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## THE CHANGING SKY

### I. Objective

You may not be aware of it, but the appearance of the sky is constantly changing. Which stars and constellations you can see at night depends greatly on both the time, date, and location from which you do your observations. In this lab, we will try to understand why the sky is different at different times.

### II. Exercises: Rotation of the Earth

During the course of a night or a year, the stars appear to change their positions in the sky. This is not due to the stars moving through space, but rather the fact that the Earth is moving and we are moving with it. In this exercise, we will use the computer program *Skyglobe*<sup>1</sup> to investigate these apparent motions. Be sure to notice these motions yourself during your observations of the real sky as you complete your semester observing project! We see two distinct types of motions in the sky caused by the two different motions of the Earth.

The first motion is the rotation of the Earth about its axis, which runs through the North and South Poles. This rotation produces the “diurnal” motion of the sky, that is, those motions we see throughout a day (or night). The most familiar example of this motion is day and night. The Sun rises in the east when the Earth rotates us around so that the Sun is shining down on us. It sets in the west every day because we have rotated with the Earth so that we are in the shadow of the Earth on the other side. The stars in the sky exhibit the same kind of motion. Every night, stars will also rise in the east above the horizon and then set in the west as they pass below the horizon and “behind” the Earth.

- 1. Based on the information given above, answer the following: Suppose you see a star in a certain part of the sky (say, low in the south-east). About how many hours will pass before you will observe that same star in the same position in the sky?**

\*\* Now log on to your computer and activate the *Skyglobe* program as your instructor demonstrates. The map you see before you is a map of the sky, as it appears now, from State College, as if you were facing south.

\*\* Let's take a look at some of *Skyglobe*'s buttons and features, the buttons and bars surrounding the map. You may want to spend a few minutes “messing around” with these features to get a feel for the program.

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<sup>1</sup>*Skyglobe* software 1997, by Mark A. Haney, a Shareware product of KlassM Software.

### *Skyglobe features:*

ADVISORY: Double-clicking on any button causes the action to repeat rapidly (“Turbo”), and the program’s settings run wildly away from you. Do multiple clicking SLOWLY, except where indicated. To cancel a Turbo, click on the button once.

#### On TOP

- The date and time is indicated, time is 24-hr based. (13:00 means 1:00 PM.)
- Mag – Magnitude: Add or subtract dimmer stars (left/right mouse button).
- Z – Zoom in (left mouse button) or out (right mouse button) to view less or more of the sky in your window.

#### On BOTTOM

- The NESW directional bar: click here to change your view to other compass directions.

#### At RIGHT

- The various icons here add or subtract certain features from the map. Try them all.
- You can add or remove constellation pictures, planets, star names, the horizon, and other map features with the left mouse button.
- The right mouse button here adjusts the completeness of the info shown. For example, clicking on the Vega icon with the left mouse button will turn star names on and off, but the right mouse button will include the names of dimmer and dimmer stars.

#### At LEFT

- These buttons allow you to change the time of your observation.
- E: Enter any time and date.
- 1, 5, 10: Advance time by 1, 5, or 10 minutes (left mouse button = forward in time, right mouse button = backward in time).
- H, D, W, M, Y: Advance time by one hour, day, week, month, year (left/right mouse button = forward/backward in time).
- R: Reset to the current time and date. Once you have reset, click R again to disengage – otherwise it will periodically reset you, when you don’t necessarily want it to! (Another, way to reset everything is to restart the whole program.)

\*\* Having familiarized yourself with the program, click on the *blue* dot on the left-hand side of the screen (if you cannot see the *blue* dot, you may have to enlarge the screen). This will give you the “Earth-centered” view, flattening your horizon (you may also do this by SLOWLY clicking on the arrow at the bottom ( ▽ ), with the left mouse button until the horizon looks flat.

\*\* On the top border of the window, you will see the letter Z (for zoom) and a number. Click (SLOWLY) on the Z with the right mouse-button to **bring the zoom number down to 1.5**. If you overshoot 1.5, use the left mouse-button to regain it.

One important star is the North Star or Polaris. It is (almost) directly above the North Pole so that it appears fixed while all the other stars appear to rotate about it.

2. **Go to a north view of the sky and click on the H button (at left) with the left mouse button, slowly (this advances the time of observation by hourly increments). Watch the stars, particularly the constellation Ursa Minor (the Little Dipper). Do the stars rotate clockwise or counterclockwise around Polaris?**

Set the date and time to today, 21:00 (9 PM) and set the magnitude to 4.0 (so you only see the brightest stars). Your instructor will provide you with two bright stars that appear near the central portion of view in four different compass directions (N, E, S, and W), for a total of eight bright stars.

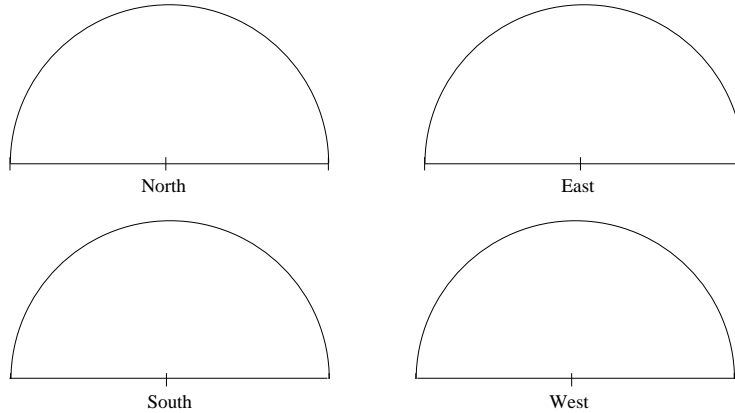
3. Face each of the four compass directions in turn by clicking on the N, E, S, and W letters that appear at the bottom of the window. For each direction, find the two bright stars provided to you by your instructor and write down the name of the constellation within which each star is found.

Do the following for EACH of the eight stars that you listed in part 3.

4. Set the date and time to today, 21:00. Locate the star by facing the correct direction. Now, double-click on the  (at left) with the left mouse button, to move forward in time. Follow the motion of the star (if the star moves off the side of the view, you may have to face another direction to find it again). Stop the motion of the sky at 3:00 tomorrow morning (six hours after you started). Describe the path of each star over the course of the six hours. (Did the star move higher or lower in the sky at certain times? Did the star move towards the north, south, east, or west? Did the star pass below the horizon? If so, what time did it set? Where is the star at 3:00?)

\*\* Now move forward in time more quickly by double-clicking on  (at left) with the left mouse button. While the sky is wheeling around, click on the N, E, S, W letters (at bottom) to look at this diurnal motion of the stars. (Also note the rising and setting of the Sun.)

5. In each semicircle below, draw arrows which represent the overall motions of the stars as the Earth rotates, when facing north, east, south, and west.



### III. Exercises: Revolution of the Earth

The second motion is the revolution of the Earth about the Sun. This rotation produces the “annual” motion of the sky, that is, those motions we see throughout the year.

Because of the Earth’s motion around the Sun in a year, the Sun APPEARS to move through the constellations, around the sky, slowly, over the course of one year. The path it appears to take is called the *ecliptic*. Therefore, the plane of the Earth’s orbit is called the *ecliptic plane*.

\*\* Reset *Skyglobe* to today, at 21:00. Face the northern part of the sky. Now move forward in time by 3 months, by slowly clicking three times on the  (at left) with the left mouse button. Notice that each step forward shows the night sky at the same time of night (21:00), but one month later.

6. Quantitatively compare the motion you see in the north sky over three months (always looking at 21:00), to the motion you saw over six hours in one night (part b). In what direction do the stars appear to move in each case? by how much? Do the stars move in the same way in each case? (in the same direction?, by the same amount?)

Again set the date and time to today, 21:00, but this time face south.

7. Over the course of three months (always looking at 21:00), which way do the stars appear to move — towards the east, or towards the west?

8. If you always look at 21:00, in how many months will the stars be in the exact same positions as they were today at 21:00? Find out using *Skyglobe*.

To help visualize the annual motion of the stars, perform the following “thought-experiment” (parts i and j).

9. Draw a circle to represent the orbit of the Earth and put the Sun at the center. Draw four small circles to represent the Earth during the four different seasons. Label the top point “Spring,” the left point “Summer,” the bottom point “Fall,” and the right point “Winter.” Darken the side of the Earth which is not being illuminated by the Sun. On each of the four Earths, draw a stick figure or mark representing a person observing the sky at midnight, and at sunset. Label these marks clearly. (NOTE: To draw this correctly, you need to know that the Earth rotates and revolves in a counter-clockwise fashion, as seen in this diagram.)

10. At midnight on the Fourth of July, you observe a star low toward the eastern horizon. At sunrise that morning, you see it at its highest point in the sky. Later in the year, you see the same star at midnight on Labor Day. Where is it in the sky as it appears to you at the beginning of September? (Use your drawing in the last part as a reference. Keep in mind that for a person standing outside at sunrise, the Sun is always in the eastern part of the sky! Also keep in mind that stars are VERY far away — to draw the above diagram to scale, the star would need to be drawn many miles away from the Sun and the Earth.)