Question 1:

Dear Cheap Astronomy – Is dark energy anti-gravity, and if so could we ever harness it to build antigravity machines?

Well, no and no, but as we like to say at Cheap Astronomy, let's get there the long way round.

The universe really is expanding – there's some sound observational evidence for that. And its rate of expansion really is accelerating, there's some pretty sound observational evidence for that too.

Dark energy, is allegedly the force that is making the universe accelerate in its expansion. But it's important to be clear that it didn't start the expansion. The standard model of cosmology, says that something started the universe expanding, something that gave it a very big push to bring about a stupendous universal inflation within the first few fractions of the very first second.

Dark energy is thought to have kicked in about the time that we might have otherwise expected that initial big push should have begun to run down, because the initial push had been dispersed in making the Universe enormous and because the cooling, gravitating energy density within it would have begun to resist further expansion.

We say dark energy must have kicked in right about then because there is no observational evidence to indicate that the Universe's expansion has ever been slowed up by the gravitational effect of its contents. Looking at the actual data we have available to us, from the earliest times where we have supernova and redshift data right up until the current day, all we can reliably say is that the Universe has expanded at an ever increasing rate.

What we hypothesise, on the basis of circumstantial evidence, is that very early on, the Universe must have expanded at a phenomenal rate to be the way it is today – and today, it isn't expanding nearly as fast as it was.

And that's all we've got to say. Early rapid inflation is the only explanation we have for the why the Universe is as even and homogenous as it is. And dark energy is out only explanation for why the Universes expands the way that it does. And hey, all that might be true and, here at Cheap Astronomy, we're not offering up any alternate hypothesis. Here at Cheap Astronomy, we're just suggesting you might want to sit back and wait for a bit more evidence to come in.

As for harnessing dark energy, if it is real... Well, there's a long tradition in the TV show Mythbusters, where, when faced with an uncertain hypothesis, the first thing you do is try a small scale experiment. Unfortunately, we're yet to come across any kind of energy that is able to expand spacetime, let alone accelerate it, at small, tiny or even nanoscales.

Of course, the absence of evidence is not evidence of absence – but it's not evidence of presence either. Once again, it's probably best just to sit back and wait to see what science still has to deliver. So, for the moment at least, it's not looking likely that we will all be riding dark energy hover boards anytime soon.

Question 2:

Dear Cheap Astronomy – Is the Universe really a black hole?

Well, probably not, but as with many ideas involving black holes, it's difficult to establish any evidence to either support or refute this. Nearly all the data we would like to have about black holes sits irretrievably behind their event horizons. This is probably why so many theories abound about black holes – no-one can easily prove them wrong.

But, in an attempt to counter the strange notion that the Universe is a black hole, let's begin at the beginning – that is, the Big Bang. At the very start of the universe, all the mass-energy density of the universe was contained within a single microscopic volume.

So, isn't that a problem from the start? How come the Big Bang didn't remain in a collapsed-gravitational state since it comprised all the compressed mass-energy density of every single black hole that would come later?

Here we are dealing with physics that we don't yet fully-understand, but which probably have something to do with entropy. The infinitely-dense singularity at the start of the Universe had zero entropy, while the infinitely-dense singularity inside a black hole has infinite entropy (or at least the highest entropy level that it is possible to have). Or, if we look at it from a space-time perspective, time starts with Big Bang expansion and time ends, at least locally, beyond the event horizons of compressed black holes, where clocks appear to slow to a standstill.

The universe-is-a-black-hole proponents try to use these concepts of opposites to support their theory. Couldn't the formation of a contracted black hole lead to the formation of an expanding white hole – where that expanding white hole represents the birth of a new universe off somewhere else in the multiverse.

Yes… but hang on. In our universe, black holes aren't exactly scarce, nor are they especially huge. The biggest supermassive black hole we know about is 40 billion solar masses and has an event horizon that's almost 250 billion kilometres in diameter. That's certainly big, but it's nowhere near big enough to represent the opposite of our entire universe in either energy-mass density or in volume.

So, maybe our universe isn't much good on creating new universes – and just hiccups a few little ones now and again. Maybe there are other universes out there in the multiverse that are so massively-engorged that their black holes punch out giant new universes for breakfast.

But, wielding Occam's razor over all this, it might be reasonable to ask whether we are just avoiding the origin problem through multiplicity. Maybe our universe does owe its origin to another universe, and that universe owes its origin to yet another universe. But, eventually, we do have to grapple with the notion of how the very first primeval universe came to be. And if we do come up with an answer to that, we might then ask, well… couldn't that answer do just as well for an explanation of why our universe came to be.

As William of Occam once said (sometime around the 14th century) plurality is never to be posited without necessity. So sure, the universe might be a black hole and every black hole in our universe might be another universe. It's not likely that anyone is going to prove this wrong anytime soon.

But perhaps a better question to ask might be whether this untestable claim serves any useful purpose. Does it actually provide us with a better understanding of the physics underlying how our universe came to be? Here at Cheap Astronomy, we say… nope.