Stages of Stellar Evolution

Evolution of Stars. Activity 8

Classroom Activity

Overview

Age Range:

14 – 17 years

Prep. Time:

5 min

Lesson Time:

45 min

Cost per activity:

Printing of student's worksheets

Includes the use of:

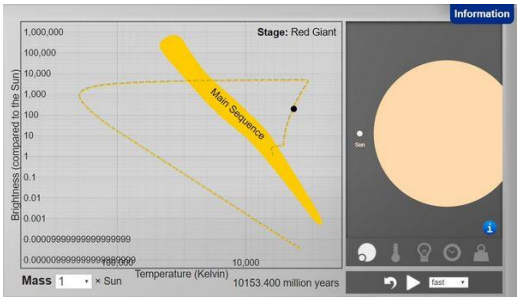
Computer for each group of students

Outline

By watching a presentation students get the information about stages of stellar evolution. Then using the computer animation students explore the changes of stellar parameters during different stages of stellar evolution. Finally they draw a schematic diagram of stellar evolution.

Pupils will Learn:

- That after the main sequence stage almost all stars become red giants, the most massive of them evolve into blue supergiants.
- Then a planetary nebula or a supernova remnant is ejected.
- Depending on the final mass, stars become white dwarfs, neutron stars or black holes.



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	5 min	Go to the online page https://starinabox.lco.global/. Make sure that the software is available at 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	15 min	Students watch the *Powerpoint* presentation *Stages of Stellar Evolution* and fill the worksheet.
Activity 2	15 min	Students work with the online animation *Star in a Box* and fill the worksheet.
Assessment	10 min	Students label the schematic diagram of the stellar evolution and answer the questions.

Introduction to the subject:

The purpose of this lesson is to introduce students to the different stages of stellar evolution. Stars are created from interstellar hydrogen and helium that is compressed under its own gravity. When the temperature at the core of the "star in the making" exceeds 4 million Kelvin, hydrogen starts to convert into helium. The star becomes a main sequence star and releases huge amounts of energy. What happens next, will be explained during the lesson.

Activity 1:

By watching the *Powerpoint* presentation *Stages of Stellar Evolution* students get the general information about the stages of stellar evolution. Students answer the questions at their worksheet:

1. A recipe. What do you need to make the star? Take hydrogen, helium, some other chemical elements and dust. Then compress until ready.

2. Write down 4 evolutionary stages of the star if the initial mass is less than 8 solar masses! "Star in the making", main sequence star, red giant, white dwarf.

3. Write down 4 evolutionary stages of the star if the initial mass exceeds 8 solar masses but the final mass is less than 2,3 solar masses! "Star in the making", main sequence star, red supergiant, neutron star.

4. Write down 4 evolutionary stages of the star if the initial mass exceeds 25 solar masses and the final mass is more than 2,3 solar masses! "Star in the making", main sequence star, red supergiant, black hole.

Activity 2:

Students go to the online page https://starinabox.lco.global/ and start the software by pressing "Open the lid". Field to the left represents the Temperature-luminosity diagram with the main sequence highlighted. Students set the speed of the animation to „fast". They change the mass of the star to 0,2 solar units and check that the right side window "Compare the size" is chosen.

They push the "Start" button and watch the changes of temperature, luminosity, size and colour of the star over time. They write to the worksheet table the final stage of evolution that appears on the main field. They switch to "Stages in your star's life" and write down the intermediate stage(s) between the main sequence stage and final stage. They switch to "Mass" and write down the final mass of the star.

Then they switch to "Data table" and calculate the sum of main sequence and giant(s) phase duration. To go back, "Open the lid" button must be pushed. This process is repeated for other stellar masses up to 40 solar units.

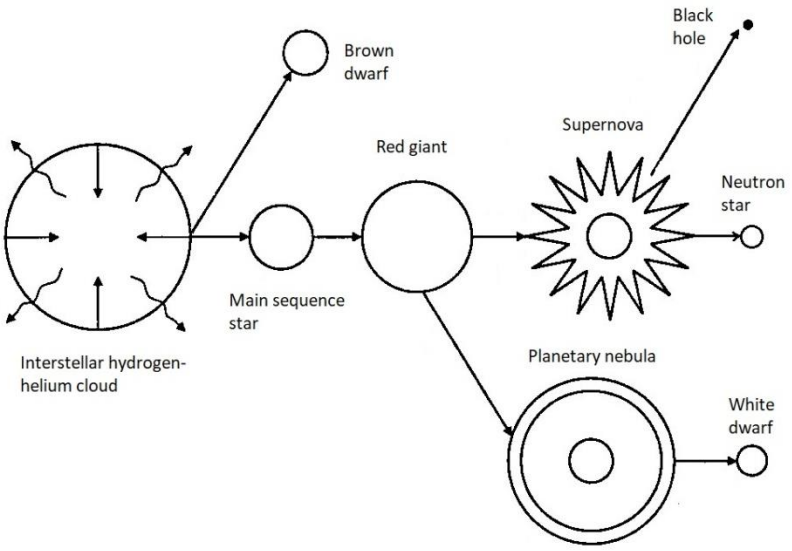
Finally students fill the worksheet column "Remnant". For stars of mass between 0,8 and 8 solar units it will be **planetary nebula**. For stars of higher mass it will be **supernova remnant**. First line of the worksheet table is already filled. Other answers are marked in red.

Initial mass, solar units	Intermediate stage(s)	Remnant	Final stage	End mass, solar units	Duration, millions of years
0,2	No*	No	White dwarf	0,183	1 034 300
0,65	Red giant	No	White dwarf	0,424	62 450
1	Red giant	Planetary nebula	White dwarf	0,536	10 070
2	Red giant	Planetary nebula	White dwarf	0,637	1492
4	Red giant	Planetary nebula	White dwarf	0,867	215
6	Red giant	Planetary nebula	White dwarf	1,138	76
10	Red giant	Supernova remnant	Neutron star	1,369	27
20	Red giant	Supernova remnant	Neutron star	2,332	10
30	Red giant, blue giant	Supernova remnant	Black hole	6,787	6,7
40	Red giant, blue giant	Supernova remnant	Black hole	9,579	5,5

* Animation says that there is a red giant stage but this is not correct. Very low mass stars gradually collapse from the main sequence stars straight into the white dwarfs.

Assessment:

Before the Assessment teacher goes back to the last slide of the presentation *Stages of Stellar Evolution* and explain in details different paths of stellar evolution. Then the presentation is closed and students label the schematic diagram of stellar evolution at their worksheets. Example of labelled diagram is given below.



Students answer the questions using the data from the table:

1. What will be the final evolution stage of the Sun? Sun has one solar mass so it will become a white dwarf.

2. Betelgeuse has an initial mass of 20 solar masses. What will be the final evolution stage of this star? A neutron star.

3. A star with the initial mass of 40 solar units becomes a black hole of about 10 solar masses. Where the all other mass is gone? It is expelled into the interstellar medium as supernova remnant.

4. *Live fast, die young*. To which stars this slogan can be applied and why their lifespan is so short? To the stars with the very high mass. Thats because their luminosity is very high and hydrogen is quickly converted into helium.

5. Age of the Universe is 14 billion years. Are there stars that will last longer than this period of time? Yes, small stars with the masses up to 0,65 solar units.

Further Activities:

You may continue with the *Evolution of Stars*. *Activity 9* about Carbon Stars.

Background Material/Knowledge:

Stellar Evolution. https://en.wikipedia.org/wiki/Stellar_evolution