SPACE WEEK

Our Planet • Our Space • Our Time

Resource Book for Teachers

TOPIC: Infrared Astronomy

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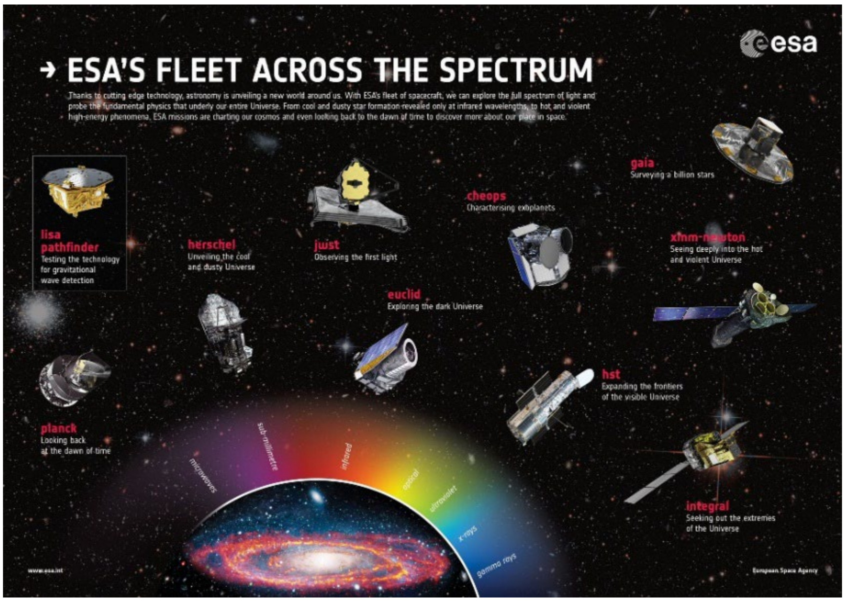
Infrared Light

Infrared radiation is primarily 'heat', or thermal radiation. Even objects that we think of as being very cold, such as an ice cube, emit infrared radiation.

Infrared light is not visible to human eyes, but we can detect it with our skin – as heat! When you hold your hand out to a burning fire you “feel” the heat being emitted by the fire. The fire gives out light and infrared (IR) radiation; from a fire most of this is near-infrared (NIR) radiation. Some of the NIR radiation is absorbed by water molecules in your skin. This raises the temperature of the water and results in an increase in temperature in the surrounding tissue which is detected by nerves in your skin.

This radiation was discovered in 1800 by Sir William Herschel, a musician and very successful amateur astronomer (he discovered the planet Uranus). He wanted to know if any particular colour was associated with heat from sunlight. He found that the amount of heat increased from blue light to red light and that the heat maximum was beyond the red end of the spectrum. Herschel called this “calorific rays” (heat rays), and it was later named infrared.

ESA named an IR telescope after William Herschel, and the Herschel Space Observatory operated between 2009 and 2013. The Webb telescope can observe IR and its stunning images can be seen here.



Near-infrared radiation is IR that is just beyond what human eyes can see. It has a longer wavelength and a lower frequency than visible light. It can be used for night goggles.

Mid-infrared radiation is IR that has a longer wavelength than near infrared.

Far-infrared radiation has even longer wavelengths than mid infrared. It is the type of IR given out by cool objects, up to about 70 °C.

Nearly all the IR given out by the Sun is NIR, but the cooler Earth emits mostly in mid-infrared or far-infrared. Instruments onboard Earth observing satellites can sense this emitted infrared radiation and use the resulting measurements to study changes in land and sea surface temperatures and to see clouds. The Earth's atmosphere blocks many IR wavelengths, so IR telescopes are usually placed in space.

For teachers: Ray Days Talk: Infrared Light (1h video from Crawford Art Gallery, look for Day 5).

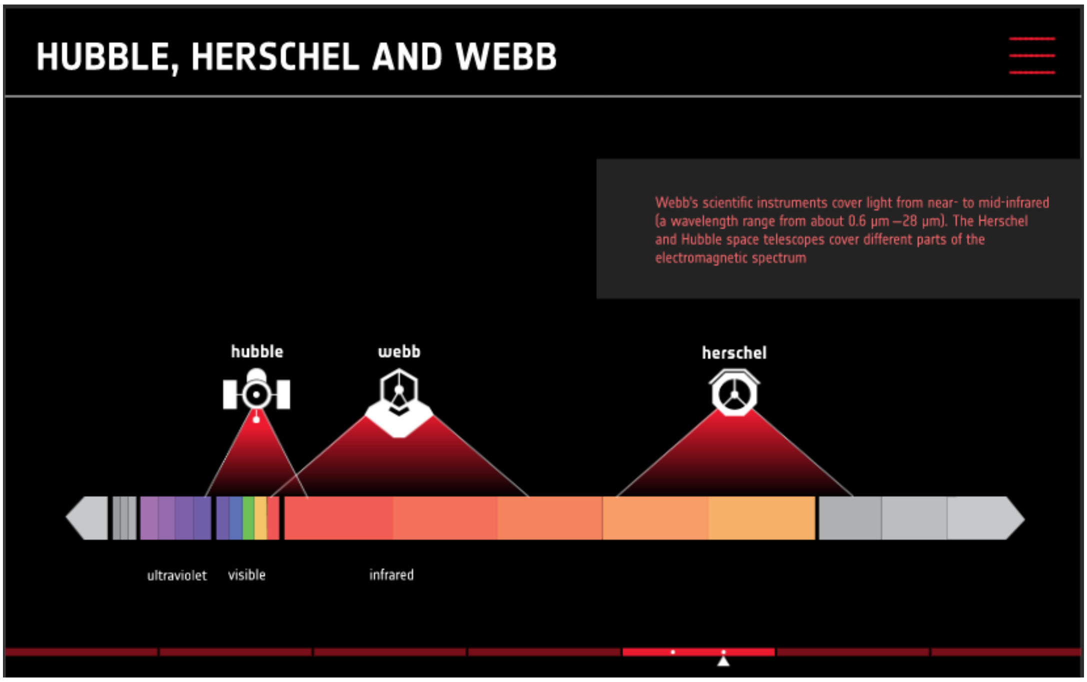
Infrared Astronomy

View https://esahubble.org/videos/hubblecast126a/ and read A brief History of Infrared Astronomy

The Sun emits visible and IR light, and our eyes have developed to respond to the light that it gives out. The temperature of an object determines the type of light that it emits, with cooler objects giving out more light at longer wavelengths.

IR astronomy is essential for:

1. The study of brown dwarfs, which are objects that form like stars, but aren't big enough to produce light in the same way that stars do. They are very cool (some have a surface temperature about the same as a kitchen oven) and give out most of their light as IR.
2. The expansion of the Universe causes light to be "red-shifted" to longer wavelengths, so to observe the most distant objects, a telescope must be able to see IR and other long wavelengths.
3. Visible light is blocked by dust particles, which are found in space in large clouds around young stars and planets. IR is able to pass through the dust more easily.



DPSM/ESERO Framework for Inquiry

Theme	Infrared Light
Curriculum	**Strand: Energy and Forces > Strand Unit: Light** **Curriculum Objectives:** • 1st/2nd class: -- recognise that light comes from different sources, -- recognise that the sun gives us heat and light, without which we could not survive • 3rd/4th class: -- recognise that the sun gives us heat and light, without which people and animals could not survive, -- investigate that light can be broken up into many different colours • 5th/6th class: -- learn that light is a form of energy, -- know that light travels from a source, -- investigate the refraction of light, -- investigate the splitting and mixing of light **Strand: Energy and Forces > Strand Unit: Heat** **Curriculum Objectives:** • Infants: -- identify ways of keeping objects and substances warm and cold • 1st/2nd class: -- become aware of different sources of heat energy, -- learn that temperature is a measurement of how hot something is • 3rd/4th class: -- measure changes in temperature using a thermometer, -- measure and compare temperatures in different places in the classroom, school and environment and explore reasons for variations, -- understand that the sun is the Earth's most important heat source • 5th/6th class: -- know that heat energy can be transferred, -- measure and record temperature using thermometer **Skills Development:** Working Scientifically: Questioning; Investigating & Experimenting; Analysing.

Engage			Considerations for inclusion
The Trigger	**Wondering**	**Exploring**	
Webb Telescope Images (from https://esawebb.org/images/) Infrared images of common objects, see https://youtu.be/baJtBDJDQDQ Show the video and ask the children to describe what they are seeing. Which objects appear bright on the infrared camera? Which appear dark? Discussion about how objects warm up (see Wondering)	Ask the children to list ways in which you can warm objects up. They may suggest: placing an object over a fire or electric cooking element; using steam; using hot water; placing an object near a radiator; placing an object in the Sun. Next, ask how each of the ways listed warm things up. Fire, electric elements, steam, and hot water must be in contact with the object. Radiators are in contact with the air, which in turn heats an object. If students try to reason that the Sun warms an object because it is hot, point out to them that the Sun is neither in contact with the object nor is there air in space for the Sun to heat. Ask, is there anything the Sun has that comes in contact with us? (Sunlight) So how does sunlight carry heat? (Infrared radiation)	Investigate infrared with a television remote control and the digital camera from a mobile phone or webcam. The digital camera is sensitive to infrared and will show a purple/pink or white light. Can you reflect infra-red light? (try with mirrors) What happens if you move further away? Children should review how they measure temperature with thermometers and check if their thermometers measure the same temperature. This is calibration and is needed to compare readings from one thermometer to another.	Consider potential area of difficulty for students with Special Educational Needs

Investigate: Herschel Experiment

Starter Question	Predicting	Conducting the Investigation	Sharing: Interpreting the data / results
Using a prism and thermometers can we recreate Herschel's experiment to find out "What part of the spectrum is hottest?"	Children should be familiar with forming a spectrum of visible light, so should know the order of the colours of the spectrum. They may associate Red with hot and Blue with cold (due to water taps!).	Children should set up the activity as described, placing their thermometers in different parts of the spectrum to compare the temperature. To check if the temperature differences are due to the sunlight, the experiment should be repeated in the shade.	Did each group find the same result? If not, what could have caused the differences? (It is likely to be a calibration issue with different inexpensive thermometers reading different temperatures).

Investigate: Infrared Remote Control

Starter Question	Predicting	Conducting the Investigation	Sharing: Interpreting the data / results
A possible question: Does the infrared signal from a remote-control go through materials that block visible light? *or* How does thickness of a material affect the transmission of infrared light? *or* Does infrared reflect like visible light?	Children should make a prediction that references their own knowledge.	Children can use a webcam from a laptop as the detector. This can be connected to a whiteboard. The whiteboard display will show them if the infrared is being detected. They might try different materials, thickness of materials or distances from the camera to determine how infrared travels.	Data may be recorded in a graph or chart and shared with other groups. Do all remote controls produce infrared? Depending on the investigation(s), the class should be able to describe: How infrared light is like visible light and how it is different.

Take The Next Step

Applying Learning | Making Connections | Thoughtful Actions

The infrared light from the Sun is at a shorter wavelength that the infrared light emitted by the Earth. Greenhouse gases absorb long wavelength infrared better than short wavelength infrared. See [PR15 Earth under the lid]
Explore the [Cool Cosmos].
Imagine you can only see infrared light, draw a car that has just returned from a long journey/ or a person who has just exercised vigorously. Which parts would appear bright?
Or, describe a sunrise, if you could only see infrared light.

Reflection	
Reflection	Did I meet my learning objectives? What went well, what would I change? Are the children moving on with their science skills? What questions worked very well? What questions didn't work well? Ask the children would they change anything or do anything differently. Are there cross curriculum opportunities here? What further questions did students have? Did I take into account the individual learning needs of my students with SEN? What differentiation strategies worked well?

Herschel Experiment

Discover the fundamentals of infrared radiation by re-creating the experiment carried out by Sir William Herschel in 1800.

Tools and Materials

- One glass prism (plastic prisms do not work well for this experiment)
- Three alcohol thermometers (see note below), optional, card to support them
- Black paint or a permanent black marker
- Scissors (to cut the cardboard box) or a prism stand
- Cardboard box (photocopier paper box works well)
- 1 blank sheet of white paper

Background:

As sunlight passes through a prism, it disperses into a rainbow of colours called a spectrum. A spectrum contains all the visible colours that make up sunlight. Sir William Herschel was interested in measuring the amount of heat in each colour and used thermometers with blackened bulbs to measure the various colour temperatures.

You will need to blacken the thermometer bulbs to make the experiment work effectively, this makes them better able to absorb heat. One way to do this is to paint the bulbs with black paint, covering each bulb with about the same amount of paint. Alternatively, you can also blacken the bulbs using a permanent black marker. (Note: the painted bulbs tend to produce better results.) You may need to calibrate the thermometers to get a consistent reading between thermometers. You can compare them in the shade to a higher quality thermometer, or to your room thermostat.

If you have liquid crystal thermometers, you can try them instead.

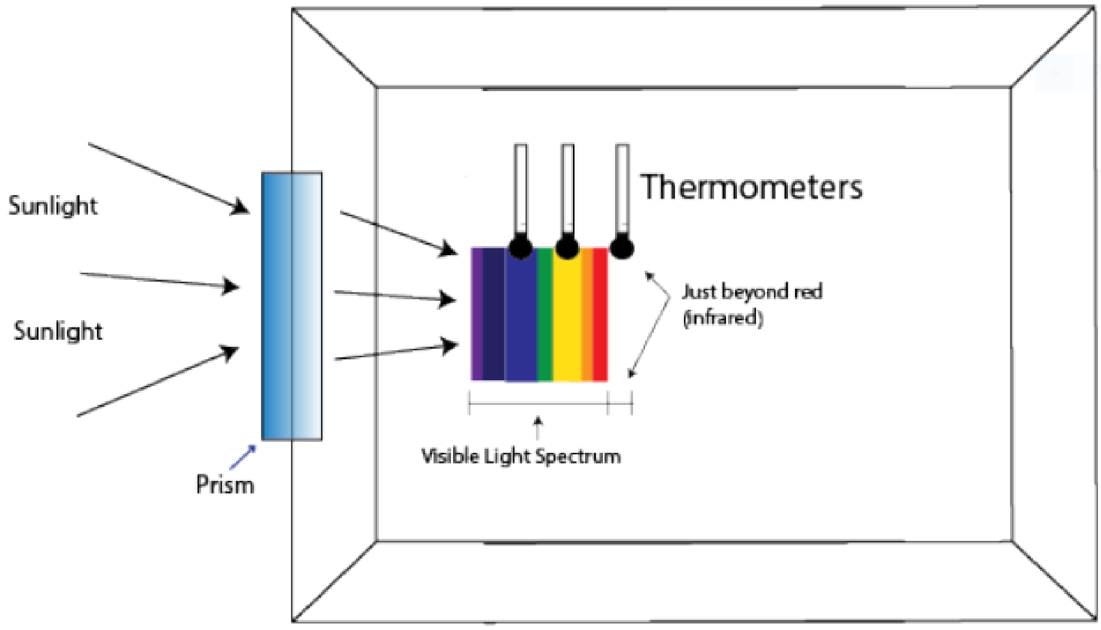
The experiment should be conducted outdoors on a sunny day.

Engage:

View a visible light spectrum. Children should set up a glass prism on the edge of a cardboard box, lined with a piece of white paper and adjust the prism so that the spectrum falls into the shaded part of the box. The whole box may be tilted towards the Sun to increase the size of the spectrum. This part of the activity can be done inside or outside. Ask: what do we see in the base of the box? (a rainbow or spectrum) Where did the colours come from? (The Sun) What different colours can we see?

Investigate:

Measure the outside air temperature in the shade. Then move the prism box into the sunlight and place the darkened bulb of the thermometers in three different places: the blue and yellow parts of the visible spectrum and just beyond the red edge of the spectrum. The thermometers can be taped to card to hold them in the same position relative to each other. Record the temperature every minute for five minutes. Take care not to block the spectrum or disturb the thermometers when making readings. Carry out the experiment in sunlight first, then repeat in the shade (can the children see a spectrum in the shade?).



Where was the thermometer that recorded the lowest temperature? The highest temperature? Did they find the same as Sir William Herschel, who found the highest temperature below the red part of the spectrum? This is now called “infra” (means below) red.

Compare your results to other groups. Did you all find the same thing?

Take the Next Steps:

Try the experiment at a different time of day, do you still find the same results?

Try to measure the temperature of the spectrum in different places, beyond blue or in green for example. What would you expect? What did you find?

Infrared Remote-Controls

Investigate infrared electromagnetic radiation by using your television remote-control as a source and a digital camera as a detector.

Tools and Materials

- Television and its infrared remote-control (some have a small lightbulb at the end of the remote and some have this part covered). I used an old Sky remote control.
- Digital camera, a phone camera can be used, but note that some iPhones have filters that block infrared light. If your phone has two cameras, check both. Laptop or web cams can be used.
- Variety of plastic bags, clear, transparent, black etc or different types of paper
- Piece of glass or clear plastic
- Mirror

Background:

The human eye is not sensitive to the infrared light used by television remote-controls. Our eyes can only see a portion of the electromagnetic spectrum, and infrared light—which has lower frequency, longer wavelengths, and less energy per photon than red light—is just outside the range of the light we can see.

Infrared light is often divided into the near-infrared, which is closest to the visible spectrum, and far-infrared, which is emitted by warm objects. To send a signal to a television, remote controls often use a diode that emits light in near-infrared light.

Engage:

Use the infrared remote-control to turn the television on and off or to increase or decrease the volume. How far to the side of the television can you point the remote-control and still have it work? How far away from the TV can you be and still have the remote-control work?

Point the remote-control at your eye. Press the button that turns the television on and off. Can you see the light coming from the bulb in the remote? Note: Do not stare at an infrared light source for prolonged periods of time.

Point the remote-control at a digital camera and press a button on the remote (on/off or volume are good choices). Can you see light coming from the bulb on the screen of the camera? This light may look pink, purple or white.

You may not see anything if your camera has an infrared light filter. If you are using a mobile device with two cameras and don't see a light, try the front-facing camera, which is less likely to have a filter. A laptop webcam can also be used.

Investigate:

Place a clear piece of glass or plastic between the remote and the camera. Use the camera to look at the remote while you press the buttons. Does the glass or plastic stop the camera from detecting the light?

Point the remote toward a mirror and look at the image through the camera while you press the buttons. Does the light from the remote bounce off the mirror into the camera? If it does, then infrared light is reflected in the same way as visible light.

Try to change channels or turn up the volume on the remote while pointing the remote control through a single layer of material from a black plastic bag. Did it work? Try the same thing through two or more layers, and then do the same experiment with the digital camera. Is there an image in the digital camera when you push buttons on the plastic-covered remote?

Try other types of material such as single layers of tissue paper, coloured papers etc.

If you can see the remote's light through the camera, but cannot see the remote, then you have found a material that lets infrared light pass but blocks visible light.

Take the Next Steps:

Astronomers use infrared light to look through dust clouds because it passes through dust better than visible light, just as it passes through a black plastic bag.

Thermal cameras like the ones you see in science museums work in the far infrared. They show the infrared light emitted by warm objects. Far-infrared light is not detected by digital cameras and will not pass through clear plastic or water.

Adapted from: https://www.exploratorium.edu/snacks/infrared-remote

DPSM/ESERO

Framework for Inquiry - Promoting Inclusion

SPECIAL EDUCATION SUPPORT SERVICE
building on ability

When planning science activities for students with Special Educational Needs (SEN), a number of issues need to be considered. Careful planning for inclusion using the framework for inquiry should aim to engage students in science with real purpose. Potential areas of difficulty are identified below along with suggested strategies. This list is not exhaustive, further strategies are available in the Guidelines for Teachers of Students with General Learning Disabilities (NCCA, 2007).

ENGAGE

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Delayed language development/poor vocabulary/concepts	• Teach the language of science demonstrating meaning and/or using visual aids (material, property, strong, weak, textured, dimpled, absorbent, force, gravity). • Have the student demonstrate scientific phenomena, for example gravity —using 'give me, show me, make me,' as much as possible. • Assist the student in expressing ideas through scaffolding, verbalising a demonstration, modelling. • Use outdoor play to develop concepts.

INVESTIGATE

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Fear of failure/poor self-esteem/fear of taking risks	• Model the speculation of a range of answers/ideas. • Repeat and record suggestions from the students and refer back to them.
Understanding Time and Chronology	• Practice recording the passing of time, establish classroom routines that draw the students' attention to the measurement of time. • Teach and practice the language of time.
Fine/Gross Motor Difficulties	• Allow time to practice handling new equipment. • Allow additional time for drawing diagrams, making models etc. • Give students the option to explain work orally or in another format.
Short Term Memory	• Provide the student with visual clues/symbols which can be used to remind him/her of various stages of the investigation.

TAKE THE NEXT STEP

POTENTIAL AREA OF DIFFICULTY	STRATEGIES
Developing Ideas	• Keep ideas as simple as possible, use visuals as a reminder of earlier ideas. • Discuss ideas with the whole group. • Repeat and record suggestions from students and refer back to them. • Encourage work in small group and in pairs.
Communicating Ideas	• Ask students to describe observations verbally or nonverbally using an increasing vocabulary. • Display findings from investigations; sing, do drawings or take pictures. • Use ICT: simple written or word-processed accounts taking photographs, making video recordings of an investigation.

REFLECTION

- Did I take into account the individual learning needs of my students with SEN? What differentiation strategies worked well?
- Did I ensure that the lesson content was clear and that the materials used were appropriate?
- Was I aware of the pace at which students worked and the physical effort required?
- Are there cross curriculum opportunities here?
- Are the students moving on with their skills? Did the students enjoy the activity?

More strategies, resources and support available at **www.sess.ie**

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