Name___________________________________ **Section** ________________

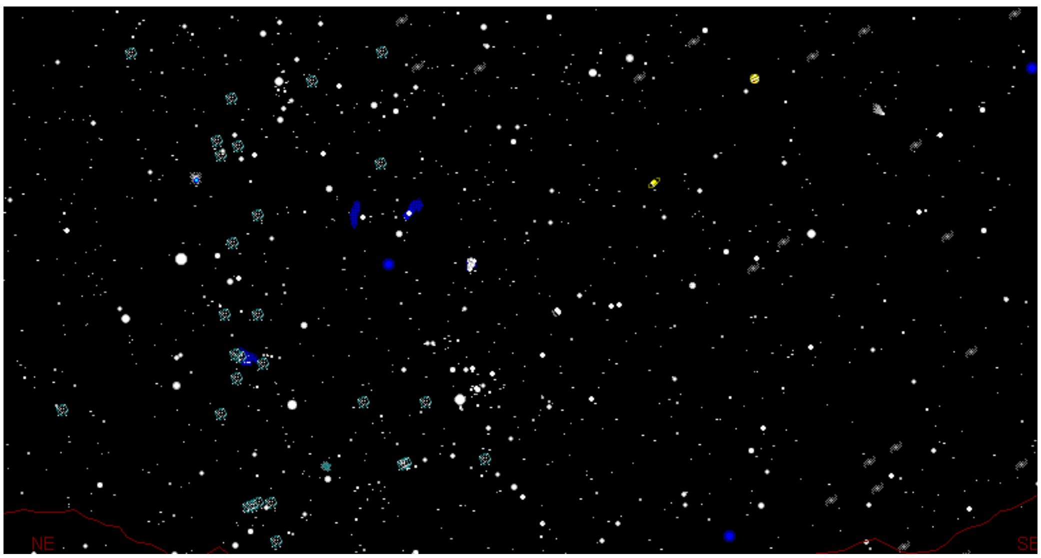
Partner(s)________________________________ **Date**___________________

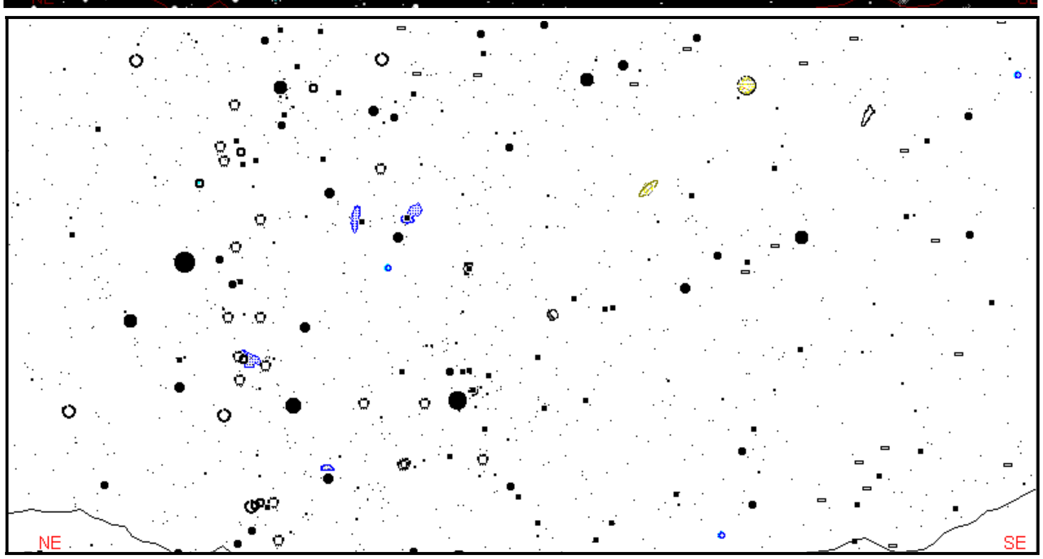
STARS AND THE INTERSTELLAR MEDIUM

When you look out at the night sky, most of the objects you see are stars. However, there are many other interesting objects to be discovered in the space between the stars within our Milky Way Galaxy. This activity is designed to explore some additional measurements of stellar properties and introduce you to non-stellar celestial entities.

Activity 1: Positive or Negative?

Below are two images of the same star field. Which one looks more like what you would see at night? Explain.





How does the second image compare to the first?

The second image is an inverse or “negative” of the first image. If you wanted to study the sky objects, what advantages might the negative have over the actual photograph of the night sky?

Our eyes are able to detect small black objects on a white surface better than white or colored on black. Astronomers frequently use negative prints to look at celestial objects. During this laboratory session you will be using negative images.

Activity 2: Temperature of Stars

When you look at the stars in the night sky do they appear to be the same size or do they vary significantly?

Stars generally appear to be the same size viewed from Earth because they are so distant from us, even though they actually vary tremendously in size.

Obtain four large laminated photographic plates labeled as follows: Plate 1 Red, Plate 1 Blue, Plate 2 Red, Plate 2 Blue. PLEASE DO NOT WRITE ON OR OVER THESE PRINTS! Look at the photograph labeled Plate 1 Blue. Most of the spots on this plate are stars.

Are the star sizes all the same on the image? Can you think of a reason why?

The emulsion on photographic film collects light emitted from the stars. Larger or brighter stars emit more photons and these photons scatter within the photographic emulsion, making the images for those stars appear larger. The circles around stars or the points you see are artifacts of the observational equipment.

In the classroom there are two gas discharge tubes set up. Carefully turn on each of the tubes. Obtain a pair of glasses that have one red lens and one blue lens. Look at the red bulb with the red lens and then with the blue lens (not both simultaneously!). Repeat the procedure for the blue bulb.

Is the red bulb brighter when viewed through the red or blue lens? Is the blue bulb brighter when viewed through the red or blue lens?

The lenses act as filters. The red lens absorbs most wavelengths but allows red to pass through to your eye. The blue lens allows blue wavelengths to be transmitted but blocks other colors (wavelengths).

Suppose you looked at a star that was M class. What color would it appear to the eye? Would the M class star appear brighter through the red or blue filter? Explain.

Now suppose you photographed the star twice, once with film more sensitive to red wavelengths and once with film more sensitive to blue wavelengths. Would the M class star appear the same on both plates? Explain.

Look at Plate 1 Red and Plate 1 Blue. These are photographs of the same region of the sky photographed with red sensitive and blue sensitive film emulsions. This would be the same as photographing through red and blue filters. Overlay Plate 1 Red on Plate 1 Blue. Now flip back and forth between the two plates. Do you see the stars that correspond on each image? Are the corresponding images for stars the same size in all cases?

Recall stellar color, spectral class, and temperature from the activity you did on stellar spectra. What color, red or blue, are the hotter stars? Would their images be larger on the red or blue plate?

By measuring and comparing the diameters of the same stars on the red and blue plates we can determine if stars are hotter or colder than others.   Suppose you measure the diameters and then calculate a ratio between the diameters:

$$Ratio = \frac{Blue\ Diameter}{Red\ Diameter}$$

What does a larger ratio tell you about the “hotness” of the star?

Plates 1 and 2 are photographs of two adjoining regions of the Milky Way in the constellation Cygnus. In each one you should see a large circular feature which is the star Deneb (lower left on Plate 1, upper left on Plate 2). From your envelope of photographs, remove these four plates. Open Plates 1 Blue and Red. On your copy of Plate 1 Blue circle the 10 largest stars. Do not include the diffraction ring when making the selections. Circle the same stars on your paper copy of Plate 1 Red.

Using the laminated photographs (higher definition), measure the diameter of each star you circled and Deneb on each of the plates to the nearest millimeter (mm) and place the information in the table below. Calculate the blue/red ratio for each star.

Star	Blue Diameter (mm)	Red Diameter (mm)	Blue/Red Ratio
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Deneb			

Which star is the coolest? Explain.

Which stars are hotter than Deneb?

The stars that are hotter than Deneb are all Class O and B stars. Stars like this use up their nuclear fuel quickly and thus burn out quickly. Their lifetimes are relatively short–less than 1/10 the age of our sun. If we can still see these stars, are they relatively young or old? Explain.

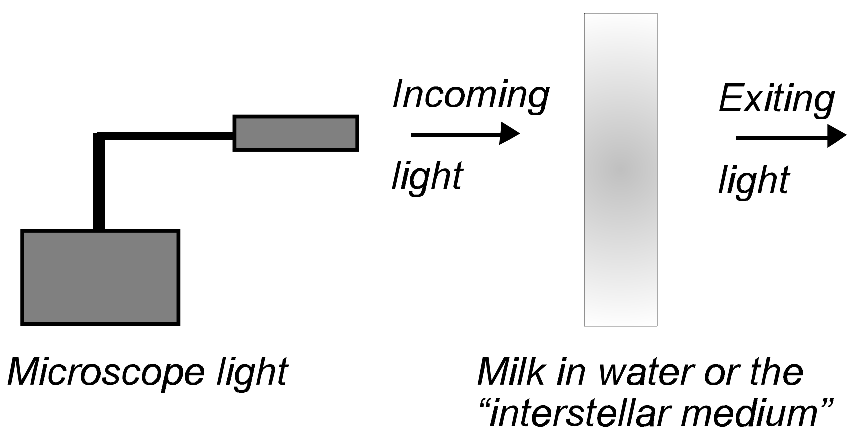
Activity 3: The Interstellar Medium

What do you suppose the *interstellar medium* refers to?

The interstellar medium is the gas and dust that is found between the stars. We are going to examine six kinds of interstellar medium on the two sets of photographs to explore differences. But first let's examine some general properties of clouds of gas and dust.

What can happen to light passing through the interstellar medium? (Hint: spectroscopy, cloudy days, and driving in fog at night)

In the laboratory your instructor will have set-up the following apparatus. Our interstellar medium will be a weak mixture of milk in water which will behave like a cloud of gas and dust.



Make the following three observations:

1. Color of incoming light beam: __________________

2. Color of milk in water where light beam passes: __________________

3. Color of exiting light beam - viewed end on: ____________________

What wavelengths or colors make up white light?

Explain what is happening to the light as it passes through the medium.

The incoming white light is scattered by the fat particles in the milk. The scattering occurs more prominently for the smaller wavelengths (blue), hence the milk has a bluish color to it. The scattering of light occurs in all directions. Since the blue wavelengths are scattered by the milk, the exiting beam of light appears reddened.

Would a thin cloud of dust behave the same as a thick cloud? Explain why or why not.

Some forms of interstellar matter are bright while others are dark. The bright forms tend to be nearer to bright stars. Suggest a reason for their glow.

We will study six kinds of interstellar medium. Examples of these are indicated on plates one and two by letters. To acquaint yourself with these different types, find the objects on both plates, red and blue, and fill in their characteristics in the table below. You may want to use the flow chart on p.128 to help characterize each.

Feature	Medium	Black or white on plate?	More red light or More blue light emitted?	Round, nebulous, stringy, or angular?
K	Dust Cloud			
A	Globule			
F	HII Region			
B	Planetary Nebula			
C	Reflection Nebula			
J	Emission Filament			

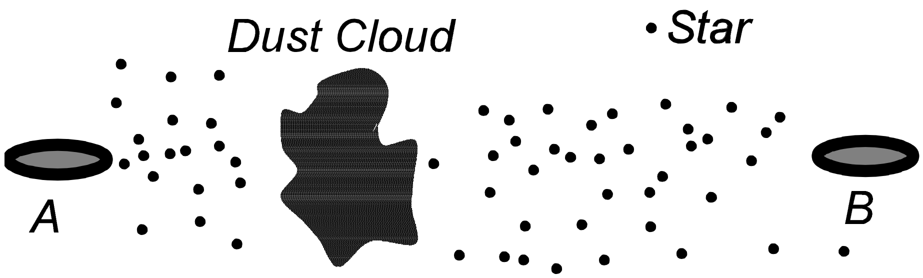
Once you have completed the table, use it and both plates, red and blue, to determine which kind of interstellar medium each of the following is:

Feature	Type of Interstellar Medium
D	
L	
E	
I	
H	
M	
G	

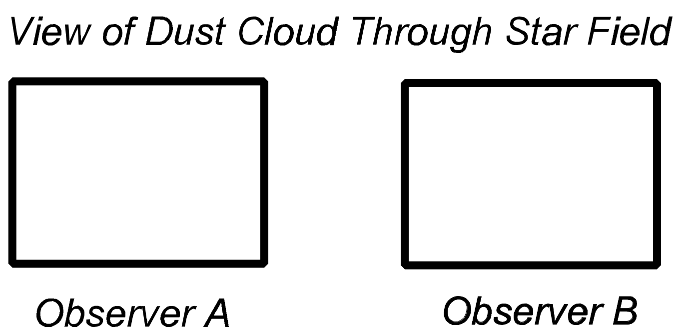
The interstellar medium is composed of gases, mostly hydrogen, and dust particles such as silica grains. Some clouds are ionized hydrogen, H^+ (H II). A vast number of molecules and molecular ions are also found by spectroscopy. The interstellar medium is an interesting and unusual pot of chemistry.

Activity 4: Distance to Dust Clouds

Two observers are looking at the same dust cloud through stars in space but are at different distances from the cloud.



In the boxes below sketch their views of the dust cloud and stars. Explain any difference between the observations of the two observers.



Are the stars about evenly spaced between the cloud and the observers?

How are the number of stars in between the observer and dust cloud related to distance? Explain.

We can use the number of stars in front of a given dust cloud to determine how far away that cloud is. The more stars in front of the cloud, the more distant it must be. Dust clouds absorb light from stars behind them; any star you see in front of them in the photo are really in front of them.

On the photograph, overlay the card with the 0.5 cm x 0.5 cm square cut out of it onto dust clouds K, L, and M. Using the magnifying glass, count and record the number of stars in each square. This square represents one square degree of sky.

After you have counted the stars, rank the clouds in terms of their relative distances (1-furthest ... 3-closest).

Dust Cloud	Number of Stars (N)	Rank by Relative Distance	Calculated Distance (d), pc
K			
L			
M			

Determining the distances to objects in space is the most difficult problem in astronomy. This is only one of many varied techniques for doing so.

In this region of the sky, we know approximately how many stars there are per cubic parsecs. The distance, d, can be estimated by:

$$d \quad ' \quad \sqrt{5800N}$$

Calculate the distance in parsecs to the three clouds and record in the table above.

In the lower right-hand corner of Plate 2 Red, there is a large cloud that looks like a butterfly. Sketch the cloud and explain the difference in the dark and bright areas.

This is an emission cloud with a dust lane dividing it in half. Are they both at the same distance or vastly separated but in a straight line to the observer? Justify your choice.