EclipseMaster

High Accuracy Eclipse Data

Publisher: Zephyr Services, 1900 Murray Ave.,Pittsburgh,PA 15217

To run the program:

For Commodore 64/128 Computers

After turning on the disk drive and the computer, type
    LOAD "ECLIPSE",8

When the program has loaded in, type

    RUN

The above commands are, as usual, terminated with a press of the RETURN key. Note that in the instructions below, sometimes upper case letters are used for emphasis. Data entries and replies should be made in unshifted mode, however.

The running program will then automatically load in two other programs from the same disk. Then the program will be ready to start. Then follow the detailed directions below.

For Apple II Computers

The disk supplied will load and run if placed in drive 1 and the computer turned on. If you already have the computer on, then with the computer prompt showing on screen, you can place the disk in drive 1 and enter; RUN ECLIPSE Then the program will load and run. Then follow the detailed directions below.

For IBM PC & Compatible Computers

At the A> prompt, place the disk in drive A:, then enter: ECLIPSE and the program will load and run. Then follow the detailed directions below. (You may also place all the files from the disk onto a hard disk and run from the C> prompt.)

necessary to press RETURN at the end of each multiple

Detailed Directions

The running program will then automatically load in information from the same disk. Eventually, you will get a screen with a menu of commands as illustrated below, summarizing the main available commands, then a prompt saying

function:

allowing you to type in one of the function commands.

The menu appears below. It can be seen again at any time my pressing the H key in response to the FUNCTION: prompt. This HELP command and the other commands are executed by typing its one- or two-character command code as described below. It is not necessary to press RETURN after the commands. It is, however, necessary to press RETURN at the end of data entries in response to prompts, for example, for date.

es - compute eclipse seasons
i - input date and time
d - change delta t
p - compute solar and lunar positions
ee - compute solar eclipse elements
s - save solar eclipse elements
l - load solar eclipse elements
oe - compute occultation elements
os - save occultation elements
ol - load occultation elements
eh - sol. ecl/occn begins/ends on horizon
en - sol. ecl/occn north or south limit
ep - sol. ecl/occn max globally
ec - sol. ecl/occn central line
el - sol. ecl/occn local circumstances
me - compute lunar eclipse elements
ms - save lunar eclipse elements
ml - load lunar eclipse elements
mt - lunar contact times & information
as - approximate solar eclipse elements computation
al or am - approximate lunar eclipse elements computation
h - help, to get this menu again

The menu just summarizes the commands that are available. Here are the detailed descriptions of the commands:

Note that all commands and responses are to be entered unshifted although the description may make use of capitals in making the keys to be pressed stand out.

i- This will cause the computer to ask you to enter the date in numeric form: month, day, year, calendar style. Do not omit the 19 in years 19xx; if you omit it you will get year xx. Calendar style is G or J. Use the former for dates according to the Gregorian calendar, which is the one we now use. If you want to input a date according to the Julian calendar, use a J when doing so. When inputting dates B.C., the astronomical form of the year number must be used; that is, 1 B.C. is input as 0; 2 B.C. as -1; 3 B.C. as -2, etc.

After you enter the date, the machine will ask you if you wish to input delta T. Delta t is a value used to represent the difference between Ephemeris Time and Universal Time, the former being a uniform time system and the latter subject to variations in the rotation of the Earth. If you press Y in response to this, you will be prompted to input the value of delta t in minutes. If you do not know it, you should press N when asked if you wish to input it, and the machine will determine from stored values an appropriate approximation.

Finally the program will prompt you to input the Universal Time in hours, minutes, and seconds, separated by commas. Universal Time is the time for the Prime meridian, and is 5 hours higher than Eastern Standard Time, 4 hours higher than Eastern Daylight Time. Note that for times near midnight it may be necessary to input a different day. Time is measured in 24-hour form, so enter 3 P.M. for example as 15,0,0.

Higher hours than 24 can be input so that you need not go back and use a higher date than you thought you would need. If you are working at a location that is east of Greenwich you may wish to enter negative times. Be careful when doing so. Midnight beginning the day is 0,0,0; fifteen minutes before that is either -1,45,0 or 0,-15,0.

es- Eclipse Seasons. If you wish to know the dates on which the Sun passes through the nodes of the Moon's orbit in a given year, press ES. You will then be prompted to input the year number (again, do not leave out the 19 in 19xx). The program will then give you these dates, which are the middles of the eclipse seasons for that year. New or Full moon from about 2 or 3 weeks before to 2 or 3 weeks after the given dates are likely to produce solar or lunar eclipses respectively. These can be investigated with further commands to be described. Alongside each date is given an A or a D indicating whether it is the Ascending node or the Descending note that the Sun is passing through.

Also shown is the age of the moon on that date; that is, the number of days since the last new moon. New moon occurs every 29 or 30 days and full moon follows every new moon by 14 or 15 days. On a separate line, the value of M', the number of degrees that the moon is past perigee on the given date, is shown. Together with the knowledge of the moon's age (phase) and thus the time adjustment (in days) necessary to get to new moon (for a solar eclipse), this can help guide you in determining whether a given solar eclipse would be total or annular (the moon travels about 13 deg. per day, and total eclipses occur near perigee, within 80 or so degrees).

As an example, when prompted for FUNCTION: type ES, and then input the year 1970 (press RETURN after year number but not after ES). You will get:

```
Mar 4 1970 Greg    A Moon 26 days old.
        M' =  351.875273
Aug 24 1970 Greg   D Moon 22 days old.
        M' =  92.1186722
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From the above it looks like March 7 or 8 will give us a solar eclipse,and also September 1 (or Aug. 31), while Feb. 20 and Aug. 16 look the most promising for lunar eclipses. As we go forward 3 or 4 days to the March 7 eclipse, M' advances about 45 deg. to about 397, or 37 (397-360) degrees, and so promises to be total. Advancing the bottom line 8 days puts M' at about 190 deg., and an annular eclipse is likely.

After doing an ES, any date that you may have input with I will be lost.

p- Positions. The P command causes the machine to compute the celestial coordinates of the Moon and the Sun at the date and time specified during the I command (remember to do the I command before the P command without doing any ES command in between). The computation takes a few seconds, and if it is near enough to eclipse season and new moon, you may get a message saying DOING ECLIPSE SPECIAL as extra terms then need to be added to the positions and this note tells you what is happening. Example: Enter the date 12,25,1980,G; reply N to "Do you wish to input delta T?"; give UT as 23,0,0 (6 PM Eastern Standard Time) and then ask for function P; you will get the following lunar and solar positions:

LUNAR (format somewhat different)

Celestial latitude	Celestial longitude	Parallax
1.4087 degrees	147.071 degrees	3376.8 arc seconds

Declination	Right Ascension
13.8115 degrees	149.777 degrees

SOLAR

Celestial latitude	Celestial longitude	Distance from Earth
0.00002 degrees	274.3307 degrees	.983439 A.U.

Declination	Right Ascension
-23.3689 degrees	-85.2814 degrees

Lunar positions are accurate within .0001 deg. lat., .0003 deg. long., .1 arc seconds parallax; solar postions: .00001 deg. lat., .0001 deg. long., and .000001 A.U. distance. Thus, do not use more of the computer-printed figures than is allowable from these accuracies. Note also that, on the screen, solar latitude is given in scientific notation as it is so small. Also the parallax of the moon is to large to fit on the line it started on, with the 3 appearing at the end of one line and the 376.76802 appearing on the next line. Celestial coordinates are given in decimal degrees, with conversion to degrees, minutes, and seconds left to the user. Also, note that customary usage would have Right Ascension in hours, minutes and seconds and always be positive. This is left to the user to convert, if the customary form is desired: -85.2814 degrees = 360 - 85.2814 degrees = 274.7186 degrees = 274.7186 / 15 hours = 18.31457 hours = 18 h 18 m 52.5 s.

Note that positions given include the effects of aberration and nutation, and thus are apparent positions, and are based on the coordinates of the date.

d- Use this command if at any time you wish to change the value of delta t without reinputting time and date. This is useful when saved eclipse elements (see below) were computed a while ago and now a better value of delta t is available. Be sure to change the delta t value after reloading the elements, as loading the elements will bring back the old value.

ee- Compute the eclipse elements for a solar eclipse. The approximate date of the eclipse must have been input with an I command; it does not matter what time of day was entered there, but if you know the value of delta t, enter it during the I function. It is not necessary to know what these elements (called Besselian elements) are, but they are listed, and they must be present in the computer to calculate any information about a solar eclipse. They can be stored on diskette (see S command below) and reloaded later. The program displays the names and values of these elements so you can see what they are. The variables printed are described below:

JD- The Julian Date rounded to the nearest integer (not to be confused with the Julian calendar date, this is a sequential numbering of days from 4713 B.C. used by astronomers).

YE,MO,DA- The Gregorian calendar date: year, month, and day.

TO- An arbitrary time during the eclipse, in hours past midnight, from which variations in elements are computed. (Time given in Ephemeris Time).

DT- The value of delta t, the difference ET-UT, measured in hours.

XO,X1,X2,X3- The value of the x coordinate of the moon's shadow at t-zero, its rate of change per hour, and the coefficients of time (in hours) squared, and cubed. Measured in earth equatorial radii.

YO,Y1,Y2,Y3- The same for the y coordinate.

L2(0),L2(1),L2(2),L2(3)- The value of l-2, at t-zero, its rate of change, and the coefficients of the square and cube terms of time, (radius of umbra at the fundamental plane, negative for total, positive for annular).

LL- The difference l-1 - l-2. (l-1 is the radius of the penumbra, at the fundamental plane.)

DO,D1- The value of d and its rate of change (declination of direction from which the shadow axis comes; in degrees).

MU(O),MU(1)- Value of mu (Ephemeris hour angle of shadow axis) and its rate of change (degrees).

TF(1),TF(2)- tan(f-1) and tan(f-2), the angular radii of the penumbral and umbral cones.

The accuracy is within 1 mile for later computations of the central line, or 1/20 of one percent in magnitude from a given location.

as- approximate solar eclipse elements will be computed if you use the AS command. These will be in the same format as those found via the EE command, but take less time to compute rather than the time that EE takes. Accuracy is to within 12 miles or 1/2 of one percent magnitude.

me- This computes elements for an eclipse of the moon. As lunar elements are not standard, a formatted listing is not provided, but every half minute you will see an hour marker indicating the ET for which elements are being computed. They are then displayed unformatted after the full computation has taken place. A formatted listing will be provided if you use the MS command, below, to save these elements to diskette. For lunar eclipses, approximate elements are usually sufficient, and the following command can be used.

am or **al**- Either of these will give the same results as the other. Either will compute approximate lunar eclipse elements. In this case 12-mile accuracy should be acceptable as the fuzziness of the Earth's shadow causes even greater discrepancies as to computation method to be used. A formatted listing of elements is provided similar to the solar eclipse one.

JD,YE,MO,DA,TO,DT have the same meaning as in a solar eclipse.

XO,X1,X2,X3,YO,Y1,Y2,Y3 have similar meanings as in a solar eclipse, except that the position refers to the moon with regard to the shadow axis rather than the shadow axis with regard to the Earth's center.

RO is the radius of the Earth's penumbra, and R1 its rate of change.

SI(O), SI(1) are the same for the umbra (measured in degrees).

D0,D1 give the moon's declination and that value's rate of change.

L0,L1 are the geographic (Ephemeris) longitude over which the Moon is located, and that value's rate of change.

S0,S1 are the Moon's semidiameter in degrees and its rate of change.

mt- Once elements of a lunar eclipse are present in the machine, either through ME or one of AM or AL or by loading previously calculated elements from the disk, the description of its visibility is available by keying MT. You will be asked if you want the results to go to the printer. Reply Y or N as appropriate, and press RETURN. The first line of resulting output gives the date in terms of the Julian Day Number at noon of that day, the day of the week, the year, month and day according to the Gregorian calendar (even before 1582), and the value of delta t in minutes. Then, for significant times during the eclipse the following are listed:

UT(GMT)- Universal Time.

PMAG- Penumbral magnitude. The fraction of the Moon's diameter covered by any shadow at all, even penumbra.

UMAG- Umbral magnitude. The fraction of the Moon's diameter covered by umbra. This is more than 1 when the moon is completely immersed in the umbra and then some. It is exactly 1 at the beginning and end of totality.

CCWFN- The position angle of the Earth's shadow on the Moon, measured counterclockwise from the north point of the Moon's disk.

LONG.,LAT.- The longitude and the latitude where the Moon is overhead on the Earth's surface. Any location within 6000 miles of this point should be able to see the given phase of the eclipse.

DIST- The distance from the center of the Moon's disk to the center of the Earth's shadow, in degrees.

RHO- The radius of the Earth's penumbra at the Moon's distance, as seen from the Earth, in degrees.

SIGMA- The radius of the Earth's umbra.

M.DIAM- The Moon's diameter in degrees.

These data are given for the beginning of penumbral eclipse, beginning of umbral eclipse (partial eclipse), beginning of totality, maximum eclipse, end of totality, end of umbral eclipse, and end of penumbral eclipse. If any of these do not exist, values of maximum will be given instead, thus eclipse maximum values may be shown more than once. After the values at the standard times are shown, you are asked if you want the data for another time. If you do, press Y, and you can then input the Universal Time whose data you wand. When you have all the data you want, press N. Extra time data are not sent to the printer.

s- Save computed elements of a solar eclipse to disk seq file with name "ECL year mo da", with the date values from the Gregorian version of the date.(xxxxxxx.ECL for IBM, xxxxxxx = Julian day #)

l- Load computed solar eclipse elements from disk, getting date from current Gregorian date in computer from I command.

ms- Save lunar eclipse elements to disk seq file "ECLM year mo da". (xxxxxxx.ECM for IBM)

ml- Load lunar eclipse elements from disk seq file "ECLM year mo da". (xxxxxxx.ECM for IBM)

ec- Gives data for points on the central line of a solar eclipse, if the eclipse is indeed central. Elements must be in machine, via EE, AS, or L command. The first displayed line shows the Julian Day Number at noon of the day of the eclipse, day of week, year, month and day, Gregorian (even for eclipses before 1582), and the value of delta in minutes. Each line of data has the Universal Time, the latitude and longitude at which the eclipse is central at that time, the width of the path of totality (negative width) or annularity (positive width), first in kilometers then in miles, the duration of totality or annularity from the point on the central line, in minutes and seconds, and the altitude of the sun in the sky at the given point on the central line, in degrees. The altitude is zero at the beginning and end points of the path. If you wish to have central line date for some other time, press the Y key in response to "Another time?" and you will be prompted to input the time (UT). Press N when you are finished finding central line data.

eh- Gives data for points on the earth where the eclipse begins or ends at sunrise or sunset. Elements must be in machine, via EE, AS, or L command. First line is as for EC command. Data shown are time (UT), latitude and longitude. Except for first and last contact, two sets of latitude and longitude appear on each line. Data are shown at intervals of 12 minutes, as in the case of central line data from the EC command. In this "horizon eclipse" mode, however, there will sometimes be a gap.

Let us take an example. Use the I command to input 3,7,1970,g; let the machine choose delta t; it doesn't matter what time you input. Then press AS to get approximate solar eclipse elements. Press EH to get horizon eclipse data. You will be asked "How many percent?". The usual reply is 0 (zero) followed by the RETURN key. This means that you want the eastern and western boundaries of the visibility of the eclipse as a partial eclipse (magnitude 0). If you wanted the same bounds for visibility of at least 50% of the solar diameter covered, you would reply 50 instead of 0, and likewise for other percentages. For now use 0. Notice that you get data for first contact at 15:05.2 and last contact at 20:12.1 with intervening data at 12-minute intervals from 15:07.3 to 20:07.3. Note the lack of data for 17:31.3 and 17:43.3. This means that the western and eastern bounds of the area of visibility are two separate loops if plotted on a map.

In some eclipses there is no such gap and the two loops merge to form one figure-8. (In this eclipse one of the two loops is a separate figure-8.) When there is no gap, and thus the two loops are joined, the combination serves not only as eastern and western limit of the eclipse visibility area, but either the northern or the southern as well. Note the times that are missing (if any are); they may be of interest when finding the northern and southern bounds of the area of visibility.

ep- Gives the time of maximum eclipse for a solar eclipse. First line is same as for EC command. Elements must be in machine via EE, AS, or L command. Shown below the first line is the time (Universal, or Greenwich Mean, Time) at which the Moon's shadow axis will pass nearest the center of the Earth, and the distance from that point in earth equatorial radii. If the eclipse is not central (the distance gamma is more than about 1 in absolute value), the location of maximum eclipse on the Earth's surface will be given by latitude and longitude, preceded by the magnitude at that point. Negative gamma indicates southern hemisphere.

For an example, try Jan. 25, 1982. If you use approximate elements (AS command), you get the shadow axis passing 1.231 earth radii south of the Earth's center at 4:43 GMT. It will be of magnitude .566 from 69.3 deg.S, 91.7 deg.W. If EE elements (accurate ones) were used, the UT would show as 4:42.0 and gamma as -1.2312. Magnitude .566 is the same, from latitude 69.27 deg.S, longitude 91.67 deg.W.

en- Finds latitudes and longitudes of points on the northern or southern limit of a solar eclipse. Elements must be in machine via EE, AS, or L command. You are asked for what percent you want the bound. Reply 0 if you want the limit of the area of visibility of the eclipse as a whole (partial eclipse). If you want the bound of visibility of totality, usually the data from the EC command are sufficient as that gives latitudes and longitudes on the central line and width of the path; but for eclipses of low altitude, some asymmetry may be present. If you wish to be certain, you can use the EN command with 100 percent given. For annular eclipses, to get the northern limit of annularity use 100 percent but specify S as if for south. Similarly use N for the southern limit.

Let's try the eclipse of 3,7,1970,g as an example of the limit of the eclipse (partial eclipse). The fact that when we did the EH function for this eclipse, there was a time gap indicates that both northern and southern limits exist for this eclipse. First it is advisable to do an EP for this eclipse.

If you are using approximate elements you get maximum at about 17:39 UT. Note that this is within the gap found in EH. Especially for eclipses without a gap, it is advisable to start with the time found from EP, as, if the given (N or S) limit exists, it exists at the time of maximum. Give the EN command; reply 0 to the percent question; ask for northern limit; and start with UT 17,39,0. The program will prompt you for an interval. Let's use -5 minutes; enter -5 (negative so we go backward in time).

When you are asked for an ending UT, enter a time sufficiently back to insure that you find all possible times; in this case it is easiest to enter 0,0,0. For this eclipse you should get latitudes and longitudes for three more times: 17:39, 17:34, and 17:29. When the machine asks "more?", reply Y. This time start with 17:44 (five minutes after 17:39, entered as 17,44,0) and use a positive 5-minute interval. Specify a time far ahead, such as 24,0,0, for ending UT, and you will get data for two more times, 17:44 and 17:49.

After you reply N to the "more?" question, you can command EN again and do the southern limit similarly. As you can see, on the northern limit the timing is critical so use of EP was important, as the program will not continue if the initial time does not have a limit location (that is it assumes that the first occurrence of not finding a value means that it can stop and ask "more?"). If you use the time of maximum and get no data before the "more?" it means that the given (N or S) limit does not exist.

el- Solar eclipse local circumstances. To find what the eclipse will be like from a given location, use this command. It will prompt you to input the latitude and longitude, each in degrees and minutes, positive being north and west respectively. When entering negative values you must put minus signs on both portions of the latitude (or longitude if that is the one that is negative); for example, enter 40 deg.31'S, 23 deg.12'E as -40,-31,-23,-12. Another example: 20 deg.2'N, 15 deg.45'E is entered as 20,2,-15,-45. Then you will be prompted to input the altitude in feet of the given location. If you do not know it, use 0, or a better approximation if you can make one.

The usual date identification line will appear as described under EC. You will be asked if you want the output to go to the printer. Reply Y or N as appropriate and press RETURN. Then the latitude and longitude, converted to geocentric latitude and Ephemeris longitude, will be shown in decimal form. The following data are then tabulated for the beginning of the eclipse, maximum eclipse, and end of the eclipse, as seen from the given location. On the screen they require two lines per time due to the 40-column restriction. They fit on one line on the printer.

UT- Universal Time (GMT).

M- Magnitude. What fraction of the sun's diameter is covered at the given time.

AREA- What fraction of the area of the apparent solar disk is covered. Unlike M, this is kept limited to no more than 1 (all the area).

CCWfN- The position angle of the moon in degrees counterclockwise from the north point of the sun's disk.

CCWfV- The position angle counterclockwise from the uppermost point on the sun's disk.

ALT- The number of degrees up in the sky that the sun is at the time.

AZ- The sun's azimuth: 0=north; 90=east; 180= south; 270=west; 360=north again, and various positions in between.

DUR/UMB- The duration of totality or annularity as seen from this location, in minutes and seconds, negative if total, positive if annular, shown only at time of maximum and only if the eclipse is total or annular from the given location. Trust this figure only if accurate elements were used (from EE
command). It is also advisable to use an accurate value of delta t for this datum.

D/RATIO- Ratio of lunar to solar diameter in sky.

HR ANGLE- Local hour angle of the Sun in degrees.

oe- This command initiates the computation of the elements of an occultation of a star or planet by the moon. You will need to know the apparent coordinates of the occulted body as the program will ask for these. The date and time must have been entered via I. When you key in OE, you will be asked to input coordinates for two times; for each time enter: Ephemeris Time (decimal hours), Right Ascension (decimal degrees), declination (decimal degrees), and distance to the object (Astronomical Units).

For a star, a distance of 200000 can be used, and values will be equal at the two times. For conversion of mean coordinates of one epoch to apparent coordinates of another (including nutation and aberration) a program (Astro-Aid) is available. You are then asked to input the semi-diameter the body would have at unit distance (that is, at a distance of 1 A.U.) in seconds of arc. This is available from various tables of planets. For stars use 0, or any small figure. For planets, values are: Mercury 3.37, Venus 8.46, Mars 4.68, Jupiter 98.37, Saturn 82.8, Uranus 32.9, Neptune 31.1, Pluto 4.1.

Usually you would use EP to find the midpoint of the occultation and EN to find the northern or southern limit (the graze path). Also EL can be used to find local circumstances. In this case, remember that the position angles given are for the moon relative to the star; add 180 deg. to get the more usual position angles of the star relative to the moon.

When EN is used with a star, it does not matter what percent you specify. With a planet, of course, it does, but the paths will be close; use 50 percent for the middle of the graze path. If for some reason you use EC, the width of the path will be four digits wide, over 2000 miles, over 3000 km, and the figures will thus not be separated with spaces between the columns.

os- Save occultation elements on diskette seq file named "OCCN year mo da", by the Gregorian calendar date.

ol- Load occultation elements from diskette using Gregorian date entered via I command.