Cold Webb activities

What's it all about?

Activities for the Webb L2 & space fridge part of the show:

1. Where is Webb (measure distances to show orbit)
2. Pressurise/depressurise gas (use IR camera to show temperature changes)

Objectives:

3. Appreciate why it is necessary for Webb to be cold (ie reduce IR interference)
4. Get an idea of where Webb is in space (especially that it is not in low Earth orbit)
5. Get a feeling that spacecraft systems are explicable (especially KS3)

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1. Where is Webb

Objectives:

- Webb is far from Earth
- Webb does not orbit Earth

Set up:

- 2 cm Earth model / 6mm Moon model / Webb model, all hung on untangled threads.
- Tape measure
- SPACE! You need over 2.4 m along the room, and (to swing the model) 2.6 m height. This is slightly higher than a standard room (for a quick estimate, know that standard doors are 2 m).
- Test swing Webb. Consider safety, and also the circle your hand makes so you can subtract its diameter from the length of string.
- For extra awesome, work out somewhere the kids know that is 235 m from where you are, so you can refer to this when mentioning the Sun's location.

Point out that the slide is not to scale …

I have models here for Earth, Moon and Webb, but can't hold them all myself so will need two people just to help me hold them [make it clear this is not a hugely exciting volunteer opportunity].

Bring up volunteers one at a time, taking their names and getting each in position before bringing up the next. This saves them waiting in an awkward queue.

Earth volunteer – hold Earth! Spend a bit of time pointing out the scale we are working at here – that tiny ball is our entire planet. Ask the volunteer how small they can imagine they would be at this scale. Ask people to imagine where the Sun is, but fairly quickly let them know it would be 235 m away.

Moon volunteer – hold Moon! Ask audience where they should stand – how close to Earth. Show with your hands. Ask them what they think etc. Then measure it – 60 cm. If there is room, get them to walk around the Earth once to demonstrate the motion of the Moon.

Webb model – presenter does this unless there is oodles of room. Explain this isn't to scale because if it was it would be about 10 nm wide - the size of a big molecule. Slowly carry it from Earth on its journey to L2, saying anything you like about how this journey is managed, when the sunshield opens etc.

Explain that Webb does not stay in that one position, but orbits L2. And it has a BIG orbit. Swing the model! (Check that everyone is well out of the way before and during this activity). If there is room, ask Moon to orbit as well (once everyone has had a chance to see Webb's motion).

Try to involve the volunteers if you can, by eg waving at Earth when talking about comms, or holding up your hand to shield yourself from them in a comedy way.

* Understanding what L2 is / how the gravity works is not a learning objective. The audience's prior knowledge is unlikely to be advanced enough to allow a full explanation within the limits of the show.

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2. Pressurise / Depressurise gas

Demonstration of how pressurisation/depressurisation of gas is used by the space fridge to cool MIRI.

Objectives:

- Pressurising / depressurising gas affects its temperature
- Fridges work by means of heat *transfer* (ie they don't just remove heat from the universe)

Set up:

- Infrared camera, projecting onto screen (colourised image)
- Cannister of compressed air (safety: store away from heat)
- Bicycle pump
- Consider how the pump should be used to minimise possible hilarity (eg not held between legs)

Webb's sunshield keeps the the telescope cool enough for the other instruments, but because MIRI detects longer-wavelength IR it needs to be particularly cold. For this reason MIRI has an active cooling system.

It works very much like a home fridge; it moves heat from one place to another. Home fridges take heat from inside and dump it into the room. MIRI's fridge takes heat from MIRI's detectors and dumps it on the sunny side of the telescope.

Both fridges control heat transfer by pressurising and depressurising gas.

Let me show you what I mean, using this can of compressed air and this bicycle pump. We'll use the infrared camera to track temperature changes. I need a volunteer who knows how these pumps work.

Bring up a volunteer, check that they know what to do - verbally explain / mime the motion. [Usually we'd test the motion, but this will heat the pump so that the demo was less impressive - option to get a second pump for testing purposes].

Point out that the compressed air in the can has been at room temperature this whole time so the very squashed-up air inside it is at room temperature. And the pump will of course be taking air at room temperature from the room.

Ensure both of you are on camera, ask the audience to guess what will happen. Countdown, then you squirt the air (away from faces) and they pump the pump. Keep the air pressed down for a long time. Ask the audience what they can see. If the pump volunteer is facing away from screen, tell them to look around to see what is happening (do this after the audience have seen the effect).

Stop the squirting/pumping and ask the audience in a controlled way what has happened to the air from the can (it cooled), and what has happened to the air in the pump (it warmed). Thank the pump volunteer and have them sit down so they're not stood like a lemon during the explanation.

The air from the can cooled down when it was released and could spread out. The air in the pump got hotter when [Fred] pressurised it inside the pump. Note that the pump has a smooth motion so there is little friction - it is not warming due to friction.

In MIRI's space fridge, gas is depressurised - spread out - just before it gets to the detectors, to make it really really cold. It takes heat away from the detectors, then is moved to the sunny side of the telescope, where it is pressurised to heat it, so that it can radiate the heat energy away into space.

[Science warning: the reason why gases cool on expansion is surprisingly complicated and you may well find simple explanations that are not technically correct. I'd advise avoiding discussing this in detail!]

AstroBoost Project

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