HOW LARGE IS THE UNIVERSE?

The mind-blowing answer comes from a theory describing the birth of the universe in the first instant of time.

The universe has long captivated us with its immense scales of distance and time. How far does it stretch? Where does it end? And what lies beyond its star fields and streams of galaxies extending as far as telescopes can see?

These questions are beginning to yield to a series of extraordinary new lines of investigation and technologies that are letting us to peer into the most distant realms of the cosmos. But also at the behavior of matter and energy on the smallest of scales. Remarkably, our growing understanding of this kingdom of the ultra-tiny, inside the nuclei of atoms, permits us to glimpse the largest vistas of space and time.

In ancient times, most observers saw the stars as a sphere surrounding the earth, often the home of deities. The Greeks were first to see celestial events as phenomena, subject to human investigation, rather than the fickle whims of Gods. One sky-watcher, for example, suggested that meteors are made of materials found on Earth, and might even have come from the Earth. Those early astronomers built the foundations of modern science. But they would be shocked to see the discoveries made by their counterparts.

The stars and planets that once harbored the gods are now seen as one infinitesimal part of a vast scaffolding of matter and energy extending far out into space. Just how far began to emerge in the 1920s. Working at the huge new 100-inch Hooker Telescope on California's Mt. Wilson, astronomer Edwin Hubble, and his assistant named Milt Humason, analyzed the light of fuzzy patches of sky, then known as nebulae. They showed that these were actually distant galaxies far beyond our own. Hubble and Humason discovered that most of them are moving away from us. The farther out they looked, the faster they were receding. This fact, now known as Hubble's law, suggests that there must have been a time when the matter in all of these galaxies was together in one place.

That time, when our universe originally sprung forth, has come to be called the Big Bang. How large the cosmos has gotten since then would depend on how long it's been growing and how fast it's been expanding. Recent precision measurements gathered by the Hubble space telescope and other instruments have brought a consensus that the universe dates back 13.7 billion years. The radius of the visible universe , then, is the distance of a beam of light that would have traveled in that time 13.7 billion light years. That works out to about 1.3 quadrillion kilometers. In fact, it's even bigger. Much bigger. How it got so large, so fast, was until recently a deep mystery.

That the universe could expand had been predicted back in 1917 by Albert Einstein, except that Einstein himself didn't believe it...until he saw Hubble and Humason's evidence. Einstein's general theory of relativity suggested that galaxies could be moving apart because space itself is expanding. So when a photon gets blasted out from a distant star, it moves through a cosmic landscape that is getting larger and larger, increasing the distance it must travel to reach us.

The orbiting telescope named for Edwin Hubble began to take the measure of the universe by looking for the most distant galaxies it could see. Pointing at our north, then t our south, taking the expansion of the universe into account, the space telescope found galaxies that are now almost 46 billion light years away from us in either direction

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and almost 92 billion light years from each other. And that would be the whole universe according to a straightforward model of the big bang. But remarkably, that might be a mere speck within the universe as a whole, according to a dramatic new theory that describes the origins of the cosmos.

It's based on the discovery that energy is constantly welling up from the vacuum of space in the form of particles of opposite charge, matter and anti-matter. Back in the 1980s the physicist Allan Booth proposed that energy fields invaded in the vacuum of space suddenly tipped into a higher energy state,causing space and time to literally inflate, to go from atomic size to cosmological size within an infinitesimally short time. As a result, according to some calculations, the whole universe would have grown to some ten billion trillion times the size of the observable universe. That's 10 followed by 24 zeros!!!!! Put another way, *the complete universe is to the observable universe as the observable universe is to an atom!!!!* The fury of this period of cosmic implosion also explains the inmense size and relative smoothness of the universe. But to succeed, the theory must also account for how the universe produced what we see around us, all those stars and galaxies and clusters of galaxies and ultimately us.

Scientists are now seeking to piece together the chain of events that launch star universe in its earliest moments by generating what you might call "a little bang". At the the *Brookhaven National Lab*, in NY State they are blasting gold atoms in opposite directions down tunnels almost two and half miles long, when these atoms reach velocities just short of the speed of light, they are sent into a violent collision, a fireball erupts reaching a temperature exceeding two trillion degrees centigrade. As far as we know, the last time anything in our universe was that hot, was about a millionth of a second after the universe was born. What interests the scientists is this bladder of subatomic particles; a superhot soup of *quarks* and *gluones*, particles that probably gave rise to matter as we know it.

In initial tests, this quark cluoned plasma had shown a crucial property, extremely low viscosity, that's the resistance to flow.To grasp its importance, we go back to those primordial energy fields that the theory says respond to the Big Bang. The thinking is that those fields contained tiny fluctuations that were blown up to huge size during inflation. In the ultra dense quark cluonics, these fluctuations generated pressured areas or *ripples*. As the universe evolved, these *ripples* led to variations in the density of matter.

Amazingly, the inprint of those ripples is out there today first seen in a fade signal discovered accidentally in the 1960s. Working for the Bell telephone company, physicists Arnold Penzias and Robert Wilson had built a giant horn-shaped antenna, but wherever they pointed it, the construction picked up excessive noise in the microwave portion of the electromagnetic spectrum.That noise turned out to match a prediction made years earlier. That in the wake of the big bang, the universe was built with a cloud with extremely hot gas that scattered all light. As the universe cooled, that cloud disappeared. Light then shone through. Overtime it shifted as the universe expanded and cooled to just the band of noise detected by Penzias and Wilson. What they'd heard was the echo of the Big Bang.

This image shows the smooth contours of the light recorded by the Bell team. But scientists would have to look much closer to find the inprint of cosmic inflation.

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The space shuttle *Discovery* lifted the *Hubble Space Telescope* into orbit on April 24 1990, in one of the most important scientific milestones of our time. But another launch, arguably just as important, had taken place five months earlier.

This was the *Cosmic Observation Background Explorer-COBE,* for short-. It was sent up to take a harder look at the microwave radiation discovered by Penzias and Wilson. The results came out two and a half years later, the early universe contained a pattern of hot and cold spots. One *COBE* scientist called it "*the fingerprint of creation"*, for it showed the origin of the universe that we see around us today. Smooth on a large.scale but with significant clumps from which gravity would have formed the gas clouds, then stars, then galaxies. With this cosmic template in hand, astronomers set out to discover how the structures had evolved over time. In an age of computer-controlled telescopes and automatic observing, astronomers could now launch complex international collaborations with the goal of mapping a large fraction of the universe in three dimensions.

At Apache Point in New Mexico, the *Sloan Digital Sky Survey* set the standard for mass production astronomy. A series of steel plates are drilled with holes that exactly match the locations of galaxies in the nightsky. After plugging fiberoptic centers into the holes, the plates capture the light of hundreds of galaxies per night, and that light determines their distances from the Earth.

Another survey is named *The Two Micron All Sky Survey* or *2MASS*, after the frequency of infrared light its detectors are tuned to capture. Here this data go out to a region 60 million lightyears across. This is our neighbourhoood. Jammed further out, to a region about 200 million lightyears across, our galactic neighbourhood merges into the densely packed Virgo supercluster, which is the nearest intergalactic city. Stepping out to a region over 320 million lightyears across, galaxies line up in walls and archs that bound in a ray of spartially populated voids, the rural cosmic countryside.

Moving out with the data, this region is over 650 million lightyears across and finally out to a region 6.5 billion lightyears from into it: the cosmic continent. In the middle of it all, our galaxy, so inmense from our earthly perspective is less than a speck. The *2MASS* study, the *Sloan Digital Sky Survey* and the *Two-degree Field-2dF-* in Australia have extended our maps to a quarter of the way back to the beginning of the universe.They've laid out a ground cosmic roadmap and gravitational routes.

Now, *COBE* successor- the *Wilkinson Microwave Anisatropy Probe* or *WMAP*, was ready to scan the early universe for the fine scale origins of this cosmic atlas. *WMAP* was launched far beyond any interference from Earth to a position balanced between the Earth and the Sun. There for two years, its detectors took in the pristine light of deep space.This is what WMAP saw, the pattern consistent with the filaments and void that had evolved in the universe at large, and with the tiny scale structures, sketched by inflation, at the very birth of the cosmos.

Researchers at *Brookhaven National Lab* in the US and at the new *Large Hadron Collider* in Europe will be proving ultrahigh energy collisions in the coming years to tease out more details of the early universe. One group looks for repeating patterns that could be evidence of pressure waves that might have reshaped through the hot gas of realkly times, but this unknown implies that the universe had grown so large during inflation that waves could not cross it. Then it did the math.

15:00

The entire universe has a minimum diameter of 156 billion lightyears .Not quite twice the size of eveything out there that we can see, the observable universe. What is its maximum size? And what’s beyond that? We cannot know for sure what lies beyond our visual horizons. But astronomers are turning up some surprising things in the cosmos they can see.

To ancient observers, the universe was made of five classical elements: earth, water, air, fire and the fifth, quintessence, or space. The philosopher Aristotle believed the stars, unchanging and incorruptible, were made of this fifth element. Today, we’re finding space, in fact, as a character on its own. Astrophysicists have calculated the gravitational pull needed to bime stars as they orbit a galaxy , or galaxies as they orbit a cluster of galaxies. And they found that there’s simply nowhere near enough visible matter out there to hold the structures together. The missing ingredient, its identity still unknown, they call *Dark Matter.*

In supercomputer simulations of cosmic evolution, dark matter is added in to supply the gravitational tag needed to form the web of filaments and walls, voids and dense clusters we see in the universe at large. But something else appears to be happening on these large scales. Astronomers have been making refined measurements of the cosmic expansion rate with a new type of distance marker, and they wanted to know if gravity was slowing down the pace at which the universe is spreading out.

But what they found, comes as a shock: the markers they used- type 1A supernovae- are thought to burn at uniform intensities throughout the universe. By measuring changings in the brightness of these so called “standard candle” at various distances, the researchers have been hunting changes of the rate at which the cosmos is expanding. They have shown that while local regions of the universe are drawing together, the universe as a whole is not only expanding, it’s accelerating outward. The culprit is thought to be energy welling up from the vacuum of space, similar to what occured in the early moments of the Big Bang, causing cosmic inflation. Now, it’s happening in minute quantities across vast regions. Overtime this so-called Dark Energy has grown to an astonishing ¾ of all the matter and energy in the universe!

With data like these, pointing to an underlying dynamic in our universe, some scientists have suggested this is part of an even larger cosmic dynamic, much broader and deeper than we ever thought. There is a version of inflationary theory that suggests we live in one of many universes, coexisting side by side but out of touch with one another. Like bubbles, they’re continually rising up and expanding across the ocean of infinity. Just 500 years ago, many people looked out into space and saw a universe of lights, small and nearby, centered on the Earth. The birth of Astronomy revealed stars far from our planet, then galaxies, clusters of galaxies, and vast walls and filaments of matter. Our newest ideas about the size of the universe amount to a Quantum leap in our sense of scale by extending the structures far, far beyond the horizon we can observe.

Do these discoveries push us on our tiny, out-of-the-way planet into a smaller and smaller corner of the cosmos? Or does our ability to comprehend and imagine the far limits of time and space expand our importance in the grand scheme of things?

20:00