ASTROEDU

Peer-reviewed Astronomy Education Activities

Light in a matchbox

Build a homemade spectrometer to discover light

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KEYWORDS

light, hands-on, spectrum, spectrometer

CATEGORY

Physics, Scientific instrumentation

AGE

8 - 14

LEVEL

Middle School, Primary

TIME

1h 30m

SUPERVISED

Yes

COST

Low Cost

SKILLS

Analysing and interpreting data, Constructing explanations, Planning and carrying out investigations

TYPE OF LEARNING

Guided-discovery learning, Observation based, Structured-inquiry learning

MATERIALS

- A match box (or any other small box similar to a matchbox).
- Black marker or black paint and a brush.
- A cutting blade.
- Glue.
- Paper and color pencils to draw the observed spectrum.
- A CD/DVD.

GOALS

- Generate interest in science.
- Creativity and resourcefulness development of the students.

LEARNING OBJECTIVES

- Build a spectrometer.
- Learn about light and the visible spectrum.

BACKGROUND

What is visible light?

Visible light is the portion of the electromagnetic spectrum that can be detected by the human eye.

Visible light is a form of electromagnetic (EM) radiation, as are radio waves, microwaves, infrared radiation, ultraviolet radiation, X-rays and gamma rays, see Figure 1. Generally, visible light is defined as the wavelengths that are visible to most human eyes.

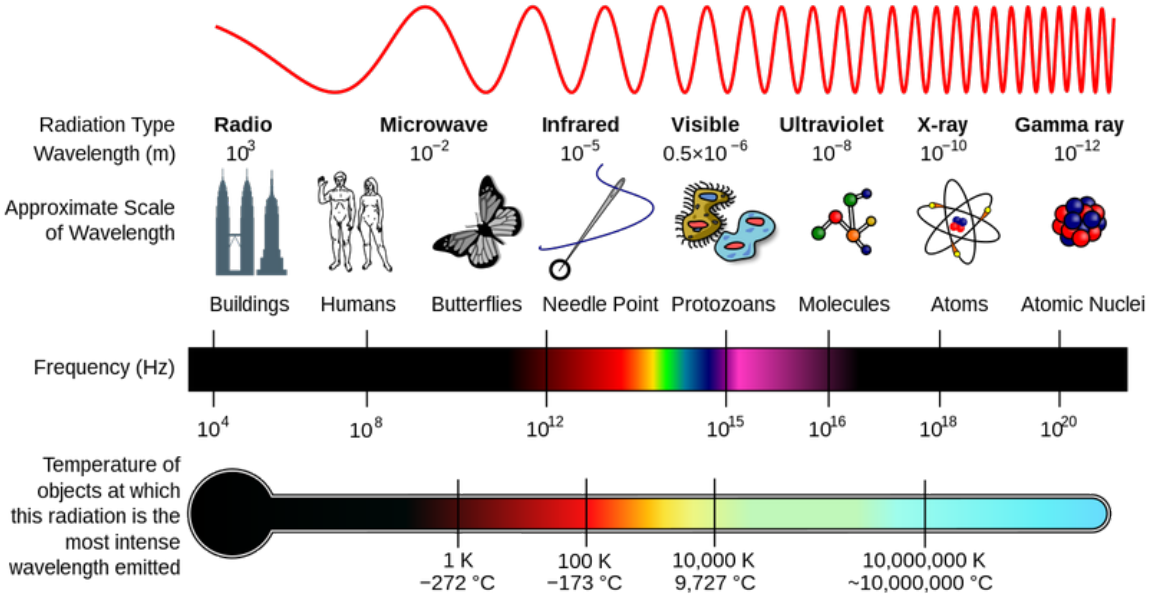

Figure 1: An overview of the electromagnetic spectrum. Adapted from the original image. Source: Wikimedia Commons. This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license.

Electromagnetic Spectrum Range

Visible light is a form of electromagnetic radiation, which propagates through waves with varying wavelengths and frequencies, see Figure 2. This wide range of wavelengths, collectively referred to as the electromagnetic spectrum, is divided into seven distinct regions based on the wavelength decreasing and energy/ frequency increasing order. These regions are:

- Radio waves (wavelengths greater than approximately 10 cm)
- Microwaves (wavelengths of the order of 1 cm)
- Infrared (IR) (wavelengths of the order of 10 micrometers)
- Visible light (wavelengths between approximately or 380 and 740 nanometers)
- Ultraviolet (UV) (wavelengths between approximately 10 and 100 nanometers)
- X-rays (wavelengths between approximately 1 picometer to 10 nanometers)
- Gamma-rays (wavelengths shorter than 1 picometer).

A micrometer (also called a micron), a nanometer, and a picometer are one thousand, one million, and one billion times smaller than a millimeter, respectively.

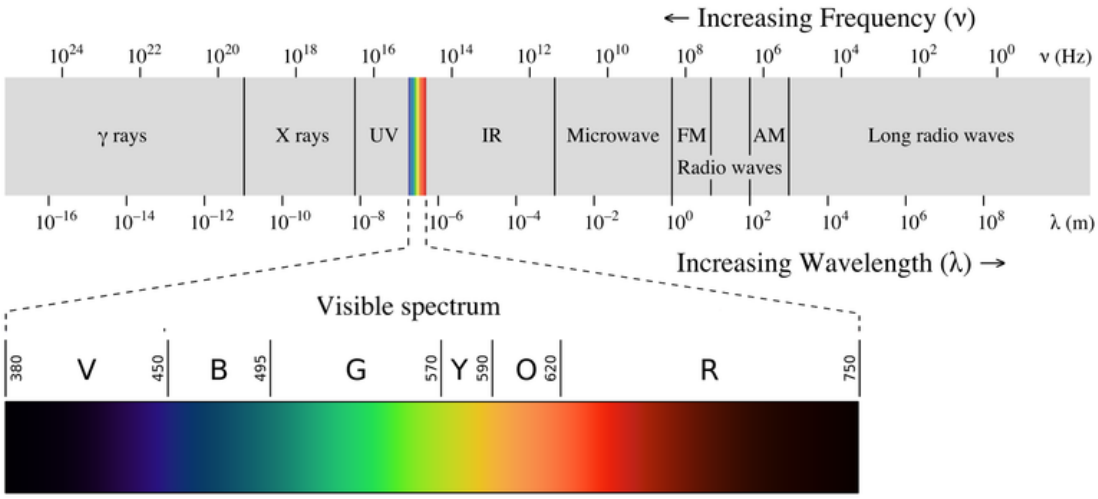

Figure 2: The spectrum of visible light as part of the whole electromagnetic spectrum. Source: Wikimedia Commons. This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license.

Visible light spectrum and colour

Our eyes perceive visible light as different colours, depending on the wavelength. This occurs thanks to specialised cells in our eyes, called cones. We perceive as red the light at the lower end of the visible spectrum (approximately 740 nm), while light in the middle of the visible spectrum is seen as green. Finally, light at the upper end of the spectrum, with a wavelength of about 380 nm, is perceived as violet.

All the other colours that we see are a mixture of red, green and blue. For example, the color yellow is a blend of red and green, magenta is a mixture of red and blue, and cyan is a combination of green and blue. Black results from the complete absence of light, while white light is a combination of all colors. The discovery that white light is a mixture of all colors was first made by Isaac Newton in 1666. He projected the colours onto a wall after letting sunlight go through a narrow slit and a prism.

FULL DESCRIPTION

Step 1

The matchbox must be empty. The inside of the box is to be painted with marker or black vinyl, see Figure 3.

Figure 3: Painting of the internal part of the matchbox.

Step 2

On the top of the box, carve a small slit approximately 1 cm high and 3 cm wide, leaving 7-8 mm free from the box end. See Figure 4

Figure 4: Carving the small slit on the top of the matchbox.

Step 3

Take a CD/DVD and then cut a piece with a radius of approximately 4 cm and an angle of 30 to 40º of arc, see Figure 5.

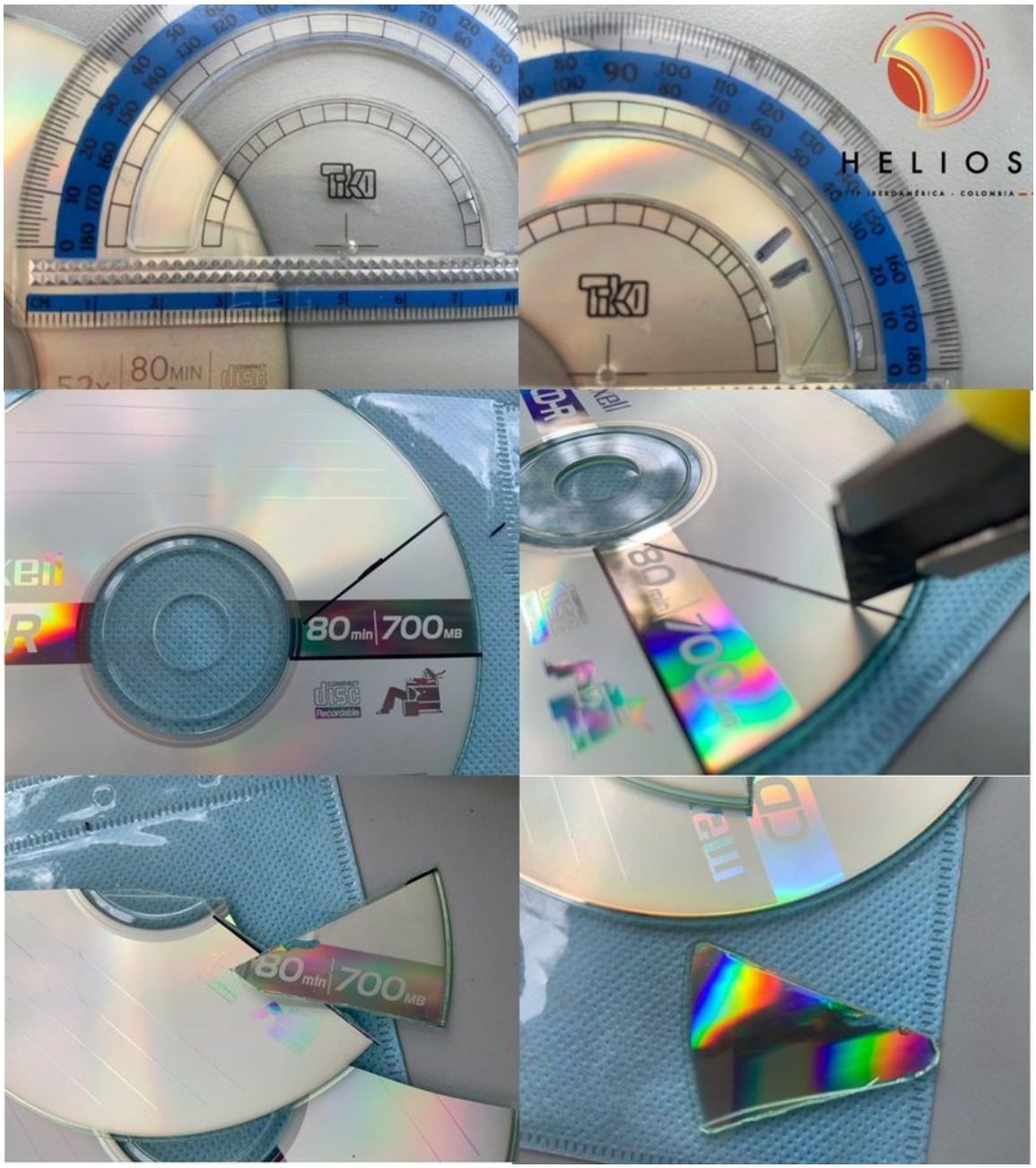

Figure 5: Cutting the CD/DVD.

Step 4

Glue the piece of CD/DVD inside the matchbox, see Figure 6.

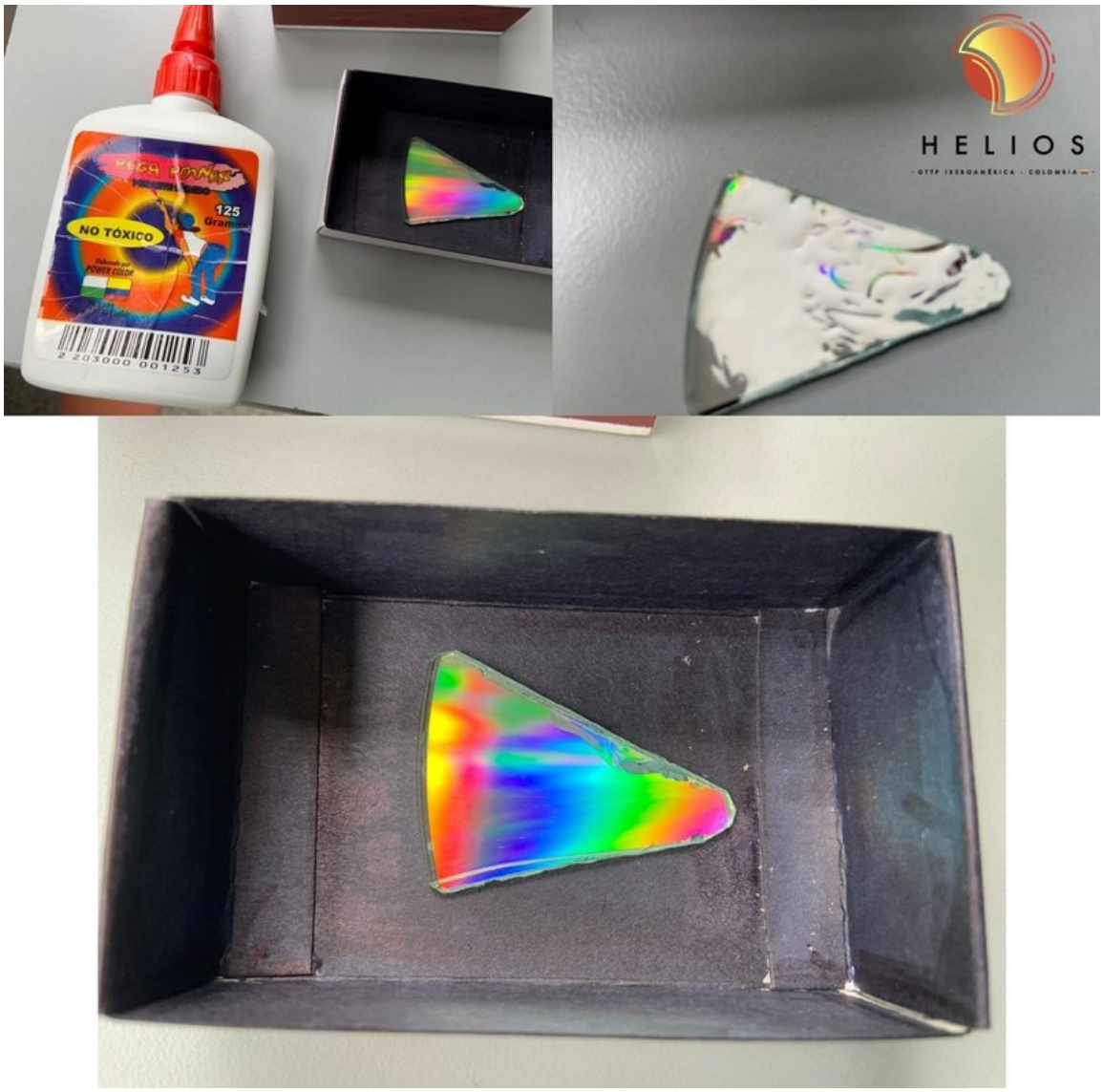

Figure 6: Gluing the piece of CD/DVD inside the matchbox.

Step 5

Close the matchbox.
Then proceed to open the matchbox a little at the end on the opposite side of the small slit previously made, see Figure 7.

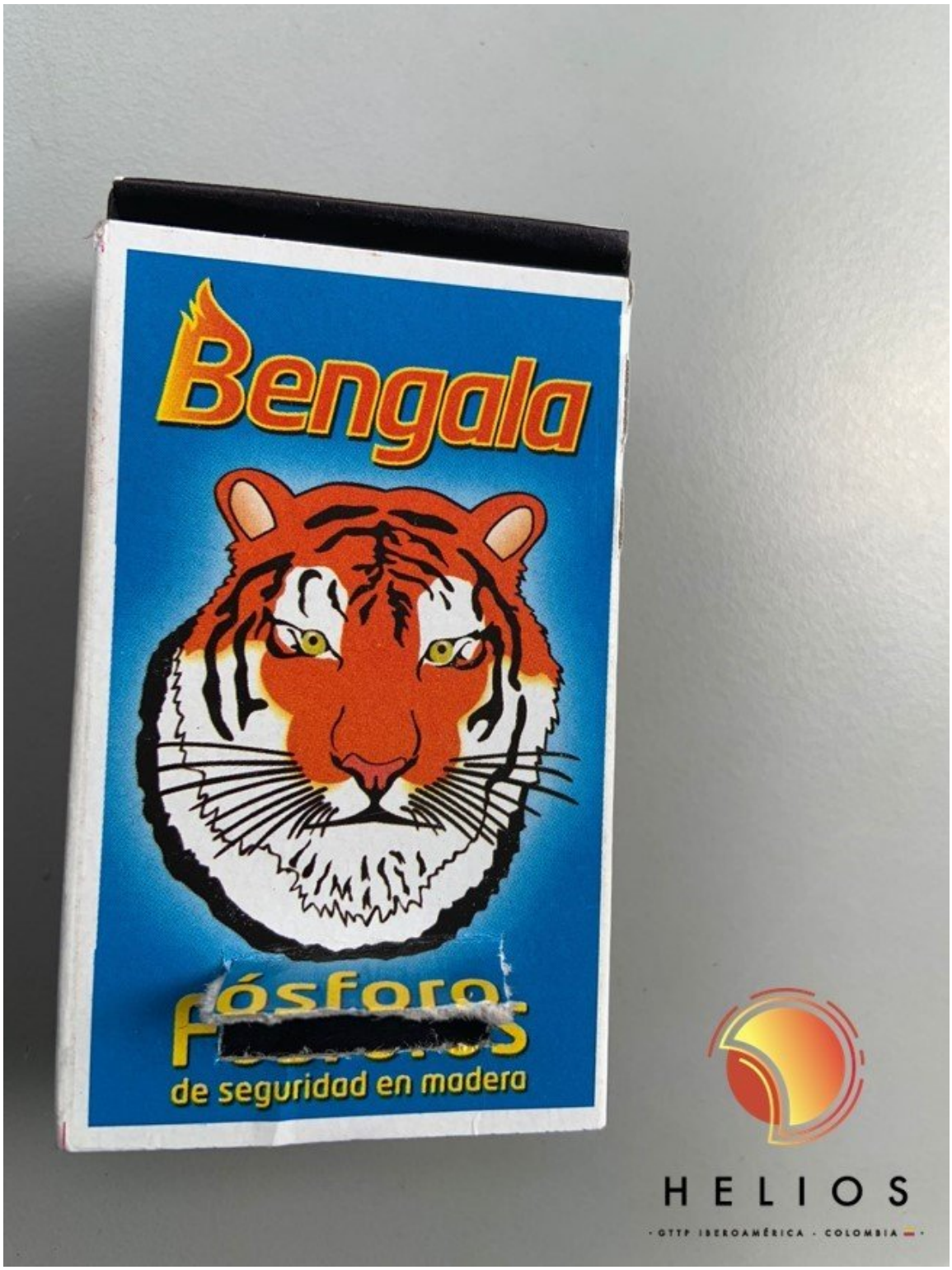

Figure 7: Preparing the matchbox for observation.

Step 6

Look for a place where there is natural or artificial light, but without pointing directly to the light source (for example, the Sun) and look through the small slit of 1cm located on the lid of the box.

For example, the student will use the spectrometer to investigate the spectrum of a white light lightbulb, a yellow light lightbulb, the Sun.

Step 7

Students are required to draw their observed spectra. At the end of registering the information obtained, the spectrum types are investigated, and the results are compared.

EVALUATION

After having built the spectrometer, students can be asked to observe different sources of light and draw their observed spectrum. The different spectrum types can be investigated, and the results are compared.

Ask the following questions:

- What is the visible spectrum?
- Why is each observed spectrum different?
- Do lightbulb materials influence the result?
- Do our eyes influence how we see colors? Why?
- Are there other wavelengths that we can't see? Which ones?

CURRICULUM

It connects with the physics course.

CONCLUSION

Understanding the concept of light and visible spectrum can be difficult because it can be a bit abstract. However, the construction and use of a spectrometer can make the teaching of the concept easier. Furthermore, these activities are important because of the dynamic nature of the learning process and how they stimulate the student's engagement during the class.

Since it is a low-cost activity, students can repeat it at home with family and friends.

FURTHER READING

Arcand, Kimberly. Watzke, Megan. Light: The Visible Spectrum and Beyond. Black Dog & Leventhal Editorial. 2015

CITATION

Carolina Escobar García, 2023, *Light in a matchbox*, astroEDU, 2302

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