# Exercise 10.0

# LOCATING THE PLANETS IN THE SKY

## I. Introduction

It is expected that Ex. 4.0 has been completed before attempting this exercise, since many of the definitions and concepts developed there will be needed here. Recall that the planets revolve around the sun in almost concentric orbits that lie nearly in the same plane as the Earth's orbit, with the exception of Pluto. Hence, in the sky, the planets are always to be found near the ecliptic. However, Pluto can be as much as $17^o$ off the ecliptic and the dwarf planet Eris has an orbit that is inclined to the plane of the ecliptic by $44^o$.

Recall also that the angular distance of a planet from the Sun, as measured E/W along the ecliptic, is called elongation. Furthermore, there is a simple relation between a planet's elongation and the approximate time it will rise, make UT, or set. This is:

$$\mathbf{T_P = T_\odot - T_E}$$

The meanings of the symbols in the above equation are as follows:

$\mathbf{T_P}$ = Local Time when a planet will rise, make upper transit, etc.
$\mathbf{T_\odot}$ = Local Time for corresponding solar event: rise, set, etc.
$\mathbf{T_E}$ = Planetary elongation in time units.

The above equation works best when the planet and the Sun are both near the celestial equator. We can then assume that sunrise is 06:00, upper transit (UT) for the Sun is 12:00, and sunset is at 18:00. *Do not use A.M. or P.M. in the above equation; use a 24 hour clock only*. If the Sun, planet, or Moon is not near the celestial equator, the above equation may be off by more than an hour. The farther away one or both objects are from the celestial equator, the larger the error. The equation of time is another factor that can introduce error. In this exercise, you will be studying how elongation is represented on a rectangular chart of the celestial sphere.

## II. Tutorial

Logon to **SKYLAB2** and select program "SKYMATION." A rectangular chart will then be drawn that represents the entire celestial sphere. An example is provided at the end of this exercise. The ecliptic appears as a wavy red curve. As soon as the chart is displayed, an animation will begin that shows the changing positions of the Sun, Moon, and planets in one day steps for the equatorial frame of reference. The positions of the planets, the Sun, and the Moon are indicated by small circles that are letter coded. The key to this code can be viewed as a window by typing "S" for symbols. Watch the animation run for a while to see what is happening and how the elongations of the Moon and planets change from day to day.

Note that the planets move along curves that are nearly coincident with the ecliptic. These curves are the projections of the planetary orbits onto the plane of the sky. The fact that the planets move along curves that are nearly coincident with the ecliptic expresses the fact that the planetary orbits lie nearly in the plane of the Earth's orbit, which is the same as the ecliptic plane.

Now note the vertical blue line that is slowly moving eastward each day. This is the LCM. Remember that the sidereal time is indicated by the hour circle of RA coincident with the LCM.

Since the screen is being displayed for the same ZT on successive days but the sidereal clock runs faster than the mean solar clock, the motion of the LCM indicates the daily gain of the sidereal clock on the solar clock.

Now change the step size to 3 hours and delay factor to 0.8 second. This will enable you to see details happening over each day. Note the planets hardly move at all in three hours, but the Moon's motion is noticeable. The large jumps in the position of the LCM are the result of seeing where it is relative to the stars every 3 hours and thereby indicating the sidereal time for the corresponding ZT indicated at the top of the screen. This eastward motion of the LCM is an alternative way of representing diurnal motion of the celestial sphere westward relative to the LCM. Recall that the parallels of declination are the diurnal circles.

## III. Assignment

Set the time, date and year to correspond to when you will be doing your observations (E. G. 21:00) or use the time and date given to you by your instructor. Call for a “grid” and “plot star” under Options. Then get a printout of this chart to be used with this exercise.

The chart shows where the Sun, Moon, planets, and most of the visible stars are located relative to your **LCM**. Recall that what is shown on the chart is actually the half of the **LCM** where upper transit occurs and, therefore, it is called the upper local celestial meridian, **ULCM**. Also recall that the position of the **ULCM** along the RA scale indicates the local sidereal time, LST.

**1**. Label the **ULCM** on your chart and answer question 1 on the answer sheet. Also label the equinoxes and solstices on your chart (See the table in Ex. 7.0).

**2**. Return to the Skymation animation. How much does the LCM move, in minutes, relative to the stars in one day and it what direction? To do this, set the step size to exactly one day and let the animation run so that the LCM moves some definite amount of RA in a given number of days.

**3.** How many degrees does it move each day on the average and in what direction?

**4.** Note that the Sun is always on the ecliptic and moves eastward from day to day. How many degrees does it move each day on the average?

**5.** Which object has the largest day to day displacement relative to the stars and in what general direction, E or W?

**6.** Note that as the moon traverses its orbit it is sometimes north of the ecliptic and sometimes south of the ecliptic. Why is this?

**7.** Which planet has its orbit inclined the most to the ecliptic plane?

**8.** Estimate how far this planet is currently from the ecliptic on your chart? Will it always be at this distance?

Examine the sample chart at the end of this exercise and note the way the elongation of a planet can be determined. To make an actual measurement of an elongation, it will be necessary to set up an interpolation scale on your chart as was done on the sample chart. This is done by using the fact that there are $90^o$ between an equinox and a solstice.

**9.** Use your chart and determine the elongations of Venus, Mars, Jupiter, and Saturn. Don't forget to identify east or west.

**10.** On your chart, identify whether a planet will be observable in the evening sky or morning sky. In the space on the answer sheet write either PM or AM.

Telescopic observations of the planets are best when the planet is within a few hours of upper transit. Hour angles on your chart are horizontal lines drawn from the ULCM to the planet. It may also be computed from: $HA_{planet} = LST - RA_{planet}$.

**11.** Examine your chart and list below the planets that have hour angles that are less than 3 hours E/W.

Now concentrate your attention on the motion of Mercury? Note that this planet appears to oscillate east and west of the sun by a limited angular distance. Reset the date to about a month before today's and run the animation at high speed using the right cursor key to determine when Mercury is approximately at its next greatest elongation after today's date. If this occurs close to today's date, you may need to start further back from today's date. After you have the approximate date, run the animation at a slower rate to make a more accurate determination. **Warning: If the planet attained a greatest elongation just shortly before today's date, the next elongation after today's date won't occur until the planet moves to the other side of the Sun.**

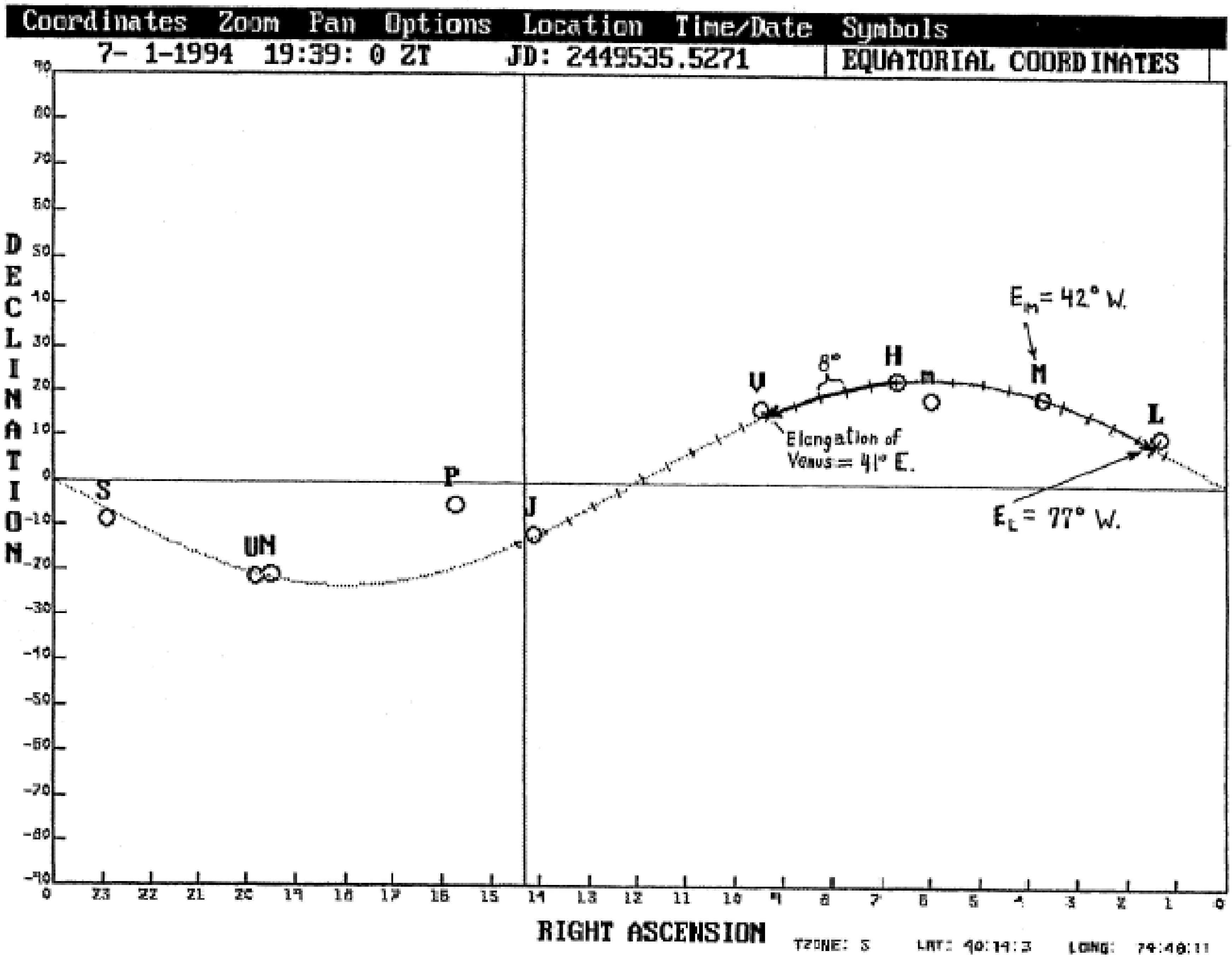
**12.** Is this east or west of the sun? Circle which on the answer sheet and record the date when the next greatest elongation after today happens.

Sometimes the superior planets stop moving eastward (**prograde**) and reverse direction to move westward (**retrograde**) for a while. Then they reverse direction again and move prograde, thereby forming a loop in the sky. To see this, reset the date to Sept. 1, 2009 and select to trail Mars. Allow the motion to run and watch the trail.

**13**. Determine the date that Mars halts its eastern motion and begins to move westward. You can use the left arrow key to reverse the motion and make several determinations of this date, then record the average.

**14**. Estimate the elongation of Mars on this date.

**15.** Now determine the date when Mars halts its retrograde motion and begins to move prograde again. Record this on the answer sheet.



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# ANSWER PAGE

## APPARENT PLANETARY MOTIONS AND ASPECTS

1. What is the sidereal time hours and minutes? ……………………..………….. _____________

2. Amount of LCM motion in minutes per day: ________________ Direction___________________.

3. Amount of LCM motion in minutes per day: ________________ .

4. Sun's motion per day: ____________.

5. Object with largest daily motion: _______________ Direction___________________.

6. Why Moon moves N/S of ecliptic: ___________________________________________

______________________________________________________________________.

7. Planet with most inclined orbit is ________________________.

8. Distance of above planet from ecliptic is ________________________.

9. Elongations: Venus ______________, Mars ___________________, Jupiter _______________ ,

Saturn _______________ .

10. Visibility: Venus ______________, Mars ___________________, Jupiter _______________ ,

Saturn _______________.

11. Planets within 3 hours of UT:

__________________________________________________________________.

12. Date Mercury is next at greatest E / W (circle which) elongation is___________________.

13. Date Mars halts prograde motion: _______________________.

14. Elongation of Mars on above date: _____________________.

15. Date Mars resumes prograde motion: ________________________ .