Lab 4 – Light Pollution & Seeing

ASTR 1010

Name: _____

Overview:

In this activity, you will explore what light pollution is, how it effects the perceived brightness of astronomical objects, and what we can do to help mitigate it.

Objectives:

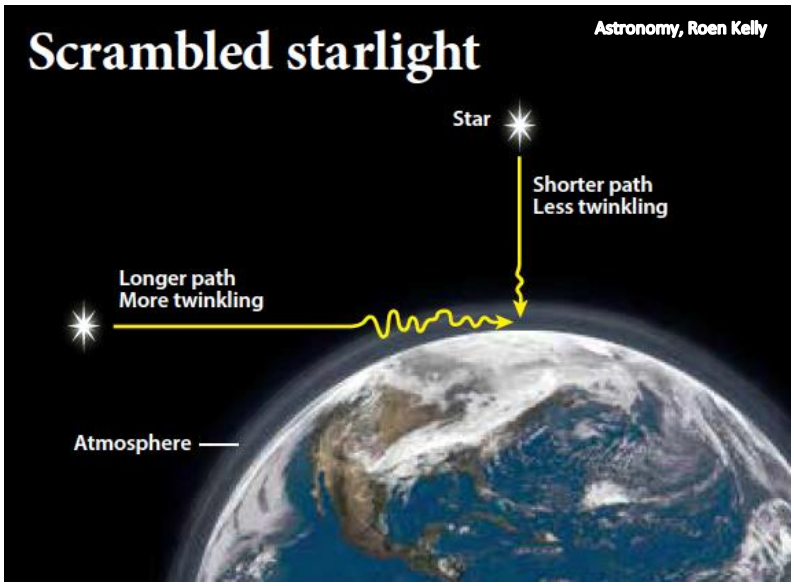
After completing this activity, students will be able to:

- Describe what light pollution is
- Investigate what areas of the United States have more/ less light pollution
- List ways people can mitigate light pollution

Definitions

Here are some terms from lecture that we will be using today in lab:

- **Light pollution** – the brightening of the night sky by human-made sources.
- **Scintillation** – disruption of light's path due to turbulence in the higher reaches of the atmosphere (AKA "twinkling" of stars).
- **Telescope** – an optical instrument containing an arrangement of lenses, or of curved mirrors and lenses designed to make distant objects appear nearer.
- **Seeing** – the amount of apparent blurring and twinkling of observed objects due to turbulence in the atmosphere



- **Apparent Magnitude** – How bright an object appears to be from a viewer observing from Earth.
- **Absolute Magnitude** – How bright an object appears to be from 10 parsecs away (1 parsec is equal to approximately 3.2 light years, or 19 trillion miles.
- **Dark Sky Park** – publicly or privately-owned spaces protected for natural conservation that implement good outdoor lighting and provide dark sky programs for visitor.

Part 1: What is Light Pollution?

In this section you will perform an experiment to understand what light pollution is. This part of experiment will need to be performed in a dark room or during the night.

a. Take a flashlight (the one on your phone will work just fine), turn it on, and prop it up so you can see the bulb from across the room.
b. Take a sheet of paper and poke a hole in it with a pencil or pen.
c. Set this sheet of paper in front of your flashlight so the hole lines up with the bulb of the flashlight.
d. Turn the lights in the room on.
e. Stand across the room from your setup. Take note of how bright the light coming through the hole appears to be.
f. Turn the lights in the room off and repeat step e. Again, take note of how bright the light appears to be.

1. Did the light appear to be brighter with the lights in the room on or off? Why do you think this is?

2. Is this difference in brightness the apparent OR absolute magnitude of the flashlight?

The presence of lights such as those in the room interfere with your ability to see small points of light. This is what light pollution is: lights from human life and civilization interfere with our ability to see points of light, such as astronomical objects.

In this figure of Orion, the left panel is an example of the sky viewed not far outside of a large city. The right panel is the same portion of the sky viewed from the middle of nowhere. The further you are from cities or towns the better the sky will look.

Sustaining Out World/ Light Pollution

3. Have you personally ever seen the sky as vibrantly as depicted in the right panel of the previous figure? If yes, where?

Astronomers are not the only ones that enjoy looking at the stars. The International Dark Sky Association (IDA) has recognized the need for public places where people are free to spend the night and see the true beauty of the sky and has designated a plethora of locations as Dark Sky Parks. The land can be publicly or privately owned, and new locations for a Dark Sky Park can be proposed via their website. Go to the IDA website to see where they have recognized parks:

https://www.darksky.org/our-work/conservation/idsp/finder/

4. Which Dark Sky Park is closest to you?

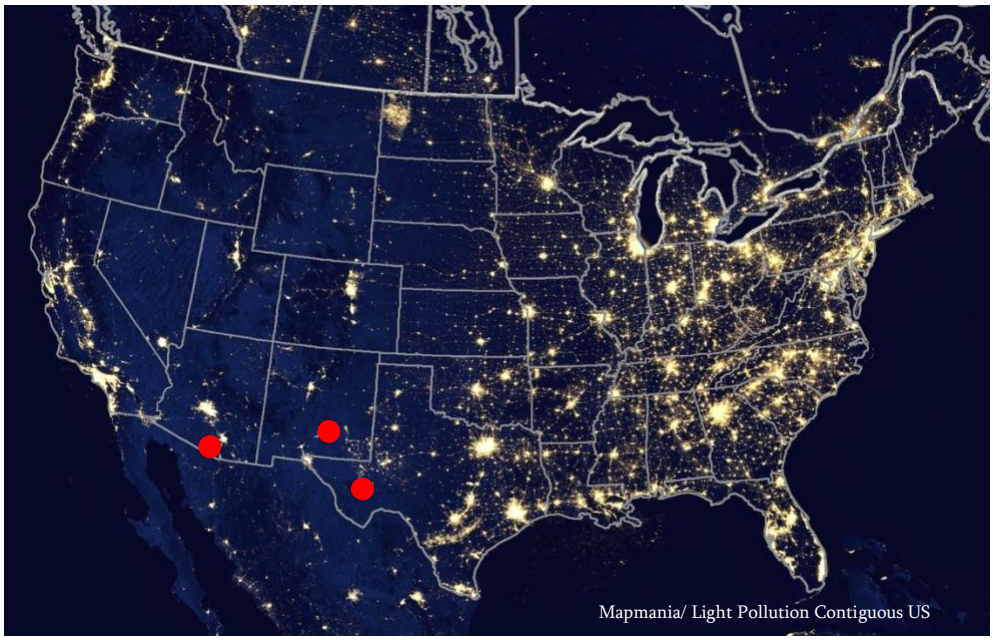
Part 2: How does light pollution affect astronomers?

Astronomers need to minimize light pollution, so they have to be particular about where they build telescopes. Using Google (or a search engine of your choosing) search for the three telescopes listed and complete Table 1.

Table 1. Telescope Locations

Telescope	Observatory	Location of Observatory
ARC 3.5m Telescope		
Hobby–Eberly Telescope		
Mayall 4-meter Telescope		

Below is a map of light pollution in the United States. Bright spots of light are large cities or areas where light pollution is severe. Observatories from Table 1 are marked with red circles.



Using the observatory locations and the light pollution map on the previous page to answer the next few questions:

5. Why do you think these telescopes located where they are?

6. All of these observatories share one common feature in their building locations (Hint. They are all built on the tops of the same kind of thing). What is it and why would this be a benefit?

7. Using the light pollution map and the building hint from Question 6, where in the US would you go to if you wanted to build a telescope?

Part 3: Ways we can Reduce Light Pollution

In order to avoid light pollution, observatories have to observe as far away from cities as possible. However, this creates additional complications.

8. What might be some difficulties when observatories are built hundreds of miles from the nearest city?

9. What in cities cause the light pollution that requires the observatories be built so far away?

For the disadvantages you listed in Question 8 and to the fact that there are not many dark observing spots left in the US due to the ever expanding and growing human population, some telescopes are constructed relatively close to cities (ex. Kitt Peak National Observatory is only an hour drive from Tucson). As a result, compromises between astronomers and cities can be made to keep everyone happy. One example is the type of streetlights used in a city near an observatory.

The figure below illustrates why different streetlamp designs are worse or better for light pollution. If the light is contained to pointing straight down at the street (labeled 'BEST' in the picture) not only saves energy and better illuminates what people want to see, but the light does not travel straight up into the sky. This helps minimize light pollution and is a good compromise for cities with observatory neighbors.

10. Go outside and take a look at a streetlight near your house. Which of these designs does your city use?

11. Would where you live be a good place to build an observatory?

Part 4: Seeing

In addition to light pollution, astronomers also have to take 'seeing' into consideration. **Seeing describes the amount of apparent blurring and twinkling of observed objects due to turbulence in the atmosphere.** Seeing is measured as a value increasing from 0 to infinity. The lower the value, the better the seeing.

Have a look at these two images of Jupiter taken about a week apart. The seeing is way worse in the image from December 11 than it is in the image from December 6.

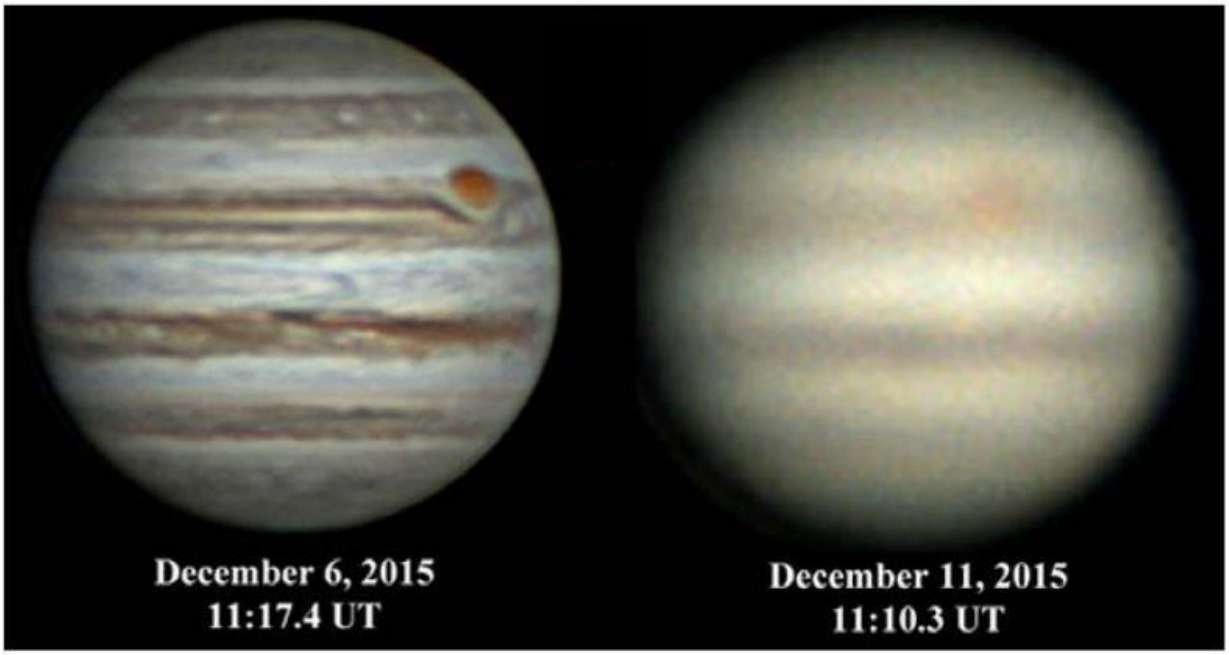


Figure 2. Jupiter, captured with the same equipment in good (left) and bad (right) seeing conditions. ***Cliff Ashcraft, New Jersey, USA*** British Astronomical Association

12. What phenomena influence the seeing of an object? (Hint: Think of what we are looking through when we observe from the ground.)

13. We know that atmospheric turbulence influences seeing. What is atmospheric turbulence and what causes it?

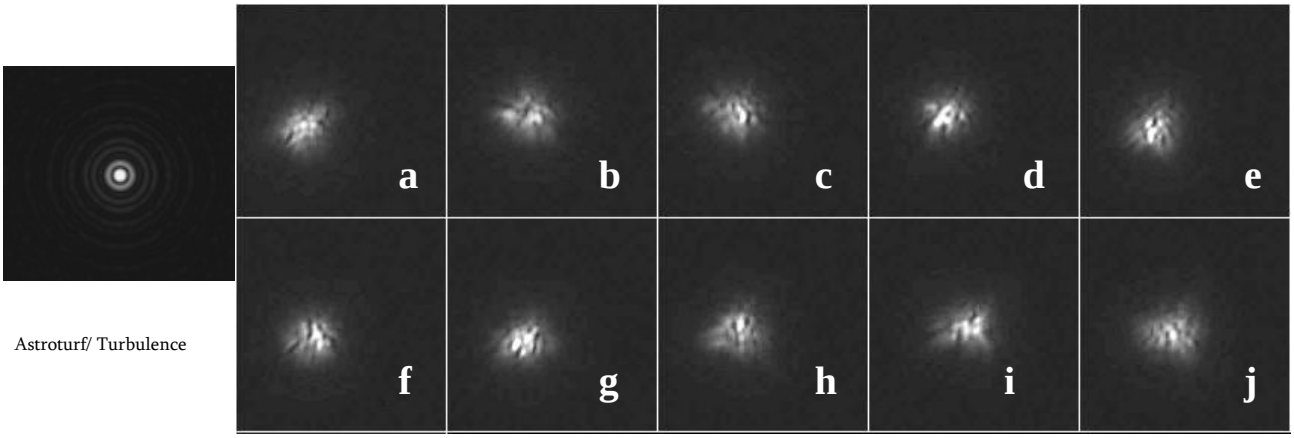
14. How would turbulence effect how we see an object in space? Hint: Think of what happens to a plane as it flies through a turbulent air pocket.

15. How would turbulence effect objects that are significantly closer to us than stars other than our sun are?

16. Which would be more greatly affected by atmospheric turbulence: a star, or a planet? Why is this?

17. Why do stars twinkle and planets do not?

For the last hurrah of this activity, let's move outside the Solar System. Below is an example of how seeing effects a point source like a star. On the left is an image of the star if all of the atmospheric distortion was removed. On the right is a montage of images of the same star with different seeing values.



Astroturf/ Turbulence

Using a ruler (a IRL one or an online one - www.piliapp.com/actual-size/cm-ruler/) measure the width of the images in **CENTIMETERS**! Your lab instructor will show you how to use the online ruler in the lab video! Record your width measurements in Table 2.

Table 2. Seeing Values

Image	Width (cm)
a	
b	
c	
d	
e	
f	
g	
h	
i	
j	

18. Which of these panels has the best seeing and which has the worst seeing? (Hint: Earlier in this section we established if a low value for seeing is good or bad.)

To complete this assignment for grading:

- File → Save As… → Rename the file 'YourLastName – LightPollLab'
- Upload to the file to the 'Lab 4 – Light Pollution assignment in iCollege (click Add Attachments → Upload → upload renamed saved file Update).
- Complete the Reflection activity on iCollege
- Consider if you would like to go to a dark sky location in the Southern Hemisphere or Northern Hemisphere!