Herschel's Experiment

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NASE's proposal is included in the International Day of Light, which commemorates the day when a human-created laser beam was lit for the first time. It is about repeating Herschel's experiment any day between March 21 to September 23, 2021, and filling the dates in the sepate file "table to send":

The table with the data and results, and 2 or 3 photos of the experiment, must be sent before September 23, 2021 to newsletter.nase@gmail.com

Infrared

The infrared region of the electromagnetic spectrum was discovered by William Herschel (the discoverer of the planet Uranus) in 1800 using a prism and thermometers. To do this, he obtained the visible spectrum, passing the white light of the Sun through a prism and placed several thermometers, one in the blue region, another in the red (both colors detectable by the eye) and placed a third thermometer beyond red, immediately after. With a fourth thermometer he measured the ambient temperature and discovered that the temperature marked by the thermometer in the area "below" red (hence its name "infra" red) was higher than that of the environment.

Herschel did other experiments with the "heat rays" (as he called them) that existed beyond the red region of the spectrum: they were reflected, refracted, absorbed, and transmitted just like visible light. These "heat rays" were later called infrared rays or infrared radiation. Those discoveries were followed by others that led to various technological applications.

Bodies emit electromagnetic radiation at frequencies that depend on their temperature. For example, our body and that of animals emit infrared radiation that our eyes do not detect, but other devices do, such as night vision goggles or current clinical thermometers, which allow us to measure body temperature without contact (Fig. 1 and 2).

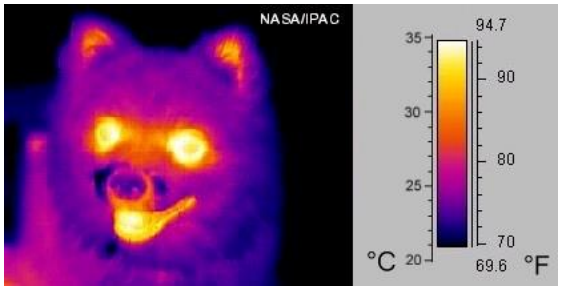


Fig. 1: Infrared photography. More or less hot areas are distinguished, and their temperatures.

Fig. 2: Infrared thermometer. Measure body temperature without contact

Herschel's Experiment

The goal is to repeat the experiment of 1800, by which the famous astronomer William Herschel discovered a form of radiation other than visible light. We will need a glass prism, four thermometers, a permanent black ink marker, scissors, masking tape, a cardboard box, and a white sheet. We put tape on the thermometer bulbs and paint them with a black marker to better absorb heat.

The experiment should be done outdoors, on a VERY sunny day. If there is a lot of wind, the experience can be done indoors, as long as it has a window through which the Sun enters directly. A white sheet is placed at the bottom of the cardboard box. The prism is carefully placed on the top edge of the box, so that it is on the side of the Sun. The inside of the box should be all or almost all in shadow (Fig. 3 and 4). The prism is carefully rotated until the widest possible visible spectrum appears on the sheet at the bottom of the box. You can see it in this video and in this one

After taping the prism in place, we positioned three thermometers so that each bulb was in one of the colors: one in the blue region, one in the yellow region, and the third just beyond the

visible red region. You must be able to see the graduated scale well, so as not to move the thermometer when we take measurements. We put the fourth thermometer in the shade, not aligned with the previous ones.

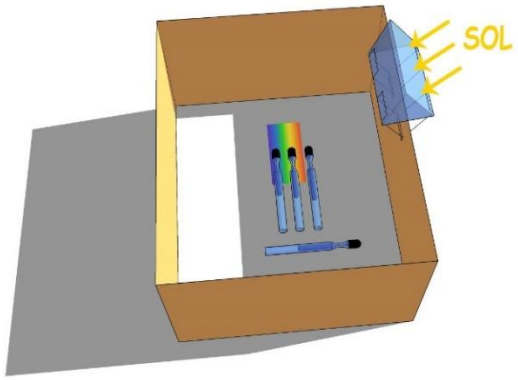


Fig. 3: Box with the prism and the four thermometers

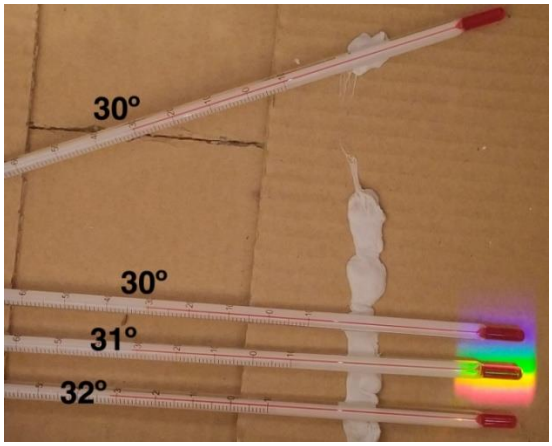


Fig. 4: What the three thermometers show in blue, yellow and infrared, and in the shadow, after 5 minutes.

The thermometers take about five minutes to reach their final measurements. Every minute we record in the table below, the temperatures in each of the three regions of the spectrum and in the ambient one. There is no need to move the thermometers from their position on the spectrum or block their light.

	Thermometer # 1 in the blue	Thermometer # 2 in the yellow	Thermometer # 3 beyond red	Thermometer # 4 in the shadow
After 1 minute				
After 2 minutes				
After 3 minutes				
After 4 minutes				
After 5 minutes				

The thermometer in the yellow (Fig. 4) should indicate a temperature somewhat higher than in the blue and in the environment, and the thermometer that is close to the red should indicate an even higher temperature, so it is logical to deduce that some kind of radiation comes from the Sun, invisible to our sight.

Bibliography

- 14 steps to the Universe, 2ª. Edición. Ed. Rosa Ros & Beatriz García, Editorial Antares, Barcelona, 2018.

- Moreno, R, *Experimentos para todas las edades*, Ed. Rialp. Madrid, 2008.

Herschel's Family: Astronomy and Music

The father of the Herschel brothers, Isaac, was a very talented musician, who set out to give his six sons training in different disciplines: music, mathematics, astronomy, languages. Caroline Herschel fell ill at age 10, first with smallpox and later with typhus. These diseases stopped the growth of it permanently. Her parents realized that due to this physical situation, she could not get married. Her father secretly gave Caroline music lessons and taught her some astronomy.

In 1772, William Herschel, who was working in Bath, England, asked his mother that his sister Caroline, who was then 22, come to live with him as a housewife. William saw that her younger sister had an aptitude for music and science, and taught her math, astronomy, and English.

William gave concerts as an organist and conductor in the city of Bath; and Caroline acted as a soprano. But William Herschel started building telescopes, and his reputation reached such a point that he decided to quit his job as a musician and devote all his time to astronomy.

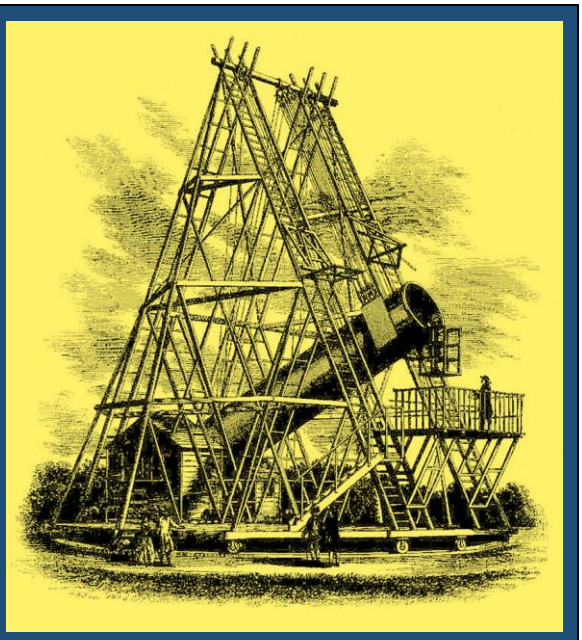
Caroline Herschel also decided to abandon her musical career to become an assistant to her older brother. Her job consisted of grinding and polishing mirrors, recording observations night after night, reviewing them during the day, and doing algebraic calculations to establish astronomical distances. She went on to become a notable astronomer.

Together, they discovered a thousand double stars, and showed that many were binary star systems revolving around each other. This was the first physical proof of the action of gravity outside the solar system.

One of the stories that shows the spirit of the wonderful Herschel family is derived from a letter from John Herschel, son of William, addressed to the director of the Dublin Observatory, Sir William Rowan Hamilton. In addition to informing her that Alpha Orionis was a variable star, he shares with her a song that all the family members sang together when they were gathered inside the 12-meter tube of the reflecting telescope, celebrating the new year of 1840:

Happy, happy let's sing
grinding and jingling
to the old telescope ...

The postscript reads: "The above was sung loudly by our entire family, dad, mom, Madame la Governante and seven juniors, at 0 hours, 0 minutes, 0 seconds of the average hour, January 1, 1840, inside the tube. We gathered fourteen, but fourteen more could easily have fit. "



Telescope built by the Herschel brothers.
Credit: Leisure Hour.

Acknowledgments to Caroline Herschel

Caroline Herschel

William Herschel

Caroline Herschel was the first woman to discover a comet. She did it on August 1, 1786, between the constellations of Ursa Major and Coma Berenice.

As time and the comet were running fast, and her brother William hers was out of town on business, she Caroline saw fit to immediately communicate her discovery to the Secretary of the Royal Astronomical Society. Back then, it was unusual for a woman to do scientific work, and Caroline was just her brother's assistant. Upon his return, William had to corroborate the discovery.

Shortly later, in 1787, Caroline published an article in the Philosophical Transactions scientific journal of the Royal Astronomical Society. She was the first woman to do it.

In the period from 1786 to 1797 she discovered three nebulae and eight comets. In the years that followed, she cataloged every discovery that her and her brother had made. Two of the astronomical catalogs published by Caroline Herschel are in use today.

Her hard work led her to complete, in 1798, the "Index of observations of fixed stars of John Flamsteed", where he included 560 stars that the English astronomer had not collected in his catalog of more than 3,000 stars. Caroline Herschel presented the list to the Royal Astronomical Society. Subsequently, she published the "General Reference Index of each observation, of each star mentioned in the British Catalog", also with the Royal Astronomical Society.

When her brother died, on August 25, 1822, her Caroline returned to Hanover, where she received numerous honors. Among them, the gold medal of the Royal Astronomical Society in 1828, of which she was made an honorary member in 1835, at the age of 85. On her 96th birthday, she received the Gold Medal of Science, from the King of Prussia, for her achievements during her lifetime. Caroline Herschel died on January 9, 1848, at the age of 97.

Collaborating institutions: