Cosmos At Least 250x Bigger Than Visible Universe, Say Cosmologists

The universe is much bigger than it looks, according to a study of the latest observations.

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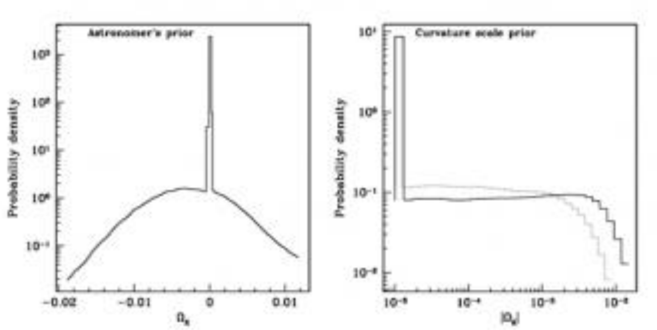
When we look out into the Universe, the stuff we can see must be close enough for light to have reached us since the Universe began. The universe is about 14 billion years old, so at first glance it's easy to think that we cannot see things more than 14 billion light years away.



That's not quite right, however. Because the Universe is expanding, the most distant visible things are much further away than that. In fact, the photons in the cosmic microwave background have travelled a cool 45 billion light years to get here. That makes the visible universe some 90 billion light years across.

That's big but the universe is almost certainly much bigger. The question than many cosmologists have pondered is how much bigger. Today we have an answer thanks to some interesting statistical analysis by Mihran Vardanyan at the University of Oxford and a couple of buddies.

Obviously, we can't directly measure the size of the universe but cosmologists have various models that suggest how big it ought to be. For example, one line of thinking is that if the universe expanded at the speed of light during inflation, then it ought to be 10^23 times bigger than the visible universe.

Other estimates depend on a number factors and in particular on the curvature of the Universe: whether it is closed, like a sphere, flat or open. In the latter two cases, the Universe must be infinite.

If you can measure the curvature of the Universe, you can then place limits on how big it must be.

It turns out that in recent years, astronomers have various ingenious ways of measuring the curvature of the Universe. One is to search for a distant object of known size and measure how big it looks. If it's bigger than it ought to be, the Universe is closed; if it's the right size, the universe is flat and if it's smaller, the Universe is open.

Astronomers know of one type of object that fits the bill: waves in the early universe that became frozen in the cosmic microwave background. They can measure the size of these waves, called baryonic acoustic oscillations, using space observatories such as WMAP.

There are also other indicators, such as the luminosity of type 1A supernovas in distant galaxies.

But when cosmologists examine all this data, different models of the Universe give different answers to the question of its curvature and size. Which to choose?

The breakthrough that Vardanyan and pals have made is to find a way to average the results of all the data in the simplest possible way. The technique they use is called Bayesian model averaging and it is much more sophisticated than the usual curve fitting that scientists often use to explain their data.

A useful analogy is with early models of the Solar System. With the Earth at the centre of the Solar System, it gradually became harder and harder to fit the observational data to this model. But astronomers found ways to do it by introducing ever more complex systems, the wheels-within-wheels model of the solar system.

We know now that this approach was entirely wrong. One worry for cosmologists is that a similar process is going on now with models of the Universe.

Bayesian model averaging automatically guards against this. Instead of asking how well the model fits the data, its asks a different question: given the data, how likely is the model to be correct. This approach is automatically biased against complex models–it's a kind of statistical Occam's razor.

In applying it to various cosmological models of the universe, Vardanyan and co are able to place important constraints on the curvature and size of the Universe. In fact, it turns out that their constraints are much stricter than is possible with other approaches.

They say that the curvature of the Universe is tightly constrained around 0. In other words, the most likely model is that the Universe is flat. A flat Universe would also be infinite and their calculations are consistent with this too. These show that the Universe is at least 250 times bigger than the Hubble volume. (The Hubble volume is similar to the size of the observable universe.)

That's big, but actually more tightly constrained than many other models.

And the fact that it comes from such an elegant statistical method means this work is likely to have broad appeal. If so, it may well end up being used to fine tune and constraint other areas of cosmology too.

Ref: arxiv.org/abs/1101.5476: Applications Of Bayesian Model Averaging To The Curvature And Size Of The Universe