Introduction in the scientific method using the Hertzsprung-Russel-Diagram

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Abstract

Use the Hertzsprung-Russel-Diagram (HRD) to introduce the scientific method to students.

Zusammenfassung

Der Hertzsprung-Russel-Diagramm (HRD) wird verwendet, um Schülern die wissenschaftlichen Methode näher zu bringen.

1 Introduction

In our observatory we tried to introduce the scientific method to a group of students aged 11–13. Being an astronomical observatory, we decided to use the Hertzsprung-Russel-Diagram (HRD).

2 Lesson structure

What is science?

Ask the students what science is [1]. Lead them to the understanding that sciences uses the following method [2]:

1. Observe, Measure, Record
2. Classify, Analyze, Interpret
3. Hypothesize, Test, Verify

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[1] This is easier in German as science translates to Wissenschaft which literally means knowledge creation.

[2] Most still do and almost all did so in the past

Observe, i.e. the stars

You can use the night sky, a star globe, some planetarium software such as `stellarium.org` or a photo of the night sky.

Goal is to realize that stars have different brightness and color.

Start to ask questions about the observation, e.g.:

- Do we have stars of all colors?
- Do we have stars of all brightnesses?

Measure

Before continuing to the next step we need to link color with temperature. Most kids are familiar with the blue and yellow part of the candle flames.

With older students you can mention absolute vs. apparent magnitude (see section 3).

Classify

Introducing the Hertzsprung-Russel-Diagram Explain that Hertzsprung and Russel had the same questions we asked in the observation section above. They found a way to visualize the stars in a diagram.

Show the empty Hertzsprung-Russel-Diagram (HRD) in figure 1.

Ask the students what's odd about it. Explain the axes:

- Brighter stars have lower magnitudes because the Greak astronomer Hipparchus used a scale from 1 to 6, where 1 is the brightest and 6 the dimmest.
- Temperature goes from hot to cold because 100 years ago, astronomers thought that starts are born hot and cool down. This is not true, but the convention is still used.

Filling the Hertzsprung-Russel-Diagram Now we want to fill the HRD with stars. We use the stars from table 1 and the empty diagram from figure 1. Make sure each students gets a copy of each.

We found that it helps when the teacher joins the students in this task. It will make her humble as the task is hard and the students will feel more comfortable.

Analyzing

After filling the HRD, we can analyze it. Ask the students to find patterns in the HRD. They will find that stars are not randomly distributed, there are different groups of stars.

Note: The stars were ordered randomly. This ensures that also with only 50% of the star the students should already see some structure.

Interpret

Explain the groups and link them to the life cycle of stars. Stress that this was discovered much later but that the HRD was an impoortant step in this discovery.

3 FAQ

Visual brightness or magnitude All brighness in this document refers to the visual brightness of stars. This differs especially for hot stars which are very bright in the ultra violet.

Absolute brightness or magnitude In this document, we use the absolute brightness of stars. The absolute brightness of a star is the brightness it would have at a distance of 10 parsec. You may show that the sun is not a very bright star.

4 Material

Name	Temperature (K)	Brightness (abs. mag)	Type
Wega	9602	0.58	white gient
61 Cygni A	4450	7.49	orange dwarf
Polaris	6015	-3.64	yellow gient
Canopus	7350	-5.71	yellow super giant
Sonne	5778	4.83	yellow dwarf
Antares	3400	-5.28	red super giant
Spica	25400	-3.55	white gient
Betelgeuse	3500	-5.85	red super giant
Sirius B	25200	11.18	white dwarf
Procyon B	7740	13.0	white dwarf
Alpha Centauri B	5260	5.71	yellow dwarf
Rigel	12100	-6.69	white super giant
Aldebaran	3910	-0.63	orange gient
Bernard's Star	3134	13.21	red dwarf
Gliese 725 A	3400	10.0	red dwarf
Gliese 725 B	3100	11.0	red dwarf
61 Cygni B	4040	8.31	orange dwarf
Procyon	6530	2.66	yellow dwarf
Epsilon Eridani	5084	6.18	orange dwarf
Proxima Centauri	3042	15.53	red dwarf
Alpha Centauri A	5790	4.38	yellow dwarf
Achernar	15000	-1.46	white gient
Arcturus	4286	-0.3	orange gient
Pollux	4865	1.09	orange dwarf
Deneb	8525	-8.38	white super giant
Lacaille 9352	3460	10.68	red dwarf
Atair	7550	2.21	white dwarf
Sirius	9940	1.42	white dwarf
Bellatrix	22000	-2.78	white gient
Beta Centauri	25400	-4.53	white gient

Table 1: List of example stars

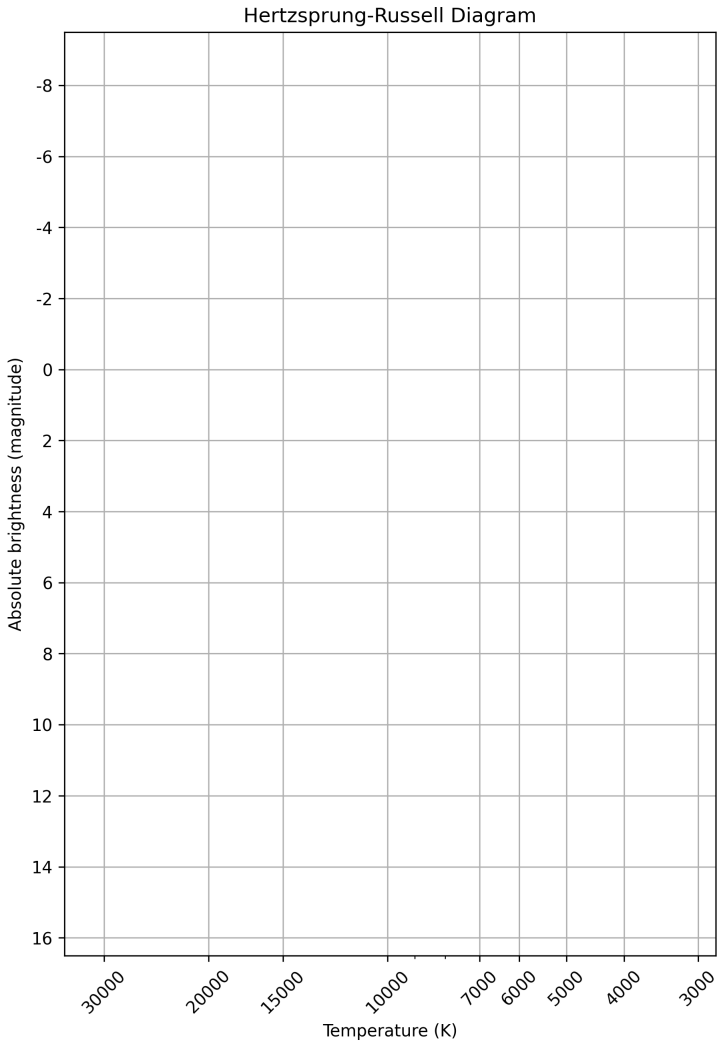

Figure 1: An empty Hertzsprung-Russel-Diagram (hrd_empty.png)

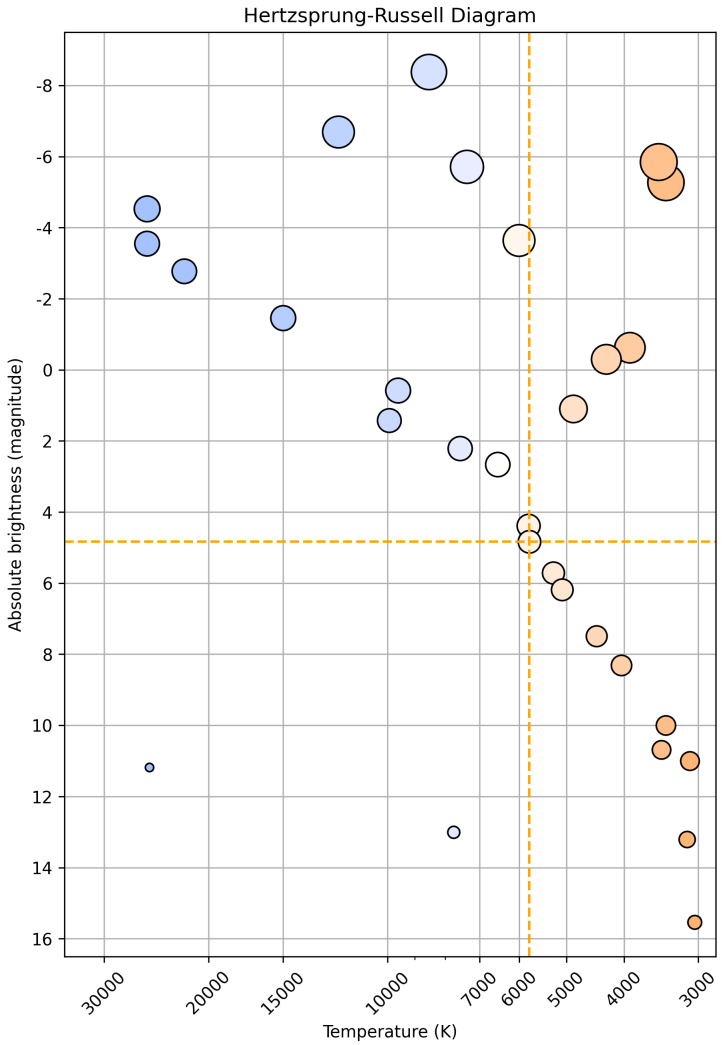

Figure 2: The diagram from figure 1 with stars from table 1. Our home star is marked with dotted lines.