



Universe

Everything that exists, from the smallest subatomic particle to the largest galaxy

The Universe is the name given to everything around Earth, including the tiniest subatomic particles, huge clusters of galaxies, and the enormous areas of space between them. Astronomers who specialize in studying the Universe and explaining how it came into existence and why it behaves the way it does are called cosmologists (kahz-MAH-luh-jihsts). In the past century, cosmologists have made huge leaps forward in understanding the Universe and Earth's place within it.

The expanding Universe

The Sun, the center of Earth's Solar System, is just one star among 100 billion orbiting in the spiral galaxy called the Milky Way. Until the early 20th century, most astronomers thought Earth's home galaxy was the whole Universe. They explained the mysterious spiral and ball-shaped smudges of light they saw among the stars as gas clouds or nebulas within the Milky Way. Then in the 1920s, U.S. astronomer Edwin Hubble (1889–1953) found a way of measuring the distance to the nebulas. He proved that the closest of these nebulas were so far away that they must be distant galaxies themselves.

Modern cosmology dates from Hubble's discovery of other galaxies, but he later made another equally important finding. By splitting the light from distant galaxies into a rainbowlike spectrum, he was able to see bright and dark lines caused by elements in the galaxy's stars giving out colored light. However, the groups of dark lines were often shifted from their expected position, toward the red end of the spectrum. This "red shift" is caused by the Doppler effect and is similar to the way the pitch of a fire truck's siren seems to be quieter as the vehicle races past. A red shift shows that a galaxy is moving away from Earth. Hubble found that the farther away a galaxy was, the greater the red shift in its light, and the faster it was moving away.

HIGHLIGHTS

- The Universe is made up of all the matter observed or unobserved, as well as the space and time around Earth.
- The Universe is still expanding away from a huge explosion called the Big Bang, which created the Universe around 12 billion years ago.
- The farther away a source of light is, the longer the light takes to reach an observer, and the farther he or she can look back in time.
- The mass of the Universe causes space to curve and could cause it to collapse on itself.

The Big Bang theory

There was no reason to think that the Milky Way is a fixed point at the very center of the Universe, so astronomers began to think it must be moving, too. Since all the galaxies in the Universe are moving away from each other, it followed that they were much closer together in the past. Some astronomers suggested that the Universe was pulsating (getting larger and then shrinking back again) over billions of years. However, most concluded that, at some point, all the matter in the Universe was packed into one tiny point in space, which then exploded in the Big Bang.

According to the Big Bang theory, the Universe was created in a sudden explosion about 12 billion years ago. The explosion began in a space far smaller than an atom, and in these extreme conditions the normal laws of physics do not apply. The temperature of the Big Bang was incredibly hot—many trillions of degrees—and this allowed various unusual subatomic particles to be created. An instant after the Big Bang, a huge release of energy triggered an event called inflation, blowing the Universe up from smaller than an atom to bigger than a galaxy. In this event, tiny ripples in the Universe were blown up into huge variations that became the galaxies.

The Big Bang created similar amounts of matter and antimatter, which is made up of subatomic particles with opposite charges to those of matter. As they collided, they annihilated (uh-NI-uh-lay-tuhd; wiped out) each other with a burst of energy. There was slightly more matter than antimatter around, so some was left behind. This is the matter that makes up the Universe today.

All this happened within a fraction of a second. For the next three minutes, the Universe's temperature dropped. Many of the particles created in the Big Bang could not exist at lower temperatures, so they transformed into the subatomic particles known today. These gradually grouped together to form the central nuclei of atoms—nearly all hydrogen—swimming in a sea of electrons. The Universe at this time was opaque (oh-PAYK). Light waves bounced off the tightly packed matter instead of passing through. About 300,000 years after the Big Bang, the nuclei and electrons combined to form atoms, and the Universe became transparent (allowed light through). Radiation from this time can still be detected. After a few million years, matter began to accumulate into stars. Today's telescopes can detect starlike quasars 10 billion light-years (the distance light travels in a year) away. Light from these quasars has taken so long to reach Earth, it is like looking back in time at the younger Universe.

The shape of the Universe

From Earth, astronomers can see for around 12 billion light-years in every direction. However, an astronomer on a planet 12 billion light-years away also sees a Universe that stretches for 12 billion light-years all around. This gives the impression that the Universe goes on forever, but in fact it does not. German-born U.S. scientist Albert Einstein (1879–1955) suggested that the mass of the Universe causes space to curve back on itself. One way to think of space is as the surface of a balloon—if a spaceship travels far enough in one direction, it will eventually come back to where it started.

Whether the Universe will keep expanding forever, or will eventually collapse back on itself in billions of years' time depends on how much matter there is in the Universe. Astronomers think that not all matter is visible, and the amount of this invisible "dark matter" could decide the fate of the Universe. However, recently, astronomers made another important discovery—time and space may be expanding. This suggests the Universe will last forever—although eventually everything in it will run out of energy.

LOOK CLOSER

Dark Matter

As well as the visible matter that makes up stars, planets, and interstellar gas clouds, the Universe is thought by some scientists to contain invisible dark matter. Astronomers can estimate the mass of galaxies by the speed at which gas clouds or companion galaxies orbit them. When they worked out the mass of Earth's galaxy, the Milky Way, based on the orbits of its small satellites, the Magellanic Clouds, they found that the galaxy contains roughly ten times more matter than is visible. The Sun's orbit, however, proved that most of the matter close to the galactic center was visible, so dark matter must be mainly in the outer parts of galaxies.

Astronomers think that dark matter comes in two varieties. MACHOs (*massive compact halo objects*) include rogue planets, brown dwarfs (dead stars), and black holes. WIMPs (*weakly interactive massive particles*) are subatomic particles that pass through other matter without interacting with it, such as neutrinos (nyoo-TREE-nohz; tiny particles produced by nuclear reactions inside stars). MACHOs account for a small proportion of all dark matter, with WIMPs making up the rest, but because WIMPs do not interact with matter, they are very difficult to detect.

See also: [BLACK HOLE](#); [DOPPLER EFFECT](#); [GALAXY](#); [MATTER](#); [QUANTUM THEORY](#); [QUASAR](#); [RELATIVITY](#); [SOLAR SYSTEM](#); [SPACE](#); [STAR](#); [SUN](#).

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