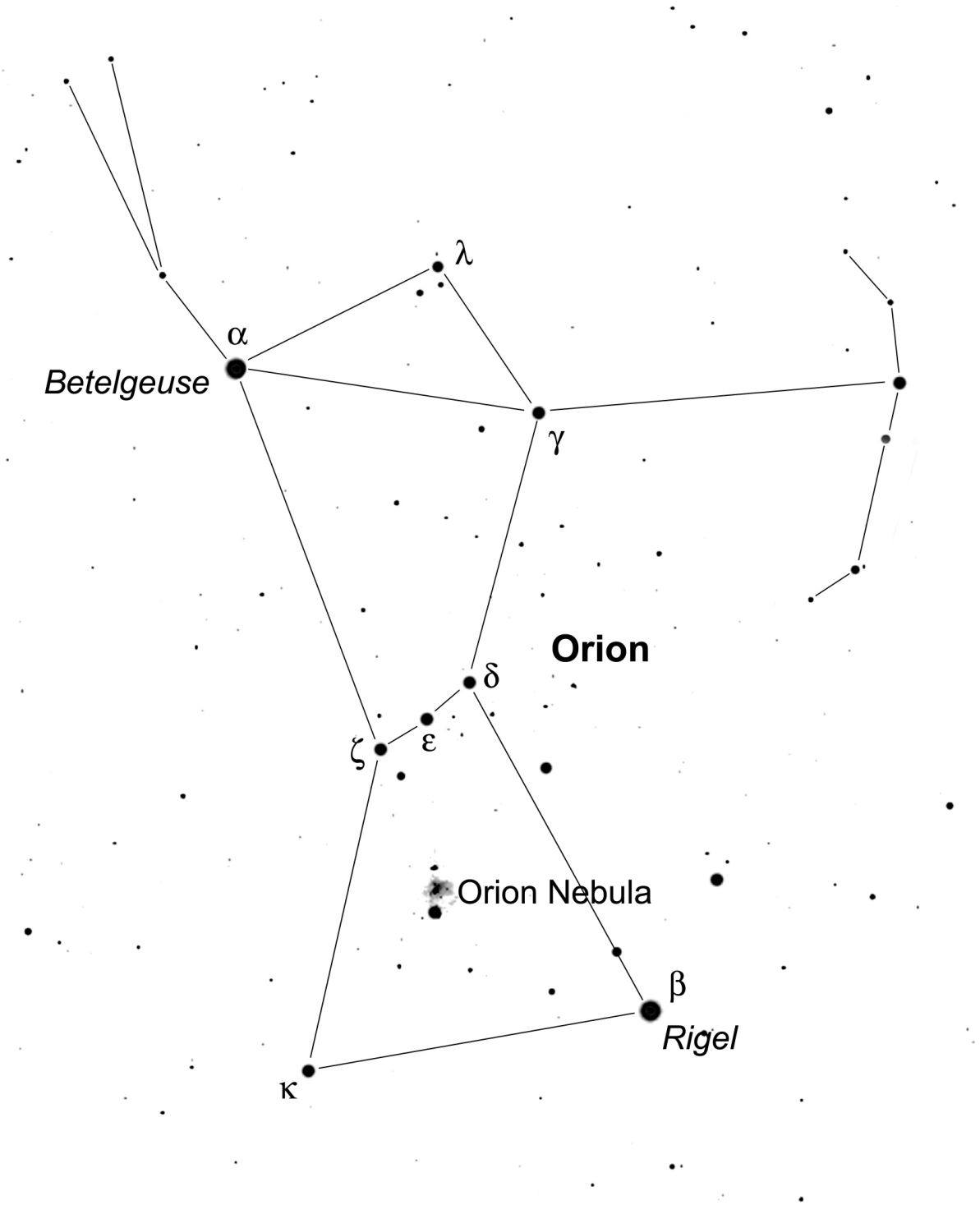
ASTROEDU

Peer-reviewed Astronomy Education Activities

How Light Pollution Affects the Stars: Magnitude Readers

Build a Magnitude Reader to explore the magnitude of stars.

Amee Hennig, Globe at Night


λ
α
Betelgeuse
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Orion
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Orion Nebula
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AGE

10 - 19

LEVEL

Middle School, Secondary

TIME

1h

GROUP

Group

SUPERVISED

No

COST PER STUDENT

Medium Cost

LOCATION

Outdoors

CONTENT AREA FOCUS

Astronomy, Earth Science

ASTRONOMY CATEGORIES

Astronomical instrumentation, Stars

EARTH SCIENCE KEYWORDS

Atmospheric Sciences

CORE SKILLS

Asking questions, Planning and carrying out investigations

TYPE(S) OF LEARNING ACTIVITY

Modelling, Observation based

KEYWORDS

Light pollution, Dark skies, Stars, Magnitude

GOALS

To learn how light pollution affects the visibility of stars by making measurements and calculations.

LEARNING OBJECTIVES

- Employ simple equipment and tools to gather data and extend the senses.
- Use data to construct a reasonable explanation on light pollution.

- To describe how light pollution affects the visibility of stars.
- Apply scientific inquiry skills, ability and attitudes associated with science.
- Estimate the impact of light pollution in particular location.

EVALUATION

Place the limiting magnitude and number of stars lost on a map of your town at the location where the students took their measurements. Discuss the results and following questions with the students:

- What do you think the result would be (e.g., how many stars are lost) if you took a measurement closer to the nearest town or city?
- How about farther away?
- Are the outdoor lights bright or dim?
- Are they as bright as a full Moon?
- How many are they?
- How far away are they?
- How did each star compare to the other students' data in the context of their lighting situations (e.g., at different locations)?
- In situations with brighter light, were the same stars dimmer or brighter?
- How accurate is this data?
- What is the impact of light pollution? How can we reduce its impact?

MATERIALS

- Inkjet transparencies (1 transparency for 3 magnitude readers)
- Scissors (1 per student or they can share)
- Index cards (1 per student)
- Scotch tape
- A coin (optional) (1 per student)
- Templates for transparencies (1 template printout makes 3 templates)

BACKGROUND INFORMATION

Light pollution:

Light pollution is stray light emitted from poorly designed and aimed lighting installations. This happens mostly around urban centres, where city lights diminish the view of stars and planets. A satellite view at night shows light pollution as glowing regions around urban areas.

Magnitude:

Magnitude is the logarithmic measure of the brightness of an object, in astronomy, measured in a specific wavelength or passband, usually in optical or near-infrared wavelengths. The sun has an apparent magnitude of -27, a full moon -13 and the brightest planet Venus measures -5. The brightest man-made objects, Iridium flares are ranked at -9 and the International Space Station -6.

FULL ACTIVITY DESCRIPTION

Preparation:

Before making the Magnitude Reader in class, overlay the transparency on the printout of the template. Notice that the template printout repeats a pattern of rectangles labelled 1 through 5 three times. Cut the template printout and transparency into thirds, preserving that pattern of rectangles. Make as many templates as there are students.

Choose the constellation you will be viewing as part of the activity, and find a picture of it (as with Orion in this activity). Print out 1 constellation picture per student. (During the winter months in the Northern Hemisphere and the summer months in the Southern Hemisphere, Orion is an easily recognizable constellation in the early evening).

Before students estimate the magnitudes of the stars, you may want to have a star party to teach students how to find the constellation and how to use their magnitude readers to estimate stellar magnitudes in the chosen constellation.

Making the Magnitude Reader:

Step 1

Have the students cut out the 5 rectangles (attachment 1) which labelled as 1 through 5 with each transparency still overlaid on top of each template. From this point on, the students do the following.

Step 2

Use a coin to trace and cut out 5 circles on the index card or, instead, slightly bend the card lengthwise in half and cut 5 ‘V’s to create 5 diamond shaped cut-outs. Make sure that the cut-out holes are all slightly spaced in a row across the widest portion of the index card.

Step 3

Label the 5 cut-out holes #1 through 5 from left to right across the index card as shown in the picture below.
Tape transparency piece #1 across hole #1, making sure that the transparency piece covers that hole. In all these steps, when you tape the transparency piece to the index card, the tape should not cover the holes. It does not matter if the rough side of the transparency is face up or down.

Step 4

Tape transparency piece #2 across holes #1-2, making sure that the transparency piece covers those holes.

Step 5

Tape transparency piece #3 across the holes #1-3, making sure that the transparency piece covers those holes.

Step 6

Tape transparency piece #4 across holes #1-4, making sure that the transparency piece covers those holes.

Step 7

Tape transparency piece #5 across the length of the index card.

Step 8

The 1st hole should have 5 layers of transparency and the 5th hole should have only 1 layer of transparency.

Estimating the Magnitudes of the Stars:

During winter months in the Northern Hemisphere and the summer months in the Southern Hemisphere, the constellation Orion is visible in the first half of the evening. You can choose to use the drawing of Orion (attachment 1) or that of another constellation that is up in the evening at another time of year. Have the students go out on a moonless, cloudless night in their backyard for a few minutes with the drawing of the constellation and a pencil in hand, and ask them to find the constellation in the night sky. Backyard lights should be off. The students should allow at least 5 minutes outside for their eyes to adapt to the dark.

The students view each star in the constellation through the Magnitude Reader. For each star in the drawing of the constellation, the students write down the smallest number of the hole through which they can see the star. This is an estimate of the magnitude or brightness of the star. For instance, a star that has a magnitude of 3 will be seen through holes #3, 4 and 5. But the student will record only hole #3.

Note that the students will not be able to see some of the stars on the drawing because of light pollution. Once they have recorded the magnitude for all the stars shown on the drawing of Orion, the highest magnitude (highest number that they record) will be the limiting magnitude (the faintest star) overall that can be seen in the Orion. The students should also record the lighting situation where their data are recorded.
Have the students bring their results to class. As a class, compare the results. Remember that the lower the magnitudes are, the brighter the stars; the higher the magnitudes are, the dimmer or fainter stars. The students can then estimate how many stars they have lost (e.g., they are unable to see) across their whole sky because of light pollution in their location.

Extension: Estimating How Many Stars are Lost

(Based on ‘Calculating Stars Lost’ by Fred Schaaf in Seeing the Sky, John Wiley & Sons, 1990)
In order to complete this activity you will need to determine your local limiting magnitude using your results from the ‘Estimating the Magnitudes of the Stars’ activity described above.

By now you know that the number of stars visible is affected by the quality of the night sky. The Moon, atmospheric conditions, and light pollution can make it hard or impossible to see the fainter stars. You have also probably discovered that astronomers use the magnitude scale to measure the brightness of stars. Remember that magnitude 1 stars are brighter than magnitude 2 stars, which are bright than magnitude 3 stars, and so on.

Through the ‘Estimating the Magnitudes of Stars’ activity, you have learned to measure the limiting magnitude of your night sky, that is, what are the dimmest stars that can be seen. Under perfect conditions—no Moon, clear skies, and without any interference from any lights—the human eye can see stars down to about 6th or 7th magnitude. According to the table below, a limiting magnitude of 7 is about 14,000 stars!
Now you are ready to calculate how many stars you are missing at your location. All you have to do is subtract the approximate number of stars visible from your location from 14,000. For example, if you measured your limiting magnitude to be 3, you can see about 150 stars with the naked eye, but you are missing around 13,850 stars (14,000-150 = 13,850)!

CURRICULUM

Country | Level | Subject | Exam Board | Section
— | — | — | —
UK | GCSE | Physics | AQA Science A | P1.4.1f
UK | GCSE | Physics | Edexcel | P1.1.4
UK | GCSE | Physics | OCR A | P1.1.13
UK | GCSE | Physics | OCR B | Not in current curriculum
UK | GCSE | Physics | WJEC | Not in current curriculum
UK | GCSE | Astrophysics | Edexcel | Unit 1: P1.1d, Unit 2: Observation A7
UK | A level | Physics | AQA | 3.9.1
UK | A level | Physics | Edexcel | Not in current curriculum
UK | A level | Physics | OCR A | Not in current curriculum
UK | A level | Physics | OCR B | Not in current curriculum
UK | A level | Physics | WJEC | Unit 1 6d)
UK | KS3 | Physics | - | Space Physics: Other Stars in Our Galaxy
UK | KS2: Year 5 | Science | - | Earth and Space

ADDITIONAL INFORMATION

- What is Light Pollution: http://www.globeatnight.org/learn_light.html

- Light Pollution Interactive Game: http://www.globeatnight.org/learn_orionsky.html
- Stellar Magnitude System: http://www.skyandtelescope.com/howto/basics/Stellar_Magnitude_System.html
- The astronomical magnitude scale: http://www.icq.eps.harvard.edu/MagScale.html

CONCLUSION

The results of the activity should be discussed along with the questions from the Evaluation section. Light pollution, its impacts, and how it can be mitigated should also be discussed.

ATTACHMENTS

- Attachment 1
- Attachment 2

ALL ATTACHMENTS

All attachments

CITATION

Hennig, A., 2014, *How Light Pollution Affects the Stars: Magnitude Readers*, astroEDU, , doi:10.14586/astroedu.1402

ACKNOWLEDGEMENT

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