

Herschel Infrared Experiment

What's it all about

Re-create Hershel's 1800 experiment where he discovered infrared (IR) by measuring a raised temperature just outside the visible spectrum. This was a surprise to him – he had put the thermometer there only as a reference, to compare with those he placed within the visible spectrum.

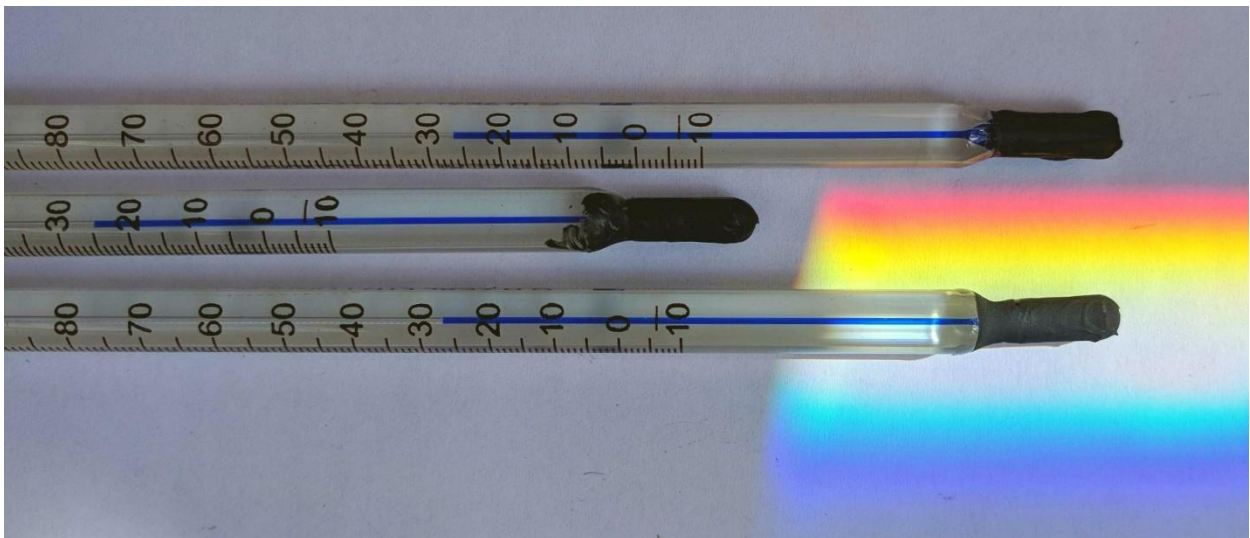
Warning: this experiment is a bit tricky to pull off, so I'd recommend having a good practice, and avoiding its use in any context where failure would cause difficulty.

Objectives:

1. Sunlight can be split into different colours of light
2. Sunlight contains a 'colour' of light that we cannot see, but which can warm a thermometer

In the photograph below:

- The thermometer in the infrared (27°C) has absorbed infrared radiation
- The thermometer outside the spectrum (25°C) is the reference
- The thermometer in the visible spectrum (27°C) has absorbed visible light



Visible light is higher energy, but infrared is more easily absorbed by the black thermometer bulb.

SCIENCE WARNING: this experiment is very often used incorrectly to suggest that *only* infrared light is warming, as though it possesses a unique property compared to other forms of light. It's true that Hershel read a higher temperature in the IR than in any colour, but this is due to the angle of incidence - the other colours are more spread out on arrival due to the angle at which they refract through the prism. Practically speaking it's really too complicated to draw any conclusions other than that there is invisible radiant energy arriving in the infrared zone.

Equipment / requirements

- Direct sunshine! You will need to leave them for a number of minutes in strong sunlight. Passing clouds are your enemy. Sunlight must be direct, NOT through a window: normal glass is opaque to IR.
- Optical glass prism.
- 3x thermometers, capable of seeing a 1°C change. These MUST be painted matt black on their bulbs or the experiment will NOT work! The paint massively increases their absorption of the light energy. I used matt black paint designed for painting fire grates.
- Thermometers must be checked to ensure their readings match under equal conditions. The difference being looked for is very small, and thermometers are not always calibrated correctly.
- A sheet of white card or similar to go under the thermometers. Helps you see what is happening and lets you move the thermometers as a group without touching them. Using a thermal insulator might be useful, especially if you're unsure that your surface is the same temperature all over.
- Some way to hold the prism in place. Plasticine is provided from which you could fashion a stand. Else perhaps stand it in a heavy cup. There is also a method using a cardboard box (the box also providing shade), but it is not sturdy and the sides of the box may radiate heat, so use this method with care.

See http://coolcosmos.ipac.caltech.edu/cosmic_classroom/classroom_activities/herschel_example.html for a photo of the box set-up. If using this, make sure you have control measures ref the risk of the prism falling out of its place.

What to do

1. To get a good spectrum, you will need to angle one of the prism's long edges towards the Sun. Remember the Sun's angle will change and so the spectrum will move over time.
2. Work out where/how you can place the prism so that it casts an intense spectrum into a cool, shaded area. Make sure there is a smooth surface for the experiment (provide one if necessary).
3. Consider accessibility eg for toddlers or wheelchair users.
4. Place the white paper so that the spectrum is shining onto it.
5. Place the thermometers as shown in the picture on the previous page. Make sure their entire length is on the white paper so you can move them easily as a group by sliding the paper.
6. Remove the prism (or block its light) – you now have three thermometers sat in the shade. Leave them a while and check that they are reading equal temperatures.
7. Replace the prism (or unblock its light), adjusting the paper position / thermometer positions as required to keep them in their correct locations with respect to the spectrum.
8. Wait for a good few minutes! You need intense sunlight.
9. Adjust prism/paper/thermometers as required throughout this time. Avoid moving the thermometers across the paper if you can – else people might think you are moving the IR thermometer into the 'warm patch' left by the retreating visible red light. Instead, slide the whole piece of paper to follow the spectrum's path.
10. Alternatively, if you are using the box method, move the whole box.

11. Look carefully – the observed difference in temperature is likely to be very small!
12. It is always better for people to see the temperature difference themselves rather than relying on your word for it.

AstroBoost Project

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