Laboratory Exercise 2
Planetary Motion (*Stellarium Version*)

Introduction

In this exercise, you will have the opportunity to observe general aspects of planetary motion, and to observe and describe the retrograde motion of Mars. You will study the average rate of motion, the sidereal and synodic periods of the planets. Finally, you will see Kepler's third law, in graphical form, based on your own measurements.

The Basics of Planetary Motion

Follow the instructions below carefully, and keep notes of your observations.

1. Start *Stellarium* on your computer.

2. For much of the exercise, you will find it useful to view the entire sky. Adjust the zoom to allow for this view, and place South at the bottom of the screen. As seen from Canada, the ecliptic is basically toward the south.

3. As planetary motion is slower than that of the Moon (see Laboratory Exercise 1), you should also experiment with time update modes. The Help window (press F1 to toggle) explains several time update modes. Keep in mind that the 7 key stops time—it can be handy if you get into an update mode you do not want.

4. Using what you have learned about the *Stellarium* time and view functions, observe the motion of the planets using one-day updating (solar with = key, sidereal with Alt-=; you may hold the keys down for continuous motion).

   Concisely describe the motion of all planets and of the Sun. You will have to observe for about one year to do this. Note that if you use the keys you should not see DST effects, but if you use the Date and Time box, you will see them as described in the previous lab.

5. The motion of Mars was one of the great puzzles in astronomy until Kepler explained it. Reset the time to today's date by pressing 8. Set the time to about midnight. If Mars is not visible on the screen, advance in time by solar days (i.e. so that the time displayed near the bottom of the screen stays near midnight) until it is. Note its position and the date when it first became visible about midnight. Advance in solar days until Mars is near the meridian at about midnight (the southern

meridian is the line of azimuth 180° arising out of due South). What is the position of Mars relative to the Sun near this time? Use the correct technical term. We will refer to this date as the date on which the study started.

6. Use the update mode you feel is best suited to displaying the motion of Mars, and study its motion. Is Mars in retrograde motion on the date at which you started?

7. Find when Mars begins retrograde motion. Describe the change in its motion which indicates this situation. Follow a cycle of retrograde motion and adjust the zoom and centre to get a good view of the loop.

8. Make a screenshot that will allow good display of the retrograde loop and print it. Since the time has been changed using keys, it is best not to have the Date and Time box visible. Note the actual date as read from the bottom of the screen beside Mars on the printout.

9. Again advance in a suitable mode, stopping when there seems to be significant change in the position of Mars. Using Mars's position with respect to the stars, sketch in its position on your printout, and mark the date or a key number beside each position. Describe the overall motion near the retrograde period, including your inferences about Mars's position with respect to the Earth and Sun.

10. We have seen that Mars has very irregular motion. To study the period of a planet, it is best not to use Mars, even though what we will do, if properly interpreted, will be as correct for Mars as for any other planet. We will first study the motion of the other naked-eye superior planets, Jupiter and Saturn. Face south, set the time to midnight, and advance time until both are visible and close together in the night sky. This may require advancing in time by many years.

11. Using what you now know about retrograde loops, adjust the time and zoom so that retrograde loops of both planets can be seen on the screen and take a screenshot/printout. As you did for Mars, step through time to enable yourself to plot the entire retrograde loop for both planets. Note the times of beginning and ends of the retrograde loops, and thus deduce their lengths in days.

12. Using the grid lines as reference, as you did before, find the angular size of the retrograde loops of Jupiter and Saturn. Based on this information, estimate the relative distances of the planets. Explain your reasoning.

13. If the semimajor axis of Jupiter is 5.2 AU, calculate its expected sidereal period. Find a time when Jupiter is near a bright star. Note this time, and then advance time until Jupiter again is near that star. Are your results consistent with the calculation of the sidereal period? Infer a semimajor axis for Saturn based on Step 12, and similarly test this result.

14. Observe the inner planets, Mercury and Venus, and determine a period for them. Which type of period is this?

15. Calculate the other relevant period for these two planets. Can you verify this conclusion as for the outer planets?

16. Using what you feel is the best sidereal period you have determined, with the information in the textbook about Kepler's Third Law in SI units, find the mass of the Sun in SI units.

Mail your reports, with printouts, tables and graphs, to your tutor for grading. Be sure to attach a completed tutor-marked exercise form, from the course package, and to keep a copy, in case the original goes astray in the mail.