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HOW BIG IS THE UNIVERSE?

Ken Tapping, 16th September, 2014

Visitors to our observatory often ask this seemingly obvious question. How big is the universe? We know how long it has been since the Big Bang, when the universe started to expand from something infinitesimally small: about 13.8 billion years. If we can quote a number like that for the age of the universe, it is logical that we should have as good a number for the size of the universe. However, that is a tougher question.

Picture us living on the surface of an expanding "bubble". If we imagine stars and galaxies scattered all over its surface, we would see them all being carried away from us by the expansion, and the further things are from us, the faster they will be receding. However, if we start travelling over the surface of our bubble universe, we will never encounter an edge; we will eventually be back where we started.

For the sort of distances we have here on Earth, we can neglect the amount of time taken for light to travel from an object to our eyes. In a millionth of a second light travels 300 metres. We see an object that far away as it was a millionth of a second ago. We can forget that tiny delay. However, once we get into space the distances get larger, and the times become noticeable. We see the Moon as it was 1.25 seconds ago, and the Sun as it was 8 minutes ago. The time delay for the nearest star after the Sun is 4.3 years. We see Capella, that star glittering in the northern sky on late summer evenings as it was 42 years ago.

Kilometres, millions or even billions of kilometres, are too small to be useful units of distance for astronomy. One of the units we use is the light year. This is the distance light travels in a year, which is a little less than 10,000,000,000,000 km. Therefore, if the radiation from the big bang started on its way to us 13.8 billion years ago, so at that time the radius of the universe must have been 13.8 billion light years. We call that the size of the "Observable Universe". However, during the time those light waves were travelling to us, the

universe has continued to expand. We cannot update the size of the observable universe because that light has not reached us yet. However, from measurements of the expansion of the universe for objects we can see, the radius of the universe today is something like 46 billion light years. That is a diameter of about 92 billion light years. There is no way we can yet see light from that more modern universe; it is still on its way to us. The light now starting on its journey should arrive in around 32 billion years. By that time of course that number will be too small. Moreover, that still will be just the size of the patch of universe we can see, not the full size of it.

We have always taken the word "Universe" to refer to the summation of everything there is. Obviously, if this were the case, there would be no meaning to the possibility of anything else. However, the problem is not with the word; it is with us. A few centuries ago, the Universe consisted of the Earth, with everything we see in the sky being part of the heavens. Until well into the 20th Century, the universe was taken to be only our galaxy. Then when other galaxies were discovered, for a while they were referred to as "Island Universes". Eventually there was one thing we call the Universe, which started 13.8 billion years ago. Now there is some evidence of our universe being just one of many, forming like bubbles in some great, multidimensional cosmic foam. When I was reading astronomy books on the bus taking me to high school, I read that it was unlikely if we would ever know for sure about the Big Bang. So much for that! What will we know in a decade or two?

The Sun crosses the celestial equator on the 22nd, marking the Autumn Equinox. Venus lies very low in the predawn sky; Jupiter rises in the early hours. Saturn and Mars lie close together in the sunset twilight. The Moon will be New on the 23rd.

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