Lab 02: Determining the Solar and Sidereal Days

Introduction

Some of our most basic knowledge of astronomy is based on observing the sun and its position in the sky. Unfortunately, some of things we "know" are not entirely correct! One common misconception is that the sun is directly overhead at noon. Whether or not the sun is straight overhead depends on where you are on the globe, what time of year it is, and what you mean by "noon."

Similarly, we all know that one day is 24 hours long. Our entire calendar is based on this fact! However, the measurement of the rotation rate of any object must be done with respect to some reference point. When we measure the time it takes for the Earth to complete one full rotation, it turns out that it makes a difference whether we measure it with respect to the sun or with respect to a distant star.

Objectives

- ◉ Improve your ability to navigate Stellarium fluently
- ◉ Clearly define the concept of solar noon
- ◉ Examine the position of the sun in the sky over the course of a year
- ◉ Compare the position of the sun at the same time in different global locations
- ◉ Observe the lengths of solar and sidereal days

Procedure

Launch the Stellarium program and set your location for right here in Conway, AR. Make sure you are located at the correct place on the map before you continue. If it is not already, make this your default location (so that the program will automatically place you at the correct location on startup).

Noon Is 12:00, Right?

Again, we all know when noon is…it's 12:00 noon. The sun is straight overhead at noon, right? Check it.

1. **Locate the sun:** For the four dates shown below, find the sun at noon exactly (12:00). Record the Az/Alt coordinates of the sun on each of these days.

A more precise definition for solar noon is the time when the sun crosses the **meridian** (the imaginary line from due N to due S can be turned on from the Viewing Options window). Toggle the meridian on.

2. **Is the sun on the meridian?** On any of the days you observed, is the sun on the meridian (az = 180° is the meridian) at noon? Is 12:00 on the clock before or after solar noon for our location?

Date	12:00 Noon		Sun Crosses Meridian		
	Az	Alt	Time	Az	Alt
09/21/16					
12/21/16					
03/21/17					
06/21/17					

3. **Find solar noon:** Advance the time until the sun crosses the meridian. For each of the four dates, record the time and the

az/alt coordinates (do not try to fill in this example table, there is simply not enough room).

4. **Is the sun directly overhead?** On any of the days you checked, does the sun ever reach an altitude of 90° (directly overhead)?

5. **Where will the sun be directly overhead?** The figure below shows the positions of the sun for an observer located at 35°N latitude (Hey! We are located at 35°N latitude!). Use this figure to help you determine at what northern latitude the sun will be directly overhead on June 21. Where will the sun be if you are in a location 10° south of this latitude?
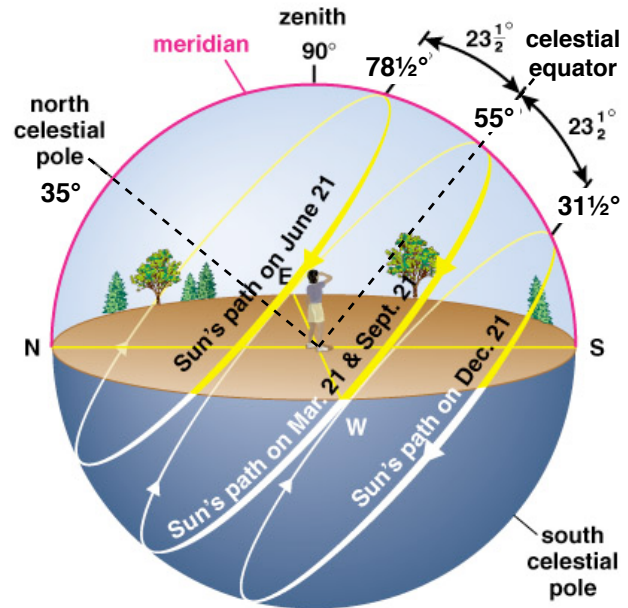
Copyright © Addison Wesley

And a Day Is a Day Is a Day…

A solar and sidereal day each measure the rotation of the earth, but in relation to different objects. The solar day looks at rotation with respect to the sun: how long does it take for the earth to complete one rotation with respect to the sun (noon to noon, as long as you are measuring noon with respect to the meridian). The sidereal day measures the same thing, but uses a distant star instead (any star will do).

6. **How long is one solar day?** For any random day you like, position the sun precisely on the meridian. Use the Date and Time Window to advance by exactly one calendar day, and notice the position of the sun. Record the day you selected, and the Az/Alt coordinates of the sun on that day, and the next.

7. **How long is one sidereal day?** For the same day as above, position a star on the meridian (if you toggle off the atmosphere, you can see the stars even if it is still daytime). Advance the time until the same star is again on the meridian (an easy way to do this is to advance one calendar day, then increase or decrease minute by minute until the star is back on the meridian).

Shown below is **Figure 0.5** (page 06) from the textbook. It has been color-inverted so that the sky appears white and the starlight appears gray or black. A long photographic exposure will show the apparent path of the stars as the earth spins. Thus, in exactly one sidereal day, a star would trail out a complete circle of 360°. By measuring the fraction of that circle exposed, and knowing the length of the exposure, you can experimentally calculate the length of the sidereal day.

8.   **Measure the trails:** With a ruler and protractor, measure the angles of the three star trails labeled A, B, and C. Follow the example on the figure, labeled with a 1. Calculate the average angle of the star trails.

9.   **Calculate the sidereal day in minutes**: The photographic exposure time was 287 minutes. Use this time (t) and the average angle (θ) to find the length of the sidereal day (day) in minutes:

$$\frac{\theta}{360°} = \frac{t}{day}, \text{ or}$$

$$day = (t)\left(\frac{360°}{\theta}\right)$$

10. **Convert this time to hours:** $hours = \dfrac{day(\min)}{60\left(\frac{\min}{hour}\right)}$

11. **Compare this value to a standard 24 hour solar day.**
     Also compare your value to the accepted value of a sidereal day (23h56m, or 23.93h). Is your value higher or lower than the accepted value?

12. **Explain the difference:** Refer to the figure below, or to Figure 0.7 (page 08) of your text, and explain in your own words why the solar and sidereal day cannot be the same length of time.
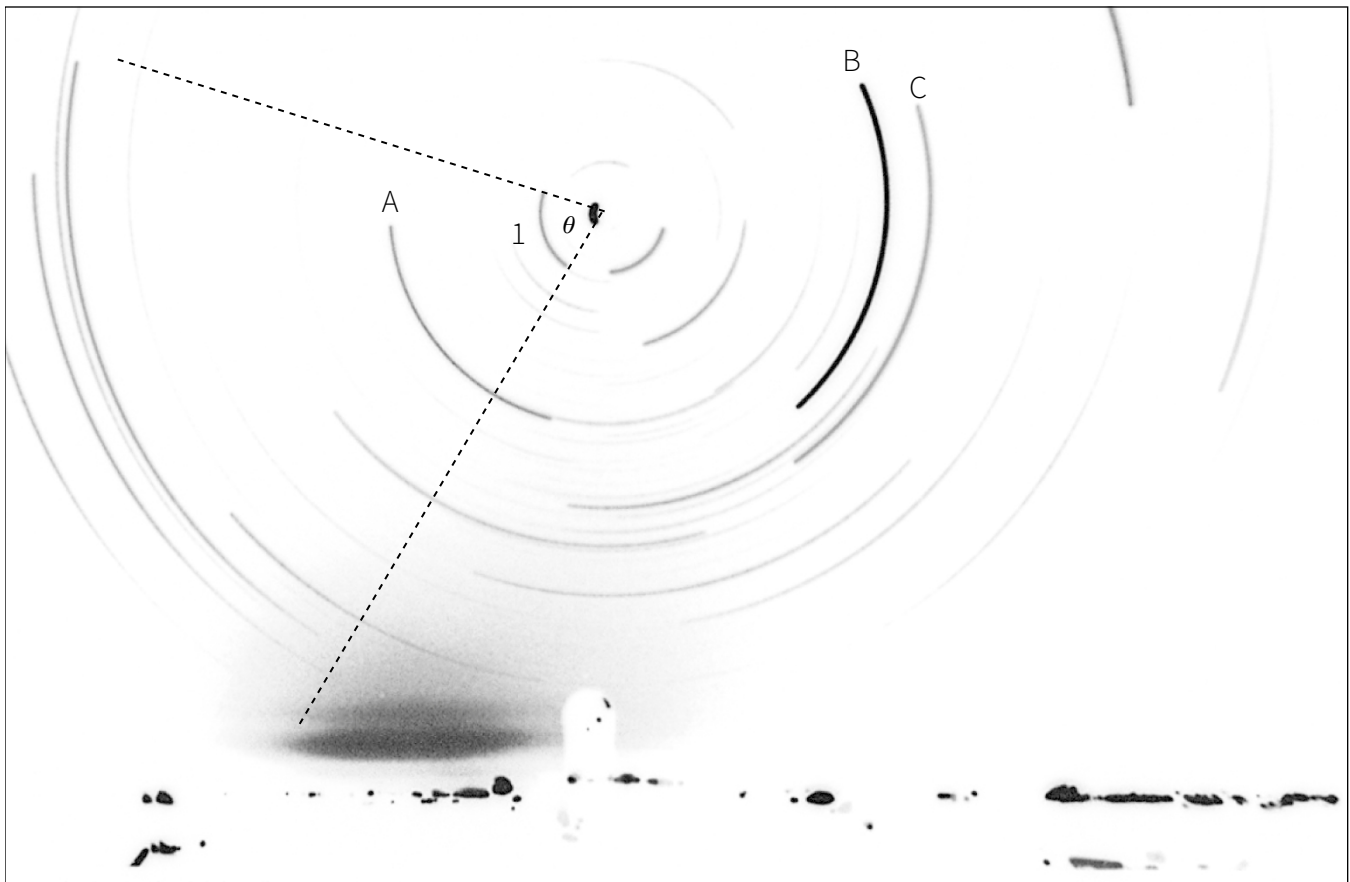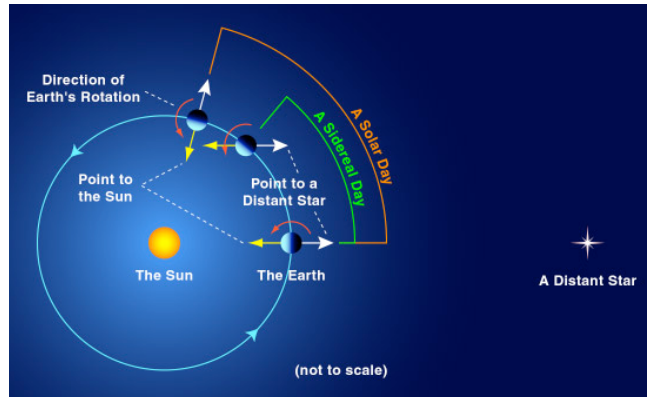
Example Calculation for Star Trail 1

Measure: $\theta = 76°$

Calculate: $day = (287\min)\left(\dfrac{360°}{76°}\right) = 1359\min$

Convert: $hours = \dfrac{1359\min}{60\frac{\min}{hr}} = 22.7hr$

Compare: $sidereal = \left(\dfrac{22.7}{24}\right)solar = 0.95solar$

Make sure that you are recording all your answers in your lab notebook. Include any sketches or additional explanations that you think may help you answer quiz questions!