

Question 1:

Dear Cheap Astronomy – What is time made of?

So firstly, time is not something you can deal with in isolation. It is just one aspect of spacetime, where the other aspect is space. The reason the Universe has an ultimate speed limit is that you can never cross any distance of space without time also passing. By using more energy and better technologies you can certainly reduce the duration of travel between points A and B, but that duration will never reach zero. Similarly when we look far out into the universe, or even when we look across the room we are also looking into the past – and the further away something is, the further back in time it is. Time and space are so intrinsically connected that we just call the whole thing spacetime.

So what is spacetime made of? Tricky. It is intangible to any of our senses in a material sense. We can measure the distance between objects, noting that distant objects are distant in both space and in time. But all we are doing there is measuring the expanse without saying anything about what it's actually made of.

There are various grounds for arguing that spacetime does not really exist – although if you're stuck in a queue to pass customs and your international flight departs in 15 minutes you may not be all that partial to this line of thinking. But consider the humble photon, it moves from point A to B with no proper duration of time, that is if it had some kind of consciousness or some kind of measuring device, it could neither experience nor measure the passage of time. Equally if no time passed between it moving from point A and point B, then it would be at point A and B at the same time – indeed if you extended its line of travel out to point C it would also be a point C at the same time. So just as a photon would have no perception of time, it would have no perception of distance (or space) either.

But really this is just an issue of frames of reference. For a photon, it's absolutely true that there is no time and space, but that's because a photon moves at the speed that defines the interconnection between space (distance) and time. Spacetime in our universe is measured as the ratio of 300,000 kilometres of distance to 1 second of time, so if you can cross 300,000 km of distance in one second then there's no duration and there's no gap, but if it takes you two seconds to cross 300,000 km, then you start to notice that there is a gap and that it takes a bit of time to cross that gap. And if you're a slightly overweight sub-light speed entity facing a 16 hour flight from Sydney to Los Angeles – that's 50,400 seconds to cross just 12,000 km – and you're stuck in a queue to pass customs and the flight departs in 15 minutes, then you'll have no problem in acknowledging that spacetime is very real.

But what's it made of, or why don't we just ask what is it? Well, we do think there was no spacetime before the Big Bang and immediately after there was – and there's a heck of lot more of it now. So, it could be argued that an external observer would see an energetic quantum fluctuation burst into momentary existence, its momentary bubble of energy quickly expanding so as to cool back down to the background zero point energy possessed by the background tapestry of whatever fundamental reality allows the occasional and temporary outbursts of Universes.

As we like to say here at Cheap Astronomy, this is just an example of avoiding the origin problem. If your response to the question of how the Universe came to be is to say that well actually there's a multiverse in which Universes appear and disappear all the time, you're not

really adding much in the way of useful information. Thanks dude, but I actually want to know how this Universe came to be, because my (bleep) international flight is leaving in 15 (bleep) minutes and it's a (bleep) long way to (bleep) Los Angeles. So, I don't give a flying (bleep) about anyone else's Universe I want to know about this one. OK?

A good deal of the world's philosophical conundrums are readily dealt with such circumstances. I queue, therefore I am – indeed, the Universe must be, because why the (bleep) else would I be queueing. I hate (bleep)ing queing

Postscript: I want acknowledge our North American listeners, who are the majority of our listeners, and who might be thinking, what the (bleep) is a queue. Although in the 21st century era of globalization you probably already know a queue is a line right? But come on: I line, therefore I am – that's terrible.

Question 2:

Dear Cheap Astronomy – Is Betelgeuse about to blow?

Firstly, we know it's not really pronounced Betelgeuse and we don't care. Douglas Adams said Betelgeuse and that's good enough for us. Anyway, recently several media outlets got all het up about a prolonged phase of dimming in Betelgeuse's radiance. Of course, it is a variable star and an irregularly variable star at that, so it is meant to brighten and dim on an unpredictable basis – but this did seem like an unusually long dimming phase and so some folks started speculating that it might be about to blow – like, supernova-blow.

We have a reasonably good understanding of the approximate lifetimes of different stars, partly through observation and partly through physics and math, working from the star mass and its spectral class – which is pretty much means its colour. So Betelgeuse's lifespan should be about hundred million years and its actual age is about a hundred million years, so yes it is definitely about to blow in astronomical timeframe terms, but there's enough variance in our calculations that it could go supernova now or a hundred thousand years from now.

And is prolonged dimming a clear sign of a pending supernova event? Well, we don't actually know, having had no prior close- up observations of a star just before it went supernova. However, the physics behind a build up to supernova detonation should involve a steadily-increasing output of energy from the fusion shells around the core until they finally give out with that sudden loss of radiation-pressure leading to the outer parts of the star collapsing inwards very, very fast - and then kablooeey.

But does that all mean the star should dim just before it blows? Well, probably not. Remember it takes around a million years for a photon to work its way out from our Sun's core to the surface. And here we're talking Betelgeuse which is ten to twenty solar masses. Of course, being near the end of its life it has ballooned out a lot to become a red giant and its diameter thought to be larger than the diameter of our asteroid belt. So, its current average density is lower than it was during its main sequence youth, but the general rule should apply. If something happens at a star's core it's going to take a very long time for that event to be communicated out to the star's surface. Well, unless of course, it is the actual

core-collapse event in which case the entire star will be completely annihilated within a matter of minutes. But that's not we're talking about here – the suggestion here is that something has happened deep within the star that heralds its pending destruction and that something has been communicated to the surface well ahead of the actual event.

But how far well ahead? If we use the Sun as the benchmark – if something happened at the core to cause a dimming at the surface it must have happened about a million years ago. It's possible there could be some kind of precursor event that always happens almost exactly one million years before a 10-20 million solar mass red giant goes supernova, but that doesn't seem especially likely. And there's nothing in our current understanding of supernova evolution that suggests that the start of a minus one million years countdown to detonation should result in a dimming of the star's brightness.

We may just have to accept that an irregularly variable star we've been monitoring with some accuracy for around a century has suddenly dimmed down a little more than what we're used to. After all this is what irregularly variable stars do – they vary irregularly. The underlying physics behind Betelgeuse's dimmings and brightenings is not well understood. It could be that the whole star's radiative output is pulsating, but alternatively it could be some quirk of the star's geometry, which is not especially spherical or be some magnetic field shift it could be something to do with its stellar wind, which at this late stage of its lifetime would be sloughing off some pretty-huge coronal mass ejections that could act like fog. More than likely when the kablooeey moment comes we'll all be totally surprised by it, but perhaps by then we'll monitoring Betelgeuse with such constancy that we will pick up all the precursor signs of its imminent destruction so that we'll know what to look for next time.