Question 1:

Dear Cheap Astronomy – What is near infrared astronomy good for?

Near infrared is near the visible spectrum while far infrared is farther away and mid infrared – yep you guessed it is in the middle. Something that's apparent every day on Earth is that our atmosphere scatters the blue part of the visible spectrum, which is why the sky is blue – and once the Sun gets down near the horizon the thicker atmosphere blocks completely blocks blue, as well as green and yellow, so you only see oranges and red shining through. And even when the Sun is high in the sky, if there's a lot of wildfire smoke in the air you get the same effect – the Sun looks red because it the only part of the visible spectrum that can get through.

So that is the advantage of infrared – which is even redder than red, it will shine through dust that will otherwise scatter or block shorter wavelengths. So, in infrared, you can peer into dust-shrouded stellar nurseries and watch planets form within a protoplanetary disk. Infrared astronomy can also detect objects that are too dim to produce much visible light, such as brown dwarf stars and also very distant objects whose light has been red-shifted beyond the visible spectrum.

Near-infrared is particularly popular with astronomers since you can use a normal optical telescope with a specialised infrared detector on the end, while mid and far infrared work need more specialized equipment. For example, the mirrors of the James Webb infrared space telescope are coated in gold, while telescopes optimized for visible light use silver or aluminium, such as the Hubble Space telescope. But despite that, for many years the Hubble had an instrument called NICMOS, the Near Infrared Camera and Multi-Object Spectrometer – though that was later superseded by the Wide Field Camera 3, which works across a wide range of wave lengths from UV to optical to infrared. But anyway, that is the general idea, near infrared you can use a standard optical telescope, but for mid and far infrared, you're better off with a purpose-built infrared telescope.

What complicates infrared astronomy on Earth is that water vapour tends to block it, so you'll generally find telescopes with near infrared detectors on mountains and high plateaus, notably Mauna Kea and the Atacama plateau. If you want to go full infrared, you could put a telescope in a plane like SOFIA the Stratospheric Observatory for Infrared Astronomy, but the ideal location is in space – as we did with the Spitzer telescope, which was operational until 2020 and now the James Webb Space Telescope.

Like James Webb, the Spitzer telescope had a gold-coated beryllium mirror, beryllium being preferred as it doesn't change shape in extreme cold. Extreme cold is important because with infrared you are aiming to observe faint heat sources, so the telescope and its detector should ideally be kept cooler than those faint sources. The James Webb space telescope deals with this by having a multi-layered vacuum gapped sunshield in front of which are its solar panels for power and its antenna for communicating with Earth, while shadowed behind it are the telescope mirror, sub-reflector and its various cameras, detectors and instrumentation. The sunshield keeps everything in shadow at a temperature of around 34 Kelvin, which isn't bad, but for optimal infrared observations, its detectors are cooled by slowly evaporating liquid helium down to about 7 Kelvin.

As similar approach was adopted with the Spitzer infrared space telescope, which had a telescope tube rather than a sunshield. Launched in 2003, it had a cool mission phase followed by a warm mission phase after its liquid helium ran out in 2009. During the cool mission it could observe in far infrared, while in the warm mission, it could still do near infrared and optical. James Webb's liquid helium could all be gone by 2028, ending its cool 7 Kelvin mission after which it will have a continuing warm 37 Kelvin mission which could extend as far as the early 2040s, or whenever its hydrazine propellant runs out. And of course, the closing line for this podcast is that near infrared astronomy is cool – even if far infrared astronomy is cooler.

Question 2:

Dear Cheap Astronomy – What are the viable alternatives to CSOTM?

Regular listeners will be aware of CA's CSOTM plan to manage asteroid mining by crashing $#!+ on the Moon, a plan widely regarded as a naïve, if not delusional, by critics within the very small population of people who have even heard of the idea. So, it's probably not unreasonable to spend an episode investigating some alternatives.

At this time, most mainstream thinking involves mining asteroids in situ, meaning that you either rendezvous briefly with them as they pass by Earth or you chase them around the Sun. Either way, the general idea is to chip bits off them and then fly the chipped-off material back to a space-based refinery. No crashing required. If a human crew are going to do the chasing, chipping and refining, that could mean a long time in microgravity, with all the associated physiological deterioration that entails. If robots are going to do it, they need some capacity for self-repair and self-direction since the radio delay to and from Earth could be up to twenty minutes or more if they are going to keep working through an asteroid's full orbit around the Sun.

Another less talked about alternative is to divert asteroids into lunar orbit, which does collect them all in one place and then you can put your space refinery in lunar orbit too. You still face the challenge of mining fast-moving rocks, but chasing them around the Moon seems an improvement on chasing them around the Sun, plus you get all your materials queued up ready for processing.

This is perhaps the first fork in the road in deciding on the best asteroid mining strategy. Do you chase them around the Sun or bring them in for processing. Either way is beyond our current technological capability, though we made some baby steps in both directions – so we have visited and sampled asteroids and we've also diverted their trajectory, at least a bit – and in both cases, we've used robots.

In situ mining is the more-favoured approach right now, since we can keep on taking baby steps towards it, while with diverting near-Earth asteroids, there's a worry that one false move could wipe out a city. But in parallel, we do need an eventual solution to dealing with asteroids that are coming right at us on a natural trajectory, so more baby steps are required anyway. So that's one decision point – or maybe there'll be a hybrid solution, where we divert all the sub-kilometre near-Earth asteroids, but leave the big ones for in-situ mining.

The next fork in the road is refinement. It's not too likely we find an asteroid where we can just chip off big chunks of platinum, instead there'll be a mess of mixed ores you need to process to get the stuff you want and then dump the rest. The refinery is really the defining part of the argument for a space-based versus surface-based mining strategy. If a space-based refinery can operate effectively and efficiently in microgravity, then there's no point in firstly making a mess of the Moon and then wasting fuel launching refined materials out of its gravity well. Instead, you really can just chip bits off passing asteroids, refine them down to the essentials and then fly those essentials back to Earth.

The catch is that bit about effective and efficient operation in microgravity. Pretty much everything about mining on Earth takes advantage of gravity and refining even more so. So, your space-based refinery will need giant centrifuges to mimic gravity's ability to sort light things from heavy things. If you need fluid solvents for your refining, you can't just pour stuff into a pot and stir. Instead, you'll need some complex plumbing with valves and pressure gradients and filters. Like the giant centrifuges, it's not an unsurmountable problem, just more complexity and expense. So, viable alternatives? Well, it's hard to be sure about the viable part, but yes there are certainly alternatives to crashing $#!+ on the Moon.