Hi this is Steve Nerlich from Cheap Astronomy www.cheapastro.com and this is *Our inferred Universe.*

The Universe is a big place – and getting bigger all the time. The current standard model of the Universe, which is just called Lambda-Cold Dark Matter, assumes that the Universe is expanding in accordance with the geometrical term Lambda – which represents the cosmological constant used in Einstein's general relativity field equations.

Lambda might be assumed to represent dark energy, a mysterious force supposedly driving what we now now believe to be an accelerating expansion of space-time. And then Cold Dark Matter is assumed to be the invisible scaffolding that underlies the distribution of all visible matter across the Universe. This Cold Dark Matter, or CDM, neither radiates, reflects or absorbs electromagnetic radiation. But in the arcane world of dark matter theory *cold* means slow moving - unlike hot dark matter which moves near the speed of light - one known example being neutrinos.

But really, the Lambda-CDM model attempts to describe the entire Universe by starting with this huge assumption that the entire Universe is roughly the same everywhere. This huge assumption also has to apply to the past, present and future - incorporating a single originating Big Bang event, a current flat geometry and a future dominated by accelerating expansion - here, there and everywhere.

This huge assumption is sometimes called the Cosmological Principle and captures the idea that when viewed on a sufficiently large scale, the properties of the Universe are the same for all observers. The Cosmological Principle encompasses two key concepts – that of isotropy, which means that the Universe looks roughly the same anywhere you might look – and there's also the concept of homogeneity, which means that the properties of the Universe look roughly the same for all observers regardless of wherever they might happen to be.

In reality, obtaining the perspective of all possible observers, just isn't possible. When we look out into the Universe we only receive historical information about how it behaved in the past. From there, all we can really do is assume that those parts of the Universe we can observe have continued to behave in a consistent and predictable manner up until the present – even though we can't confirm whether this is true or not until more time has passed and updated information about distant objects finally reaches us.

And then of course there's a whole other level of uncertainty about just how big the Universe is. It is generally said that the particles that emitted the photons of the cosmic microwave background are now about 45.7 billion light years away – since we know those photons have been travelling for almost 13.7 billion years before they reached us and we know roughly how much the Universe has expanded over that time. Hence, by inference, the absolute edge of the observable Universe should be 46.6 billion light years away since we know the cosmic microwave background was released 380,000 years after the Big Bang.

However, you can't conclude that 46.6 billion light years is the actual radius of the Universe – nor should you conclude that the cosmic microwave background has a distant origin. Your coffee cup may contain particles that originally emitted the cosmic microwave background –

and the photons they emitted may be 45.7 billion light years away now – perhaps just now being collected by alien astronomers who will hence have their own 46.6 billion light year radius Universe to infer.

So, all of us universal residents are in a situation where we have to infer the scale of the Universe from the age of the photons that come to us and the other information that they carry. And this will always be out of date information.

From Earth we can't expect to ever come to know about anything that is happening *right now* in objects that are more distant than around 16 billion light years away, which we call the cosmic event horizon (equivalent to a redshift of around z = 1.8).

This is an event horizon because those objects are right now receding from us at faster than the speed of light, even though we may continue receiving updated historical data about them for many billion of years to come – until they eventually become so redshifted as to appear to wink out of existence.

So, in a nutshell, homogeneity is not something we can expect to ever confirm by observation – so we must assume that the part of the Universe we can directly observe is a fair and representative sample of the rest of the Universe.

The isotropy of the observable Universe can be strongly implied if you look out in any direction and find:

1. consistent matter distribution - that is, wherever you look there's a bunch of stuff - in approximately equal numbers and densities.
2. consistent bulk velocities of galaxies and galactic clusters - that is, wherever you look the contents of the Universe is moving away from you due to universal expansion at about the same velocity.
3. consistent gravitational lensing by large scale objects like galactic clusters – that is, if you see consistent lensing in any direction, this confirms an even distribution of both light and dark matter – or cold dark matter if you prefer.
4. consistent measurements of angular diameter distance - that is, wherever you look equivalent-sized objects look smaller if they are further away - until you find objects, with a redshift of about 1.5, actually start looking bigger again.

So, that point 4 - weird huh? This effect happens because you are looking back in time as you look out at the Universe. So, as you look out, things that are genuinely nearer (and hence less red-shifted) start getting mixed up with things that are very red-shifted and hence much further away now - but when the light that you are seeing first left them, they were actually much closer. If you ever needed proof that you live in an expanding Universe, this angular diameter distance effect is it.

The last step we have to take is to determine that the observable Universe has *always* been isotropic – and is likely to continue being so into the future. Evidence for this comes from observations of the cosmic microwave background, which is isotropic down to a very fine scale - which means that the very early Universe was isotropic and the current Universe appears to be also isotropic. So it seems reasonable to assume that the future Universe will also be... isotropic. So, if this same isotropy is visible to all observers across the Universe – then it is likely that the Universe has been, is and may always be homogenous.

Although we have no likelihood of ever confirming this fundamental assumption of homogeneity, we can still appeal to the Copernican Principle – which requires that not only are we not at the centre of the Solar System, but that the Solar System is not at the centre of the Universe. Indeed our position is essentially arbitrary. In other words, the part of the Universe we can observe may well be a fair and representative sample of the wider Universe. At least, we currently have no reason to think that it isn't.

Thanks for listening.This is Steve Nerlich from Cheap Astronomy, www.cheapastro.com. Cheap Astronomy offers an educational website where you might think it's a long way down the road to the chemist, but that's just peanuts to space. No ads, no profit, just good science. Bye.