Temperature–Luminosity Diagram

Evolution of Stars. Activity 6

Classroom Activity

Overview

Age Range:

14 – 17 years

Prep. Time:

Zero, if Activity 2 is done before

Lesson Time:

40 min

Cost per activity:

Printing of student’s worksheets

Includes the use of:

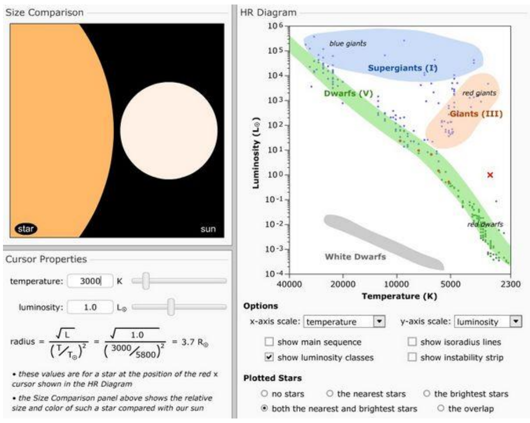
Computer for each group of students

Outline

By using a computer animation students will explore the connection between the temperature and luminosity of stars to understand that stars form specific groups on the diagram corresponding to the stage of their evolution.

Pupils will Learn:

- That stars on the temperature-luminosity diagram are not dispersed randomly, they form specific groups instead.
- These groups correspond to different stages of stellar evolution.



Screenshot of the animation used for this activity

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

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 work with the *ClassAction* animation *Stellar Properties/HR Explorer (NAAP)*, discuss the answers with the teacher and fill the worksheet.
Activity 2	15 min	Students work with the *ClassAction* animation *Stellar Properties/ HR Explorer (NAAP)* and fill the worksheet.
Assessment	10 min	Students answer the questions.

Introduction to the subject:

The purpose of this lesson is to introduce students to the temperature-luminosity diagram of stars, one of most important diagrams in astronomy, also named Hertzsprung-Russell diagram. This diagram helps to distinguish the different stages of stellar evolution.

Activity 1:

Students work with the *ClassAction* animation *Stellar Properties/ HR Explorer (NAAP)*. "show main sequence" and "show isoradius lines" must be switched off.

1. At first students move the red cross around the diagram and watch the changes of star size and colour. They discuss with the teacher where are the large and small stars placed (at the top and bottom of the diagram correspondingly) and where are the blue and orange (so called red stars) placed (at the left part and the right part of the diagram correspondingly).

2. Then they switch on "both the nearest and brightest stars". What pattern can be seen? Stars on the temperature-luminosity diagram are not dispersed at random. Most of them form a diagonal line across the diagram called the **main sequence**. There are stars to the right of the main sequence as well.

3. Now students switch on "show luminosity classes". Some stellar luminosity classes (familiar from the *Evolution of Stars. Activity 5*) appear on the screen. Teacher explains that stars on the diagram are placed according their evolutionary stage. After forming from the

hydrogen and helium clouds stars stay on the main sequence according to their mass (size and luminosity as well). The higher is the mass, the higher is the position on the diagram. This position is defined by the mass of the star and cannot be random.

Stellar parameters (temperature, luminosity) gradually change with time and the star "moves" on the diagram, following specific path. Low mass stars evolve into red giants and then become white dwarfs. High mass stars become supergiants and explode as supernovae. There is no other way. We can say that each star has its own "destiny" prescribed by its mass. This will be explained in details at the *Evolution of Stars. Activity 8*.

Activity 2:

Students continue to work with the *ClassAction* animation *Stellar Properties/ HR Explorer (NAAP)*. They input (write in) the temperature and the luminosity of the stars mentioned in the table, observe their size, colour and the position on the HR diagram, check the calculated radius. Then they fill the two last columns of the worksheet. Expected answers are marked in red.

Table. Stars belonging to different groups

Star	**Temperature, K**	**Luminosity, solar units**	**Radius, solar units**	**Group (colour, luminosity class)**
Rho Cassiopeiae	6500	500 000	560	0; yellow hypergiant
Betelgeuse	3600	120 000	900	I; red supergiant
Gamma Cygni	5800	33 000	180	I; yellow supergiant
Theta Scorpii	7300	1800	27	II; yellow-white bright giant
Arcturus	4300	170	24	III; orange (red) giant
Vega	9600	40	2,3	V; white main sequence star
Sun	5800	1	1	V; yellow main sequence dwarf
Barnard star	3000	0,0004	0,075	V; red main sequence dwarf
Sirius B	25 000	0,03	0,0093	VII; white dwarf

Assessment:

Questions for students:

1. At which part of the diagram stars of high luminosity and big size are placed? At the upper part of the diagram.

2. At which parts of the diagram red (low temperature stars) and blue (high temperature stars) are placed? At right and left parts correspondingly.

3. At which part of the diagram red supergiants, blue supergiants, red main sequence dwarfs and white dwarfs are? Red supergiants are in the upper right corner, blue supergiants are in the upper left corner, red main sequence dwarfs are in the lower right corner and white dwarfs are in the lower left corner.

4. Why the stars cannot be at random places in the temperature-luminosity diagram? Expected answer: their position is determined by the mass of the star and during the evolution they follow specific paths on the diagram.

5. What is the radius of Betelgeuse in kilometres if the radius of the Sun is 700 000 km? Compare the radius of Betelgeuse with the radius of the Jupiter orbit 780 millions of kilometres! Radius of Betelgeuse is 630 millions of kilometres, little less than the radius of the Jupiter orbit. If Betelgeuse would be instead of the Sun, it would spread almost to the orbit of the Jupiter. Earth would be inside the star.

6. What is the radius of Sirius B in kilometres if the radius of the Sun is 700 000 km? Compare the radius of Sirius B with the radius of the Earth 6400 km! Radius of Sirius B is 6510 km, very close to the radius of the Earth. Star has a size of the planet!

7. Name the four main groups of stars on the temperature-luminosity diagram! Supergiants, giants, main sequence stars/dwarfs, white dwarfs.

Further Activities:

You may continue with the *Evolution of Stars*. *Activity 7*.

We suggest the practical activity *Hertzsprung-Russell diagram* where students make a classroom-sized diagram.

Background Material/Knowledge:

Hertzsprung-Russell diagram https://en.wikipedia.org/wiki/Hertzsprung%E2%80%93Russell_diagram