# Motion of the Sun

Based on our previous observations we have now constructed a model for how the stars move (the *Celestial Sphere*). We have also developed a new coordinate system to fit this model (the RA/Dec system). In this activity we will examine the motion of the stars in greater detail and begin examining the motion of the Sun.

- Go to a computer and launch Starry Night Enthusiast 6.
- Click the tab on the left marked Favorites. Select Rome, GA. Click the Favorites tab again to close this menu.
- Click Now at the top left and then stop the animation. Turn off daylight savings time by clicking the tiny sun that is just to the left of the time display (if the sun is lit up then daylight savings time is on, if it is dark then it is off).
- Turn off the daylight by pressing Control-D.
- Click the Options tab on the left. Under the Guides menu click on the Celestial Grid box. This brings up a grid showing the equatorial coordinate system. Let's use this grid to find the coordinates for a few stars. Let's start with Polaris. You should be able to find Polaris on your own, but this time let's use the software to help us. Click the Find tab on the left and type "Polaris" into the text box. Double-click on Polaris in the list that appears. The software may ask you if you want to change the time (if Polaris isn't currently visible) - do so if you need to. This should point you directly toward Polaris (and it even labels the star for you). DO NOT PUT THE CURSOR ON POLARIS YET! What are the coordinates of Polaris in the equatorial system? After you have determined the coordinates on your own you can check your answer by placing the cursor on Polaris.

  RA = _____ Dec = _____

- At what special point in the equatorial coordinate system is Polaris located?

- Now let's go back to Mintaka in Orion. You can find this on your own or use the Find function. DO NOT PUT THE CURSOR ON MINTAKA YET! Estimate the coordinates of Mintaka. Once you have made your estimate you can put the cursor on Mintaka and check your answer.

  RA = _____ Dec = _____

- On what special line in the equatorial coordinate system is Mintaka located?

- Now let's run the animation at 3000x speed. You may need to deselect Mintaka and/or Polaris to maintain a fixed direction of view. When we let time pass the stars move through the sky. Do they move relative to the RA/Dec coordinate grid?

- Stop the animation and direct your view toward the zenith (click the Z at the top right). What are the coordinates of your current zenith in the equatorial system?

  RA = _____ Dec = _____

- What would be the equatorial coordinates of your zenith one hour from now? Try to figure this out without using the software, but you can check your answer with the software.

RA = _____ Dec = _____

- What is the significance of the Declination coordinate of your zenith? What does it tell you?

- OK, enough about equatorial coordinates for now. Hopefully the advantages of the equatorial system are clear. Now we want to see how long it takes the stars to go around the sky (or how long it takes our Celestial Sphere to complete on rotation). Click on the Options tab and turn off the Celestial Grid. Turn on the Local Grid. Then find Sirius, the brightest star in the sky. Run the animation until Sirius is on the Meridian in the Southern sky at az=180° (it may already be there). Try to get it right on the Meridian (use the T button to advance in one minute increments if needed). Record the time (to the nearest minute) and date of this transit below.

- Now run the animation until Sirius returns to the Meridian at az=180° once more. Again, try to get it exactly on the Meridian. Record the time and date of this transit below.

- What is the time interval between transits for Sirius (and for all the other stars)? Give your answer to the nearest minute. This time interval is known as a *sidereal day*.

- Now let's do the same thing for the Sun. Find the Sun and run the animation until the Sun is on the Meridian at az=180°. Record the Sun's transit time and date below. Note that the time at which the Sun transits (as seen from a particular location) is known as *local noon* because it is the time when the Sun is highest in the sky.

- Run the animation until the Sun's next transit. Try to get it right on the Meridian again. Record the time and date of this transit below.

- What is the time interval between transits for the Sun? Give your answer to the nearest minute. This time interval is known as a *solar day* (or usually just a day).

- Note that both the stars and the Sun move East to West across the Southern sky. But it apparently takes the Sun a little longer to go all the way around. *Relative to the stars* which direction is the Sun moving?

- Let's verify this by advancing time by exactly one sidereal day. To do this find the Time Flow Rate window (top center). Click on the down arrow to open the menu and select "sidereal d." Now advance by one time step (using the VCR button on the far right) and watch what happens to the Sun. What direction does the Sun appear to move relative to the stars?

- Did you notice anything else moving? If so, what do you think these strange stars might be?

- Click the Options tab on the left. Under the Guides the Local Grid box should already be checked. Go ahead and click the Celestial Grid box as well. Click The Ecliptic, Summer/Winter Solstice, and Vernal/Autumnal Equinox boxes. Then click the Options tab again to close it.
- The ecliptic (the green line on your screen) is the name of the path that the Sun follows among the stars. Find where the ecliptic crosses the Celestial Equator and use the protractor provided to determine the angle between these two lines. Zoom into this point using the + button near the top right. Record your result below.

- Find the Sun again, if necessary, and right click it. Select Centre. Zoom back out to the normal view. Now go to the Time Flow Rate menu and select "days." Then **set the time to the time you determined for local noon above**.
- Now play the animation until the Sun crosses the Celestial Meridian with an RA of $0^h$. Note that the Declination of this point is $0°$, indicating that it is a point on the Celestial Equator. This point is the origin of the RA/Dec coordinate system, known as the *vernal equinox*, $\Upsilon$. Record the date and the Sun's altitude below.

  date = _____ alt = _____

- Let the animation run again and stop it when the Sun is at an RA of $6^h$ (this is the summer solstice). Note that here the Sun's Declination is not zero. What is it?

- Record the date of the summer solstice and the Sun's altitude at local noon below.

  date = _____ alt = _____

- Let the animation run again and stop it when the Sun is at an RA of $12^h$. Again, the Sun's Declination is zero at this point, which is known as the *autumnal equinox*, ♎. Record the date and the Sun's altitude at local noon below.

  date = _____ alt = _____

- Let the animation run again and stop it when the Sun is at an RA of $18^h$ (this is the winter solstice). What is the Sun's Declination at this point?

- Record the date of the winter solstice and the Sun's altitude at local noon below.

  date = _____ alt = _____

- Let the animation run again and stop it when the Sun returns to an RA of $0^h$. Record the date below.

- How many days does it take for the Sun to go all the way around the ecliptic? (Hint: compare the first date when it was at $0^h$ to the next date when it was at $0^h$.)

- Through approximately what angle does the Sun move against the stars during one day?

- During what month is the Sun highest in the sky at local noon?

- During what month is the Sun lowest in the sky at local noon?

- Set the date to the date of the winter solstice. You can do this by playing the animation, or by using the M key to advance a month or the D key to advance a day (Shift-M or Shift-D to go backward). Set the Time Flow Rate to 3000x. Find the time for sunrise (the time when the Sun rises above the horizon line). It may be helpful to go into Options and uncheck the Local Horizon box in the Local View menu. Record the sunrise time below.

- Determine the time for sunset on the winter solstice.

- What is the length of the period of daylight on the winter solstice?

- Now determine the time for sunrise on the summer solstice.

- Determine the time for sunset on the summer solstice.

- What is the length of the period of daylight on the summer solstice?

- Why are the days longer in the summer and shorter in the winter? How is this related to the orientation of the ecliptic relative to the Celestial Equator?