

# Observing the Night Sky: Tracking the Motion of Solar

## System Objects in the Spring 2004 Semester

(An alternative to the Moon Orbit Project)

The goal of this semester-long project is to get you outside observing the night sky. This includes tracking the phases of the Moon, identifying and observing the planets, and finding constellations. For the Spring 2004 semester, you will be carefully monitoring the motion of the planet Jupiter through the constellation Leo. To perform this lab properly, you will have to record your work in an observing notebook, and learn how to use the star charts at the back of the lab manual. So, obtain a small spiral notebook, or some other set-up that allows you to write down your observations *and* keep them organized (having a bound notebook is also useful due to the windy conditions that frequently occur during the spring in Las Cruces!). ***This project is worth two regular lab grades, and should be taken very seriously!*** Note that all of the observing projects must be started as soon as possible to insure that bad weather does not eliminate the possibility of making your observations. *This is especially true of Exercise #3, since you need to track the planet Jupiter for the entire semester to insure you detect its motion.*

### Setting Up Your “Observatory”

To enable you to complete the exercises in this lab, you must find a site from which you can conduct your observations. This may be your backyard, near your dorm, or somewhere else of your choosing. The key requirements for a good observing site are clear views of the southern and western horizons (it would also be nice to have a clear view to the East, but it is not always possible to find such a perfect location). You also must not have any bright lights at this site—no streetlights, etc. To conduct your observations it must be as dark as possible. One excellent location on campus to perform these observations is on the activity fields above the track, near the campus observatories. Mark your chosen location (mentally or otherwise) so that you can return to the same spot each time you observe.

After choosing the site for your observatory, you must then find the directions of the cardinal points (North, South, East and West). To find the direction of West is probably the easiest: simply note the point of sunset on one evening in January. This is West. If you face due West, and stick out your left hand horizontally, it will be pointing South. North is directly opposite South, and East is directly opposite West. Note these directions so that you can orient yourself each time you observe. You then need to have a watch, a flashlight, a pencil and your notebook for all of your observing projects.

## Observing Highlights Spring 2004

Here are some of the most important solar system events that occur during the Spring 2004 semester:

January 4:	Earth reaches perihelion (closest approach to the Sun)
January 5:	Latest sunrise
January 7:	Full Moon
January 11:	Mars sets at midnight (about the same for a week or two on either side of this date)
January 14:	Uranus can be found $1^\circ$ due north of Venus (need binoculars)
January 17:	Mercury reaches greatest western elongation ( $24^\circ$ ) [See lab #5.]
January 21:	New Moon
February 1:	Jupiter rises at 8 pm (about the same for a week or two on either side of this date)
February 6:	Full Moon
February 20:	New Moon
March 3:	Jupiter is at opposition (rises at sunset, transits at midnight, sets at sunrise)
March 6:	Full Moon
March 19:	Spring begins 11:49 pm MST
March 20:	New Moon
March 29:	Both Mercury and Venus reach greatest eastern elongation ( $19^\circ$ & $46^\circ$ , respectively)
April 5:	Full Moon
April 19:	New Moon
April 20:	Saturn sets at midnight (about the same for a week or two on either side of this date)
May 4:	Full Moon
May 19:	New Moon
May 14:	Mercury reaches greatest western elongation ( $26^\circ$ )

During the spring semester in 2004, several planets put on excellent shows: During the entire semester, Venus is above the western horizon. Venus is the brightest “star” in the nighttime sky. You can easily locate Venus by looking towards the West after sunset (in fact, you might be able to see Venus before sunset!). Saturn is high in the sky all semester long, and is located in the constellation Gemini. You will have an opportunity to look at Saturn during the observatory sessions this semester. Jupiter is also easily seen this semester. Beginning February 1<sup>st</sup>, Jupiter rises in the East at sunset, and is high in the sky by 10 pm. Jupiter spends 2004 in the constellation Leo. After its close approach last August, the Earth is rapidly leaving Mars behind and the planet grows dimmer (and smaller) day by day. At the beginning of the semester, Mars can be found high in the Southwest sky at sunset. By the end of the semester, Mars will become difficult to find in the twilight sky after sunset. At the end of March, it should be easy to see the most elusive of the naked-eye planets: Mercury. Mercury and Venus reach “greatest elongation” on the same date (March 29<sup>th</sup>). At this time, Mercury has its largest angular separation from the Sun. To find Mercury, go out right after sunset--all you have to do is draw an imaginary line from Venus, to the point where the Sun just set. Mercury will be slightly more than halfway down that line from Venus towards the western horizon. To see Mercury requires you to observe it within a few days of the 29<sup>th</sup> (on either side). Mercury moves quickly, and spends only a few days near its greatest elongations. Finding these planets will be part of this semester-long project.

## Observing Project #1: The Ever-Changing Moon

The goal of the first project is to get you familiar with the motion of the Moon, and the changing phases of the Moon. In the Observing Highlights calendar just presented are listed the times of New and Full Moon. For this exercise, you will track the phases of the Moon as it progresses from New to Full. This exercise will require you to go outside for about eight different nights over a two week period, one time during the semester—DO NOT LEAVE THIS PROJECT UNTIL APRIL!!! If so, you might not have good enough weather to allow you to complete this exercise. You need to conduct this project from your observatory site.

**Step #1:** Find the date of the next New Moon. As you have found out in your lecture class, during New Moon, the Sun, the Earth and the Moon are all on a straight line. At the time of New Moon, the un-illuminated side of the Moon is facing us, and the Moon is located close to the Sun in the sky. Thus we cannot see the Moon during its New phase (unless there is a solar eclipse!). It is usually not possible to see the Moon until two full days after New. Among amateur astronomers, there are contests on who can be the first to see the Moon after a New Moon. The record is 12.1 hours after New Moon. For most people though, it is difficult to see the Moon much less than 24 hours after New Moon. For people in the Northern Hemisphere, however, the days following the New Moons in February and March offer the best chances for seeing a “young Moon” because the tilt of the Earth’s axis with respect to its orbit places the Moon vertically above the point of sunset during these months. Given a clear western horizon, and a pair of binoculars, you might be able to see a very young Moon yourself.

**Step #2:** Beginning (one or) two days after the chosen New Moon, go out about 20 minutes after sunset and look for a very thin crescent Moon near the western horizon. Can you find the Moon? Either way, note the time of your observation in your logbook, and whether you were successful at seeing the Moon. If you saw the Moon, draw a sketch of its appearance. [For this sketch, it might be handy to find a bottle top or drinking glass that is about 1.5 to 2 inches in diameter and use this to make a perfect circle for the Moon, and then shade in the part you cannot see to render a drawing of the phase of the Moon. Use the same circle-maker for the entire exercise.] In your notebook note the time and date of this observation along with your drawing. Note whether there are any bright stars or planets near the Moon.

**Step #3:** You **must** attempt to observe the Moon three days after the time of New Moon. Make a drawing of the phase of the Moon and note the time and date. Observe the Moon about 30 minutes after sunset so that it is fairly dark. Besides the bright crescent, can you see the other parts of the Moon glowing faintly? Within a few days after New Moon, it is often quite easy to see the “dark” portion of the Moon (the part not directly illuminated by the Sun). This phenomenon is called “Earthshine”, or “the old Moon in the New Moon’s arms”. For step #3, you need to research the nature of Earthshine. You can use the web (for example enter “Moon and Earthshine” on Yahoo or another search engine) or look in a book to find out the cause of Earthshine. Write-up a paragraph or two in your observatory logbook describing the phenomenon of Earthshine, with a

drawing/diagram showing how it arises.

**Step #4:** Continue to observe the Moon every other day until the Full Phase, and make sure you observe on the night of the Full Moon! Note the time and dates of your observations, and make drawings of the appearance of the Moon. Note the locations of any nearby bright stars or planets. Use the star charts at the back of the lab manual to see if you can identify which constellations the Moon happens to be passing through. Note that the star charts are different for each month, and that the positions of the constellations change throughout the night and month!

**Step #5:** Describe/summarize your observations of the Moon. When did the Moon reach a phase of “First Quarter” (when exactly one half of the Moon was illuminated)? Was it possible for you to tell on which date the Moon was perfectly Full, or did it look Full to you for several days? Which direction did the Moon move over the course of this two week period? Did it come close to any planets (see Exercise #2 to make sure you know where the planets actually are)? Any other interesting observations?

### **Observing Project #2: Locating the Naked-Eye Planets**

As described in the Observing Highlights section, several bright planets are easy to observe this semester. Your goal is to observe as many of them as possible. Note that Mercury will be the hardest of the planets to observe. It is only easily seen near the times of greatest elongation. Even then, you have to observe right before sunrise (greatest western elongations), or right after sunset (greatest eastern elongations). Mercury is fairly bright at these times, so it can be seen easily with the naked eye, but you must have a clear horizon to have any chance of seeing it. There are several methods to identifying the planets. Perhaps the easiest is to have one of the TA's at the observatory session point them out to you. But we would like you to be able to search for and find them on your own. One way is to use the sky charts in the back of the lab manual. Read about how to use those charts, and then orient yourself by identifying some of the constellations in the nighttime sky using the sky charts. But there are two other good sources: online, or in a magazine. “Sky & Telescope” and “Astronomy” are magazines for the amateur astronomy community. Sky & Telescope is a more advanced magazine than Astronomy. Both magazines can be found in the library, or at a book store (such as that in the Mall). Inside these magazines are monthly columns that talk about which planets are visible, and where they can be found (including sky charts). In addition, however, both magazines have websites ([www.astronomy.com](http://www.astronomy.com) and [www.skypub.com](http://www.skypub.com)). Both websites have interactive sky charts that show where the planets are in the sky. At the Sky & Telescope website, hit the “Interactive Sky Chart” link. At the Astronomy magazine website, after you register (its free), you can access the sky chart by clicking on the link “The SkyOnline for Beginners” found on the lefthand side of the main webpage (note that it reads your zip code to figure out your latitude to make a chart just for you!). The yellow line that runs across the resulting sky map is the “ecliptic” (the plane of the Earth's orbit), and all of the planets will be found close to this line. Note where these planets are with respect to the stars, and find the same constellations on your sky charts and make a little note on the chart so that you can find the planet when you go observing.

**Step #1:** During the semester identify as many planets in the nighttime sky as possible. Write down the details of the time, date of your observations, and constellation in which you found the planet. Mark the location of the planet on the appropriate sky chart (make sure to turn-in this chart, or a handmade version of this chart, with the rest of your materials at the end of the semester). Note that the planets are just about always the brightest “stars” in each constellation, and thus are very hard to miss! You should conduct this exercise from your observing site (unless your western horizon is not good enough to allow you to see Mercury—if so, you can observe Mercury from the campus observatory, or some other site with a good western horizon).

### **Observing Project #3: Tracking the Motion of the Planet Jupiter in 2004**

For this exercise you will be plotting the position of Jupiter about once per week during the entire semester. You need to make at least ten observations of Jupiter spread out over the entire semester—you must start this by the second or third week of lab to insure that you have enough time and observations to complete this exercise. Jupiter spends all of 2004 in the constellation Leo. This constellation rises in the East about 8 pm in February. It can be seen on the February sky chart on the left hand side (northeast of Orion). It is almost in the center of the sky chart for April. The Big Dipper can be found due North of Leo. This is the hardest of the three observing exercises. If you need some help, ask your TA, or one of the TAs at the observatory. You can conduct this exercise from any location that works best for you.

**Step #1:** Identify the constellation Leo. Go out after 9 pm in late January or early February (dress warmly!!), and look to the East to identify Leo. Use the February or March sky charts to find Leo. The brightest star in Leo is named “Regulus” (“Heart of the Lion”). Of course, the brightest “star” in Leo this year is Jupiter! Regulus forms the bottom of a backwards question mark (“?”). Jupiter is to the southeast of Regulus. On the next page is a close-up map of the constellation Leo. The stars have their names and numbers located next to them (including some Greek letters). The bigger the star symbol, the brighter the star. Note where Regulus is on this chart to orient yourself. We have drawn-in the lines that define the main stars in Leo (including the backwards question mark). The underlined names found on this chart are the neighboring constellations. Note in your logbook the time and date when you finally identified the constellation Leo.

**Step #2:** Identify Jupiter. This is easy—in fact, it might be easier for you to first find Jupiter than the constellation Leo! Jupiter will be the brightest object in the nighttime sky after Venus and the Moon. Look for the brightest star in the eastern sky after 9pm in January/February. Note the time and date when you first found Jupiter.

**Step #3:** Finding  $\sigma$  (Sigma),  $\rho$  (Rho), and  $\chi$  (Chi) Leo. Over the last two thousand years, astronomers have used Greek letters to label the brighter stars in a constellation (see the introduction to the Sky Charts). The brightest star in a constellation was usually given the designation  $\alpha$  (Alpha),

the first letter in the Greek alphabet. This progresses all the way to the last Greek letter  $\omega$  (Omega). After that, the fainter stars were given numbers. Regulus is known as  $\alpha$  Leo. On the close-up sky chart of Leo, we have drawn a black arrow to identify the star  $\rho$  Leo. This is a fairly faint star. It has several other stars (45, 44, 43, 48 and 49) located near it. You need to locate this star, and the two stars called  $\sigma$  and  $\chi$  Leo.  $\sigma$  and  $\chi$  Leo are located to the East (left) of  $\rho$  Leo.  $\chi$  Leo has another star numbered "59" close to it.  $\sigma$ , 59 and  $\chi$  Leo make a small little triangle, with the side of the triangle defined by 59 and  $\sigma$  being the longest side.  $\chi$  Leo is the faintest of these three stars. Jupiter will spend the entire semester in this small region of sky (between  $\sigma$  and  $\rho$  Leo). If you have too many bright lights near your observatory, you might have to do this exercise at a location where the sky is a bit darker. If you are still having trouble seeing these three stars, see if you can borrow a pair of binoculars to help you identify these three stars. Write down in your logbook how successful you were at finding these three stars. Note any tricks you used to identify them so that you can use that technique in the future.

**Step #4:** Tracking the motion of Jupiter. On the page following the Leo sky chart is another sky chart that only shows the small region of sky that includes  $\sigma$  Leo on the bottom left (southeastern) edge of the chart, and  $\rho$  Leo on the right hand side. The dotted line that goes through this chart is the ecliptic, the apparent path of the Sun through the sky (the projection of the Earth's orbital plane). Most planets are found close to the ecliptic. This ultra-close up map of the sky will be your worksheet for plotting the position of Jupiter. Using the two sky maps, locate the position of Jupiter in the constellation Leo. Mark its position on the "Jupiter Worksheet" with the date of observation. Note in your logbook the time of this observation. Every week or ten days, go out and observe Jupiter, and plot its position on your worksheet. You should have ten observations spanning the semester to complete this project.

**Step #5:** Summarize the motion of Jupiter during the semester. How far did Jupiter move? To do this, note that the little squares formed by the grid lines in the close-up sky chart are exactly one degree on a side. How many degrees did Jupiter move? Which direction did Jupiter move during the semester? Did Jupiter follow the ecliptic, or did it move north/south of the ecliptic? Why do you think it did this?