ASTRO 100/G – Experiment 1

The use of a computer planetarium

Links to Lectures 2, 3, and 4

Name:
ID:
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Grade

/10

Astronomers today use programs like this one to produce current and future astronomical maps. The programs can also interface with telescopes, to move them around automatically. In this experiment, you will use such a program to look at the behaviour of the planets over time.

Planets mostly rise and set with the stars; however, they too orbit the Sun and move slowly relative to the background celestial sphere. Jupiter orbits the Sun once every 12 years, so its motion is difficult to see; but for Mercury, Venus and Mars, which are closer to the Sun with orbital periods more like the Earth's (1 year), they do move noticeably relative to the celestial sphere.

Starting Stellarium

Stellarium is installed by default on all computers in this lab. Go to to Start and search Windows for "Stellarium".

Stellarium allows you to control time by hovering over the bottom left panel. Turn off the ground and the atmosphere by pressing the G and A key, then accelerate time using the controls shown in Figure 1. You should see the sky move, with everything moving at roughly the same speed. This is because of the Earth's rotation, and is the same reason we have a 24-hour day. The stars appear to be fixed relative to one another because they're so far away, but the planets move. This is why they're called planets – it's from the Greek word *planētes*, for 'wanderer'.

The 11$^{\text{th}}$ symbol on the bottom menu switches you between an equatorial mount and an azimuthal mount. If the symbol is highlighted, the virtual telescope is mounted on an equatorial mount that has an axis parallel to the Earth's rotation axis, with the celestial sphere as the reference frame. Therefore the stars appear fixed while the ground appears to move as you change time. This means that when you advance in time, the stars will not move but horizon will. This setting makes it easiest to see how the planets are moving relative to the background stars.

Figure 1: Stellarium's time controls: (a) slow down time, (b) pause/play time, (c) set time to right now, (d) speed up time, (e) the current simulation date and time

There are two intuitive ways to measure orbital periods. An orbital period is the length of time that something takes to make one full revolution around its Sun. If you know where it originated from, and that the orbit appears truly circular to you, then you are able to measure its **sidereal** period (think "side-**real** is the **real** period"). When we speak of periods, this is the one we normally mean. However, there is another method:. If you measure the time between successive orbital phenomena (such as retrograde to retrograde), if these phenomena occur once an orbit, you measure another kind of period: the synodic period (think "syn-**odd**-ic period is the **odd** period"). This period takes into account the fact that the Earth is moving throughout the solar system too. The synodic period will be longer than the sidereal period, because it measures the time the planet appears to go back on itself. For some things, we can only measure the synodic period. For other things, we can only measure the sidereal period. What do you think the difference is that causes this?

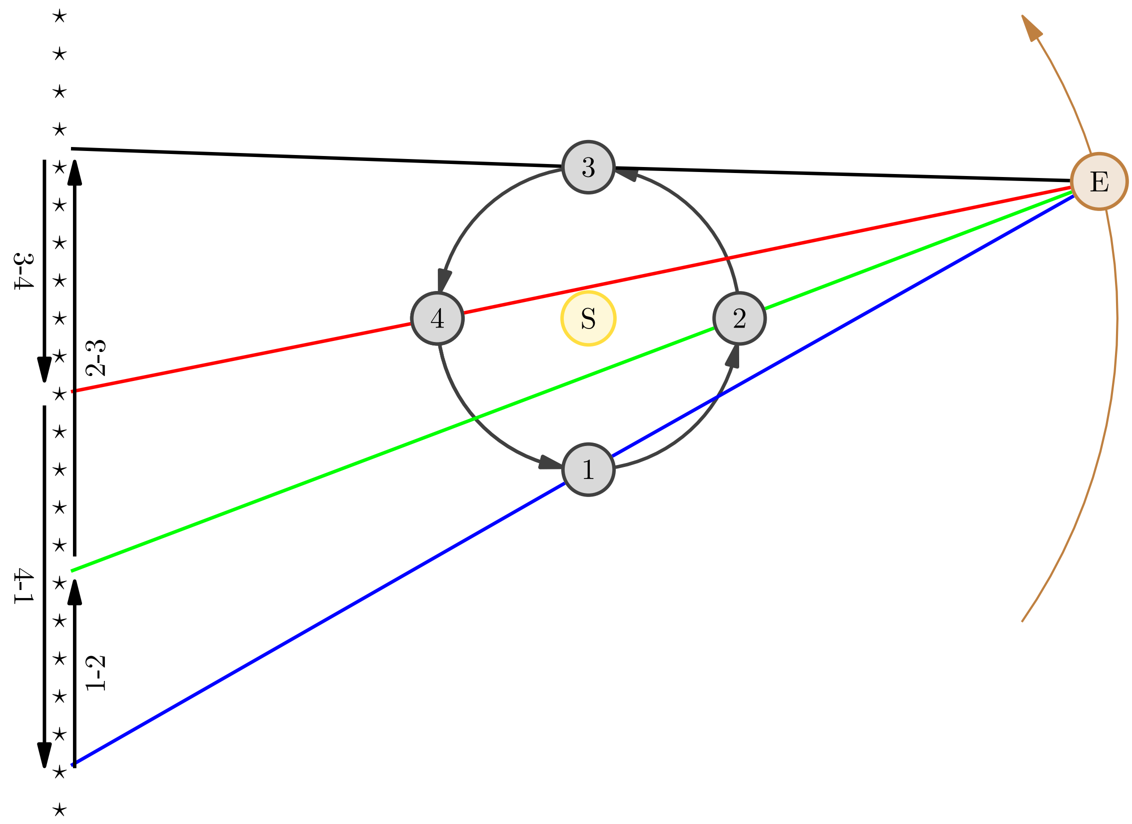
At the end of this lab, students will be able to:

- **Qualitatively compare** views of a telescope in equatorial and azimuthal mounts.
- **Estimate** orbital periods of solar system objects using planetarium software.
- **Contrast** the cause of apparent planetary retrograde motion for inner and outer planets.
- **Describe** the difference between synodic and sidereal periods of a planet.

1. (2 marks) Complete the diagram below to show the apparent retrograde motion of Mercury (gray) as it orbits the Sun (yellow with an S) as seen from Earth (brown with an E). Mercury is shown in four positions in its orbit around the Sun.

   (a) Draw lines from Earth through each of the four positions in Mercury's orbit to the background stars. The first line is drawn for you in blue.

   (b) Add arrows to the line of background stars (on the left of the page) showing the direction of motion from 1 to 2, 2 to 3, 3 to 4, and 4 to 1.



   1 mark for correct lines, 1 mark for correct arrows

2. There are two kinds of periods that we can measure: **synodic** and **sidereal**. In your own words:

   (a) (½ mark) Define the **synodic** period.

   Solution: The synodic period is the period between two retrogrades.

   (b) (½ mark) Define the **sidereal** period.

   Solution: The sidereal period is the orbital period absent any retrograde motion – the "bird's eye" orbital period so to speak.

3. (2 marks) Now let us look at Stellarium. Speed up the simulation by using the fast forward button at the bottom (you may have to click it several times). Experiment with switching between the equatorial and azimuthal mounts for your virtual telescope (Ctrl+M or click 11$^{\text{th}}$ symbol from the left on option buttons, it looks like a telescope). **Compare** the views: what stays stationary, and what moves, in each view?

   In the **equatorial mount**, the <u>**stars**</u> stay(s) stationary, while the <u>**Earth**</u> move(s).

In the **azimuthal mount**, the **Earth** stay(s) stationary, while the **stars** move(s).

Now go to the bottom edge of the screen (towards the left) and another menu will appear. Make sure the option for planet labels are enabled. Turn on the equatorial mount and ensure the program is running in full screen. Make sure you turn **off** ground and atmosphere so that you can see the stars and planets in all directions. The bottom panel should look like the image in Figure 2 (but with a different date!)

Figure 2: The second menu can be found by moving your cursor to the bottom of the screen. Make sure that your menu looks like the one shown above for the remainder of the experiment.

Now we will compare the motions of the Moon, Mercury and Mars. These three objects are different: the Moon orbits the Earth, while Mercury and Mars go around the Sun. Mercury is closer to the Sun than the Earth, while Mars is further away. Therefore, we expect the motions of all three objects to be qualitatively different. First, zoom out and adjust the view until everything appears to move in a circle. Make sure your telescope is set to an **equatorial** mount. You want to be able to see the entire circle without having to adjust the view again.

4. (1 mark) Find the Moon, it should be bright and easy to find. You should find that it appears to move in a circle on the Sky. Measure how long it takes to make a full circle on the sky and give this value in days below.

   Orbit begins on: **Varies** .

   Orbit ends on: **Varies** .

   The period is: **28** days. 1 mark for within 20%, 0.5 if not, 0 marks for guess.

5. (1 mark) Now look at Mercury. Notice that during its orbit it appears to move behind the Sun, like as shown in Question 1. Use this apparent retrograde motion to estimate the period of Mercury.

   Orbit begins on: **Varies** .

   Orbit ends on: **Varies** .

   The period is: **113** days. 1 mark for within 20%, 0.5 if not, 0 marks for guess.

6. (1 mark) Now search for Mars. You should see once every orbit that it stops, moves backwards then forwards again in retrograde motion. This is because it is outside Earth's orbit and from our viewpoint we overtake it. Use this retrograde motion to help you measure the period of Mars, and give your answer below.

   Orbit begins on: **Varies** .

   Orbit ends on: **Varies** .

   The period is: **770** days. 1 mark for within 20%, 0.5 if not, 0 marks for guess.

7. (1 mark) For each celestial body, identify which period (synodic or sidereal) you measured.

   The Moon: **sidereal** period.

   Mercury: **synodic** period.

   Mars: **synodic** period.

You are now finished. Please hand your sheet to the demonstrator for marking.

Stellarium is freeware – you can download it from http://stellarium.org/.