively. (The code is a modified version of "SETART" in the module "PGENER").

ARLIST
LIBRARY: MJS

**PROGRAM:** ARLIST

**DATE:** April 6, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To list the area tables

Program to list area tables for main and side sensors used by "PMODEL". Calls "SETART" to access tables.

ARMAIN
LIBRARY: MJS

**FUNCTION:** ARMAIN

**DATE:** April 6, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To obtain the area of the main sensor

"ARMAIN" is called by "CPRESP" in the 'PMODEL' package to obtain the effective area of the main sensor.

```
FUNCTION ARMAIN(X,Y)
12/26/78   VMV
OBTAINS AREA OF VOYAGER MAIN SENSOR AS FUNCTION OF
   X=VX/VZ AND Y=VY/VZ IN CUP COORDINATES
      BY LINEAR INTERPOLATION IN 2-DIMENSIONAL LOOK-UP TABLE
VZ.GT.0 PARTICLE MOVES INTO CUP
VY.GT.0 PARTICLE MOVES TOWARD SYMMETRY AXIS

LOOK-UP TABLE FOR AREA OF MAIN SENSOR
TABLMN(IX,IY)= AREA OF MAIN SENSOR AT X=VX/VZ8 Y=VY/VZ
NSTPX, NSTPY SIZE OF ARRAY IN X,Y
DSTPX= STEP SIZE IN X,    DSTPY= STEP SIZE IN Y
XMAX,YMIN,YMAX   LIMITS BEYOND WHICH AREA IS ZERO
PRESUME  XMIN=0.     AREA SAME FOR +X,-X
```

ARSIDE
LIBRARY: MJS

**FUNCTION:** ARSIDE

**DATE:** April 6, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To obtain the area of the side sensor

"ARSIDE" is called by "CPRESP" in the 'PMODEL' package to obtain the effective area of the side sensor.

```
FUNCTION ARSIDE(DAS,DSC)
12/30/78
COMPUTES AREA ,IN SQ.CM, OF VOYAGER SIDE SENSOR

DAS=RELATIVE DISPLACEMENT OF APERTURE AND SHIELD
    CIRCLE CENTERS, CM
DSC=RELATIVE DISPLACEMENT OF SHIELD AND COLLECTOR
    CIRCLE CENTERS, CM


LOOK-UP TABLE FOR AREA OF SIDE SENSOR

 TABLSD(IAS,ISC) = AREA OF SIDE SENSOR AT (DAS,DSC)
 NDAS,NDSC SIZE OF ARRAY
 DDAS,DDSC RESPECTIVE STEP SIZEA
```

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Center for Space Research
April 20, 1984

*LIBRARY PLS*

**MEMORANDUM**

**TO:** MJS Internal

**FROM:** George S. Gordon, Jr.

**SUBJECT:** CLRTEK

**PURPOSE**

To CLeaR a TEKtronix screen and move the cursor to the home position.

CUPINT
LIBRARY: MJS

**MODULE:** CUPINT

**DATE:** April 6, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To simulate the response of the main sensor to a cold convected Maxwellian plasma.

The module "CUPINT" contains the following subroutines:

1) CUPINT
2) TRANSP
3) AREAOV

"CUPINT" has been modified to always initialize the output array "DIST" to zero before filling it with calculated values. (RLM 4/6/84)

---

SUBROUTINE CUPINT(DN,W,U,A,Z,MODE,NCHN,SS,LDIST,DIST)

THIS SUBROUTINE SIMULATES THE RESPONSE OF THE VOYAGER PLS EXPERIMENT MAIN SENSOR TO A COLD (M>5) CONVECTED MAXWELLIAN PLASMA. THE COMMON BLOCKS ARE FILLED BY THE SUBROUTINE CONRD, WHICH MUST BE CALLED BEFORE THE FIRST CALL TO CUPINT.

---

SUBROUTINE TRANSP(X,Y,P1,P2,T)

THIS SUBROUTINE COMPUTES THE GRID TRANSPARENCY FOR THE MAIN SENSOR.

---

SUBROUTINE AREAOV(X,Y,P1,P2,R)

THIS SUBROUTINE COMPUTES THE SENSITIVE AREA FOR THE MAIN SENSOR USING THE TRAPEZOIDAL APPROXIMATION.

**MODULE:** DCPINT

**DATE:** April 6, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To simulate the response of the side sensor to a cold convected Maxwellian plasma.

The module "DCPINT" contains the following subroutines:

1) DCPINT
2) TRNSPD
3) CLAROV
4) SHIFT

"DCPINT" has been modified to always initialize the output array "DIST" to zero before filling it with calculated values. (RLM 4/6/84)

---

SUBROUTINE DCPINT(DN,W,U,A,Z,MODE,NCHN,SS,LDIST,DIST)

THIS SUBROUTINE SIMULATES THE RESPONSE OF THE VOYAGER PLS EXPERIMENT SIDE SENSOR TO A COLD (M>5) CONVECTED MAXWELLIAN PLASMA. THE COMMON BLOCKS ARE FILLED BY THE SUBROUTINE CONRD, WHICH MUST BE CALLED BEFORE THE FIRST CALL TO CUPINT.

---

SUBROUTINE TRNSPD(PSI,PHI,P1,P2,T)

THIS SUBROUTINE COMPUTES THE GRID TRANSPARENCY FOR THE SIDE SENSOR.

---

SUBROUTINE CLAROV(R2,RL,RS,D,A)

THIS SUBROUTINE COMPUTES THE COMMON AREA OF TWO CIRCLES.

---

SUBROUTINE SHIFT(PSI,P1,P2,DCA,DCG,DAG)

THIS SUBROUTINE COMPUTES THE SHIFT FUNCTIONS FOR THE SIDE SENSOR

**SUBROUTINE:** DISPLD

**DATE:** April 9, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To use in PMODEL for the side sensor

"DISPLD" is used in the "PMODEL" package for the side sensor:

```
SUBROUTINE DISPLD(V,U,UU,SUP,DAS,DSC)
    12/30 78   VMV
COMPUTES RELATIVE DISPLACEMENT OF APERTURE, SHIELD, AND COLLECTOR
   PROJECTED ALONG BEAM IN VOYAGER SIDE SENSOR
     V=VELOCITY VECTOR, CUP COORDINATES
     U= PARTICLE ENERGY ASSOCIATED WITH VZ, IN EV
     UU=MODULATOR VOLTAGE
     SUP=SUPPRESSOR VOLTAGE
     DAS=APERTURE-SHIELD DISPLACEMENT, IN CM
     DSC=SHIELD-COLLECTOR DISPLACEMENT, IN CM

 CONSTANTS
     TAS=APERTURE-SHIELD DISTANCE
     TSC=SHIELD-COLLECTOR DISTANCE,  CM
     EAS=SEPARATION OF GROUNDED GRIDS ABOUT MODULATOR, CM
        (BUCK-OUT IGNORED, TREATED AS GROUND)
     ESC=SAME, SUPPRESSOR
        DATA TAS/4.60756/,TSC/1.45034/,EAS/2.0955/,ESC/0.83566/

*****NOTE*****
SUPPRESSOR ASSUMED NEXT TO SHIELD. IF NEXT TO COLLECTOR
INSTEAD, VALUE OF ESC SHOULD BE 1.41224.
```

DISPLN
LIBRARY: MJS

**FUNCTION:** DISPLN

**DATE:** April 9, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To use in PMODEL for the main sensor

"DISPLN" is used in the "PMODEL" package for the main sensor:

```
FUNCTION DISPLN(U,UU,SUP)
  11/13/78   VMV
  REVISED 12/30/78   VMV
COMPUTES BEAM DISPLACEMENT IN VOYAGER MAIN SENSOR,
AS FACTOR MULTIPLYING VX/VZ,VY/VZ
   U= PARTICLE ENERGY ASSOCIATED WITH VZ, IN EV
   UU=MODULATOR VOLTAGE
   SUP=SUPPRESSOR VOLTAGE

CONSTANTS IN SHIFT FORMULA, MAIN SENSOR
   DATA EP/0.3717/,ES/0.1958/,EG/0.0929/
```

Library: PLS

What about JCAT=5. ?

July 2, 1984

Subroutine: DTJPDC (ANS, JTB, JDATA, JNE, LSTAT, JTLMOD, JCLK, TEMP, IEOD, IL, ITYPE)

Author: J. Belcher and R. Selesnick

Purpose: This is a routine to read the combined analysis records for the Jupiter encounter. These records have been submitted to the National Space Science Data Center (documentation entitled, "Voyager Plasma Science Analysis Tape", January, 1983, hereafter referred to as DCDOC). This routine reads the records and returns the information in a form suitable for use with HITIME. It is a version of the subroutine DATTIM which is called by HITIME and is meant to provide data and time points. It also computes some additional parameters not on the original tape, such as pressures, Alfvén Mach numbers and the "best" ion density estimate.

Usage: The information is returned in the answer array (ANS) which is dimensioned up to 150. The location of the information in the array depends on the mode of measurement which is identified by the variable JTLMOD. The time of measurement is returned in the time array JTB. The full definition of this and the other call variables is given in the documentation of HITIME. Following are the locations of information in the answer array for each possible value of JTLMOD.

L-Mode: JTLMOD = 1

[ANS(1) → ANS(40) contain information from JMOD = 1, JCAT = 1 records (the L-mode moment analysis), as described in DCDOC]

ANS(1): Radial distance of the s/c from Jupiter, in Jovian radii (1 $R_J$ = 71,372 km), at the beginning time of the mode.

ANS(2): System III latitude of the s/c, degrees

ANS(3): System III longitude of the s/c, degrees

ANS(4): Cup number from which moment density derived (1,2,3,4 is A,B,C,D cup). This is 4 in the middle magnetosphere, switching to 1,2 or 3 near closest approach. For analysis, we chose that cup which has maximum response to a cold corotating beam.

ANS(5): Response r of the chosen cup to a cold corotating cold beam ($0. \leq r \leq 1.$, and r is 1. at normal incidence).

ANS(6): Component of properly aberrated rigid corotation velocity into the chosen cup, in km/sec.

ANS(7): Estimate of $N_+$, using rigid corotation for an estimate of $V_n$ (from ANS(6), with $A_{eff}$ = 67.34 $cm^2$ for the main cluster and $A_{eff}$ = 56.24 cm2 for the side sensor (see Voyager Memo #99).

ANS(8): Estimate of $N_m = \Sigma A_i N_i$, not reliable.

ANS(9): Estimate of solar wind or magnetosheath proton density from A cup of main sensor, computed using standard solar wind scheme (Bridge et al., 1977). Not useful in the magnetosphere.

ANS(10): Gain state of the instrument (not useful to the general user)

ANS(11): Capacitor state (not useful)

ANS(12): Conversion factor from digital numbers to femtoamps (not useful).

ANS(13): Cylindrical radial component of magnetic field at the time of peak current in this positive ion spectrum.

ANS(14): Cylindrical azimuthal component of magnetic field.

ANS(15): Cylindrical Z-component of magnetic field, where z-axis is parallel to Jovian rotation axis.

ANS(16): Fill (Z7FFFFFFF)

ANS(17): Number of current channels used in computing density.

ANS(18) → ANS(27): Fill

ANS(28): Angle in degrees between the projection of the magnetic field in the r -z plane and the r -axis, positive toward +z ($-180^{\circ}$ to $180^{\circ}$).

ANS(29): Angle in degrees between the magnetic field and its projection in the r -z plane, positive toward corotation ($-90^{\circ}$ to $90^{\circ}$).

ANS(30): Fill

ANS(31): Energy density of the magnetic field in units of $10^{-10}$ dynes/cm$^2$

ANS(32): Magnitude of the magnetic field (nanotesla).

ANS(33): The "best" ion moment density estimate, computed from the last contiguous M-mode and the current L-mode (with the time for the current L-mode, even though it may be an M-mode density). ANS(33) is the L-mode density except after day 63.1300 on Voyager 1 and between 2100 and 2200 on day 190 on Voyager 2. In the intervals where it is not the L-mode density, it is the larger of the current L-mode density and the last M-mode density (contiguous). This density is also corrected to corotation inside of 17.5 $R_J$ and a constant 200 km/s outside of 17.5 $R_J$. On Voyager 1, day 63, 0000 to 0500, densities greater than 2/cc are eliminated. On Voyager 2, the 2/8 LECP hits on day 189 are eliminated. This density is the density plotted--the JGR article of McNutt et al., except for the cup area correction of 1.21. NOTE: TO GET L/M COMPARISON, MUST ALSO BE PLOTTING M-MODE DATA WITH HITIME.

ANS(34): Fill

ANS(35): Fractional difference between ANS(33) and last contiguous electron density. NOTE: TO GET COMPARISON, MUST ALSO BE PLOTTING ELECTRON DATA.

ANS(36) → ANS(40): Fill

ANS(41) → ANS(80) Contain middle magnetosphehre fit information from JMOD=1, JCAT=2 records (McNutt's L-mode fits), as described in DCDOC]

IA = 8 * (I-1), I = 1,2,3 for Ith positive ion species.

ANS(41 + IA): fit density of the I-th species, number/cc, correct for a side sensor area of 56.24 $cm^2$.

ANS(42 + IA): uncertainty in density, fraction

ANS(43 + IA): fit velocity component into the D-sensor (same for all species), in km/sec. Fill if optimal cup is not D-cup.

ANS(44 + IA): uncertainty in velocity component, fraction

ANS(45 + IA): fit thermal speed for the I-th species, in km/sec

ANS(46 + IA): uncertainty in thermal speed, fraction

ANS(47 + IA): mass number for I-th species

ANS(48 + IA): charge number for I-th species

ANS(65): Ratio of kinetic to field energy density (square of Alfvén Mach number)

ANS(66): Alfvén Mach number

ANS(67): Sonic Mach number with respect to protons

ANS(68): Guess for proton density based on three channels, number/cc

ANS(69): Guess for proton velocity component, km/sec

ANS(70): Guess for proton thermal speed, km/sec

ANS(70 + I): Temperature of $I^{th}$ species (eV)

ANS(74): Pressure due to all three species (erg/$cm^3$)

ANS(75): Fill

ANS(76): Effective mass density (amu/$cm^3$), as in McNutt's JGR article.

ANS(77): Effective charge density (elementary charges/$cm^3$), as in JGR article.

ANS(78): Effective mass density/proton mass density

ANS(79): Difference between the velocity component into the D-cup and the component of rigid corotation velocity into the D-cup in units of the fit thermal speed of the third species. Fill if optimal cup not D-cup.

ANS(80): Measured ratio of actual rotation component to rigid corotation component. Fill if optimal cup is not D-cup.

ANS(81) → ANS(150): Fill

M-Mode: JTLMOD = 2

[ANS(1) → ANS(80) contain information from JMOD=2, JCAT=1 records (M-mode moment analysis) and JMOD=2, JCAT=2 (McNutt's M-mode fits), as described in DCDOC].

ANS(1): → ANS(80): same as for L-mode, with the following exceptions:

ANS(68, 69, 70 and 78): now fill

ANS(67): Sonic Mach number with respect to third species in McNutt's M-mode fits.

ANS(75): Velocity difference due to spacecraft potential based on current M-mode fit velocity of heavy species and recent L-mode proton velocity component estimate (within last 600 seconds) normalized to thermal speed of third component in M-mode fit.

[ANS(81)→ (ANS(115): contain Io torus fit information from JMOD=2, JCAT=3 or 4 (Bagenal's M-mode fits), as described in DCDOC)]

ANS(81): Cup number from which data taken

ANS(82): Number of positive ion species fit (always 5).

ANS(83): Undefined flag.

ANS(84): Undefined flag

ANS(85) → ANS(89): Mass numbers of five species based on a main sensor area of 67.34 $cm^2$.

ANS(90) → ANS(94): Charge numbers of five species based on a main sensor area of 67.34 $cm^2$.

ANS(95) → ANS(99): Fit number densities of the five species.

ANS(100)→ ANS(104): Velocity component into the sensor of the five species (all the same, not a fit parameter).

ANS(105)→ ANS(109): Fit thermal speeds of the five species.

ANS(110): Fill

ANS(111): Effective mass ($amu/cm^3$)

ANS(112): Average temperature weighted by number density (eV) (corrected for the factor of 2 error)

ANS(113): Alfvén Mach number

ANS(114): Sonic Mach number based on thermal speed of third species (corrected by $\sqrt{2}$).

ANS(115): Ratio of kinetic to field energy density (Alfvén Mach number squared).

ANS(116)→ ANS(150): Fill

[NOTE: In the original documentation DCDOC, A(20→24) and A(25→29) were defined in the wrong order].

Electron Moment and fit parameters: JTLMOD = 3

ANS(1): Core fit density (number/$cm^3$)

ANS(2): Core fit temperature (eV)

ANS(3): $X^2$ for core fit

ANS(4): Halo fit density (number/$cm^3$)

ANS(5): Halo fit temperature (eV)

ANS(6): $X^2$ for halo fit

ANS(7): S/C potential from fit

ANS(8): Total fit density (sum of 1 and 4)

ANS(9): Total fit temperature (density weighted average of 2 and 5)

ANS(10): Moment density, #/cc (integration over observed distribution function)

ANS(11): Moment temperature, eV (second moment of observed distribu;tion function)

ANS(12): S/C potential from fits

ANS(13): Angle between D-cup normal and magnetic field direction

ANS(14): Angle between D-cup normal and s/c sun line

ANS(15): Fill

ANS(16): Estimate of total electron feed-through current (into positive ion mode) in main sensor due to fit electrons (halo + core), femtoamps

ANS(17): Average energy of electron feed-through spectrum in main sensor, eV

ANS(18): Inverse of the average of 1/energy of electron feed-through spectrum, in main sensor, eV

ANS(19 → 21): Same as 16 → 18, except for side sensor

ANS(22 → 24): Same as 16 → 18, main sensor, except using moment density and temperature taken as a single Maxwellian to compute feed through (a bad approximation, useful for an upper limit estimate)

ANS(25 → 27): Same as 22 → 24, except for side sensor

ANS(28): Ratio of core to halo feed-through current, side sensor

ANS(29): Fill

ANS(30): Fill

ANS(31): Electron pressure based on fit core pressure plus fit halo pressure ($10^{-10}$ erg/cm$^3$)

ANS(32): Field strength in nanotesla that would yield above pressure

ANS(33): Electron feed-through density into positive ion mode for D-cup using ANS(19) for feed-through current. Best estimate of this density.

ANS(34): Same as ANS(33) using ANS(25) for feed-through current. Upper limit.

ANS(35) → (150): Fill

The following subroutine is stored in the same module as DTJPDC

Subroutine: SPNJDC (JTB,IND,SEC,X,IEOD,TRAJ)

This is a version of SPEIND for use in processing Jupiter Data Center records using the subroutine DTJPDC. SPEIND is a subroutine called by HITIME which specifies the independent variable to be plotted and returns its value corresponding to the supplied time.

The independent variable is specified by the integer variable IND which can take on values from one to five corresponding to the independent variables given below:

IND = 1: Time

IND = 2: Undefined

IND = 3: Spherical radius in $R_J$ with change of sign after closest approach

IND = 4: Cylindrical radius in $R_J$ with change of sign after CA

IND = 5: Base ten logarithm of spherical radius with change of sign after closest approach

The value of the independent variable is returned in the real variable X. If the independent variable is time (IND=1) which is contained in the time array JTB, then X contains the number of hours from a reference time. The full definitions of all the call variables are given in the documentation of HITIME.

JRVMVB
LIBRARY: MJS

**PROGRAM:** JRVMVB

**DATE:** April 9, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** For non linear least squares fit using the simulation program calculates currents for one species given the plasma parameters (analogous to "SUBROUTINE BASE")

```
      SUBROUTINE JRVMVB (BACC,VP,B,Z,A,WPAR,WPER,DEN)
```

```
*************************************************************************
*                                                                       *
*          MODIFICATIONS BY R. L. MCNUTT  5/11/83                       *
*          OUTPUT IS INTO POSITIVE ION MODE ONLY                        *
*          RESULTS ARE PLOTTED FOR EACH CUP                             *
*                  ** MAY 24, 1983 **                                   *
*                  ** JUN 14, 1983 **                                   *
*                  ** JUN 15, 1983 **                                   *
*     EPSMOD=0.0, RSTEP = 7.0 12/22/83                                  *
*          MODIFIED TO USE ALAN'S PROGRAM ABSO 12/22/83                 *
*          MODIFIED TO OBTAIN 'MP','ME','RSTEP','R1','R2',              *
*            AND 'EPSMOD' FROM COMMON BLOCK 'NLLS' RLM                  *
*            3/26/84                                                    *
*                                                                       *
*************************************************************************
```

LINTST
LIBRARY: MJS

**FUNCTION:** LINTST

**DATE:** April 9, 1984

**AUTHOR:** R.L. McNutt, Jr.

LOGICAL FUNCTION LINTST(INUM1,INUM2)

LINTST is .TRUE. if INUM1 and INUM2 are both either integers or 0. Method is by checking IBM 360 BIT pattern.

(USED BY "SXRED" -- RLM 3/28/84)

MJSANL
LIBRARY: MJS

**PROGRAM:** MJSANL

**DATE:** April 9, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To act as a general magnetospheric data analysis program

```
*************************************************************************
*                                                                       *
*                              MAIN                                     *
*                                                                       *
*                            RLM 3/27/84                                *
*                                                                       *
*     GENERAL MAGNETOSPHERIC PLASMA DATA ANALYSIS PROGRAM:              *
*                                                                       *
*     AN INTERACTIVE SYSTEM FOR PERFORMING NON-LINEAR LEAST             *
*    SQUARES FITS TO DATA OBTAINED BY THE "PLASMA SUBSYSTEM"            *
*    (PLS) EXPERIMENT ON BOARD THE VOYAGER 1 AND 2 SPACECRAFT           *
*    DURING THEIR ENCOUNTERS WITH THE OUTER PLANETS JUPITER,            *
*    SATURN, URANUS, AND NEPTUNE.                                       *
*                                                                       *
*                                                                       *
*    ALSO CONTAINS THE COMMON BLOCK "BMODEL".                           *
*                                                                       *
*************************************************************************
```

MODIFIED - RLM 4/1/84 PMODEL CONSTANT VALUES
CAN BE INPUT AT RUN TIME.

LIBRARY: MJS

DATE: March 26, 1984

PROGRAM: MRSEDR

AUTHOR: P. Milligan

PURPOSE: To merge or edit SEDR tapes received from JPL

DESCRIPTION: Frequently, members of the group need to use data sets that are either comprised of several concatenated SEDRs or of partial SEDRs. The program MRSEDR is used to generate these files and put them onto an output tape. If desired, the program CPYTPFDK may then be run over this resultant tape to make a FORTRAN readable tape image on disk.

MRSEDR recognizes and accepts the different size of Jupiter encounter navigation blocks as compared to any other navigation block; it **does not**, however, accept any non-standard size blocks. If a block is read that does not correspond to any known SEDR format, an error message is written and the job is terminated.

The user supplies one or more time cards as input. Each card not only has a start and stop time on it, but also specifies a unit number (1 for FT01F001, 2 for FT02F001). The unit number establishes which tape drive has the data for the requested time period. Records that are one minute or more to either side of the desired time period are rejected and are not written to the output tape. If no records within the requested interval are read by the specified tape drive, nothing is written, even if the tape on the other unit does have data for that time. MRSEDR accepts or rejects data purely by the time period associated with it; it does not discriminate between pointing and navigation blocks.

The program "saves" the most recently read SEDR header. That header is written to the output tape when a valid time period is encountered on the appropriate input unit. The origin of an edited SEDR, therefore, is readily determined.

USAGE:

1. Input on unit FT05F001 (all variables are I*4)

   ITAPE,IYEAR,IDAY,IHOUR,IMIN,JYEAR,JDAY,JHOUR,JMIN

   FORMAT(I2, 3X, 2(I4, 1X, I3, 1X, 2I2, 1X))

   **ITAPE** Unit number (1 or 2) of tape drive that contains favored data

   **IYEAR(etc.)** Time to start accepting data for merge

   **JYEAR(etc.)** Last acceptable time for data that is to be merged

2. Output on unit FT06F001

   For every input data card, at least one line of printout is generated. This includes the value of ITAPE and the start and stop times requested by the user. Following this, the headers of any tapes that were edited onto the output tape are printed one line at a time.

   Error messages are issued for time card errors, tape read errors and wrong size blocks. An end of job message is also printed.

SOFTWARE REQUIREMENTS: MRSEDR uses BAT7 as its tape reading routine and uses MVC to move data. If one wants to read from disk a file that has been generated by MRSEDR, an

```
INCLUDE SYSLIB(RDFTPDM)
```

card must be included in the deck. This routine simulates the BAT7 calls that are used to read SEDR tapes.

EXAMPLES:

1. The following job was used to merge two new SEDR tapes with the concatenated master tape (which contains all previously received final CRUISE format tapes plus predict data extending years into the future). The object here is to replace predict data with the new, final data. The master tape has final data spanning from 1977 248 14 09 to 1983 226 21 00; its predict data extends from 1983 227 00 00 to 1995 363 00 00. The new tapes contain data covering 1983 227 00 00 to 1983 317 21 00. The new master tape will have final data from 1977 248 14 09 to 1983 317 21 00 and predict data from 1983 318 00 00 to 1995 363 00 00.

```
/*COMMENT  WILL REQUEST 3 TAPES FROM M.I.T. CSPR CART
/*SETUP UNIT=T6250,ID=(PT2799,NORING,SAVE,BLP)
/*SETUP UNIT=T800,ID=(SR333,NORING,SAVE,BLP)
/*COMMENT WILL ALSO REQUEST TAPE SR444
/*SETUP UNIT=T6250,ID=(SR555,RING,SAVE,BLP)
/*MAIN TIME=2
/*SRI W
//LG EXEC FORTXLG,PARM.LKED='MAP,LIST,LET,SIZE=(138,16K)',
//        REGION.LKED=128K
//LKED.SYSPRINT DD SYSOUT=A
//LKED.SYSLIB DD DISP=SHR,DSN=CSR.$380300.MJS.OBJ
//            DD DISP=SHR,DSN=CSR.$380300.PLS.OBJ
//            DD DISP=SHR,DSN=SYS1.HARVARD.FORTLIB
//            DD DISP=SHR,DSN=SYS1.FORTLIB
//LKED.SYSIN  DD *
    INCLUDE SYSLIB(MRSEDR)
    INCLUDE SYSLIB(BAT7)
    ENTRY MAIN
/*
//GO.FT06F001 DD SYSOUT=A
//GO.FT01F001 DD UNIT=T6250,LABEL=(,BLP),
//            DCB=(RECFM=VBS,LRECL=7290,BLKSIZE=7294),
//            VOL=SER=PT2799
//GO.FT02F001 DD UNIT=T800,LABEL=(,BLP),
//            DCB=(RECFM=VBS,LRECL=7290,BLKSIZE=7294),
//            VOL=SER=(SR333,SR444)
//GO.SEDROUT  DD UNIT=T6250,LABEL=(,BLP),DCB=(DEN=4),DISP=(NEW),
//            VOL=SER=SR555
//GO.SYSIN    DD *
 1   1977 248 1409 1983 226 2100
 2   1983 227 0000 1983 317 2100
 1   1983 318 0000 1995 363 0000
/*
```

Here is a partial sample of output from this job:

```
VGR  SEDR          1 SPL16304  21583 131734 N2239     12883  85916 N2235    XCRUIS
VGR  SEDR          1 SPL16305  22483 143829 N2216     22483 124211 N2235    XCRUIS
VGR  SEDR          1 SPL16306  22553  75916 N2203     22483 130602 N2235    XCRUIS
VGR  SEDR          1 SPL16307  40683  81809 N2239     40483  93122 N2237    XCRUIS
VGR  SEDR          1 SPL16308  62183  83304 N2270     61783  75532 N2272    XCRUIS
VGR  SEDR          1 SPL16309 101883 134801 N2215    100503 130227 N2219    XCRUIS
ITAPE  2  START TIME 1983 227  0 0  STOP TIME 1983 317 21 0
VGR  SEDR          1 SPL16310  21484 140930 N2207     21084 142910 N2205    XCRUIS
VGR  SEDR          1 SPL16401  21484 150305 N2220     21484 103710 N2206    XCRUIS
ITAPE  1  START TIME 1983 318  0 0  STOP TIME 1995 363  0 0
VGR  SEDR          1 SPL10048 113081  90122 A         10000      0 N2273    CRUISE
VGR  SEDR          0 SPL10047  51281 101554 B         10000      0 N2236    CRUISE
NO MORE TIME CONTROL CARDS.  END OF JOB.
```

2. The next job was used to create a file from data spanning two tapes. Because in this case the two tapes do not overlap one another, they can be serially mounted on the same tape drive. The first input tape covers 1980 307 23 50 to 1980 309 23 59; the second, 1980 310 00 00 to 1980 312 03 18. The output tape will contain 1980 308 12 13 to 1980 311 06 40.

```
/*COMMENT  WILL REQUEST 3 TAPES FROM M.I.T. CSPR CART
/*SETUP UNIT=T800,ID=(SR666,NORING,SAVE,BLP)
/*COMMENT WILL ALSO REQUEST TAPE SR777
/*SETUP UNIT=T6250,ID=(SR888,RING,SAVE,BLP)
/*MAIN TIME=5
/*SRI W
//LG EXEC FORTXLG,PARM.LKED='MAP,LIST,LET,SIZE=(138,16K)',
//        REGION.LKED=128K
//LKED.SYSPRINT DD SYSOUT=A
//LKED.SYSLIB DD DISP=SHR,DSN=CSR.$380300.MJS.OBJ
//           DD DISP=SHR,DSN=CSR.$380300.PLS.OBJ
//           DD DISP=SHR,DSN=SYS1.HARVARD.FORTLIB
//           DD DISP=SHR,DSN=SYS1.FORTLIB
//LKED.SYSIN  DD *
    INCLUDE SYSLIB(MRSEDR)
    INCLUDE SYSLIB(BAT7)
    ENTRY MAIN
/*
//GO.FT06F001 DD SYSOUT=A
//GO.FT01F001 DD UNIT=T800,LABEL=(,BLP),
//           DCB=(RECFM=VBS,LRECL=7290,BLKSIZE=7294),
//           VOL=SER=(SR666,SR777)
//GO.SEDROUT  DD UNIT=T6250,LABEL=(,BLP),DCB=(DEN=4),DISP=(NEW),
//           VOL=SER=SR888
//GO.SYSIN    DD *
 1   1980 308 1213 1980 311 0640
/*
```

NXTEDR
LIBRARY: MJS

**MODULE:** NXTEDR

**DATE:** April 9, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To get data off of EDR tapes (using appropriate version of NXTMOD)

THE MODULE "NXTEDR" CONTAINS THE FOLLOWING SUBROUTINES:

NXTMOD
EDRRED
MSTARF
TIME
TLMPRT W/ENTRIES - HEDPRT, MFPRT, SUHDPR, ENGPRT, DECPRT
PLSEDM W/ENTRIES - SCRTNB, SCRTNV
SEDRB - DUMMY ROUTINE (THE VERSION OF "SEDRB" WHICH ACTUALLY DOES ANYTHING IS AN ENTRY POINT - ALONG WITH "SCRTNB" AND "SCRTNV" - IN THE SUBROUTINE "PLSEDG" LOADED IN THE MODULE "NXTSUM").
SETBFL -DUMMY ROUTINE (THE VERSION OF "SETBFL" WHICH ACTUALLY DOES ANYTHING IS AN ENTRY POINT IN THE SUBROUTINE "NXTMOD" LOADED IN THE MODULE "NXTMAG").

MODIFICATIONS AS OF THIS DATE (4/3/84) BY RLM:

1) REMOVAL OF THE SUBROUTINE "VOYPRT" FROM THIS MODULE
2) MODIFICATION OF "PLSEDM" TO CALL "SXRED"
3) INSERTION OF THE DUMMY ROUTINE "SETBFL"

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Center for Space Research
April 12, 1984

*LIBRARY MJS*

MEMORANDUM

TO: Program Library

FROM: George S. Gordon, Jr.

SUBJECT: NXTMAG NeXT MAGnetic field data.

**Purpose.** NXTMAG reads the detailed magnetic field data from a summary tape, returning the results in the answer array. No other data is readable from the summary tape at the same time. The normal NXTMOD calling sequence is used, and the entry point SETBFL( I), SET B FieLd allows the user to select which average is returned.

**Calling Sequence.**
CALL NXTMOD( ANS, JTB, JDATA, JNE, LSTAT, JTLMOD, JCLK, TTMP, IEOD, IL, ID)

ANS(150) O R4 answer array. contains mag field data.

| | |
|---|---|
| 1 | contains the length of the answer array and the mod count as 2 I2 integers |
| 2 | magnitude of B field. F1 $(\Sigma^{N}\|B_i\|)/N$ |
| 3 | vector rms of B field average. $\sqrt{\Sigma_i(B_{i\ rms}/3)}$ |
| 4-6 | components of B field, in spacecraft coordinates |
| 7-9 | components of B field rms, in spacecraft coordinates |
| 10 | length of averageing time, in seconds.(48., 9.6, 1.92) |
| 11 | number of samples in this average. |

JTB(6) O I2 time of measurement. year, day, hour, min, seconds, milli-seconds

JDATA not used

JNE not used

LSTAT O I4 status word. set to 7 for magnetic data.

JTLMOD O I2 definition of data type. set to 10 for magnetic data.

JCLK O I2 plasma integration time code. set to 1 for magnetic data

| | | | |
|---|---|---|---|
| TTMP | | | not used |
| IEOD | O | I2 | end of data flag. 0 normal return. -1 end of data. |
| IL | | | not used |
| IDTYPE | O | I4 | source of data. 'SUM ' for magnetic data. |

**Entry Point**

```
     CALL  SETBFL( IBL)
     SET B FieLd
```

| | | | |
|---|---|---|---|
| IBL | I | I4 | code for type of average. 1-48., 2-9.6, 3-1.92 |

end

PHASE
LIBRARY: MJS

**SUBROUTINE:** PHASE

**DATE:** April 9, 1984

**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** Access SEDR data used in magnetospheric plasma analysis

"PHASE" is used by the main program "MJSANL" to access SEDR data used in magnetospheric plasma analysis.

| PLANET | TRAJECTORY ROUTINE CALLED (USES SXRED) |
|---|---|
| JUPITER | SPNJUP |
| SATURN | XSPNPL |
| URANUS | -NOT IMPLEMENTED- |
| NEPTUNE | -NOT IMPLEMENTED- |

RLM 3/28/84
(TO BE MODIFIED IN THE FUTURE WHEN A MASTER 'SBLK' FORMAT IS AGREED UPON.)

Program: PLOT3D Date: 1-5-84

Author: Writeup by G. S. Gordon, Jr.

Purpose: To plot a 3-D projection of data with hidden lines

Usage: Calling Sequence:

Call PLOT3D (A, AMAX, AMIN, IDIM, JDIM, ISTART, IDELTA, ISTOP, JSTART, JDELTA, JSTOP, MODE, THEDEG, PHIDEG,/SX/, /SY/, /SZ/.

| | |
|---|---|
| A | (IDEM, JDIM) REAL*4 array of data to be plotted. Cartesian coordinate is assumed. |
| AMAX | Maximum value A that is plotted. If zero, it is self scaling |
| AMIN | Minimum value in A |
| IDIM | X dimension of A. If IDEM=1, PLOT3D ignores A and calls user subroutine EXTSCH (A,I,J,POINTP) to get values of A. |
| JDIM | Y dimension of A |
| ISTART | X index of first value of A user |
| IDELTA | X index increment |
| ISTOP | X index for end of loop |
| JSTART | Y index for first value of A user |
| JDELTA | Y index increment |
| JSTOP | Y index for end of loop |
| MODE | =1 all points plotted straight line |
| | =2 " " " histogram |
| | =3 only visible points plotted straight line |
| | =4 " " " " histogram |
| THEDEG | observer angle in degree angle down from 2 directions |
| PHIDEG | observer angle in degree angle counter-clockwise from x-axis |
| /SX/ | size of x side of plot (optional)? |
| /SY/ | size of y side of plot " ? |
| /SZ/ | size of z side of plot " ? |

Auxiliary subprograms

PLOTYZ  plot curve method YZ plane

PLOTXZ  plot curve in the XZ plane

PTT3D  does the actual surface plot

SETPLT (LX,LY,/LEXPND/,/NPEN/)

if LX = FALSE. don't draw X connector

if LY = FALSE. don't draw Y connector

/LEYPND/ = .TRUE. expands to fill line

/NPEN/ new color number

PLTVGR
LIBRARY: MJS

SUBROUTINE: PLTVGR

DATE: April 9, 1984

AUTHOR: R.L. McNutt, Jr.

Subroutine used to plot out PLS ion spectral data for use with "MJSANL" magnetospheric analysis package.

RLM -- 3/30/84

**MODULE:** PMODEL

**DATE:** April 9, 1984

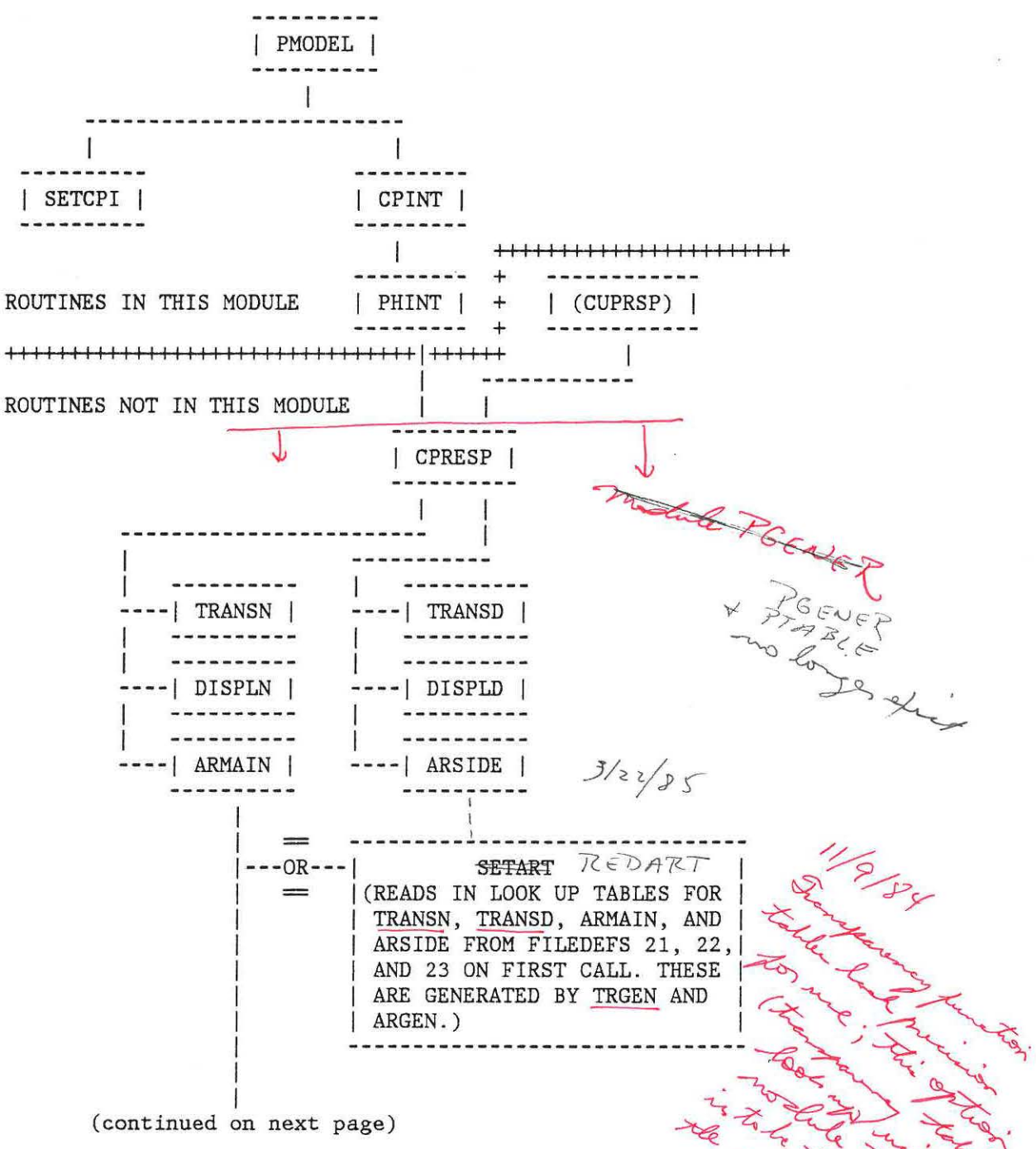
**AUTHOR:** R.L. McNutt, Jr.

**PURPOSE:** To act as a numerical simulation routine for analyzing magnetospheric data

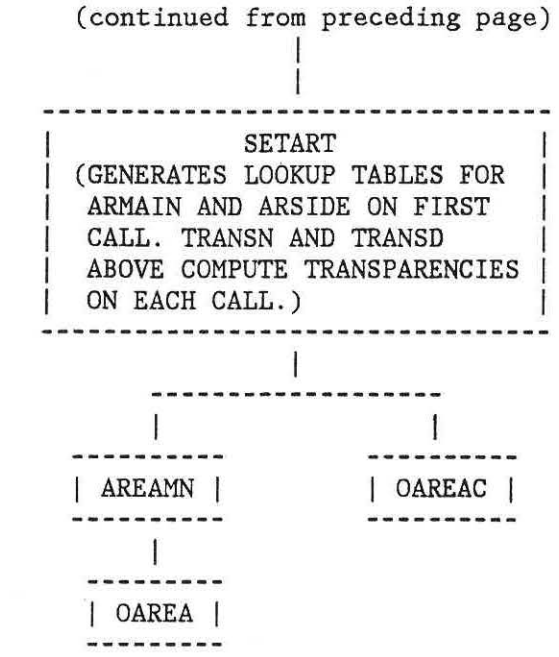
The module "PMODEL" contains the subroutine PMODEL and all other supporting subroutines used exclusively by PMODEL. These include the subroutines "PMODEL", "SETCPI", "CPINT", and "PHINT". In addition, the block data "ACCU" associated with "CPINT" is also included.

"PHINT" calls "CPRESP" which may also be called to obtain an approximate scalar cup response (this is currently done by the calling routine "CUPRSP" to determine the "COLD BEAM RESPONSE"). Please refer to the flow chart that starts on the next page.

FLOW CHART FOR PMODEL USAGE




(continued on next page)


(continued from preceding page)
SETART
(GENERATES LOOKUP TABLES FOR
ARMAIN AND ARSIDE ON FIRST
CALL. TRANSN AND TRANSD
ABOVE COMPUTE TRANSPARENCIES
ON EACH CALL.)
AREAMN
OAREAC
OAREA

The following quantities must be supplied by the calling routine when PMODEL is being used:

| | |
|---|---|
| NDOCUP(I) | .NE. 0 Skip simulation for I-TH cup |
| EPSMOD | Debug parameter to cut off cascading pickup |
| TEXT | Descriptive text for headings |
| Z | Z of species |
| A | A of species (.LT. 0.8 if electron) |
| MP | 0 for L mode, 1 for M mode (protons) |
| ME | 0 for E2, 1 for E1 (electrons) |
| INT | Integration scheme (SEE PMODEL) |
| W1,W2,DW | Integration parameters (SEE PMODEL) |
| STPSZ | Debug parameter (SEE PMODEL) |
| B | Magnetic field vector (S/C COORDINATES) |
| V | Solar wind velocity (S/C COORDINATES)****CM/SEC**** |
| RN | Density of Maxwellian (CM-3) |
| WPA | Parallel thermal speed of Maxwellian (CM/SEC) |
| WPE | Perp. thermal speed of Maxwellian (CM/SEC) |

To find simulated currents:

```
      CALL PMODEL(BARR,V,B,Z,A,MP,ME,XMAX,INT,W1,W2,DW)
```

The calling routine must have the following common blocks:

```
 COMMON /FXMAX/ WPA,WPA2,WPE,WPE2,RN,FAC,WT
 COMMON/ACCU/EPS,PVSTP,EVSTP,IBG1,IIIBG1,IBG2,IIIBG2,IPHGB,
* NDOCUP(5),STPSZ,EPSMOD,SCPOT
 COMMON/CPI/VCP(3,4),BCP(3,4),WCS(3,4),WSN(3,4),UUP(129),UUE(17),
* UP(129),UE(17),NCP,NCE,SUPMN,SUPSD,ZCU,AEVV
```

and the external statement:

```
      EXTERNAL XMAX
```

---

The user must also specify the distribution function in the plasma rest frame XMAX:

```
      FUNCTION XMAX(W,CS)
      COMMON/FXMAX/WPA,WPA2,WPE,WPE2,RN,FAC,WT

******Insert code for calculating value of XMAX******

      RETURN
      END
```

SPNJUP
LIBRARY: MJS

**SUBROUTINE:** SPNJUP

**DATE:** April 9, 1984

**AUTHOR:** R.L. McNutt, Jr.

Reads in trajectory data (via SXRED) and fills 'SBLK' with Jupiter specific parameters.

SXRED
LIBRARY: MJS

MODULE: SXRED

DATE: April 9, 1984

AUTHOR: R.L. McNutt, Jr.

PURPOSE: To read SEDR tapes

The subroutine "SXRED" is a general utility routine used in reading SEDR tapes furnished by JPL (Voyager project). This version has multiple entry points, viz. "SHDREC", "SNXNAV", "SNXPNT", and can use a variable number of arguments in its calling sequence (see June 1979 writeup). Included in this module are the following subroutines used exclusively by "SXRED":

REFSTR Only needed to satisfy external references; used with navigation only, predict SEDRs at the Voyager 2 encounter with Jupiter.

NVSTOR Stores navigation data in a general format; currently works with "LAUNCH", "CRUISE", "JUPITER", and "SATURN" formats. (At this time -3/6/84- "URANUS" and "NEPTUNE" navigation formats are unavailable).

INTERP Interpolates navigation and pointing data to time specified by a call to "SXRED". N.B. This is a linear interpolation for all quantities; rotation matrices DO NOT remain unitary. This can produce roundoff problems in other quantities as well.

REFER Returns the unit vector (Cartesian components, ECL50 coordinates) pointing towards any one of eight reference stars which can be acquired by the Canopus star tracker on board the Voyager spacecraft.

NOMDIR Given the output from "REFER", "NOMDIR" fills in all quantities in the pointing vector block associated with this nominal pointing direction.

"REFER" and "NOMDIR" can be used in any call to "SXRED" if the appropriate number of arguments is used (see June 1979 writeup for "SXRED").

Other supporting subroutines required by "SXRED" but *NOT* included in this module are:

**ONAROT** Used for computing nominal pointing data given an arbitrary S/C roll angle (away from Canopus reference).

**$TYME** Computes times in double precision milliseconds; used to locate appropriate data on the SEDR and used by "INTERP" to interpolate navigation and pointing data.

Ralph

Library: MJS

Subroutine: SXRED(IDSRN[,IEOD,ITIME[,TRAJ[,ISTAR[,ROLL]]]])

Entries SHDREC(IDSRN,IEOD)

SNXNAV(IDSRN,IEOD,HDSTAT)

SNXPNT(IDSRN,IEOD,HDSTAT,NVSTAT)

Author: Ralph L. McNutt, Jr.; modifications by Richard Selesnick and Mark Sands; additional documentation by Pamela Milligan

Date: November 7, 1985

Purpose: To read SEDR trajectory data tapes or disk files. Please note that this writeup incorporates the one of April 9, 1984 and makes the one of June 30, 1979 (concerning CXRED and SXRED) obsolete.

VARIABLES:

IDSRN Integer*4 data set reference number. This is an arbitrary integer in SXRED.

ITIME Integer*4 array 6 words long:

ITIME(1) = year, AD
ITIME(2) = day of year
ITIME(3) = hour of day
ITIME(4) = minute of hour
ITIME(5) = second of minute
ITIME(6) = millisecond of second

This is the time for which the navigation data are requested.

ISTAR Integer*4 reference star number input to override Canopus as the reference star when tapes with no pointing data are used (nominal pointing is calculated in this case). The possible choices are identified in the writeup for REFER (formerly in TESTLIB, now in TEST).

ROLL Real*4. If this variable is included in the calling sequence, ISTAR is ignored. When tapes with no pointing data are used, pointing is calculated on the basis of a spacecraft roll from Canopus by this number of degrees about the earth-spacecraft line.

IEOD Integer*4 end of data flag. Returns to the calling program the values:

+1 end of file

0 normal read
-1 read error

TRAJ Real*4 four byte character string. It returns

'JST ' for Voyager I
'JSX ' for Voyager II

HDSTAT Logical*4 variable returned as .TRUE. if new header data were encountered during the call. It is returned as .FALSE. otherwise.

NVSTAT Logical*4 variable returned as .TRUE. if new navigation data were encountered during the call. It is returned as .FALSE. otherwise.

COMMON BLOCKS:

TAPERR - contains 4 words. After each read of the SEDR, it is filled by TWAIT with the usual RB array (see the LNS writeup on BAT commands [N.B. The Basic Access to Tape routine is available at Harvard for reading tapes. For reading SEDR disk files, one must instead use the program RDFTPDM which simulates calls to BAT].).

HEADER - contains 45 words. This contains the header record as described in JPL memo 4-7008-1, Rev. B of March, 1978, Attachment B.

NVBUF - contains 600 words. If a call is executed using ITIME, NVBUF1 contains navigation data as read from the first record whose time exceeds ITIME, NVBUF2 contains navigation data as read from the last record whose time precedes ITIME, and NVBUF contains the navigation data as linearly interpolated between NVBUF1 and NVBUF2. The format used is a generalized navigation data format as described in Appendix B. If a call is issued which does not use ITIME, NVBUF contains the navigation data as read on that call.

PTBUF - contains 126 words. The pointing data are contained in these analogously to the way in which navigation data are contained in the navigation data blocks described above. The format is that of JPL Memo 4-7008-1, Rev. B, Attachment G.

SUBROUTINES USED EXCLUSIVELY BY SXRED (AND INCLUDED IN THE PROGRAM MODULE):

REFSTR Only needed to satisfy external references; used with navigation only, predict SEDRs at the Voyager 2 encounter with Jupiter.

NVSTOR Stores navigation data in a general format; currently works with LAUNCH, CRUISE, JUPITER, SATURN, EXTENDED CRUISE and URANUS formats. At this time, NEPTUNE navigation formats are unavailable, but space has been allotted for NEPTUNE information in NVBUF.

INTERP Interpolates navigation and pointing data to time specified by a call to SXRED. (N.B. This is a linear interpolation for all quantities; rotation matrices DO NOT remain unitary. This can produce roundoff problems in other quantities as well).

REFER Returns the unit vector (Cartesian components, ECL50 coordinates) pointing towards any one of eight reference stars which can be acquired by the Canopus star tracker on board the Voyager spacecraft.

NOMDIR Given the output from REFER, NOMDIR fills in all quantities in the pointing vector block associated with this nominal pointing direction.

REFER and NOMDIR can be used in any call to SXRED if the appropriate number of arguments is used.

OTHER, SUPPORTING SUBROUTINES (NOT INCLUDED IN THE MODULE):

ONAROT Used for computing nominal pointing data given an arbitrary S/C roll angle (away from Canopus reference).

$TYME Computes times in double precision milliseconds; used to locate appropriate data on the SEDR and used by INTERP to interpolate navigation and pointing data.

USAGE:

A one argument call to SXRED rewinds the tape. (N.B. SXRED will return IEOD = 1 at the end of file of each tape. If a tape is not the last, then a subsequent call will access the next tape in the series. As a result, individual tapes in a series can be rewound when the end of file is found by checking for IEOD of 1).

A three argument call to SXRED returns IEOD and all data interpolated to their values at ITIME. If no pointing information is on the tape, "nominal" pointing assuming a Canopus reference will be provided (see writeup on NOMDIR - in TEST). If a time is requested before the first record on the trajectory tape, control will be returned to the calling program. If a time is requested after the last record on the trajectory tape, the entire tape will be read through. If a tape has multiple pointing blocks, navigation data will be extrapolated if the time of the pointing block just read exceeds that of the most recently read navigation block.

A four argument call will have the same effect as the above and also identify the trajectory (and, hence, the spacecraft).

A five argument call allows the Canopus reference to be overridden if nominal pointing is to be calculated.

A six argument call allows an arbitrary spacecraft roll from Canopus to be inserted if nominal pointing is to be used.

A trajectory tape for one spacecraft can be read through and then a different tape for the other on a different tape drive can be read. Comment statements in the code note modifications to allow switching back and forth between the two spacecraft. This mode of operation is available only on the entry SXRED.

A call to SHDREC either reads the first record on the tape or finds the next record which goes with a new header (hence, can be used with stacked SEDRs to "log" them).

A call to SNXNAV reads the next navigation record on the tape. If the header information has changed on the call, the status word HDSTAT is returned as .TRUE. The tape is not advanced if the previous call was to SHDREC, but HDSTAT will be returned as .FALSE.

A call to SNXPNT reads the next pointing record on the tape. If the navigation information has changed on the call, the status word NVSTAT is returned as .TRUE. The tape is not advanced if the previous call was to SNXNAV, but HDSTAT and NVSTAT will be returned as .FALSE.

It should be noted that if the SXRED entry is used, subsequent calls to the other entries should not be issued unless the tape is rewound first. If SHDREC or SNXNAV is used, SXRED can be called if SNXPNT is called first. SXRED can always be called after SNXPNT is called.

SEDRs generated at JPL are 800 BPI; SEDRs that have been merged or edited at our computer facility are 6250 BPI. Both sets of tapes, though, do share the following characteristics:

```
//        LABEL=(,BLP),DCB=(RECFM=VBS,LRECL=7290,BLKSIZE=7294)
```

For information on encounter period tapes, see Appendix A.

Appendix B defines the terms used by JPL to describe the words on the SEDR tapes, and includes a chart depicting the generalized data format found in NVBUF.

# APPENDIX A - ENCOUNTER PERIOD TAPES

## JUPITER ENCOUNTER SEDRS

| Voyager 1 | | Voyager 2 | |
|---|---|---|---|
| SPL13101 | 79:001/00:01 - 007/23:53 | SPL03101 | 79:114/00:01 - 121/00:01 |
| SPL13102 | 79:008/00:01 - 014/23:53 | SPL03102 | 79:121/00:02 - 126/23:54 |
| SPL13103 | 79:015/00:01 - 021/23:53 | SPL03103 | 79:127/00:01 - 144/23:37 |
| SPL13104 | 79:022/00:01 - 030/04:09 | SPL03104 | 79:144/23:42 - 145/19:32 |
| SPL13201 | 79:030/04:17 - 031/23:59 | SPL03201 | 79:145/19:36 - 146/23:58 |
| SPL13202 | 79:031/23:59 - 034/05:58 | SPL03202 | 79:147/00:00 - 148/23:58 |
| SPL13203 | 79:034/05:58 - 036/12:00 | SPL03203 | 79:149/00:00 - 150/23:58 |
| SPL13204 | 79:036/12:02 - 038/18:00 | SPL03204 | 79:151/00:00 - 153/08:41 |
| SPL13205 | 79:038/18:09 - 039/23:59 | SPL03205 | 79:153/08:43 - 155/23:58 |
| SPL13206 | 79:040/00:00 - 041/23:58 | SPL03206 | 79:156/00:00 - 157/23:58 |
| SPL13207 | 79:042/00:00 - 043/23:58 | SPL03207 | 79:158/00:00 - 159/16:41 |
| SPL13208 | 79:044/00:00 - 045/23:58 | SPL03208 | 79:159/16:43 - 161/23:58 |
| SPL13209 | 79:046/00:00 - 047/23:58 | SPL03209 | 79:162/00:00 - 164/11:58 |
| SPL13210A | 79:048/00:00 - 049/23:58 | SPL03210 | 79:164/12:00 - 166/23:40 |
| SPL13211 | 79:050/00:00 - 052/03:14 | SPL03211 | 79:166/23:42 - 168/23:58 |
| SPL13301 | 79:052/03:15 - 053/23:58 | SPL03212 | 79:169/00:00 - 170/23:58 |
| SPL13302 | 79:054/00:00 - 055/23:58 | SPL03213 | 79:171/00:00 - 172/23:58 |
| SPL13303 | 79:056/00:00 - 057/23:58 | SPL03214 | 79:173/00:00 - 174/23:59 |
| SPL13304 | 79:058/00:00 - 059/23:58 | SPL03215 | 79:175/00:01 - 176/09:40 |
| SPL13305 | 79:060/00:00 - 061/23:58 | SPL03216 | 79:176/09:42 - 178/18:22 |
| SPL13306 | 79:062/00:00 - 063/12:01 | SPL03301 | 79:178/18:23 - 180/23:59 |
| SPL13401 | 79:063/12:02 - 063/21:12 | SPL03302 | 79:181/00:01 - 181/21:40 |
| SPL13402A | 79:063/21:13 - 064/14:35 | SPL03303 | 79:181/21:42 - 184/09:26 |
| SPL13403 | 79:064/14:36 - 065/02:51 | SPL03304 | 79:184/09:27 - 186/21:48 |
| SPL13501 | 79:065/02:52 - 066/11:59 | SPL03305 | 79:186/21:50 - 188/23:59 |
| SPL13502 | 79:066/12:00 - 067/17:19 | SPL03401 | 79:189/00:01 - 191/00:38 |
| SPL13503 | 79:067/17:20 - 068/23:59 | SPL03501 | 79:191/00:39 - 191/23:59 |
| SPL13504 | 79:069/00:00 - 070/23:59 | SPL03502 | 79:192/00:01 - 193/23:59 |
| SPL13505 | 79:071/00:00 - 072/23:59 | SPL03503 | 79:194/00:01 - 195/22:35 |
| SPL13506 | 79:073/00:00 - 074/08:59 | SPL03601A | 79:195/22:36 - 197/04:39 |
| SPL13601 | 79:074/08:59 - 075/23:59 | SPL03601B | 79:197/04:41 - 197/23:59 |
| SPL13602 | 79:076/00:00 - 077/23:59 | SPL03601C | 79:198/00:01 - 199/23:59 |
| SPL13603 | 79:078/00:00 - 079/23:59 | SPL03602 | 79:200/00:01 - 204/15:23 |
| SPL13604 | 79:080/00:00 - 081/23:59 | SPL03701* | 79:204/15:24 - 207/23:59 |
| SPL13605 | 79:082/00:00 - 083/23:59 | SPL03702 | 79:208/00:01 - 211/23:59 |
| SPL13606 | 79:084/00:00 - 085/23:59 | SPL03703* | 79:212/00:01 - 215/23:59 |
| SPL13607 | 79:086/00:00 - 087/23:59 | SPL03704* | 79:216/00:01 - 219/23:59 |
| SPL13608 | 79:088/00:00 - 089/23:59 | SPL03705* | 79:220/00:01 - 223/23:59 |
| SPL13609A | 79:090/00:00 - 091/23:59 | SPL03706 | 79:224/00:01 - 240/15:01 |
| SPL13610 | 79:092/00:00 - 093/23:59 | | |
| SPL13611 | 79:094/00:00 - 095/23:59 | | * indicates that |
| SPL13612 | 79:096/00:00 - 097/23:59 | | pointing records |
| SPL13613 | 79:098/00:00 - 099/16:00 | | are missing |

# SATURN ENCOUNTER SEDRS

| Voyager 1 | | Voyager 2 | |
|---|---|---|---|
| SPL15001 | 80:235/23:10 - 242/23:58 | SPL05001 | 81:156/16:05 - 161/23:57 |
| SPL15002 | 80:243/00:06 - 249/23:58 | SPL05002 | 81:162/00:05 - 167/23:57 |
| SPL15003 | 80:250/00:06 - 256/14:22 | SPL05003 | 81:168/00:05 - 173/23:57 |
| SPL15004 | 80:256/14:30 - 263/23:58 | SPL05004 | 81:174/00:05 - 179/13:41 |
| SPL15005 | 80:264/00:06 - 270/23:58 | SPL05005 | 81:179/13:49 - 181/23:57 |
| SPL15006 | 80:271/00:00 - 277/23:58 | SPL05101 | 81:182/00:05 - 187/23:57 |
| SPL15007 | 80:278/00:06 - 284/19:42 | SPL05102 | 81:188/00:05 - 193/23:57 |
| SPL15101 | 80:284/19:50 - 292/23:58 | SPL05103 | 81:194/00:05 - 200/11:09 |
| SPL15102 | 80:293/00:06 - 298/11:50 | SPL05201 | 81:200/11:25 - 205/23:57 |
| SPL15201 | 80:298/11:52 - 300/23:59 | SPL05202 | 81:206/00:53 - 212/08:37 |
| SPL15202 | 80:301/00:00 - 303/03:43 | SPL05301A | 81:212/08:38 - 214/23:58 |
| SPL15203 | 80:303/03:44 - 305/11:59 | SPL05302A | 81:215/00:00 - 217/08:19 |
| SPL15204 | 80:305/12:00 - 307/23:49 | SPL05303 | 81:217/08:20 - 219/23:58 |
| SPL15205 | 80:307/23:50 - 309/23:59 | SPL05304 | 81:220/00:00 - 223/06:09 |
| SPL15206 | 80:310/00:00 - 312/03:18 | SPL05305 | 81:223/06:11 - 226/23:58 |
| SPL15301 | 80:312/03:19 - 314/04:06 | SPL05306 | 81:227/00:00 - 230/20:44 |
| SPL15302 | 80:314/04:07 - 316/21:48 | SPL05401 | 81:230/20:46 - 234/06:52 |
| SPL15401 | 80:316/21:50 - 318/00:37 | SPL05402 | 81:234/06:54 - 237/11:42 |
| SPL15402 | 80:318/00:38 - 318/21:14 | SPL05501A | 81:237/11:43 - 239/07:00 |
| SPL15501 | 80:318/21:14 - 320/23:59 | SPL05601 | 81:239/07:02 - 241/23:59 |
| SPL15502 | 80:321/00:01 - 322/23:59 | SPL05602 | 81:242/00:01 - 245/02:46 |
| SPL15503 | 80:323/00:01 - 324/02:07 | SPL05603 | 81:245/02:06 - 248/23:59 |
| SPL15504 | 80:324/02:09 - 325/23:58 | SPL05604 | 81:249/00:01 - 252/23:59 |
| SPL15505 | 80:326/00:00 - 329/23:58 | SPL05605 | 81:253/00:01 - 256/23:59 |
| SPL15506 | 80:330/00:00 - 333/23:58 | SPL05606 | 81:257/00:01 - 260/23:58 |
| SPL15507 | 80:334/00:00 - 337/23:58 | SPL05607 | 81:261/00:01 - 264/23:59 |
| SPL15508 | 80:338/00:00 - 341/23:58 | SPL05608 | 81:265/00:01 - 268/23:59 |
| SPL15509 | 80:342/00:00 - 345/23:58 | SPL05609 | 81:269/00:01 - 271/16:42 |
| SPL15510 | 80:346/00:00 - 349/23:58 | | |
| SPL15511 | 80:350/00:00 - 351/02:08 | | |

# APPENDIX B

The first six words of navigation data are integers:

1) years, AD
2) day of year
3) hour of day
4) minute of hour
5) second of minute
6) millisecond of second

(Spacecraft Event Greenwich Mean Time - SCE GMT)

All of the rest of the words are real numbers. The units used are:

| | |
|---|---|
| kilometers | (distance) |
| kilometers/sec | (velocity) |
| degrees | (angle) |

Definition of terms in navigation format:

SCE GMT Spacecraft Event Greenwich Mean Time

S/C Spacecraft

RANGE Distance between "object located" and "coordinate system origin"

Cartesian State: 6 words: 1,2,3 are the x,y,z components of position in the given coordinate system; 4,5,6 are the x,y,z components of velocity again referred to the given coordinate system.

Cartesian Position: 3 words: 1,2,3 are the x,y,z components of position in the given coordinate system.

RA Right ascension - measures like longitude (counterclockwise)

DEC Declination - measures like latitude

CLK Clock Angle (see below)

CON Cone Angle (see below)

Celestial Clock and Cone: Coordinate system in which the Z axis points toward the sun and 0° clock angle is toward Canopus. The cone angle is that angle which the given body makes with the sun and the spacecraft. The clock angle is measured counterclockwise about the Z axis from the position of Canopus as projected into the 90° cone angle plane. (See also JPL Software Interface Specification #4-7006-1, Rev. A, 1 Aug. 1977, Table G-1, p. 51).

ECL50 Earth Mean Ecliptic and Equinox of 1950.0

JTEED Jupiter True Equinox and Equator of Date

SMEE50 Saturn Mean Equinox and Equator of 1950.0

STEED Saturn True Equinox and Equator of Date

SUTEED Sun True Equinox and Equator of Date

JMMED Jupiter Magnetic Meridian and Equator of Date

JMOPMS Jupiter Mean Orbit and Prime Meridian in Sun Direction

System I - JTPMED: Jupiter System I True Prime Meridian and Equator of Date (Longitude measured clockwise).

System III - JTPMED: Jupiter System III True Prime Meridian and Equator of Date (Longitude measured clockwise).

STPMED Saturn True Prime Meridian and Equator of Date

EME50 Earth Mean Equator and Equinox of 1950

## NAVIGATION FORMAT KEY (FOR NVBUF ARRAY)

In the availability column on the subsequent pages, the letters have the following meanings:

| | |
|---|---|
| L | Launch format |
| C | Cruise format |
| J | Jupiter format |
| S | Saturn format |
| EC | Extended Cruise format |
| U | Uranus format |
| N | Neptune format |

An 'x' in the appropriate column means that the datum is available if the particular format is used on the tape being read. If a word is accessed which is not available, e.g., word 56 when using a Cruise format tape, a value of 0.0 will be returned from the common blocks.

| WORD | DESCRIPTION | | | | AVAILABILITY | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | OBJECT LOCATED | COORDINATE SYSTEM | COORDINATES | COORDINATE SYSTEM ORIGIN | L | C | J | S | EC | U | N |
| 1 - 6 | SCE GMT Time | ___ | ___ | ___ | × | × | × | × | × | × | |
| 7 - 12 | S/C | ECL50 | Cartesian State | Earth | × | × | × | × | × | × | |
| 13 - 18 | S/C | ECL50 | Cartesian State | Sun | × | × | × | × | × | × | |
| 19 - 24 | S/C | ECL50 | Cartesian State | Jupiter | × | × | × | | | | |
| 25 - 30 | S/C | ECL50 | Cartesian State | Io | | | × | | | | |
| 31 - 36 | S/C | ECL50 | Cartesian State | Europa | | | × | | | | |
| 37 - 42 | S/C | ECL50 | Cartesian State | Ganymede | | | × | | | | |
| 43 - 48 | S/C | ECL50 | Cartesian State | Callisto | | | × | | | | |
| 49 - 54 | S/C | ECL50 | Cartesian State | Saturn | × | × | | × | | | |
| 55 - 60 | S/C | ECL50 | Cartesian State | Titan | | | | × | | | |
| 61 - 66 | Earth | ECL50 | Cartesian State | Sun | × | × | × | × | × | × | |
| 67 - 72 | Jupiter | ECL50 | Cartesian State | Sun | × | × | × | | × | | |
| 73 - 78 | Saturn | ECL50 | Cartesian State | Sun | × | × | | × | × | | |
| 79 - 84 | Earth | ECL50 | Cartesian State | Jupiter | | | × | | | | |
| 85 - 90 | Io | ECL50 | Cartesian State | Jupiter | | | × | | | | |
| 91 - 96 | Europa | ECL50 | Cartesian State | Jupiter | | | × | | | | |
| 97 -102 | Ganymede | ECL50 | Cartesian State | Jupiter | | | × | | | | |
| 103-108 | Callisto | ECL50 | Cartesian State | Jupiter | | | × | | | | |
| 109-114 | Earth | ECL50 | Cartesian State | Saturn | | | | × | | | |
| 115-120 | Titan | ECL50 | Cartesian State | Saturn | | | | × | | | |
| 121 | S/C | ___ | Range | Earth | × | × | × | × | × | × | |
| 122 | S/C | ___ | Range | Sun | × | × | × | × | × | × | |
| 123 | S/C | ___ | Range | Jupiter | × | × | × | | | | |
| 124 | ___ | ___ | Range | ___ | | | | | | | |
| 125 | ___ | ___ | Range | ___ | | | | | | | |
| 126 | ___ | ___ | Range | ___ | | | | | | | |
| 127 | ___ | ___ | Range | ___ | | | | | | | |
| 128 | S/C | ___ | Range | Saturn | × | × | | × | | | |
| 129 | S/C | ___ | Range | Titan | | | | × | | | |
| 130 | Earth | ___ | Range | Sun | × | × | × | × | × | × | |
| 131 | Jupiter | ___ | Range | Sun | × | × | × | | | | |
| 132 | Saturn | ___ | Range | Sun | × | × | | × | | | |
| 133 | Io | ___ | Range | Jupiter | | | × | | | | |
| 134 | Europa | ___ | Range | Jupiter | | | × | | | | |
| 135 | Ganymede | ___ | Range | Jupiter | | | × | | | | |
| 136 | Callisto | ___ | Range | Jupiter | | | × | | | | |

| WORD | DESCRIPTION | | | | AVAILABILITY | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | OBJECT LOCATED | COORDINATE SYSTEM | COORDINATES | COORDINATE SYSTEM ORIGIN | L | C | J | S | EC | U | N |
| 137 | Titan | ___ | Range | Saturn | | | | × | | | |
| 138-139 | S/C | EME50 | RA and DEC | Earth | × | × | × | × | × | × | |
| 140-141 | Sun | EME50 | RA and DEC | Earth | × | × | × | × | × | × | |
| 142-143 | Jupiter | EME50 | RA and DEC | Earth | × | × | × | | | | |
| 144-145 | Saturn | EME50 | RA and DEC | Earth | × | × | | × | | | |
| 146-147 | S/C | JTEED | RA and DEC | Jupiter | × | × | × | | | | |
| 148-149 | Sun | JTEED | RA and DEC | Jupiter | × | × | × | | | | |
| 150-151 | Earth | JTEED | RA and DEC | Jupiter | × | × | | | | | |
| 152-153 | Io | JTEED | RA and DEC | Jupiter | × | × | × | | | | |
| 154-155 | Europa | JTEED | RA and DEC | Jupiter | | | × | | | | |
| 156-157 | Ganymede | JTEED | RA and DEC | Jupiter | | | × | | | | |
| 158-159 | Callisto | JTEED | RA and DEC | Jupiter | | | × | | | | |
| 160-161 | S/C | SMEE50 | RA and DEC | Saturn | × | | | | | | |
| 162-163 | S/C | STEED | RA and DEC | Saturn | | × | | × | | | |
| 164-165 | Sun | STEED | RA and DEC | Saturn | | × | | × | | | |
| 166-167 | Earth | STEED | RA and DEC | Saturn | | × | | | | | |
| 168-169 | Titan | STEED | RA and DEC | Saturn | | | | × | | | |
| 170-171 | S/C | SUTEED | RA and DEC | Sun | × | × | | | × | | |
| 172-173 | Earth | SUTEED | RA and DEC | Sun | × | × | | | × | | |
| 174-175 | Jupiter | SUTEED | RA and DEC | Sun | × | × | | | | | |
| 176-177 | Saturn | SUTEED | RA and DEC | Sun | × | × | | | | | |
| 178-179 | | | | | | | | | | | |
| 180-181 | | | | | | | | | | | |
| 182-183 | | | | | | | | | | | |
| 184-185 | | | | | | | | | | | |
| 186-187 | | | | | | | | | | | |
| 188 | Earth-Sun-S/C | ___ | Angle | ___ | × | × | × | × | × | × | |
| 189 | Sun-Earth-S/C | ___ | Angle | ___ | × | × | × | × | × | × | |
| 190 | Jupiter-Sun-S/C | ___ | Angle | ___ | × | × | × | | | | |
| 191 | Sun-Jupiter-S/C | ___ | Angle | ___ | × | × | × | | | | |
| 192 | Saturn-Sun-S/C | ___ | Angle | ___ | × | × | | × | | | |
| 193 | Sun-Saturn-S/C | ___ | Angle | ___ | × | × | | × | | | |
| 194-195 | Earth | Celestial Clock & Cone | CLK & CON | S/C | × | × | × | × | × | × | |

| WORD | DESCRIPTION | | | | AVAILABILITY | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | OBJECT LOCATED | COORDINATE SYSTEM | COORDINATES | COORDINATE SYSTEM ORIGIN | L | C | J | S | EC | U | N |
| 196-197 | Jupiter | Celstial Clock & Cone | CLK & CON | S/C | × | × | × | | | | |
| 198-199 | Io | Celestial Clock & Cone | CLK & CON | S/C | | | × | | | | |
| 200-201 | Europa | Celestial Clock & Cone | CLK & CON | S/C | | | × | | | | |
| 202-203 | Ganymede | Celestial Clock & Cone | CLK & CON | S/C | | | × | | | | |
| 204-205 | Callisto | Celestial Clock & Cone | CLK & CON | S/C | | | × | | | | |
| 206-207 | Saturn | Celestial Clock & Cone | CLK & CON | S/C | × | × | | × | | | |
| 208-209 | Titan | Celestial Clock & Cone | CLK & CON | S/C | | | | × | | | |
| 210-211 | S/C | ETEED Celestial Lat./Long. | Celestial LAT and LON | Sun | × | × | × | × | × | × | |
| 212-213 | Earth | ETEED Celestial Lat./Long. | Celestial LAT and LON | Sun | × | × | × | × | × | × | |
| 214-215 | Jupiter | ETEED Celestial Lat./Long | Celestial LAT and LON | Sun | × | × | × | | | | |
| 216-217 | Saturn | ETEED Celestial Lat./Long. | Celestial LAT and LON | Sun | × | × | | × | | | |
| 218 | Time To/From Jupiter Periapsis Passage | — | — | — | | | × | | | | |
| 219 | Time To/From Saturn Periapsis Passage | — | — | — | | | | × | | | |

| | WORD | DESCRIPTION | | | | AVAILABILITY | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | OBJECT LOCATED | COORDINATE SYSTEM | COORDINATES | COORDINATE SYSTEM ORIGIN | L | C | J | S | EC | U | N |
| | 220 | Hour Angle of Jupiter System III Prime Meridian | JTEED | ___ | Jupiter | × | × | | | | | |
| | 221-226 | S/C | JMMED | Cartesian State | Jupiter Magnetic Dipole | | | × | | | | |
| | 227-232 | Io | JMMED | Cartesian State | Jupiter Magnetic Dipole | | | × | | | | |
| * | 233 | S/C | ___ | Range | Jupiter Magnetic Dipole | | | × | | | | |
| | 234 | Io | ___ | Range | Jupiter Magnetic Dipole | | | × | | | | |
| | 235-236 | S/C | JMMED | LAT and LON | Jupiter Magnetic Dipole | | | × | | | | |
| | 237-238 | Io | JMMED | LAT and LON | Jupiter Magnetic Dipole | | | × | | | | |
| | 239-244 | S/C | JMOPMS | Cartesian State | Jupiter | | | × | | | | |
| | 245-250 | Io | JMOPMS | Cartesian State | Jupiter | | | × | | | | |
| | 251-256 | Europa | JMOPMS | Cartesian State | Jupiter | | | × | | | | |
| | 257-262 | Ganymede | JMOPMS | Cartesian State | Jupiter | | | × | | | | |
| | 263-268 | Callisto | JMOPMS | Cartesian State | Jupiter | | | × | | | | |
| | 269-274 | S/C | SMOPMS | Cartesian State | Saturn | | | | × | | | |
| | 275-280 | Titan | SMOPMS | Cartesian State | Saturn | | | | × | | | |
| | 281-286 | S/C | System I JTPMED | Cartesian State | Jupiter | | | × | | | | |
| | 287-289 | Io | System I JTPMED | Cartesian Position | Jupiter | | | × | | | | |
| | 290-292 | Europa | System I JTPMED | Cartesian Position | Jupiter | | | × | | | | |

* These items were in error on the predict tapes. Final tapes not tested. User BEWARE.

| WORD | DESCRIPTION | | | | AVAILABILITY | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | OBJECT LOCATED | COORDINATE SYSTEM | COORDINATES | COORDINATE SYSTEM ORIGIN | L | C | J | S | EC | U | N |
| 293-295 | Ganymede | System I JTPMED | Cartesian Position | Jupiter | | | × | | | | |
| 296-298 | Callisto | System I JTPMED | Cartesian Position | Jupiter | | | × | | | | |
| 299-300 | S/C | System I JTPMED | LAT and LON | Jupiter | | | × | | | | |
| 301-302 | Io | System I JTPMED | LAT and LON | Jupiter | | | × | | | | |
| 303-304 | Europa | System I JTPMED | LAT and LON | Jupiter | | | × | | | | |
| 305-306 | Ganymede | System I JTPMED | LAT and LON | Jupiter | | | × | | | | |
| 307-308 | Callisto | System I JTPMED | LAT and LON | Jupiter | | | × | | | | |
| 309-314 | S/C | System III JTPMED | Cartesian State | Jupiter | | | × | | | | |
| 315-317 | Io | System III JTPMED | Cartesian Position | Jupiter | | | × | | | | |
| 318-320 | Europa | System III JTPMED | Cartesian Position | Jupiter | | | × | | | | |
| 321-323 | Ganymede | System III JTPMED | Cartesian Position | Jupiter | | | × | | | | |
| 324-326 | Callisto | System III JTPMED | Cartesian Position | Jupiter | | | × | | | | |
| 327-328 | S/C | System III JTPMED | LAT and LON | Jupiter | | | × | | | | |
| 329-330 | Io | System III JTPMED | LAT and LON | Jupiter | | | × | | | | |
| 331-332 | Europa | System III JTPMED | LAT and LON | Jupiter | | | × | | | | |
| 333-334 | Ganymede | System III JTPMED | LAT and LON | Jupiter | | | × | | | | |

| WORD | DESCRIPTION | | | | AVAILABILITY | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | OBJECT LOCATED | COORDINATE SYSTEM | COORDINATES | COORDINATE SYSTEM ORIGIN | L | C | J | S | EC | U | N |
| 335-336 | Callisto | System III JTPMED | LAT and LON | Jupiter | | | × | | | | |
| 337-342 | S/C | STPMED | Cartesian State | Saturn | | | | × | | | |
| 343-345 | Titan | STPMED | Cartesian Position | Saturn | | | | × | | | |
| 346-347 | S/C | STPMED | LAT and LON | Saturn | | | | × | | | |
| 348-349 | Titan | STPMED | LAT and LON | Saturn | | | | × | | | |
| 350-355 | S/C | ECL50 | Cartesian State | Uranus | | | | | × | × | |
| 356-361 | S/C | ECL50 | Cartesian State | Miranda | | | | | | × | |
| 362-367 | S/C | ECL50 | Cartesian State | Ariel | | | | | | × | |
| 368-373 | S/C | ECL50 | Cartesian State | Umbrial | | | | | | × | |
| 374-379 | S/C | ECL50 | Cartesian State | Titania | | | | | | × | |
| 380-385 | S/C | ECL50 | Cartesian State | Neptune | | | | | × | | |
| 386-391 | S/C | ECL50 | Cartesian State | Triton | | | | | | | |
| 392-397 | Uranus | ECL50 | Cartesian State | Sun | | | | | × | × | |
| 398-403 | Neptune | ECL50 | Cartesian State | Sun | | | | | × | | |
| 404-409 | Earth | ECL50 | Cartesian State | Uranus | | | | | | × | |
| 410-415 | Miranda | ECL50 | Cartesian State | Uranus | | | | | | × | |
| 416-421 | Ariel | ECL50 | Cartesian State | Uranus | | | | | | × | |
| 422-427 | Umbrial | ECL50 | Cartesian State | Uranus | | | | | | × | |
| 428-433 | Titania | ECL50 | Cartesian State | Uranus | | | | | | × | |
| 434 | Earth | ECL50 | Cartesian State | Neptune | | | | | | | |
| 435 | Triton | ECL50 | Cartesian State | Neptune | | | | | | | |
| 436 | S/C | ___ | Range | Uranus | | | | | × | × | |
| 437 | S/C | ___ | Range | Neptune | | | | | × | | |
| 438 | Uranus | ___ | Range | Sun | | | | | × | × | |
| 439 | Neptune | ___ | Range | Sun | | | | | × | | |
| 440 | Miranda | ___ | Range | Uranus | | | | | | × | |
| 441 | Ariel | ___ | Range | Uranus | | | | | | × | |
| 442 | Umbrial | ___ | Range | Uranus | | | | | | × | |
| 443 | Titania | ___ | Range | Uranus | | | | | | × | |
| 444 | Triton | ___ | Range | Neptune | | | | | | | |
| 445-446 | Uranus | EME50 | RA and DEC | Earth | | | | | × | × | |
| 447-448 | Neptune | EME50 | RA and DEC | Earth | | | | | × | | |
| 449-450 | S/C | UTEED | RA and DEC | Uranus | | | | | × | × | |
| 451-452 | Sun | UTEED | RA and DEC | Uranus | | | | | × | × | |

| WORD | DESCRIPTION | | | | AVAILABILITY | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | OBJECT LOCATED | COORDINATE SYSTEM | COORDINATES | COORDINATE SYSTEM ORIGIN | L | C | J | S | EC | U | N |
| 453-454 | Earth | UTEED | RA and DEC | Uranus | | | | | × | | |
| 455-456 | Miranda | UTEED | RA and DEC | Uranus | | | | | | × | |
| 457-458 | Ariel | UTEED | RA and DEC | Uranus | | | | | | × | |
| 459-460 | Umbrial | UTEED | RA and DEC | Uranus | | | | | | × | |
| 461-462 | Titania | UTEED | RA and DEC | Uranus | | | | | | × | |
| 463-464 | S/C | NTEED | RA and DEC | Neptune | | | | | × | | |
| 465-466 | Sun | NTEED | RA and DEC | Neptune | | | | | × | | |
| 467-468 | Earth | NTEED | RA and DEC | Neptune | | | | | × | | |
| 469-470 | Triton | NTEED | RA and DEC | Neptune | | | | | | | |
| 471-472 | Uranus | SUTEED | RA and DEC | Sun | | | | | × | | |
| 473-474 | Neptune | SUTEED | RA and DEC | Sun | | | | | × | | |
| 475 | Uranus-Sun-S/C | ___ | Angle | ___ | | | | | × | × | |
| 476 | Sun-Uranus-S/C | ___ | Angle | ___ | | | | | × | × | |
| 477 | Neptune-Sun-S/C | ___ | Angle | ___ | | | | | × | | |
| 478 | Sun-Neptune-S/C | ___ | Angle | ___ | | | | | × | | |
| 479-480 | Uranus | Celestial Clock & Cone | CLK & CON | S/C | | | | | × | × | |
| 481-482 | Miranda | Celestial Clock & Cone | CLK & CON | S/C | | | | | | × | |
| 483-484 | Ariel | Celestial Clock & Cone | CLK & CON | S/C | | | | | | × | |
| 485-486 | Umbrial | Celestial Clock & Cone | CLK & CON | S/C | | | | | | × | |
| 487-488 | Titania | Celestial Clock & Cone | CLK & CON | S/C | | | | | | × | |
| 489-490 | Neptune | Celestial Clock & Cone | CLK & CON | S/C | | | | | × | | |
| 491-492 | Triton | Celestial Clock & Cone | CLK & CON | S/C | | | | | | | |
| 493-494 | Uranus | ETEED Celestial Lat./Long. | Celestial LAT and LON | Sun | | | | | × | × | |

| WORD | DESCRIPTION | | | | AVAILABILITY | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | OBJECT LOCATED | COORDINATE SYSTEM | COORDINATES | COORDINATE SYSTEM ORIGIN | L | C | J | S | EC | U | N |
| 495-496 | Neptune | ETEED Celestial Lat./Long. | Celestial LAT and LON | Sun | | | | | × | | |
| 497 | Time To/From Uranus Periapsis Passage | — | — | — | | | | | | × | |
| 498 | Time To/From Neptune Periapsis Passage | — | — | — | | | | | | | |
| 499-504 | S/C | UMOPMS | Cartesian State | Uranus | | | | | | × | |
| 505-510 | Miranda | UMOPMS | Cartesian State | Uranus | | | | | | × | |
| 511-516 | Ariel | UMOPMS | Cartesian State | Uranus | | | | | | × | |
| 517-522 | Umbrial | UMOPMS | Cartesian State | Uranus | | | | | | × | |
| 523-528 | Titania | UMOPMS | Cartesian State | Uranus | | | | | | × | |
| 529-534 | S/C | NMOPMS | Cartesian State | Neptune | | | | | | | |
| 535-540 | Triton | NMOPMS | Cartesian State | Neptune | | | | | | | |
| 541-546 | S/C | UTPMED | Cartesian State | Uranus | | | | | | × | |
| 547-549 | Miranda | UTPMED | Cartesian State | Uranus | | | | | | × | |
| 550-552 | Ariel | UTPMED | Cartesian Position | Uranus | | | | | | × | |
| 553-555 | Umbrial | UTPMED | Cartesian Position | Uranus | | | | | | × | |
| 556-558 | Titania | UTPMED | Cartesian Position | Uranus | | | | | | × | |
| 559-564 | S/C | NTPMED | Cartesian State | Neptune | | | | | | | |
| 565-567 | Triton | NTPMED | Cartesian Position | Neptune | | | | | | | |
| 568-569 | S/C | — | LAT and LON | Uranus | | | | | | × | |
| 570-571 | Miranda | — | LAT and LON | Uranus | | | | | | × | |
| 572-573 | Ariel | — | LAT and LON | Uranus | | | | | | × | |
| 574-575 | Umbrial | — | LAT and LON | Uranus | | | | | | × | |
| 576-577 | Titania | — | LAT and LON | Uranus | | | | | | × | |
| 578-579 | S/C | — | LAT and LON | Neptune | | | | | | | |
| 580-581 | Triton | — | LAT and LON | Neptune | | | | | | | |
| 582-600 | (Spares) | | | | | | | | | | |

mf Natt

PROGRAM: SWTRAV Library: MJS

AUTHORS: P. Gazis, K. Hester

DATE: July 16, 1984

## DESCRIPTION

This subroutine calculates the solar wind propagation time between two points taking into account the solar wind radial expansion, the longitudinal separation of the two points, and their radial and longitudinal velocities. Rigid corotation of the stream structure is assumed.

Input variables-

XOBS,XARR- These are the "cartesian states" of the observation and arrival points and are of dimension 6. The first three variables of each array are the position coordinates of the point in a sun-centered cartesian coordinate system (Earth mean ecliptic and equinox of 1950.0) in units of kilometers. The last three variables of each array give the three components of velocity of the point in kilometers/second.

VPLS- This is the proton bulk velocity in kilometers/second.

Output variables-

TD(1)- This is the delay time in days.

TD(2)- This is the radial expansion factor, i.e. the ratio of the densities at the arrival and observation points, assuming that the density falls off as $1/r^2$.

## METHOD

The "cartesian states" of the observation and arrival points are transformed to positions and velocities in a heliocentric spherical coordinate system- ROB,TOB,VOB,WOB,RAR,TAR,VAR,WAR (R=radius, T=longitude, V=radial velocity, W=angular velocity). The propagation time is then calculated by means of the equation-

$$t = \frac{\Delta\phi + \frac{\Omega}{V}\Delta r}{\frac{\Omega}{V}(V - v_r) - \dot{\phi}}$$

where

$\Delta r$ = r(arrival) - r(observed)
$\Delta\phi$ = longitude(arrival) - longitude(observed)
$\Omega$ = angular velocity of the sun

$V$ = velocity of the solar wind

$v_r$ = radial velocity of arrival point

$v_\phi$ = longitudinal velocity of arrival point

The equation of an Archimedean spiral is

$$\phi = \phi_o - \frac{\Omega r}{V}$$

where $\phi_o$ = azimuthal angle at $r = 0$.

At t=0, a spiral stream is observed by the first s/c at some point $(r_1, \phi_1)$, so

$$\phi_o = \phi_1 + \frac{\Omega r_1}{V}$$

Thus, the equation for this particular stream is

$$\phi = \phi_1 + \frac{\Omega}{V}(r_1 - r) + \Omega t$$

At t=0, the second s/c is at some point $(r_2, \phi_2)$ and is moving at some radial velocity $V_r$, and angular velocity $\dot{\phi}$, therefore the spiral stream arrives at the second spacecraft at some time t when

$$r_2' = r_2 + v_r t$$

$$\text{and} \quad \phi_2' = \phi_2 + \dot{\phi}\, t$$

Substitute these expressions into that for the stream

$$\phi_2 + \dot{\phi} t = \phi_1 + \frac{\Omega}{V}(r_1 - r_2 - v_r t) + \Omega t.$$

Solving for t, the arrival time at the second spacecraft is given by

$$t = \frac{\Delta\phi + \frac{\Omega}{V}\Delta r}{\frac{\Omega}{V}(V - v_r) - \dot{\phi}}$$

The radial expansion factor is calculated by means of the equation

$$\text{expansion factor} = \left(\frac{r(\text{observed})}{r(\text{arrival})}\right)^2, \text{ assuming that the}$$

density falls off as $1/r^2$.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Center for Space Research
April 10, 1984

*LIBRARY PLS*

MEMORANDUM

**TO:** MJS Internal

**FROM:** George S. Gordon, Jr.

**SUBJECT:** TIMER and $TIMER

## PURPOSE

To print out the amount of CPU time used between successive calls to TIMER. Both the incemental time and the totat time are printed out.

## METHOD

TIMER reads the amountof time used since the last call to TIMER. This implies that the first call will give a large number. The incemental CPU time ac well as the total time are printed in units of 26.04166 microseconds. A CALL HOTIME, for HOld TIME, will stop the accumulation running time . HOTIME will effect the current time segment, i.e. the timesegment between the last call to TIMER and the next call to TIMER. A common block TIME$$ ITT, IAA allows the user program to access both the total CPU time, ITT, and the time between the last two calls to TIMER.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Center for Space Research
April 5, 1984

*LIBRARY PLS*

MEMORANDUM

TO: MJS Internal

FROM: George S. Gordon, Jr.

SUBJECT: TRACE

PURPOSE

Prints out a trace back from the calling routine. TRACE also prints out the save area. TRACES only prints the trace back.

METHOD

TRACE searches back through the string of save areas calling $WRTRC to print out the trace back, and if needed the save area. The save area has the contents of the general registers at the time the subroutine is called.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Center for Space Research
June 22, 1984

LIBRARY PLS

MEMORANDUM

TO: Program Library

FROM: George S. Gordon, Jr.

SUBJECT: Vector and Tensor handling routines

1. This is for three dimensional Euclidian geometry only.

2. Conventions.

   A) All vectors are considered as column vectors and have the prefix V, e.g. VG(3)

   B) All tensors, matrices have normal FORTRAN storage as though dimensioned with one or two indices and have the prefix T, e.g. TG(9) or TH(3,3)

   C) All other variables follow normal conventions. All angles are in degrees.

   D) Example:

Real VP(3),TG(9),TH(3,3),V(3)
then $V' = T_G V$ means

$$v'_i = \Sigma_j \, tg_{i+3j-3} v_j$$

$$\begin{bmatrix} V'_1 \\ V'_2 \\ V'_3 \end{bmatrix} = \begin{bmatrix} tg_1 & tg_4 & tg_7 \\ tg_2 & tg_5 & tg_8 \\ tg_3 & tg_6 & tg_9 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

and $V' = T_H V$ means

$v'_i = \Sigma_j \, th_{ij} v_j$

$$\begin{bmatrix} V'_1 \\ V'_2 \\ V'_3 \end{bmatrix} = \begin{bmatrix} th_{11} & th_{12} & th_{13} \\ th_{21} & th_{22} & th_{23} \\ th_{31} & th_{32} & th_{33} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

also $\bar{V}$ denotes a unit vector in the direction V,

and $\tilde{T}_G$ denotes the transpose of $T_G$

$\tilde{v}_{ij} = v_{ji}$

$$\tilde{T}_G = \begin{bmatrix} tg_1 & tg_2 & tg_3 \\ tg_4 & tg_5 & tg_6 \\ tg_7 & tg_8 & tg_9 \end{bmatrix}$$

3. The standard calling sequences.

A) Vector Routines.

I) Functions returning a scalar. (module name SCLR )

1. $|V|$
   = VECABS( V)

2. $V_A \cdot V_B$
   = VECSCL( VA, VB)

3. $V_A \cdot (V_B \times V_C)$
   = VEC3SC( VA, VB, VC)

4. $(V_A \times V_B) \cdot (V_C \times V_D)$
   = VEC4SC( VA, VB, VC, VD)

II) Vector product routines. (module name VCTR)

1. CALL VECNOR( V)
   . returns V = V/|V|

2. CALL VECCPY( V, VA)
   . returns V = $V_A$

3. CALL VECCRS( V, VA, VB)
   . returns V = $V_A \times V_B$

4. CALL VEC3CR( V, VA, VB, VC)
   . returns V = $V_A \times (V_B \times V_C)$

5. CALL VEC4CR( V, VA, VB, VC, VD)
   . returns V = $(V_A \times V_B) \times (V_C \times V_D)$

III) Coordinate conversion routines.

1. CALL VSPXYZ( V, POLANG, AZANG, R)
   Vector SPherical to XYZ
   INPUT
   POLar ANGle, AZimuth ANGle, Radius.
   OUTPUT
   V = ($V_x$, $V_y$, $V_z$)

2. CALL VXYZSP( V, POLANG, AZANG, R)
   Vector XYZ cartesian to SPherical coordinates.
   INPUT
   V = ($V_x$, $V_y$, $V_z$)
   OUTPUT
   POLar ANGle, AZimuth ANGle, Radius.

B) Tensor Routines.

I) CALL ROTEUL( R, ALPHA, BETA, GAMMA)
   INPUT
   R, rotation matrix
   OUTPUT
   ALPHA, BETA, GAMMA. Euler angles corresponding to R

II) CALL TEQAB( T, TA, TB) T = $T_a \times T_b$ T EQuals AB

III) CALL TEQAIN( T, TA) T = $T_a^{-1}$ T equals A INverse

IV) CALL TEQATR( T, TA) T EQual to A TRanspose

V) CALL TINVAR( T, S, Q, D) T INVARiants
   $S = \lambda_1 + \lambda_2 + \lambda_3$ trace
   $Q = \lambda_1\lambda_2 + \lambda_2\lambda_3 + \lambda_3\lambda_1$

$D = \lambda_1\lambda_2\lambda_3$ determinant

C) Mixed Vector/Tensor Routines.

I) EUL Euler routines

1. CALL EULSTT( ALPHA, BETA, GAMMA, THA, PHI, THAP, PHIP)
set new rotation matrix with Euler angles ALPHA, BETA, and GAMMA
rotate THA, PHI to THAP, PHIP

2. CALL EULTRN( THA, PHI, THAP, PHIP)
rotate THA, PHI to THAP, PHIP

3. CALL EULSET( ALPHA, BETA, GAMMA)
set new rotation matrix with Euler angles ALPHA, BETA, and GAMMA

4. CALL EULRTT( ALPHA, BETA, GAM, T)
set new rotation matrix with Euler angles ALPHA, BETA, and GAMMA
return new rotation matrix T

II) CALL VTRNS( VP, T, V, V0) Vector TRaNSformation
$V_P = TV + V_0$

III) CALL DYAD( T, VA, VB) $t_{ij} = a_i b_j$

IV) CALL ONAXR( VP, V, VR, ANGLE) ONe AXis Rotation
VP = V rotated angle degrees around axis VR

METHOD: $V_p = (\cos\theta)V + (\sin\theta)(\bar{V}_R \times V) + (1-\cos\theta)(V \cdot \bar{V}_R)\bar{V}_R$

CALL ONAXRT( VP, V, VR, ANGLE, T)
same as ONAXR except it returns the rotation matrix T

V) CALL ROTAXS( T, VR, ANGLE) ROTate around AXiS
T = matrix to rotate ANGLE degrees around VR

VI) CALL ROTMTX( VA, VB, VAP, VBP, T, VR, ANGLE)
ROTMTX generates a transformation matrix T, and corresponding rotation axis vector VR, and rotation angle which will rotate vectors VA & VB into VAP & VBP

D) Special Routines.

I) DEL( I, J)
$= \delta_{ij}$

II) EPSILN( N, IP)
$= \varepsilon_{ip(1),\ldots,ip(n)}$
parity of permutations of up to six objects

The INDEX has a list of JDS's old VECTOR subroutine names with their calling sequences, followed by the new routine's names and calling sequences. Note that the number of arguments often determines the function in the old routines, while the new routines have a fixed length call sequence. The routines are grouped by function.

# INDEX


C

Coordinate Conversion.
VPOLAR( V, POLANG, AZANG, R)
VSPXYZ( V, POLANG, AZANG, R) . . . . . .3
VSPHER( V, POLANG, AZANG, R)
VXYZSP( V, POLANG, AZANG, R) . . . . . .3

M

Mixed
DYAD( T, VA, VB)
DYAD( T, VA, VB) . . . . . .4
EULER( ALPHA, BETA, GAMMA)
EULSET( ALPHA, BETA, GAMMA) .4
EULER( ALPHA, BETA, GAMMA, THA, PHI, THAP, PHIP)
EULSTT( ALPHA, BETA, GAMMA, THA, PHI, THAP, PHIP) .4
EULER( THA, PHI, THP, PHIP)
EULTRN( THA, PHI, THP, PHIP) . . . . . .4
EULROT( ALPHA, BETA, GAM, T)
EULRTT( ALPHA, BETA, GAM, T) . . . . . .4
ONAROT( VP, V, VR, ANGLE)
ONAXR( VP, V, VR, ANGLE) . .4
ONAROT( VP, V, VR, ANGLE, T)
ONAXRT( VP, V, VR, ANGLE, T) . . . . . .4
ROTAXS( T, VR, ANGLE)
ROTAXS( T, VR, ANGLE) . . . .4
ROTMAT( VA, VB, VAP, VBP, T, VR, ANGLE)
ROTMTX( VA, VB, VAP, VBP, T, VR, ANGLE) . . . . . .4
VTRANS( VP, T, V, V0)
VTRNS( VP, T, V, V0) . . . . . .4

S

Special
DEL( I, J)
DEL( I, J) . . . . . .4
EPSIL( IP(1), IP(2), ..., IP(N))
EPSILN( N, IP) . . . . . .4

T

Tensor
ROTEUL( R, ALPHA, BETA, GAMMA)
ROTEUL( R, ALPHA, BETA, GAMMA) . . . . . .3
TEQAB( T, TA, TB)
TEQAB( T, TA, TB) . . . . . .3
TEQAIN( T, TA)
TEQAIN( T, TA) . . . . . .3
TEQATR( T, TA)
TEQATR( T, TA) . . . . . .3
TINVAR( T, S, Q, D)
TINVAR( T, S, Q, D) . . . . .3

V

Vector routines
SCALAR( V)
VECABS( V) . . . . . .2
SCALAR( VA, VB)
VECSCL( VA,VB) . . . . . .2
SCALAR( VA, VB, VC)
VEC3SC( VA, VB, VC) . . . . .2
SCALAR( VA, VB, VC, VD)
VEC4SC( VA, VB, VC, VD) . . .3
VECTOR( V)
VECNOR( V) . . . . . .3
VECTOR( V, VA)
VECCPY( V, VA) . . . . . .3
VECTOR( V, VA, VB)
VECCRS( V, VA, VB) . . . . .3
VECTOR( V, VA, VB, VC)

VEC3CR( V, VA, VB, VC) . . .3
VECTOR( V, VA, VB, VC, VD)
VEC4CR( V, VA, VB, VC, VD) .3

Library: MJS

Program: VGR3D

Purpose: To produce three-dimensional perspective plots of Voyager positive ion spectra.

Date: August 21, 1985

- Structure

  1. Control card deck organization

     Plot 1 control cards
     Plot 2 control cards
     .
     .
     Plot N control cards

  2. Sample control cards for any given plot

     card one
     card two
     card three
     optional data cards + blank card

- Card One

| Internal variable | Input Format | Explanation |
|---|---|---|
| ISYR | I4 | Start year |
| ISDY | I4 | Start day of year |
| ISHR | I3 | Start hour of day |
| ISMIN | I2 | Start minute of hour |
| | 7X | space |
| PMAX | F10.3 | Maximum value for scale of 3-D plot (if zero, actual data maximum is used) |
| PMAX1 | F10.3 | Maximum value for side panel 1 (if zero, data maximum is used) |
| PMAX2 | F10.3 | Maximum value for side panel 2 |
| PMAX3 | F10.3 | Maximum value for side panel 3 |
| K1 | I5 | Skip parameter for side panel 1 (see PTT3D); if zero, use K |
| K2 | I5 | Skip parameter for side panel 2 |
| K3 | I5 | Skip parameter for side panel 3 |

- Card Two

| | | |
|---|---|---|
| NSAD | I5 | number of spectra/day (7200:CR1; 900:GS-3; 450:CR5,6) |
| ICUP | I5 | Sensor number (1-4 = A-D) |
| MODE | I5 | Mode (1=L, 2=M) |

- Card Two (continued)

| | | |
|---|---|---|
| PHI | F5.1 | PTT3D projection angles |
| THETA | F5.1 | |
| SLOW | F5.1 | limits for spline fit |
| SHIGH | F5.1 | |
| IA | I5 | Start channel number |
| IB | I5 | Stop channel number or number of file points in spline (≤128) |
| K | I5 | Skip parameter for 3-D plot |
| IPEN | I5 | Pen number of accented lines (if zero, default to 1) |
| NSP | I5 | Number of spectra in plot (≤160) (if zero, default to 160) |
| JANS | I5 | Number of item in answer array to be plotted in side panel 1 (if negative, plot flux from E2 mode) |
| JANS2 | I5 | Side panel 2 (if negative, plot flux from E1 mode) |
| JANS3 | I5 | Side panel 3 (if negative, plot temperature from E1 mode) |
| JA | I5 | Side panel start channel number (if zero, JA=IA) |

- Card Three (logical variables)

| | | |
|---|---|---|
| TFOR | L1 | True for time forward |
| CFOR | L1 | True for channel forward |
| REVC | L1 | True for second plot reversing channels |
| REVT | L1 | True for second plot reversing time (if both true, there are 3 plots) |
| FPCUR | L1 | True for current distribution, false for current |
| LOG | L1 | True for plotting logarithm of data |
| LX | L1 | True for lines parallel to X axis |
| LY | L1 | True for lines parallel to Y axis |
| | 2X | space |
| EXPAND | L1 | True to expand X axis scale to fill line |
| PLTYZ | L1 | True for side panel 1 plot |
| NOSPLT | L1 | True for NO spline fit; false for spline fit |
| VELPLT | L1 | True for speed on X axis; false for energy/charge |
| EFFAZ | L1 | True for effective $A/Z^*$ normalization |
| REJ255 | L1 | True to reject DN values of ≥254 |
| LREAD | L1 | True to read a data deck after card 3 |
| REPLOT | L1 | True to replot data from last plot |
| | 2X | space |

- Card Three (continued)

| | | |
|---|---|---|
| CHAN | L1 | True for channel number on X axis (overrides VELPLT) |
| PLTYZ2 | L1 | True for side panel 2 plot |
| PLTYZ3 | L1 | True for side panel 3 plot |
| LOGS1 | L1 | True for plotting log of values on side panel 1 |
| LOGS2 | L1 | True for plotting log of values on side panel 2 |
| LOGS3 | L1 | True for plotting log of values on side panel 3 |

- Optional Data Cards

| | | |
|---|---|---|
| | I4 | Year (blank to terminate data cards) |
| | I4 | Day |
| | I3 | Hour |
| | I2 | Minute |
| | 7X | space |
| Z1 | F10.4 | Data value for side panel 1 |
| Z2 | F10.4 | Data value for side panel 2 |
| Z3 | F10.4 | Data value for side panel 3 |
| K1 | I5 | See card one description (these |
| K2 | I5 | values need only appear on the |
| K3 | I5 | last "blank" card) |

- Comments

1. In the Z vs. Y plane, one may plot any answer array item.
2. The Y axis is time (spectrum number).
3. In the Z vs. X plane, one may plot the distribution function, the current, or the effective $A/Z^*$ distribution function.
4. All 4 pens may be used when plotting.
5. Plots are labelled with the time of the last spectrum plotted.

- Sample CMS job

1. Here is a sample exec file to run a 3-D plot:

```
&TRACE ERR
EXEC PRECALC MJSTXT PLSTXT
FILEDEF * CLEAR
FILEDEF 5 DISK VGR3D CONTROL (PERM
FILEDEF 18 X DSN CSR $380340 V2 SPL JUP DATA (RECFM VBS LRECL 17596 BLKSIZE
17600 DSORG PS
&EXIT &RC
```

2. This is the data file VGR3D CONTROL used by the above exec:

```
1979 189 2300        0000.     100.
00900    4    1 315. 045.                                        8
TFFFFFTF  TTFFFFFF  TFFFFF
```

3. Here is how one would submit this job:

```
 LOAD VGR3D RUNBEG (START
```

4. Any non-graphical output would be written to FILE FT06F001, which could then be edited.

- Sample batch jobs

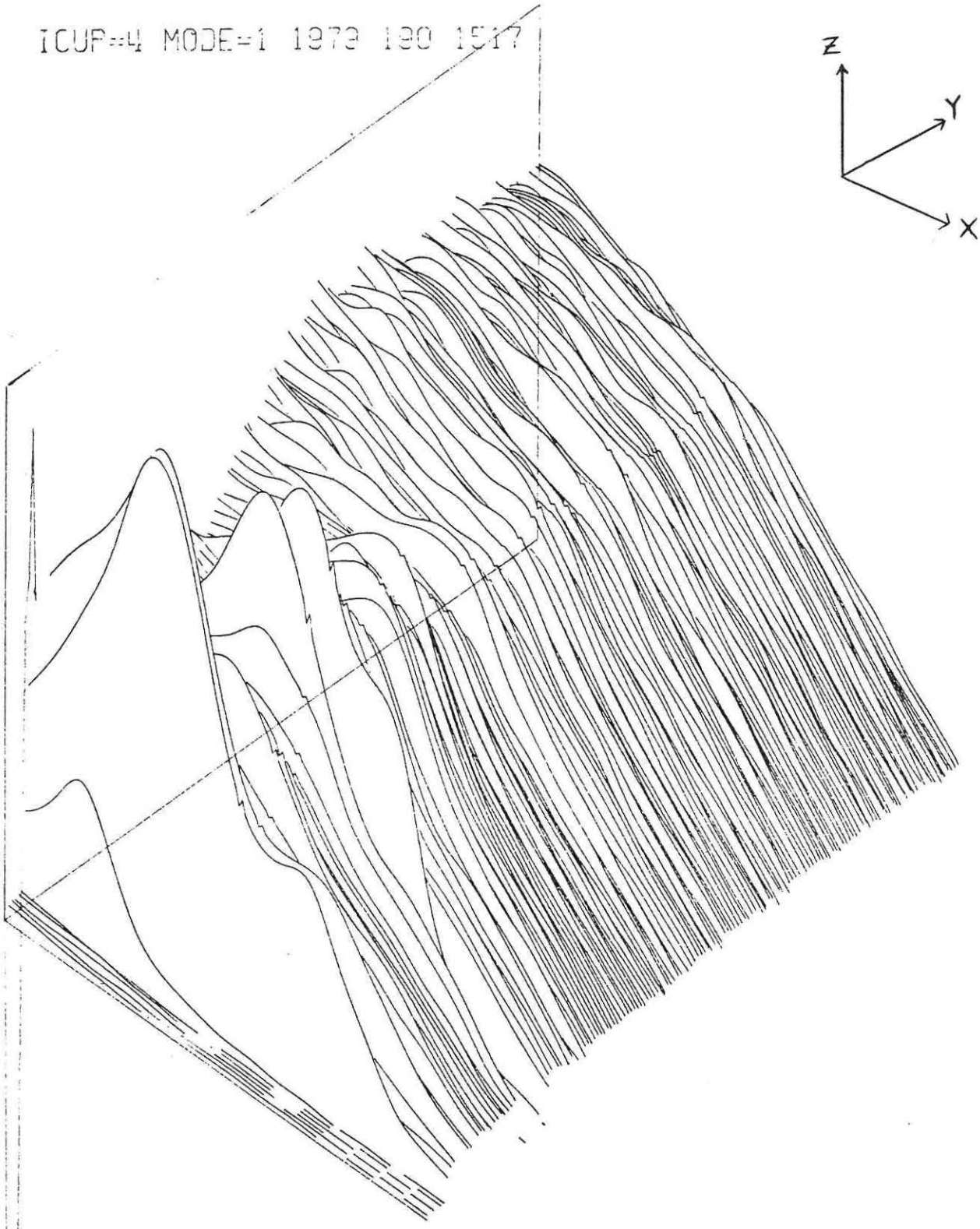
```
//*  ***  3D PLOTS USING SUMMARY TAPES FOR INPUT  ***
/*SETUP UNIT=T1600,ID=(PT1638,NORING,SAVE,BLP)
/*SETUP UNIT=T800,ID=(PT2678,RING,SAVE,BLP)
/*MAIN TIME=5
/*SRI D
//LG EXEC FORTXLG,PARM.LKED='MAP,LIST,LET,SIZE=(164K,16K)',
//         REGION.LKED=128K
//LKED.SYSPRINT DD SYSOUT=A
//LKED.SYSLIB DD DISP=SHR,DSN=CSR.$380300.TEST.OBJ
//            DD DISP=SHR,DSN=CSR.$380300.MJS.OBJ
//            DD DISP=SHR,DSN=CSR.$380300.PLS.OBJ
//            DD DISP=SHR,DSN=CSR.$380300.GSG.OBJ
//            DD DISP=SHR,DSN=SYS1.HARVARD.FORTLIB
//            DD DISP=SHR,DSN=SYS1.FORTLIB
//LKED.SYSIN  DD *
 INCLUDE SYSLIB(VGR3D)
 INCLUDE SYSLIB(NXTSUM)
 INCLUDE SYSLIB(VGRREW)
 INCLUDE SYSLIB(BAT7)
 ENTRY MAIN
/*
//GO.FT06F001 DD SYSOUT=A
//GO.SYSIN    DD *
1981 236 0600       20000.    50.
00900    4    1 315. 045.                                          8
TFFFFFTF  TTFFFFFF  TFFFFF
/*
//GO.SUMMARYT DD UNIT=T1600,LABEL=(,BLP),DISP=OLD,
//            DCB=(EROPT=SKP,OPTCD=Z),
//            VOL=SER=PT1638
//GO.FT37F001 DD UNIT=T800,DISP=(MOD,PASS),
//            DCB=(RECFM=VS,LRECL=364,BLKSIZE=368,DEN=2),LABEL=(,BLP),
//            VOL=SER=PT2678
/*
```

The following JCL was used to create the sample plot that is shown in the last page of this writeup.

```
//*  ***  3D PLOTS USING AN 'SPL' DISK FILE FOR INPUT  ***
/*SETUP UNIT=T800,ID=(PT2963,RING,SAVE,BLP)
/*MAIN TIME=1
/*SRI W
//LG EXEC FORTXLG,PARM.LKED='MAP,LIST,LET,SIZE=(164K,16K)',
//         REGION.LKED=1000K
//LKED.SYSPRINT DD SYSOUT=A
//LKED SYSLIB DD DISP=SHR,DSN=CSR.$380300.TEST.OBJ
//            DD DISP=SHR,DSN=CSR.$380300.MJS.OBJ
//            DD DISP=SHR,DSN=CSR.$380300.PLS.OBJ
//            DD DISP=SHR,DSN=CSR.$380300.GSG.OBJ
//            DD DISP=SHR,DSN=SYS1.HARVARD.FORTLIB
//            DD DISP=SHR,DSN=SYS1.FORTLIB
//LKED.SYSIN  DD *
 INCLUDE SYSLIB(VGR3D)
 INCLUDE SYSLIB(NXTSPL)
 INCLUDE SYSLIB(VGRREW)
 INCLUDE SYSLIB(RDFTPDM)
 INCLUDE SYSLIB(RUNBEG)
 ENTRY MAIN
/*
//GO.FT06F001 DD SYSOUT=A
//GO.SYSIN    DD *
1979 190 11 5                0.        1.
00900    4    1 315. 045.                                        0
TFFFFFTF  TTFFFFTF  TFFTFF
1979 190 11 5           0.1042
1979 190 11 6           0.1281
1979 190 11 8           0.1517
1979 190 11 9           0.2502
1979 190 1111           0.1467
1979 190 1113           0.9948
1979 190 1114           3.4321
1979 190 1116           4.0434
1979 190 1117           7.6651
1979 190 1119           3.4953
                                                      0    0    0

/*
//GO.FT18F001 DD DISP=OLD,DSN=CSR.$380340.V2.SPL.JUP.DATA
//GO.FT37F001 DD UNIT=T800,DISP=(MOD,PASS),
//            DCB=(RECFM=VS,LRECL=364,BLKSIZE=368,DEN=2),LABEL=(,BLP),
//            VOL=SER=PT2963
/*
```

Please note: if one were using an EDR tape instead of a Summary tape or a spectral disk file as input, NXTEDR would have to be loaded instead of NXTSUM or NXTSPL.




AMAX= 118381.87

VIEWING ANGLE
THETA = 45.00
PHI = 315.00

MODE = 3

ARRAY SIZE

| | NATURAL DIMENSION | REGION PLOTTED | | |
|---|---|---|---|---|
| X | 128 | 1 | THRU | 128 |
| Y | 160 | 1 | THRU | 160 |