Prelab for Bright Sky/Dark Sky

1. What is light pollution?

BRIGHT SKY/DARK SKY LAB

What will you learn in this Lab?

This Lab consists of two parts to investigate the effects of light pollution or bright skies. This week you will make the best observations you can from the bright conditions on the ASU campus to see just how faint you can see. For the second part, you will conduct similar observations from your home to determine which is the darker site.

What do I need to bring to the Class with me to do this Lab?

For this lab you will need:

- A copy of this lab script
- A pencil
- A calculator
- Your flashlight
- Your star charts
- Your planisphere

I. Introduction:

You have no doubt noticed that the sky viewed from the ASU campus looks different from the sky viewed from somewhere out in the countryside. This is due to the effects of *light pollution* from artificial sources that brighten the sky. The sources contributing to light pollution are estimated to be roughly one-third street lights and one-third lighting for advertising and sports, with the other third coming from other sources, including private lighting. Here on the ASU campus, we are particularly affected by the lights on the athletic fields, which shine brightly over a large portion of campus. Because of the current levels of light pollution in metropolitan areas and the increasing shift of population from rural to urban areas, many people have never seen a truly dark sky.

In the Phoenix area, the level of light pollution is such that the city lights can easily be seen 80–100 miles from the city! This means that roughly 30% (by area) of the state of Arizona is affected by the Phoenix lights. In addition, almost 60% of the population of Arizona lives in the Phoenix metro area and therefore does not have easy access to totally dark skies.

In this lab, you will make some quantitative measurements of the brightness of the sky in order to estimate how the amount of light pollution varies from place to place.

A Note on Night Vision:

One of the goals of this lab is to try to see as many stars as possible from a given site. As discussed above, one constraint that limits the number of stars you can see is the amount of light pollution. However, even with a given amount of light pollution, there are things you can do to maximize the quality and depth of your observing. The most important of these is achieving and preserving good dark adaptation of your eyes.

Your eye has several responses to different levels and colors of light. The most obvious of these is the fact that your pupil expands to let more light in when you are in a dark place. While this helps you see better in the dark, it is *not* the dominant contributor to good night vision. Your pupil changes size relatively rapidly (in less than a minute), but your night vision will continue to improve up to half an hour (and perhaps even longer) after you go to a dark location. The reason is that your night vision is governed by a series of chemical reactions in your eye that alter its sensitivity to light. These reactions work along with the diameter of your pupil to let your eye function well under a large range of light levels. The reactions are much slower than the response of your pupil to light levels, and so your night vision changes correspondingly slowly. Thus some patience is required in attaining good night vision. While you are waiting for your eyes to adapt to the darkness, just enjoy looking at the sky without worrying about making any measurements for your lab!

Once your eyes have become fully accustomed to the dark, the most important thing to do to preserve your night vision is to avoid looking at any bright light. Not all lights are created equal in this respect, however. At night, your eyes are most sensitive to blue and green light, and the chemical reactions are most strongly affected by these colors of light. One glance at a blue or green light can ruin the good night vision you have waited patiently to achieve! (This includes fluorescent lights, which have a fair amount of blue in them.) In contrast, red light has relatively little effect on your night vision, which is why we use red flashlights in this lab.

Another technique that can maximize how much you can see in the night sky is *averted vision*. Because of the positioning of the rods (light-sensitive cells that detect contrast) in your eyes, your peripheral vision (things seen out of the corner of your eye) is more sensitive to faint objects than your direct vision. Thus, you may be able to see fainter objects if you turn your head slightly and do not look directly at whatever you are viewing.

II. Observational Procedure:

The sets of observations in the Bright Sky/Dark Sky lab are designed to give you enough evidence for you to make some assessment of how light pollution and bright skies affect observational astronomy. We're not looking for the obvious statement here – we're looking for a more definitive treatment. We will be looking for you to come up with your own hypothesis about the issues and maybe suggest what can be done about it.

A. Bright-sky observing of Stars

A good tool to use is assessing how bright the night sky is to determine how many stars can you see in the sky. One way to determine this would be simply to count all of the stars in the sky. This could be difficult, though, particularly from somewhere with a dark sky. It's not as much of a problem from the ASU campus, but still could be tedious.

The problem is similar to determining the total number of students in class on the ASU campus at a given time. One way to find this out would be to go to every classroom and count the number of students there. Another, more practical way to do it would be to count the number of students in one classroom, and then multiply that number of students by the total number of classrooms in use. The second method is less accurate, but much easier. Not only is it easier, but also it allows us to make a working estimate of something we might not otherwise be able to count at all because of the sheer time involved.

Similarly, instead of trying to count every star, we could estimate the total number of stars visible by counting the stars visible in one "box" or area on the sky, and then multiplying by the number of boxes of that size it would take to fill the whole sky.

- How accurate do you think this method might be? Why? How could it be done better to minimize these problems?

As an example of what you could do, imagine a parallelogram in the sky whose corners are made up of the bright stars Sirius, Betelgeuse, Aldebaran, and Rigel (Figure 1). This is a "box" in the sky that you could use to count stars. **Make certain that whatever stars you choose will be visible for both your sketches from campus and from home.**

FYI the area inside this "box" covers about 1/50 of the area of the sky that is visible at one time. Make a visual estimate of the stars in this box first – and use the extrapolation technique to project the total number of stars in the sky. Make some estimate of your uncertainty by comparing your numbers with those obtained for a given region of sky by other groups of students.

- What is your estimate of the total number of stars in the sky based on this extrapolation method? Estimate the uncertainty as well.

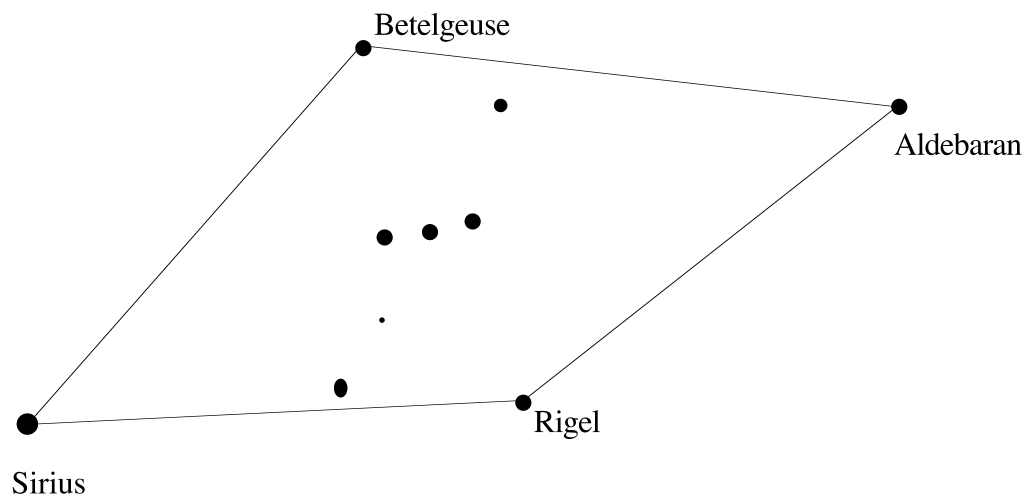

Figure 1. An example "box" for star counting

Next, subdivide the entire night sky into boxes similar to this one. **Make a visual estimate of the total star count in each box and total them up for the entire sky**. Take your time and count as carefully as possible. Hint: use your starwheel to divide up the sky and keep a record of where the boxes start and end. Also smaller boxes make it easier to count stars – smaller numbers!

- What is your estimate of the total number of stars in the sky based on this method?

- Is this answer different than that you estimated from the extrapolation method?

- Which method do you think is more accurate?

Another way to estimate the brightness of the sky as seen from a given location is to determine the magnitude of the faintest star that can be seen. Figure 2 shows a diagram of the Little Dipper with the magnitudes of many of the stars labeled. Using this diagram, estimate the faintest star you can see and write down the magnitude of that star. To help you, make a sketch of all the stars in this constellation you can see – and compare it to Figure 2.

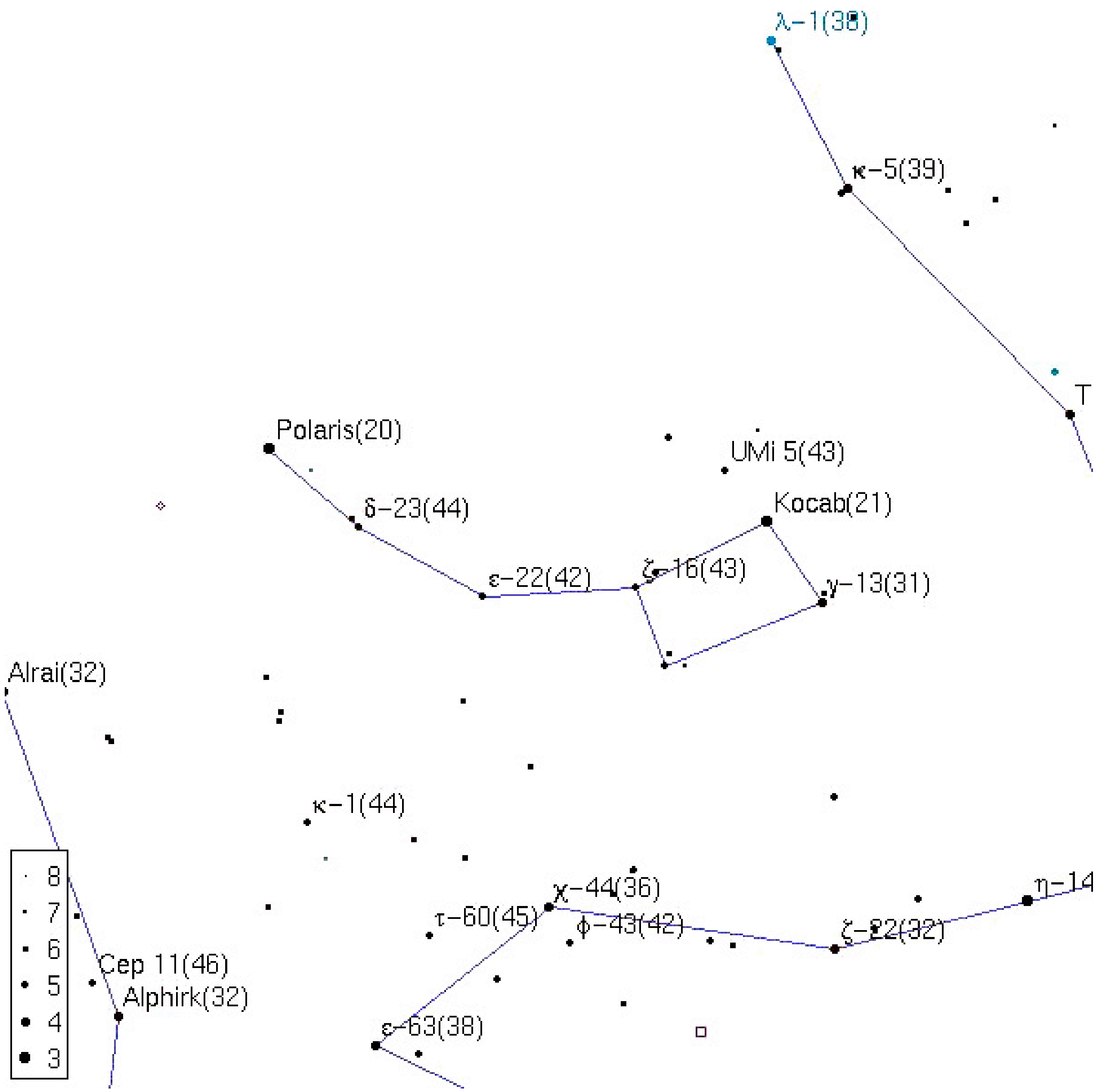

Figure 2. The Little Dipper, with the magnitude of each star labeled next to it (eg. 21 = magnitude 2.1).

- What was the magnitude of the faintest star that you could see in the Little Dipper?

- What was the magnitude of the faintest star that you could see in your parallelogram that you made for the extrapolation method used above? (Consult your sky charts for magnitude information.)

- Were these magnitudes the same or different? Why or why not?

- What is the phase of the Moon tonight? How might this affect your observations?

B. Bright-sky observing of Clusters and Nebulae

Your TA may have you observe star clusters and nebulae and answer additional questions of his/her choosing. You may attach the answers to the questions on a separate piece of paper.

C. Additional observations conducted at home – these questions must be addressed in the lab report that is due next week.

1. Recall that you counted the number of stars that you can see in your chosen parallelogram from the naked eye from campus. Do the same at home. Which site, home or campus, has a darker sky?

2. By comparing to the magnitude scale on your sky charts, determine the magnitude of the faintest star in the Little Dipper that you can see with the naked eye from home. Compare to your answer for campus. Which is the darker site – campus or your home?

3. By referring to the magnitude scale on your sky charts, compare the magnitude of the faintest star that you can see in your parallelogram during the campus portion of the lab to that of the faintest star you could see at home.

4. Name the general location of your home (Tempe, Gilbert, Paradise Valley, etc…). From your home, in which direction (N, S, SW, etc…) is the sky brightest? Darkest?

5. What is the phase of the Moon tonight (home observations)? How might this affect your comparison to your observations from campus?

6. Based on what you have done in these two labs, can you say how big of an impact domestic lighting has on optical astronomy? What would be the best way to fix this? Is it important enough to make such changes? We want to see what your honest opinions are in this matter. (This question will be considered the “Conclusion” for this lab report.)

References

City Astronomy, by Robin Scagell (Cambridge: Sky Publishing), 1994)

The International Dark-Sky Association.

IDA's goals are to be effective in stopping the adverse environmental impact on dark skies by building awareness of the issue of light pollution and of the solutions and in educating about the value and effectiveness of quality nighttime lighting. A united approach should be very supportive of the many local and individual efforts. Much has been accomplished in some locations, but much more needs to be done everywhere. We believe that we can succeed in preserving dark skies and in improving the nighttime environment for everyone. Quality outdoor lighting is the key. More information is available on the World Wide Web at http://www.darksky.org/ida/