

Characteristics Of The Universe

What Is The Universe?

The universe is all of space, time, matter, and energy that exist. Most people think of the universe as just space, but space is just the framework, the “scaffolding” in which the universe exists. Furthermore, space and time are intimately connected in a four-dimensional fabric called spacetime. Amazingly, some hypotheses suggest that the universe we live in is not all there is. In this case, there is more than just space, time, matter, and energy. Other dimensions exist, and possibly other universes. None of those models, however, have yet been confirmed.

Why Does The Universe Exist?

That, for better or worse, is not answerable by science alone. Astronomy can describe, however, a theory that explains how the universe began.

How Old Is The Universe?

The universe is not infinitely old. According to modern astronomical measurements, the universe began to exist about 13.7 billion years ago.

Is The Universe Infinite?

It has not yet been scientifically determined exactly how large the universe is. It may indeed be infinitely large, but we have no way yet to confirm this possibility scientifically.

What Is The Structure Of The Universe?

The structure of the universe—as opposed to the structure of matter in the universe—is determined by the shape of space. The shape of space is, surprisingly, curved. On a very large scale—millions or even billions of light-years across—space has a three-dimensional “saddle shape” that mathematicians refer to as “negative curvature.” In our daily lives, however, it is such a tiny effect that we do not notice it. On smaller scales—that of planets, stars, and galaxies—the structure of the universe can be altered by massive objects. This alteration manifests itself as the curvature of space and time, as explained by the general theory of relativity.

How Big Is The Universe?

Here on Earth, in the Milky Way galaxy, there is a limit to how far out into the universe humans can observe, regardless of what technology is used. Imagine, for example, being on a ship in the middle of the ocean. If you look in all directions, all you see is water, out to a certain distance. But Earth’s surface extends far beyond that horizon limit. The farthest limit to our viewing is called the cosmic horizon, which is about 13.7 billion light-years away, or about 80 billion trillion miles, in every direction. Everything within that cosmic horizon is called the observable universe. In many cases, for the sake of brevity, astronomers refer to the “observable universe” as merely the “universe.” As for the universe beyond the cosmic horizon, there is still no scientific way to measure its size. There is no reason to think there is or is not a boundary far away. However, it is possible for the universe to be limited in size and still not have an edge. Think of the surface of our planet, for example. Earth’s surface area is finite, but there is nowhere on Earth where you could reach the “end” of Earth in a boat and fall off our planet. In a huge, three-dimensional way, our universe, might be similar.

What Are The Possible Shapes Of The Universe?

There are three general categories of possible shapes of the universe: open, flat, and closed. These adjectives refer to the kind of curvature that space has overall. Massive objects cause space to bend and curve; the universe itself is a massive object, so the entire cosmos is curved, too.


Origin Of Universe

How Did The Universe Begin?

The scientific theory that describes the origin of the universe is called the Big Bang. According to the Big Bang theory, the universe began to exist as a single point of spacetime, and it has been expanding ever since. As that expansion has occurred, the conditions in the universe have changed—from small to big, from hot to cold, and from young to old—resulting in the universe we observe today.

Who Were The First Scientists To Formulate The Big Bang Theory?

In 1917 Dutch astronomer Willem de Sitter (1872–1934) showed how Albert Einstein’s general theory of relativity could be used to describe an expanding universe. In 1922, Russian mathematician Alexander Friedmann (1888–1925) derived



an exact mathematical description of an expanding universe. In the late 1920s, the Belgian astronomer Georges-Henri Lemaître (1894–1966) independently rediscovered Friedmann’s mathematical formulation. Lemaître deduced that if the universe were indeed expanding, and has been doing so for its entire existence, then there would have to be a moment in the distant past when the whole universe occupied just a single point. That moment, and that point, would be the origin of the cosmos. Lemaître’s work, and that of de Sitter and Friedmann, were eventually confirmed through observations; since Lemaître was a Jesuit priest as well as an astronomer, he has sometimes been called “the father of the Big Bang.”

What Was There Before The Big Bang?

It is not scientifically possible to ask what came “before” the Big Bang. That is because time itself did not exist until the Big Bang occurred. Just as there is nothing “north” of the North Pole, because Earth does not extend any farther north, there was nothing “before” the first instant of time. However, if you can imagine the existence of more than one universe—a possible consequence of membrane theory or string theory—then it is possible that other universes, with other dimensions of space and time, could have existed before the universe.

What Evidence Is There For The Big Bang Based On The Motion Of Objects In The Universe?

The expanding universe is a solid piece of observational evidence that the universe began as the Big Bang theory describes. If space is getting larger all the time, then that means the universe is larger now than it was yesterday. Similarly, it was larger yesterday than it was last month, and larger last month than last year. By continuing backward in time, it is possible to follow the trend all the way down to the point where the entire universe was just a point. Based on the expansion rate of the universe, that point was at a time about 13.7 billion years ago.

Who First Showed That The Universe Is Expanding?

The same astronomer who showed that galaxies exist outside the Milky Way also demonstrated that the universe is expanding. Edwin Hubble continued to study galaxies after his pioneering measurement of the distance to the Andromeda Galaxy. He examined the relationship between the motion of a galaxy and the distance the galaxy is away from Earth. He discovered that the farther away a galaxy is, the faster it moves away from us, which is the telltale sign of an expanding universe.

Black Holes

What Is A Black Hole?

One definition of a black hole is an object whose escape velocity equals or exceeds the speed of light. The idea was first proposed in the 1700s, when scientists hypothesized that Newton’s law of universal gravitation allowed for the possibility of stars that were so small and massive that particles of light could not escape. Thus, the star would be black.

How Can Astronomers Find Black Holes If They Cannot See Them?

The key to finding black holes is their immense gravitational power. One way to find black holes is to observe matter moving or orbiting at much higher speeds than expected. By carefully mapping the motion, and then applying Kepler’s third law of orbital motion, it is possible to measure the mass of an object even without seeing the object itself. The deep gravitational field of a black hole can also produce a tremendous amount of light nearby and around itself, even if the hole itself is dark. Matter falling into a black hole runs into a lot of other material that has collected around the hole. Just as a meteorite or spacecraft gets hot as it enters Earth’s atmosphere, the infalling matter gets hot from the frictional drag too, sometimes reaching temperatures of millions of degrees. That hot material glows brightly and emits far more X-ray radiation and radio waves than would normally be expected from such a small volume of space. By searching for these telltale emissions, astronomers can deduce the presence of black holes even though they cannot see the holes themselves.

What Kinds Of Black Holes Are There?

Two categories of black holes are known to exist, and a third kind has been hypothesized but not yet detected. One kind, known loosely as a stellar black hole or lowmass black hole, is found wherever the core of a very massive star (usually 20 or more times the mass of the Sun) has collapsed. The other known kind, called a supermassive black hole, is found at the centres of galaxies and is millions or even billions of times more massive than the Sun. The third kind of black hole, called a primordial black hole, is found at random locations in space. It is hypothesized that these black holes were created at the beginning of cosmic expansion as little “imperfections” in the fabric of spacetime. However, no such black hole has yet been confirmed to exist.

What Is The Structure Of A Black Hole?

The centre of the black hole—the actual “rip” or “pinch” in the fabric of spacetime—is called the singularity. It is a single

point that has no volume but infinite density. Amazingly, the laws of physics as we understand them simply do not work at the singularity of a black hole the way they do in the rest of the universe. Surrounding the singularity is a boundary called the event horizon. This is the place of no return, where the escape velocity for the black hole is the speed of light. The more massive the black hole is, the farther the event horizon is from the singularity, and the larger the black hole is in size.

Where Are Some Black Holes Located In Our Galaxy?

The table below lists some known black holes in the Milky Way galaxy.

Black Holes in the Milky Way Galaxy		
Name	Probable Mass in solar masses	Approx. Distance from Earth in light-years
A0620-00	9–13	3,000–4,000
GRO J1655-40	6–6.5	5,000–10,000
XTE J1118+480 6.	4–7.2	6,000–6,500
Cygnus X-1	7–13	6,000–8,000
GRO J0422+32	3–5	8,000–9,000
GS 2000-25	7–8	8,500–9,000
V404 Cygnus	10–14	10,000
GX 339-4	5–6	15,000
GRS 1124-683	6.5–8.2	17,000
XTE J1550-564	10–11	17,000
XTE J1819-254	10–18	less than 25,000
4U 1543-475	8–10	24,000
Sagittarius A*	3,000,000	Center of the Milky Way