Infinite Universes

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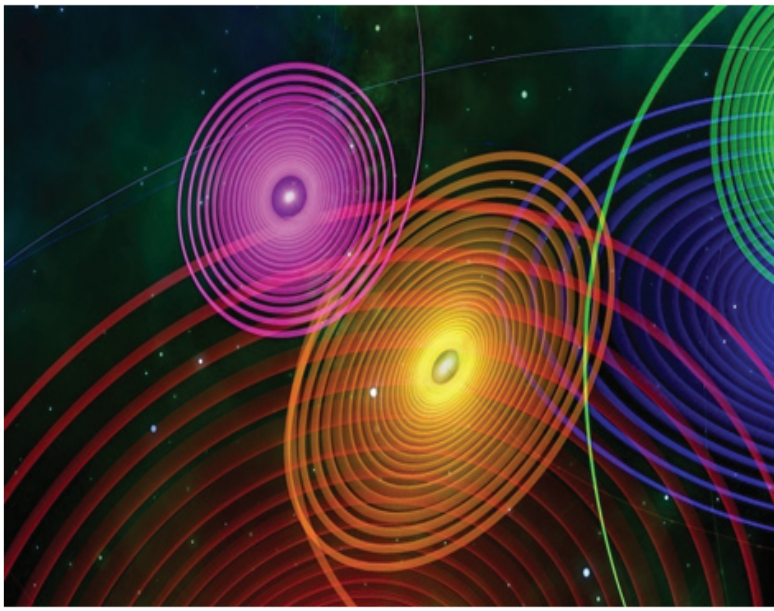


IN the long history of science, ideas and insights have played a vital role in understanding the universe. Models of the universe or the way to arrive at inferences about physical reality constructed by our finite experience have changed. But why is our experience finite?

The visible universe which is the set of astronomical realities is perceived through the finite speed of light. It is the region of space from which light rays have had time to arrive at astronomers' telescopes. What lies beyond this region is not accessible as light rays are yet to reach us. 'Experience' of the physical universe is an artefact of limited observations. Ideas and insights, however, are unconstrained and they provide clues for modelling the physical universe.

Truth stretches out far beyond the horizon of finite observation and experience. This has been realised through an affirmative answer to the deep and captivating question in all of science – *Is the universe infinite*? The notion of infinity plagues mathematicians, physicists, cosmologists, poets and philosophers alike in their attempts to understand or represent reality.

The idea of an infinite universe or universes has survived ages marked by great thinkers like Isaac Newton, Immanuel Kant, Heinrich Heine, Thomas Digges and Michel de Montaigne. Deep theories of the origin of the universe have now incorporated the plurality of the universe and perhaps life. Implications of these theories are found in astronomical observations. This idea, known as the *multiverse*, is one of the success stories of modern science.

Let us explore how the ideas of the infinite universe(s) were born long ago in brilliant minds questioning the nature of the universe. These ideas were seeded by logic and belief systems. It is true that for ancient thinkers the concept of a universe was limited to very small scales of the cosmos. But the ideas were quite general and they resound in modern cosmology.

The Loss of a Paradise

The first of the modern astronomers who pursued the idea of an infinite universe was the English astronomer, Thomas Digges (1546-1595). He was one of the first generation Copernican scientists believing in the heliocentric world model. Cosmological models before the era of Digges incorporated a spherical shell of stars concentric with the Earth and other planets beyond which lay 'paradise' – the orb of divine beings known as 'prime mover'. Digges dethroned the 'paradise' and 'prime mover' from their majestic positions and replaced them by outer space of infinite extent filled with infinite number of stars.

Bondage between matter and space manifests in the theory of relativity which discusses the structure of space and time in relation to matter. Post Digges era was of the great champion of science, Rene Descartes (1596-1650). Descartes held the idea that there is no meaning of space without the presence of matter.

This surprisingly precedes Einstein's relativity by nearly 300 years. If one reverses the argument it can be concluded that if space is infinite matter must also be infinitely extended. This harmony between matter and space is resurrected in modern cosmology which asserts that our visible universe is only a tiny bubble in an infinite ocean of other universes floating and evolving eternally in infinite space.

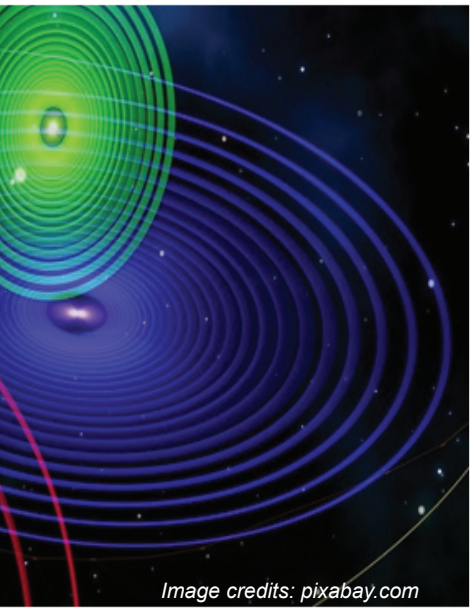
The 'Universes' of Montaigne and Newton

Long before Newton lived a French philosopher and writer, Michel de Montaigne (1533-1592). His philosophical essays included the question of many universes. He held that if there are many worlds beyond our horizon they must be governed by different sets of laws of Nature and hence must differ from ours.

During the formulation of the theory of gravitation, Newton constructed his cosmology where the universe was a finite distribution of stars surrounded by infinitely extended space. Newton treated space as a divine entity being independent of matter. This was in contrast with the universe of Digges. However, to bring divine intervention Newton left room for the creation of new and infinite variety of matter in infinite space. The 'universes' of Montaigne and Newton would meet the modern multiverse scenario.

Is Time Eternal?

In Newtonian physics time eternally exists, however, in passive mode. It is just a mathematical reality (a parameter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only) characterising all changes. It is unaffected by what happens in the universe. This 'sacredness' of time is lost in the relational science of the theory of relativity which advocates for dynamic relationship between time and matter-energy of the universe. It becomes something physical — a component of the cosmic fabric known as spacetime. Therefore, eternity of time is connected to eternity of the universe(s).

If time is absolute (eternal) and *the* universe is created *in time* it must be created out of 'nothing'. But if 'nothing' is a cause it must be preceded by itself as a cause. Therefore, it is also an effect. 'Nothing' causes only 'nothing'. Therefore, 'eternal existence of the universe(s) *with time* is indistinguishable from 'creation from nothing' as 'nothing" has not created anything.

The idea of eternity of time is related to eternal physical processes of matter and energy. Infinite recurrence of physical events in the universe was also stressed by German poet Heinrich Heine (1797-1856). He argued that infinite recurrence of physical processes making the universe requires eternity of time.

Modern Cosmology

So, finally, what is the verdict given by modern cosmology? Astronomers have seen that the universe is teeming with a faint thermal glow which is just 3 degrees above absolute zero of temperature. This is the remnant heat of an infinitely densely packed and infinitely hot soup of primordial matter and radiation that underwent colossal expansion some 14 billion years ago. This is known as the Cosmic Background Radiation (CBR). This was the Big Bang creating our visible universe.

Satellite probes such as the Cosmic Background Explorer (COBE), Wilkinson Microwave Anisotropy Probe (WMAP) and the Planck Satellite dedicated to measure this thermal glow permeating the entire cosmos have shown that its temperature has tiny ups and downs (fluctuations) across space. Although scales of these fluctuations are as large as the horizon of the visible universe, cosmologists have worked out that these scales were smaller than even an atom in the primitive phase. These quantum fluctuations grew to astronomical scales. Therefore, measurement of the present fluctuations can give us valuable clue about what exactly happened at the universe's birth.

According to the prevailing scientific theory of cosmic origin the visible universe materialised inside a bubble of empty space (vacuum) which was a thousand trillion times smaller than an atom that sprung from incessant quantum jitters of the vacuum. This primordial bubble was made of strange new form of energy that produced enormous cosmic repulsion leading to a temporary but exponential surge of expansion.

The bubble inflated and was filled with infinitely hot subatomic particles and radiations resulting from quantum fluctuation of the energy. The physical universe was born inside the enormously inflating bubble. This was the Big Bang emanating from cosmic inflation. According to a version of this theory, our universe is only one of infinite number of universes that nucleated inside infinite number of bubbles popping out of vacuum. Known as eternal inflation, this theory predicts that infinite universes originate inside infinite number of bubbles growing and expanding endlessly in eternally existing empty space. We happen to live in one of these bubbles with our own set of laws of Nature.

Infinity Puts its Signature

This process of cosmic evolution is without beginning and end. It advocates for eternity of time. Big Bang is just a transient onset of our visible universe. But how do we believe in these multiverses? Indirect evidence of basic features of cosmic inflation theory has already appeared. Quantum fluctuation of the energy which created our primordial bubble and then decayed into radiation and matter manifests in the remnant heat of the Big Bang. Detection of temperature fluctuations of the CBR by astronomical probes validates the basic prediction of cosmic inflation and is a tremendous victory of modern cosmology.

Cosmic Democracy

What about laws? Cosmic inflation also predicts that laws of Nature manifest in infinite universes with all possible legislations. It is due to quantum variations in the primordial energy field. There is no unique set of laws. All we have are the by-laws. Eternal inflation theory reminds us of the idea of plurality of worlds held by ancient thinkers.

Ideas Live their Lives

Ideas of infinite universes have lived their long lives. The possibility of infinite universes and eternity of time were speculated and argued with different attributes of thoughts. Ideas have not changed much. What changed are the scale of the cosmos and methodology of interpretation. 'Multiverse with by-laws' is the reincarnation of the universes of Newton and Montaigne. It naturally predicts infinite possibilities of lives.

'Infinite number of universes as embryos in the womb of the cosmic vacuum' is analogous to the extension of Descartes' idea and it inherits the vision of Digges. These ideas, almost underappreciated in the discussion of science were rich enough with insights. Through experiments and mathematical theories, modern science has developed an understanding of the universe by basing on the powerful insights of the giant thinkers of the past.

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