

TOOLS IN ASTRONOMY

<http://www.physics.usyd.edu.au/physopt/ao/ss.html>

Article about adaptive optics. Contains images that show what they can do to images.

http://es.rice.edu/ES/humsoc/Galileo/Student_Work/Astronomy95/telescope_design.html

How to make a cheap and functional telescope

<http://galileoandeinstein.physics.virginia.edu/lectures/galtel.htm>

A brief outline of Galileo's work with the telescope to ID features on the moon.

<http://www.hao.ucar.edu/public/education/sp/images/galileo.2.html>

Drawing of the moon.

MEASUREMENTS

<http://www.phys.ksu.edu/perg/www/pdf/parallax.pdf>

Pen and paper activity to determine the trigonometric parallax of an object.

<http://astro.estec.esa.nl/SA-general/Projects/Hipparcos/hipparcos.html>

Site about the Hipparcos satellite and information it collected. In further information ... did you know there is information about accuracy of parallax.

SPECTROSCOPY

http://www.astro.washington.edu/astro101v/lectures/hrd_clusters.html

A site that runs through the HR diagram, interactive exercises on determining magnitude and answering questions about HR diagrams.

<http://www.astro.ubc.ca/~scharein/a311/Sim/hr/HRdiagram.html>

HR diagram simulator.

<http://www.distance.hccs.cc.tx.us/~geol1346/Assign/HR-Lab.html>

Worksheet to interpret things from HR diagrams, as well as plotting stars to create your own diagram.

http://www.physics.montana.edu/phyped/papers/spec_codes.doc

A word file that takes you through classification from spectra. The spectra are simulated and simplified.

GENERAL SITES

<http://www.gettysburg.edu/academics/physics/clea/CLEAhome.html>

Best site for interactive software

Jupiter - universal force

Spectra - classification of stars according to their spectra.

<http://ngala.as.arizona.edu/dennis/instruct/ay14/hubble.html>

Measure Hubble constant. Use the spectra of stars to take measurements.

http://www.flaguide.org/tools/tools_discipline.htm

Site with assessment tools. In Astronomy it has things like surveys and concept map of the solar system, with answer schemes.

<http://solar.physics.montana.edu/aae/adt/>

Astronomy diagnostic test. Allows for pre and post testing. Did they learn anything??

<http://www.coc.cc.ca.us/departments/ASTRO/Default/links3.htm>

A series of information sites from asteroids, meteors, the sun and more. A good source of information for teachers and students alike.

<http://jersey.uoregon.edu/vlab/>

An excellent simulation site. Has applets for all areas of physics - many for year 11 physics. It also has a tools area that has graphing and spreadsheets.

http://www.explorescience.com/activities/activity_list.cfm?categoryID=11

A series of interactive activities. Most are for year 11 Physics, there are some good activities for other core areas. Activities include: Lissajous figures, shoot the monkey....

Ray tracing - allows you to explore the mirror equation, Basic prism allows you to work through Snell's law. The help buttons explain some of the physics and instruct you on the use of the program. Some require more deciphering than others.

<http://www.galileo-galilei.org/>

General site about Galileo, contains quizzes.

Eclipsing Binary Stars

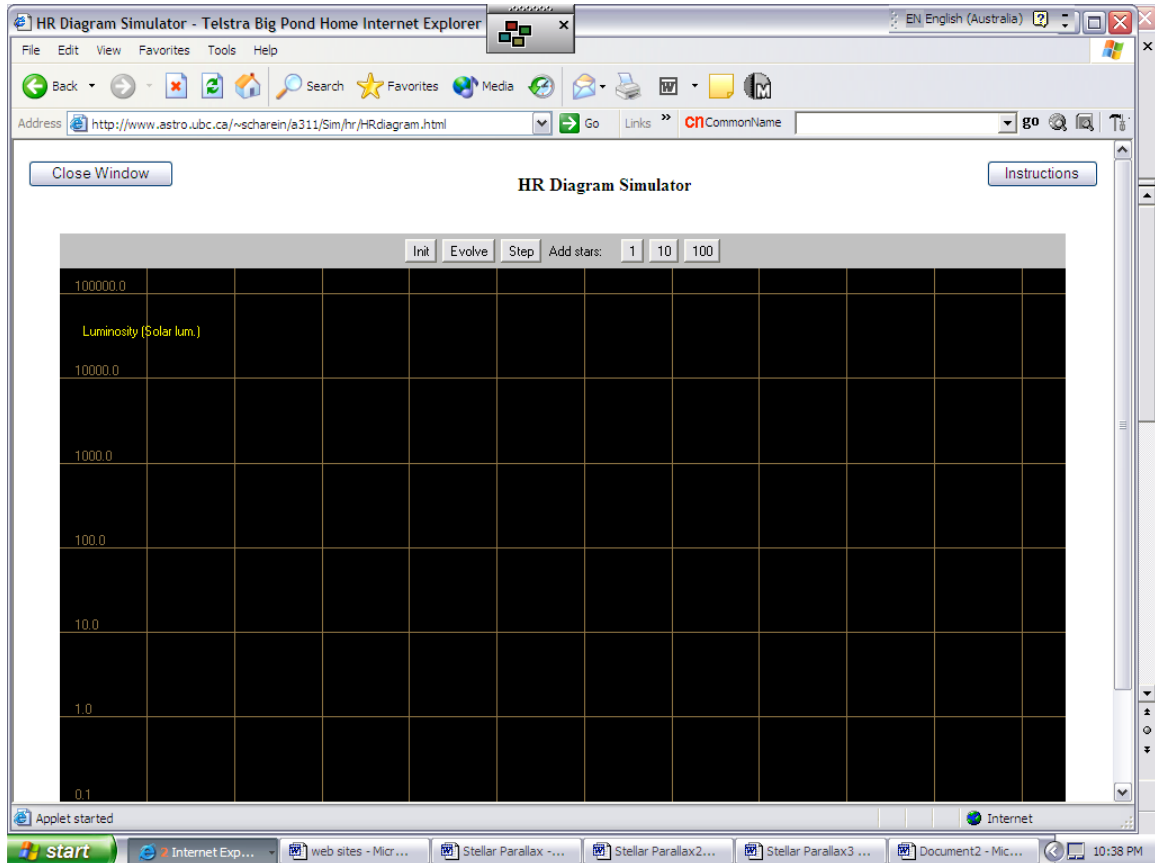
<http://instruct1.cit.cornell.edu/courses/astro101/java/eclipse/eclipse.htm>

The above website shows a simulation of eclipsing binary stars.

- 1) Define an eclipsing binary.
- 2) What do the axes of the graph represent?
- 3) Set the values as follows:
 - Star 1 type A
 - Star 2 type F
 - angle = 10
 - separation = 10
- 4) Describe the shape of the graph.
- 5) Relate the features of the graph to specific positions in the orbit of the two stars.
- 6) Change the values to see the effect that each of the following has:
 - Star Type - eg: What happens when the types are the same?
 - Separation - separate the stars by differing amounts and make a general observation.
- 7) What effect does the angle of inclination have on the graph? Can you put forward an explanation for this?

Evolution of Stars

<http://www.astro.ubc.ca/~scharein/a311/Sim/hr/HRdiagram.html>



- Select add stars 1
- Select evolve
- follow the sequence of the star and note down its luminosity and temperature at different points in its life.
- Record steps that show a significant difference in the path of the star.

	LUMINOSITY	TEMPERATURE	TIME	TYPE
START:				
STEP 1:				
STEP 2:				
STEP 3:				
STEP 4:				
STEP 5:				
END:				

- When you have finished, select INT. This will reset the graph.
- Each time you select EVOLVE, a new star start point will appear.
- Repeat the process for two different start points.

STAR 2

	LUMINOSITY	TEMPERATURE	TIME	TYPE
START:				
STEP 1:				
STEP 2:				
STEP 3:				
STEP 4:				
STEP 5:				
END:				

STAR 3

	LUMINOSITY	TEMPERATURE	TIME	TYPE
START:				
STEP 1:				
STEP 2:				
STEP 3:				
STEP 4:				
STEP 5:				
END:				

- From your own knowledge and from what you have learnt, explain why each star follows a different evolutionary trail.

Galileo and the Telescope

<http://galileoandeinstein.physics.virginia.edu/lectures/galtel.htm>

Answer the following questions based on the text from the above web site.

The Evolution of the telescope

1. In 1609 Galileo found out about a magnification device. Why did he further work on it?
2. Through experimentation, what did he discover about magnification?
3. Why was Galileo's first astronomical discovery so controversial?
4. How was it possible for Galileo to convince people of the mountainous nature of the moon?
5. In your own words explain how it is possible to determine the height of mountains on the moon.
6. The edge of the moon is seen to be round. How could this be explained if the existence of mountains was true?

Now go to the next web site and continue:

<http://www.hao.ucar.edu/public/education/sp/images/galileo.2.html>

1. Look at the drawing of Galileo's moon and write down observations that you can make from it.
2. What inferences can you draw?
3. Why were his ideas of what he saw so controversial?

ANSWERS

1. He saw it as a possible way out of his financial difficulties
2. he realized that the magnification was proportional to the ratio of the power of the concave (eyepiece) lens to the convex (more distant) lens. In other words, to get high magnification he needed a weak convex lens and a strong concave lens.
3. Galileo's first major astronomical discovery with the telescope was that the Moon's surface is mountainous, and not a perfect sphere as had always been assumed
4. He built a convincing case for the reality of the mountains by sketching the appearance of parts of the Moon's surface at different times of the month, that is, under different angles of lighting, and showing how the light and shadow seen could be simply and naturally accounted for topographically, rendering the prevailing theory at the time, that the variations in light arose from something inside a perfect sphere, a cumbersome and unappealing alternative.
5. At half moon, a little geometry is enough to calculate the heights! Galileo himself worked an example: suppose a bright spot, presumably an illuminated mountaintop, is visible one-twentieth of a moon diameter into the dark side, at half-moon. Then the picture is as shown here (and is taken from *Sidereus Nuncius*). The light from the sun fully illuminates the right-hand half of the moon, plus, for example, the mountaintop at D. (GCD is a ray from the sun.) If the base of the mountain, vertically below D, is at A, and E is the moon's center, this is exactly the same problem as how far away is the horizon, for a person of given height on a flat beach. It can be solved using Pythagoras' theorem as we did for that problem, with the center of the moon E one of the points in the triangle, that is, the triangle is EDC.
6. A problem with asserting the existence of mountains is the apparent smooth roundness of the edge of the Moon, for which Galileo had two arguments. First, ranges behind those on the edge would tend to fill in the gaps.

Sharper eyes on the sky

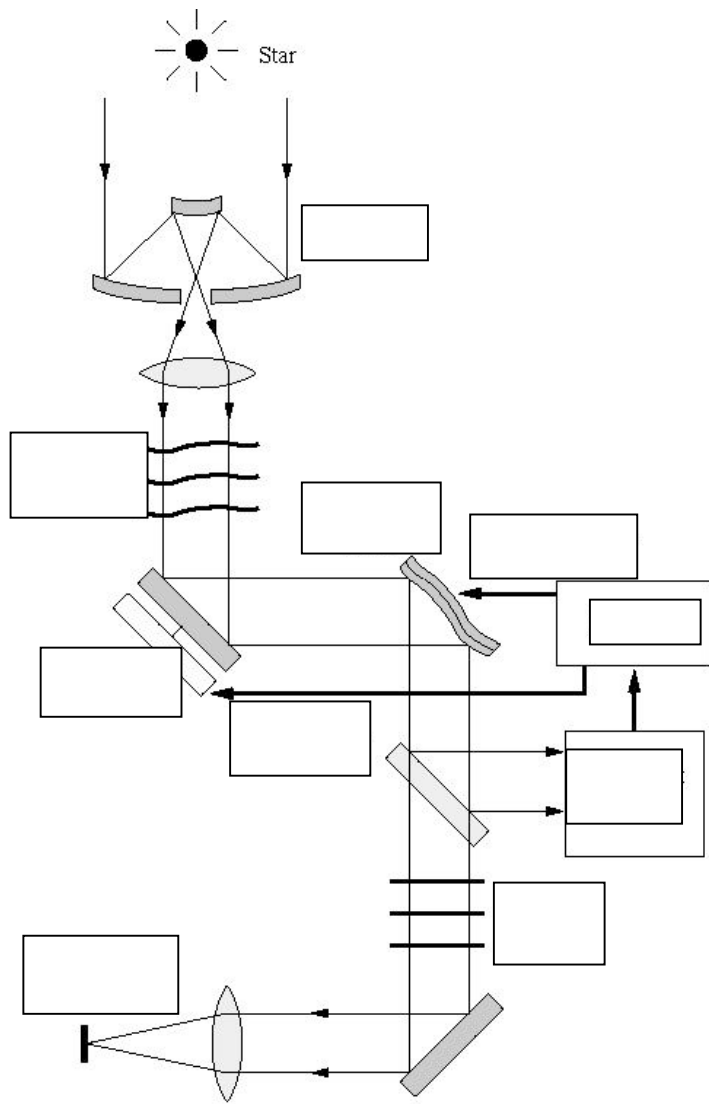
<http://www.physics.usyd.edu.au/physopt/ao/ss.html>

After reading the article on the website above, answer the questions that follow.

- 1) What are the advantages of having larger aperture optical telescopes?
- 2) Complete the following table comparing and contrasting active and adaptive optics

	Active Optics	Adaptive optics
Speed		
Method of correction		
Wavelengths used		
Examples		

- 3) Use the picture on the webpage to label the following diagram.
- 4) Explain in point form how this system “clears” up a blurry image.



Binary Stars

<http://instruct1.cit.cornell.edu/courses/astro101/java/binary/binary.htm>

The above website shows a simulation of stellar parallax.
You will need to know the following definitions to work the simulation.

Mass 1 or Mass 2	The mass of each of the two stars.
Separation	The distance between the two stars in solar radii.
Eccentricity	Eccentricity of the orbit
Inclination angle	Angle of the orbital plane of the stars to our line-of-sight. <ul style="list-style-type: none">• 0° - face on• 90° - edge on <p>Note that this is opposite from the Eclipse simulation - we'll fix this in the future.</p>
Node angle	Angle of the major axis as measured in the orbital plane (see privileged view)

- 1) Set the parameters as follows.

m1 = 1
m2 = 1
a = 0.7
e = 45
i = 45
w = 0

- 2) Describe the view from Earth in terms of motion and position of the two planets.
3) How does this convert to the graph?
4) Explain the effect on the motion if the masses are changed? Try the following combinations:

m1	m2
1	2
2	1
4	1
1	8

- 5) Explain what the spectra is telling you about the stars in this system. Relate your description to the positions of the stars in their orbits.
6) How can the period of the stars be determined?
7) Define spectroscopic binary stars.
8) Using Kepler's Law, how can the mass of the system be determined.

Colour and Stellar Temperature

<http://zebu.uoregon.edu/nsf/planck.html>

Using the applet titled: Blackbody Radiation and Stellar Temperature

1. Define black body radiation.
2. Why is a star considered an ideal black body?
3. Set the thermometer on the left to 8000 K. Sketch the black body radiation curve that results.
4. Select the red, blue and visual filters. In the box along side these, the colour index and colour ratios are displayed.
5. Set the temperature to each of the following values. Record the colour index for each.
6. Graph colour index versus temperature.
7. Determine a relationship between temperature and colour index.
8. What is colour index used for?

Using the applet titled: Total energy emitted and Temperature

1. The area under the curve represents energy output. Set the left thermometer to 10000K and the right thermometer to 5000K. Describe the area under each curve.
2. Set the thermometers to each of the values listed below. Estimate the area beneath each curve by adding the boxes enclosed.
3. Graph T versus Intensity. Describe the curve.
4. Graph T^4 versus Intensity. Describe the curve.
5. What is the relationship between intensity (energy) and temperature?
6. What law relates these two quantities together?

Stellar Spectra Classification

Leader: _____

Explorer: _____

Skeptic: _____

Recorder: _____

Learning Objectives

1. Know that starlight is often broken up into component wavelengths with diffraction gratings to produce stellar spectra.
2. Understand how stellar spectra are classified as A, B, C, D, E and so on, based on prominent characteristics.
3. Understand how stellar spectra are related to composition and temperature.

Introduction: Classifying stars based on brightness is somewhat problematic. A star's apparent brightness can be affected by its distance from the observer, its size, or by the presence of interstellar dust. Instead, astronomers classify stars based on the major components of their spectra. Much like bar-codes on grocery store items, stellar spectra are each slightly different but have many characteristics in common. The current classification system used by astronomers was created by Annie Jump Cannon and Henrietta Leavitt working at Harvard in the early 20th Century. The study of spectra provides scientists with important information about stars that is otherwise inaccessible. This information includes composition and temperature.

Part I: Classifying Stellar Spectra

Included in this activity is a table of simulated stellar spectra (page 169). Your first task is to sort the spectra by creating a classification scheme. As with real stellar spectra, you will never find two exactly the same. The thickness of each line represents how much light is received at a particular wavelength, so the both the **thickness** and the **position** of the lines are very important. Astronomers usually focus on the broadest lines first. Record your results in the table on the next page.

Note: The table contains five rows but you do not need to use them all. Also, there is no requirement that your classification scheme results in the same number of stars in each category.

Hint: *Imagine that the sixteen bar codes represent food items from four departments—meat, dairy, produce, and groceries. You might expect that all the bar codes from the same department look similar, but not identical. Your task would be to sort them into groups representing the four departments.*

	Spectra ID Numbers	Defining Characteristics <i>(provide enough detail so that anyone could use your scheme)</i>
Category I		
Category II		
Category III		
Category IV		
Category V		

Reflection: Find a nearby group and compare your classification scheme to theirs. What is the difference between how you chose to classify the spectra and how they did?

Part II: Matching Stellar Spectra

Now, let's try somebody else's scheme. Your task is to match the 16 unknown stellar spectra with the 4 known ones (standard spectra) at the end of this activity on page 172. You should identify four unknown spectra similar to standard A and the same for B, C, and D.

Known Spectra	A	B	C	D
Unknown Spectra Numbers				

Reflection: Describe the specific characteristics that your group used to match the known with the unknown spectra.

Part III: Determining Relative Stellar Temperatures

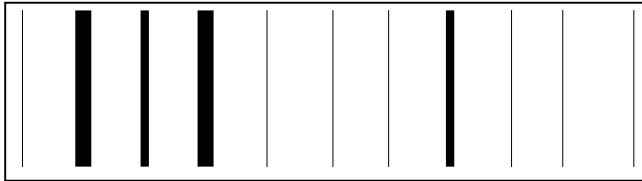
Blackbody radiation curves were acquired for all simulated stars, including the standards, and the results are listed on the Data Sheet at the end of the activity. Remembering that the peak wavelength is a measure of the star's temperature, sort all twenty stars, including stars A, B, C, and D, into four new categories and record the star ID's in the table below. The smaller the wavelength, the hotter the star.

Hot Stars	Medium-Hot Stars	Medium-Cool Stars	Cool Stars

Reflection: Carefully compare and contrast the stellar temperature classification (table above) with the stellar spectra classification scheme used in Part II. How are the two classification schemes related?

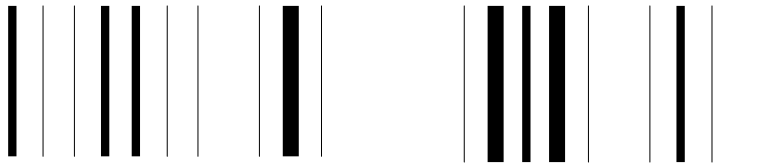
Part IV: Determining the Temperature of a Star

At the bottom of the Data Sheet, you will find a table that relates the peak wavelength of the blackbody spectrum to the surface temperature of the star. Suppose a new star is discovered and its spectrum is shown below. Determine its temperature and justify your answer.



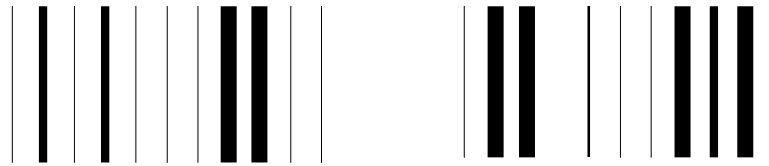
Stellar Spectra Classification Data Sheet

Standard Spectra Classifications



A

B



C

D

Blackbody Radiation Peak Values

Star ID	Peak Value (angstroms)		Star ID	Peak Value (angstroms)
1	3625		11	7005
2	2810		12	3610
3	3612		13	2805
4	7040		14	5515
5	5470		15	7010
6	2812		16	5555
7	2790		A	3600
8	3595		B	2800
9	5510		C	5500
10	6940		D	7000

Corresponding temperatures for four classes of stars studied.

Standard	Peak blackbody wavelength (angstroms)	Temperature (degrees)
A	3600	8000
B	2800	10,000
C	5500	5000
D	7000	4000

Stellar Classes

http://jersey.uoregon.edu/vlab/prf/PRF_plugin.html

Determine the characteristics of each of the stellar classes.

In the bottom right hand corner, several classes are listed.

The scale on the right is the temperature. This can be change to see the effect.

By selecting “draw limits of integration”, the colour index will be displayed.

By selecting “star data” the real radiation obtained is superimposed.

By right clicking the mouse on the curve, the wavelengths at any point will be displayed.

Go through each star in the list and fill in the table of characteristics below.

Set the temperature to 18000.

Star type	Peak wavelength	Colour Index	Appearance colour
O5V			
O7 - BOV			
O7 - B IIII			
B3 - 4V			
B5III			
B6V			
B9III			
A1-3V			

Determine a generalised view of characteristics shared by different spectral classes.

Stellar Evolution

<http://instruct1.cit.cornell.edu/courses/astro101/java/evolve/evolve.htm>

The above website shows a simulation of stellar evolution. It allows you to follow the evolution of stars of different masses

From the description answer the following questions:

- 1) How do stars on the main sequence of the HR diagram generate energy?
- 2) How are higher temperatures within the core of a star achieved?
- 3) What is the determining factor of how far a star will evolve?

Start the simulation

- 1) Using the following initial stellar masses, write down the sequence of steps that the star follows and note the relative amount of time spent in each step.
 - (a) mass = m_{\odot} (Solar mass)
 - (b) mass = $1.5 m_{\odot}$
 - (c) mass = $0.63 m_{\odot}$
 - (d) mass = $15 m_{\odot}$

- 2) What is the minimum limit of the mass of a star to become a supernova?

Stellar Parallax

<http://instruct1.cit.cornell.edu/courses/astro101/java/parallax/parallax.html#example>

The above website shows a simulation of stellar parallax.

From the description answer the following questions:

- 1) What criteria must the star fit for using this method?
- 2) What happens to the position of the star as the Earth orbits through the year?
- 3) This motion happens over a period of a year, how can astronomers measure this movement?
- 4) What is Proper motion and how can this be corrected?

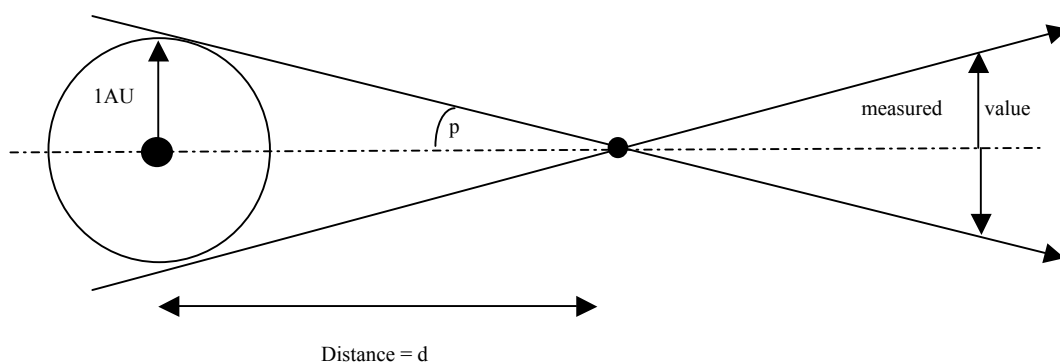
Start the simulation

- 1) Describe the motion of the star as seen from Earth.
- 2) Where in orbit around the Sun is the Earth when the star is seen to be; at the bounds and in the middle of the bounds?
- 3) Measure the distance between bounds. Use this and other information to calculate the distance to this star.

camera used is 35mm.

$\frac{\text{distance to star}}{\text{Earth's orbit diameter}} = \frac{\text{camera focal length}}{\text{star's shift in photo}}$

Use the diagram below to help you relate your measurements to the actual distance of the star.



- 4) Calculate the angle of parallax using the following relation

$$p = 1/d$$

- 5) Give reasons for the distance that you have calculated being so small.

Stellar Parallax

http://www.astro.washington.edu/labs/parallax/parallax_distance.html

The above website shows photos of star fields taken 6 months apart. Follow the instructions to determine the distance of the two stars shown.

Answer the following questions:

- 1) What is meant by the term "blinking" in relation to the star photos?
- 2) Why is this useful in helping to locate the star of interest?
- 3) Calculate twice the parallax angle of star A.
- 4) What is the parallax angle for star A?
- 5) Do the same for star B.
- 6) Answer the three questions on the website.
 1. How accurate are your distances? (Measure the parallaxes a few times; do you get the same distance each time? Is it worse for one star than the other?)
 2. Which star is closer?
 3. Based on their relative apparent brightnesses, which star is intrinsically the brightest? Explain.

Follow the link to the stellar parallax lab. Use the information on the page to answer the four questions stated.

Question 1: How long do you have to wait for a star to undergo its maximum parallactic displacement?

Question 2: How can the observation of stellar parallaxes in general be used as evidence against a geocentric view of the cosmos?

Question 3: How far, in parsecs, is an object that has a parallax p of 1 arc-second? How far is it, in light-years?

Question 4: How far, in parsecs, is an object that has a parallax p of 0.1 arc-seconds? How far is it, in light-years?