CAMERA ACTIVITIES

ASTROBOOST

Ideas for activities using the Flir-C2 infrared camera

Activities to help demonstrate how the camera works and how to interpret the images.

Learning objectives:

1. Like Webb, the camera uses infrared light to reveal information not visible to our eyes
2. Infrared is like visible light in some ways
3. Infrared is different from visible light in other ways
4. Familiarity with the words "infrared", and (for ages 11/12yr+) "emitting" and "wavelength".

Photo: Julia Gaudelli, Guildford Astronomical Society

Common misconceptions:

If someone holds a misconception, it can be very hard for them to replace this idea in their mind, even if you explain it clearly. You will need to tackle these head-on if they are to try to change their prior beliefs.

Common misconception 1: That the camera measures the temperature of the object (not true, although if you calibrate it to the correct material then the data it collects can be used to give a good estimate of temperature).

Common misconception 2: That eyes/camera are emitting something that collects information from the seen object.

Common misconception 3: 'infrared is heat'. It is not; infrared is electromagnetic radiation, just like visible light. It just so happens that mid-infrared is easily absorbed by everyday objects/bodies and so is good at heating things up (transferring energy from one object to another). So our most familiar experience of it is that it makes us feel warm

Break down the concepts:

Take it one step at a time - it's a lot to process for people who are new to the concept of infrared. Avoid getting into reflection or good/bad emitters until they are confident with the general idea of what the camera is detecting.

Separated concepts to tackle one at a time (not necessarily in this exact order):

1. The camera shows a view of the world different from that which we see with our eyes.
2. Hot objects appear bright/different colours when using the camera.
3. Both our eyes and the camera work by detecting light that happens to shine into them from outside (many people, especially children, think that the eye sends light/something out to capture the image).
4. The camera detects *infrared light*, in contrast to a normal camera, or your eye, which detect *visible light*.
5. Infared is a type of light that is invisible to eyes. It's next to red on the rainbow.
6. Infrared light is going from the object into the camera.

7. Objects give out (emit) infared. (This is difficult to grasp; they are glowing with invisible light).

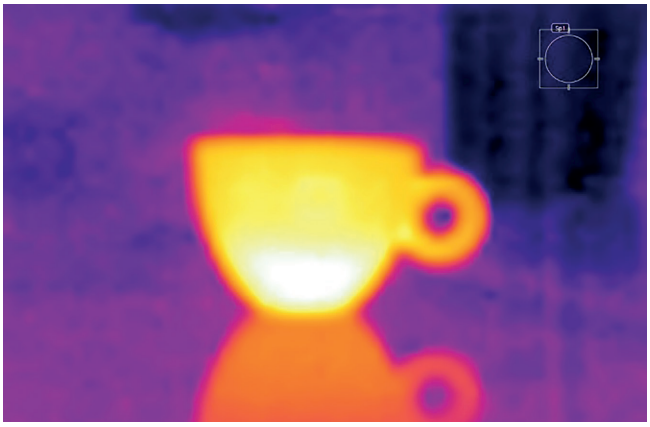
8. The hotter a thing gets, the more infrared light we see coming from it.

9. Infrared light doesn't always behave exactly like visible light. Different materials can reflect/absorb it.

10. By detecting infrared light, we get information that we cannot access just using our own eyes.

The last item is the key for understanding why the Webb Telescope uses infrared

Warming objects - Head pad



We've provided a heat pad as a way to safely warm objects without need for a complicated risk assessment. Keep the pad opened up flat and it will not overheat (if it does overheat, only the manufacturer can reset it!). Be aware it turns off periodically if left for a long time. Remember to tuck the cables out of the way, and don't use if damaged.

If you use other methods to heat things, just be careful with risk assessment for anything that gets over 40°C. Remember escapee toddlers won't read warning signs, and always have a plan for in case anything did go wrong.

Suggested activities

Attention Grabber: see yourself on screen!

This works very well on a drop-in display stand. People love to see themselves and to try different things, including taking photos of themselves. It's an effective way to attract visitors. You can then offer them different materials to experiment with, or give them ideas for things to try, depending on their ability to direct their own investigations. This gives an easy way to start a conversation.

During a Powerpoint talk, you can point the camera at the audience. Make sure you give them some time to enjoy waving their arms around etc before you start trying to explain what they are seeing as they won't be listening to you at first! With younger/excitable audiences you might need to turn the camera away to recapture their attention before continuing.

Humans are great to observe as they have both hot and cold bits, and people are (mostly) familiar with which are which. Also people enjoy looking at humans! This makes people a good thing to look at while talking about how the camera detects infrared, and that hotter things tend to give out more infrared and so appear brighter.

Top tips:

- Be ready to move the camera to preserve people's modesty if necessary! Bras may be visible through thin tops, and it's best to avoid the groin area.

- Do not ask people to undress or lift clothing (even if it's just a school jumper). However, be aware they may choose to do this! If they do, you will need to dynamically assess whether their behaviour is appropriate and safe for the context you're in (e.g. an unaccompanied child vs a child with their adult are very different).

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Decoding the images: Relating camera image to heat of objects

The following activities give you the excuse to repetitively explain what the camera does, in different ways, using the scientific language you want them to become familiar with.

It's expected that you should have to explain things a few times before people understand; repetition is required for formation of memory. Also, different people will 'get it' from different types of explanation.

Things to try:

1. **Rub hands** together or rub feet along the floor. (Friction; kinetic energy transformed to heat energy.)
2. **Press hand** against magazine or other object, then remove it and look the handprint. The magazine demo goes down very well with primary age pupils, especially if it goes through to the other side. (Conduction.)
3. **Walk** without shoes across the floor, and look for footprints. (Conduction.)
4. **Spray compressed air** onto book / hand to rapidly cool it. (Decompression.)
5. **Suck air** in through clenched teeth (this will cool them).
6. **Free exploration** by a small group – the camera is robust and easy to use even for young children. They will talk to each other about what they're doing, which is great for cementing understanding and learning new language. Teenagers may be more confident to chat to each other when you aren't close by.
7. **Ice War Paint**: let people draw on their faces/arms with pieces of ice. Beware this will quickly get messy!

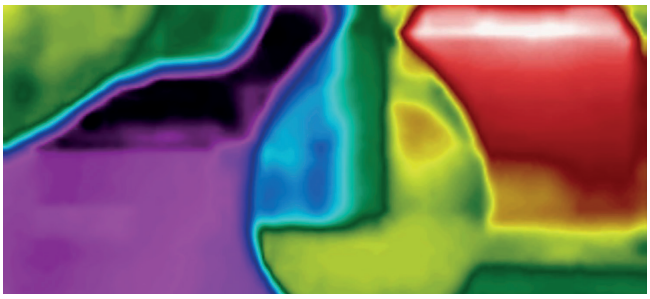
In my tests, the Flir C2 didn't appear to have good enough resolution for the mixing of hot water / ice to give a good result, but it'd be worth experimenting with this yourself to see if you can make it work.

Things to try outdoors:

1. Look at **cars!** You can see the hot engines (or spot electric cars), and see their wheels heating as they brake. Can you spot those cars which have started their journeys recently? Or recently parked cars?
2. Smoke – if you are at an event with a fire or barbecue, you could try looking through the smoke with the camera. This would be a perfect demonstration of how Webb will look through nebulae. Careful risk assessment required if you are to try this!

Top tip: you may want to fix the colour-mapping on the camera to a specific temperature range, to make temperature changes easier to track. This especially where an object is the hottest or coldest thing on screen. By default the camera will dynamically change the mapping to the range of temperatures currently in view.

Infrared properties (vs visible light)



Infrared behaves like visible light in some ways, but differently in others. Once people understand what the camera is showing, you can use it to demonstrate these differences.

Jargon words:

Opaque, translucent, transparent, transmit, transmission, absorb, reflect

1. Bin-bag material: nearly-opaque to visible light; transparent to infrared.

You'll to test this on your particular bags to be sure; cheap-ish bags are great, thick rubble-sacks will not work! Bin bags can be used to represent a 'nebula' hiding interesting objects that Webb will be able to observe. For demonstrations the material can held up in front of a person, who is still visible to the camera. (Do not let anyone put the bag over their head.) When using the bin bag to screen objects from view, ensure they are not touching the bag, else the heat will conduct through.

It's weird that Bin Bags have this properly as they are black. Black is usually good at absorbing infrared! However, this material has been specially designed to be transparent to infrared so that any heat from decomposition of the contents can escape (rather than getting trapped and speeding decomposition).

2. Glass: transparent to visible light and near-infrared; opaque to mid-infrared.

Visible/near-infrared sunlight can get into a greenhouse and be absorbed, heating the contents, but infrared radiation emitted by the heated objects cannot escape. Try looking at people who are wearing glasses. Do you think the infrared camera lens could be made of glass? *(Why not?*)*

3. Mylar (e.g. emergency blanket): reflects both visible and infrared light.

This can be a nice surprise and a good way to recall that infrared is a type of light. Webb's sunshield material similarly reflects infrared light to keep it cool. Why are emergency blankets made of Mylar?

4. Water Balloon: water is opaque to infrared; the stretched balloon is translucent.

It is possible to fill a balloon half with air and half with water to show that the water is absorbing the infrared. Else have one with water and a similarly-sized one full of air. Make sure you have something hot that you can look at through the balloon(s) to make the difference clear.

This demo can be used to explain why the water-laden atmosphere ruins our view of the infrared universe. Nb raindrops don't absorb all of the Sun's infrared and so rainbows do still have a mid-infared band.

I tried to fill a balloon with CO_2 from an acid/base reaction to see if you could talk about CO_2 absorbing infared re climate change, but I couldn't get this to work (I'm pretty sure you'd need a lot more CO_2).

Health & Safety tip: some people are allergic to latex

** This is one of the reasons these cameras are expensive (another being their specialised detector).*

Activities for older audiences

Best for secondary school age (11/12yr+) and adults, after they are confident with the concepts discussed above.

1. Why does the mirror need to be SO big

Webb's mirror is a lot bigger than that of Hubble, but its resolution is similar.

Infrared light has a longer wavelength than visible light.

2. Do all room-temperature objects look the same on camera?

They will observe that objects can look different. This happens if one is a better *emitter* than the other.

This is an excellent entry to reinforce the fact that the camera does not show temperature! The camera can only detect infrared, and different objects give out different amounts of infrared depending both on temperature AND how good an emitter it is.

Good emitters are also good absorbers, so things that heat up more easily in the sunshine are also better emitters – e.g. black things tend to be better emitters than white things. Can you find any examples of this? Are there counter-examples (e.g. shiny black things)? Can you predict which of two objects is the better emitter before looking with a camera?

3. How does the Webb space fridge work?

Demo requires a bicycle pump with value, and a compressed air cannister (you can buy the latter for cleaning electronics/keyboards). It is best to fix the colour-mapping on the camera before doing these demos, so that the temperature changes are clearer.

Concepts to demonstrate:

Depressurisation cools things down. Show the cannister is room temperature, then spray it onto an object (e.g. your own hand). As the gas escapes, it depressurises, and cools.

Pressurisation heats things up. Use a bicycle pump with nozzle and show it heating when pumped. This is a bit of a tricky demo so make sure you practice in advance especially re how to hold it so that conduction from your warm hand does not confuse the demo.

How do fridges work:

The space fridge works like a domestic fridge. Fluid circulates. On the telescope side of Webb, the fluid is depressurised, so that it gets VERY cold and is able to absorb any tiny bit of heat from the instruments. Then on the sunward side of Webb, the same fluid is pressurised, heating it up so that it can radiate the collected heat away into space.

AstroBoost

These resources are adapted from the Royal Astronomical Society's original AstroBoost project, which was funded by a STFC Spark Award. The project was managed and developed by Dr Jenny Shipway.