Question 1:

Dear Cheap Astronomy – Does infinite exist in reality?

Well, first you need to define what reality is…

If reality is what is prevalent in the here and the now then no, there is nothing that is really infinite. Any material thing you can imagine has a finite quantity. You can subdivide material things down to subatomic scales, but based on what we understand of particle physics at the moment, once you hit a fundamental particle, like an electron or a quark, then that's that. So, if the quantity of material things is finite then the quantity of fundamental particles that make up those material things is also finite.

But… if the Universe is infinite, couldn't there be an even distribution of material things existing throughout it, which means there could be an infinite quantity of material things? And this is perhaps the crux of the matter, if the Universe is infinite, then all sorts of things within it might be infinite as well.

However, it's not likely that the Universe is infinite. All indications are that it began as a point source about 13.8 billion years ago and has been expanding outwards ever since. However big it is now, it was originally contained within a point source, so regardless of how big it is now we should reasonably consider it finite.

But of course, it's not quite that straightforward. We have no idea how big the Universe is now, because it has expanded beyond our observable range. We are able to detect photons that have been travelling at the speed of light for 13.8 billion years, but since the Universe has been expanding over that whole 13.8 billion year period, these are not photons from 13.8 billion light years away, but from 13.8 billion years ago. This is where you have to accept Einstein's postulate that time is space and space is time – or, more accurately, they are just two aspects of the same thing… spacetime.

So, let us take you back to the first line of this podcast: If reality is what is prevalent in the here and the now then no, there is nothing that is really infinite. But of course, when we say the here and now we are only talking about what we can observe here and now. The light from the Sun we receive here and now, left the Sun eight minutes ago, the light from Proxima Centauri left it 4.3 years ago and the light we receive from the Andromeda galaxy left it 2.5 million years ago. So what we think of as here and now is really just a collection of very local phenomena. Everything we observe of the wider Universe is very much not here and not now.

So, even though the Universe might not have an infinite expanse, right now like today now, it is a spacetime Universe. So, we need to accept that its vast expanse is not just a matter of distance, but also a matter of duration. Although the phrase 13.8 billion years just rolls off the tongue, it is actually a really long time. Indeed it's the longest time that we know about. I mean you might think it takes a long time to go down the road to the chemist, but that's just peanuts to spacetime.

So, since we live in a spacetime Universe that is not only expanding, but accelerating in its expansion, we need to consider whether it has an end in a spacetime sense. And, that's hard to be definite about. There might come a time in the far future, when the last black hole

has evaporated and the last photons are stretched into such low energy wavelengths that they become indistinguishable from non-existence. Is that end of the Universe? Well, not necessarilyIt will still exist as an empty spacetime and still expand ever-faster. So, maybe that is the best answer. Time, or more accurately spacetime, looks like it is (or at least will become) infinite – unless we revise our cosmology in the future and determine that it isn't.

Question 2:

Dear Cheap Astronomy – With still nothing from SETI, is it possible we are looking for the wrong things?

Well, no probably not. There are some pretty smart people running SETI, the search for extraterrestrial intelligence, who have probably thought through more technological scenarios and possibilities than we could ever hope to present here. But what we can present here is one of the many offshoots to SETI – that is, SETS, S_E_T_S – the search for extra-terrestrial starships.

First, let's look at the context in which SETI is being undertaken. Who knows where Earth is on the universal intelligence development timescale. Our star formed about five billion years ago – which for an almost 14 billion year old Universe, sounds like a bit of a late start. But, it's not likely the first generation of stars would have lasted long enough to allow life to evolve before they went kablooey – and it's not all that likely the second generation of stars could have done much better. Third generation stars, also known as Population 1 stars, began to form around 10 billion years ago. So, as Population 1 stars go, ours is pretty standard and unremarkable – small enough to last for several billions of years, but not red dwarf small enough that planets in their habitable zone would have to be so close in to their star to be be tidally-locked, and so ending up being very cold on one side and very hot on the other. Although, if such a totally-locked planet had a moon that orbited it – then that moon could possess a day-night diurnal rhythm. Think Pandora, for example.

Anyhow, in a Universe that is capable of supporting life, it seems almost unreasonable that we are its one isolated example of technologically-capable life. But we don't know if we are early-starters or late-bloomers. If we are early starters, then the current radio silence out there makes sense. We might even be the first. That is statistically-unlikely – but then it's statistically-unlikely for anyone to be first, although someone has to be. And that is worth holding onto. On balance, it's much more likely that we are the first than that we are entirely alone.

On the other hand, if we are late bloomers then there may be many more-technologically advanced folk out there. Any advancing technology that follows a similar path to our own is likely to adopt increasingly efficient communication solutions that send data direct from source to target, rather than relying on inefficient radiative broadcasting techniques that leak noise all over the cosmos. So, unless an advanced civilisation is deliberately broadcasting for the purpose of getting noticed, it's entirely likely that civilisation's home-base would appear electromagnetically-silent from a distance.

This is where SETS comes in. While the aliens may have sewn up any background communications leakage, if they are living the Star Trek dream then there's a fair chance we

should be able to find evidence of their starships .We're not talking warp signatures though – it's not at all likely that anyone out will achieve faster-than-light travel – because, you know, physics. But starships travelling at close-to-light speed should leave observable signs – perhaps their propulsion system leaving an exhaust trail; or their forward-facing deflector dish clearing a path through dust clouds; or their home-based laser system pushing a light sail craft out along its way.

While no-one is anywhere near ready to stake their reputation on it, both the 2009 space roar and the 1977 Wow signal are both plausible SETS incidents, since neither is readily explained by natural phenomena and there has never been a repeat signal from either location subsequently. Perhaps as our observational equipment and our observational resolution gets better – the next time there's a SETS event, we might be able to capture a lot more detail and genuine evidence of technologically-based interstellar travel.

Incidentally, in 2012, on the 35th anniversary of the *Wow!* signal, Arecibo Observatory beamed a response, which contained 10,000 Twitter messages, transmitted in the direction from which the signal originated – towards the Sagittarius constellation. Arecibo scientists attached a repeating sequence header to each message to let any receiving entities know the messages were intentional and from another intelligent life form – although an intelligent life form that thought it was a great idea to send 10,000 messages in their local dialects. In the future, we are hopefully going to get a bit smarter about determining what signals go out, as well as determining what signals come in.