Luminosity – Energy Output of the Star

Evolution of Stars. Activity 5

Classroom Activity

Overview

Age Range:

14 – 17 years

Prep. Time:

Zero, if Activity 2 is done before

Lesson Time:

35 min

Cost per activity:

Printing of student's worksheets

Includes the use of:

Computer for each group of students

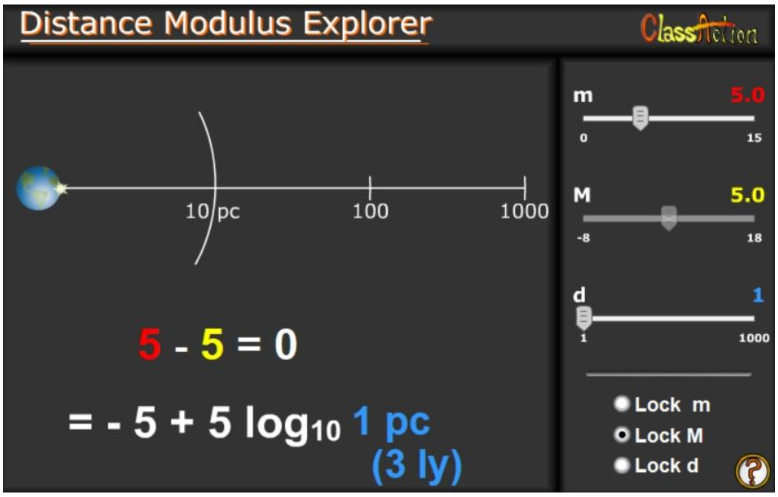
Outline

By using a presentation and a computer animation students will explore the connection between the apparent brightness, absolute brightness and the distance of stars to understand the different luminosity classes of stars.

Pupils will Learn:

- That apparent brightness of the star depends of the distance to the star and the energy output of the star (its luminosity).
- That absolute brightness is the measure of the luminosity of the star.
- That stars are divided in seven luminosity classes: hypergiants, supergiants, bright giants, giants, subgiants, main sequence dwarfs, subdwarfs, white dwarfs.

The online observatory collaboration consists of the following partners:
Baldone Observatory, Brorfelde Observatory, Cardiff University, Harestua Solar Observatory, Helsinki Observatory



Screenshot of the animation used for this activity

Lesson Plan:

Description	Time	Notes
Before the lesson: if the Activity 2 was not done before	15 min	Go to the download's page at http://astro.unl.edu/downloads to get the free *ClassAction* software. The software is courtesy of the Astronomy Education at the University of Nebraska-Lincoln Web Site (http://astro.unl.edu). Download and run the appropriate files for your system and follow the prompts to install the software on the teacher and students computers.
Pre-activity step	2 min	Divide students in groups
Introduction to the subject	3 min	Dialogue with the students
Activity 1	10 min	Students watch the *Powerpoint* presentation *Luminosity*, discuss the answers with the teacher and fill the worksheet.
Assessment	5 min	Students answer the questions.
Activity 2	10 min	Students work with the *ClassAction* animation *Stellar Properties/Distance Modulus Explorer* and fill the worksheet.
Assessment	5 min	Students answer the questions.

Introduction to the subject:

The purpose of this lesson is to introduce students to the classification of stars by their luminosity. Luminosity of stars (their real energy output) is very different and does not correspond directly to their apparent brightness because we must take into account the distances to the stars as well.

Activity 1:

Students watch the *Powerpoint* presentation *Luminosity*. Teacher explains that we can observe the apparent brightness of the star. It is measured by apparent magnitude. **Apparent magnitude** (^{m}) is a measure of the brightness of a star or other astronomical object observed from the Earth. The magnitude scale is reverse, the brighter an object is, the lower its magnitude. For example, a star of magnitude 1^m is brighter than a star of magnitude 2^m. The brightest stars have apparent magnitudes of about 0^m. The faintest stars visible with the naked eye have apparent magnitudes of about $+6^m$.

By knowing the apparent magnitude alone it is not possible to determinate the luminosity of the star (real energy output) because the distances to the stars are different. Nearby star Sirius (distance 9 light years) looks brighter than the far away star Deneb (distance 2600 light years). **Luminosity** is the total amount of electromagnetic energy emitted per unit of time by a star, galaxy, or other astronomical object. Luminosity is measured in watts. In astronomy, values for luminosity are often given in the terms of the luminosity of the Sun, solar units. Luminosity of the Sun is $3{,}8\times10^{26}$ W.

Astronomers use also the **absolute magnitude** to measure the intrinsic luminosity of a celestial object rather than its apparent brightness. Absolute magnitude is expressed on the same reverse scale. Absolute magnitude is defined as the apparent magnitude that a star or object would have if it were observed from a distance of 10 parsecs. The parsec (pc) is a unit of length used to measure the large distances to astronomical objects outside the Solar System. One parsec is approximately equal to 31 trillion kilometres.

Students write down the definitions of the apparent magnitude, absolute magnitude and the luminosity at the worksheet. At the end of the presentation teacher shows the picture of stars of different luminosity and explains that stars are divided in different luminosity classes: 0 (**hypergiants**), I (**supergiants**), II (**bright giants**), III (**giants**), IV (**subgiants**) and V (**main sequence dwarfs**). Sometimes classes VI (**subdwarfs**) and VII (**white dwarfs**) are used as well. Hypergiants have the highest luminosity, white dwarfs – the lowest. On the picture students show which star they think belong to which luminosity class. Students write down the luminosity classes.

Assessment:

Questions for students:

1. Why is not possible to determinate the luminosity of the star from its apparent magnitude alone? Because the distance is not known.

2. Spectral designation of the Sun is G5V. To which luminosity class it belongs? Main sequence dwarfs.

3. Deneb is a white supergiant of spectral class A2. What is the spectral designation of the star? Use the Roman numeral of luminosity class! A2I.

Activity 2:

Students work with the *ClassAction* animation *Stellar Properties/Distance Modulus Explorer*. Note that one of the rulers is always locked. If the students want to input data, corresponding ruler must be unlocked.

Students input the distance and the absolute magnitude of the star from the table and read the apparent magnitude from the animation. Students fill the worksheet table and discuss the results with the teacher. Expected results are shown in red.

Table. Examples of different stellar luminosity classes

Luminosity Class	**Example**	**Luminosity, solar units**	**Absolute magnitude, ^{m}**	**Distance, pc**	**Apparent magnitude, ^{m}**
0; hypergiant	Rho Cassiopeiae	500 000	–8	1000	2,0
I; supergiant	Gamma Cygni	33 000	–5,5	350	2,2
II; bright giant	Theta Scorpii	1800	–2,7	90	2,1
III; giant	Arcturus	170	–0,3	11	–0,1
IV; subgiant	Procyon	7	+2,7	3	0,1
V; main sequence dwarf	Tau Ceti	0,5	+5,7	4	3,7

Assessment:

Questions for students:

1. Are the stars mentioned in the table visible by the naked eye? Yes.

2. Gamma Cygni and Theta Scorpii have almost the same apparent magnitude. How many times the distance to Gamma Cygni is larger and luminosity higher? Distance about 4 times, luminosity about 18 times.

3. Procyon is a very bright star. Does its luminosity is high as well? No, it is only 7 solar units.

Further Activities:

You may continue with the *Evolution of Stars*. *Activity 6*.

Background Material/Knowledge:

What is the apparent and absolute magnitude? https://en.wikipedia.org/wiki/Apparent_magnitude

Definition of the luminosity. https://en.wikipedia.org/wiki/Luminosity

Luminosity classes. https://en.wikipedia.org/wiki/Stellar_classification