

THE BIG BANG

CLASSIFICATION HOW THE UNIVERSE BEGAN



The universe was born in an enormous explosion, called the Big Bang, about 15 billion years ago, and its fallout created not only mass and energy but also space and time. From a tiny, fantastically hot "seed," the universe swelled and cooled. For hundreds of thousands of years, matter consisted of a seething mass of superheated subatomic particles, buffeted by high-energy radiation. Today's universe is cold and quiet by comparison, but at its edge astronomers can still detect the faint glow of its fiery birth—and with it, the beginning of time.

ALSO BIRTH OF GALAXIES, THE ELEMENTS, DARK MATTER

Factoids

OTHER BANGS?

Scientists speculate that other Big Bangs might have occurred outside our universe. But the edge of our universe is traveling at the speed of light, so we could never catch up to look beyond it.

AFTERGLOW

In 1965, two scientists at Bell Labs discovered radiation coming from all over the sky. It was the afterglow of the Big Bang, on the very edge of the universe.

HOT AND COLD

As the edge of the universe advances, it gets colder. So now, the afterglow from the billion-degree Big Bang is just 5.8°F above absolute zero.

IN THE BEGINNING

Scientists cannot explain with any certainty why the Big Bang happened, so it is pointless to speculate about what came "before" it. Time—along with space, matter and energy—was created in the Big Bang, so there was no "before." Similarly, scientists cannot tell what happened during the very first moments. At that point the temperatures and pressures were so high that the laws of physics as we know them did not apply. But we do know for certain that as things expand, they also cool. So as the universe expanded outward from the initial explosion, the temperature and pressure began to drop.

We can start to piece together the story of the universe from a mere 10^{-42} seconds after the beginning. Around this time, the universe divided into energy and matter. For a while, energy turned into matter and matter back into energy in a seething turmoil of collision and annihilation. But as the universe expanded and the temperature fell, the type of matter in it changed. Scientists believe that at first there were many types of matter particles, but that these were short-lived and soon disappeared. It also seems that in the immediate aftermath of the Big Bang, there was only one kind of force acting between particles.

TRUE STORY

Where is the Center?

WHICHEVER WAY YOU LOOK, YOU ARE LOOKING BACK IN TIME, AS THE LIGHT FROM SOME DISTANT OBJECT TAKES TIME TO GET TO YOU. IF YOU LOOK OUT TO THE EDGE OF THE UNIVERSE, 15 BILLION LIGHT-YEARS AWAY, YOU LOOK BACK 15 BILLION YEARS—TO THE TIME OF THE BIG BANG. THE BIG-BANG'S AFTERGLOW COMES FROM EVERY DIRECTION, BECAUSE THE EDGE OF THE UNIVERSE WAS ALL IN ONE PLACE 15 BILLION YEARS AGO WHEN THE UNIVERSE STARTED.

The Four Forces

Within just a millionth of a second, the single force "broke up" into the four fundamental forces we know today: *Gravity*, which holds galaxies, stars and planets together; *electromagnetism*, which binds atoms together; the *strong nuclear force*, which holds the nuclei

of atoms together; and the *weak nuclear force*, which involved in the process of radioactivity.

The particles we know as *quarks*—thought to be the basic building blocks of all the matter in the universe today—originally existed singly. Then, after a millionth of a second, they joined together to make *protons*, *neutrons* and the other particles found in atoms.

After about 100 seconds, some protons and neutrons were moving slowly enough to join together and build up the first atomic nuclei. But it was not for about another 300,000 years, when the universe had cooled to white heat, that *electrons* fell into place, orbiting the nuclei and forming the first atoms. It was still so hot that only the lightest atoms—hydrogen, helium and lithium—could form. This hot gas of light elements expanded, thinned and cooled, and as it did so, the stars, galaxies and planets condensed out of it. The universe is still cooling. From an unimaginably high level to start with, the temperature in space is now down to -454°F . Outlook: It's getting colder!

TIMELINE FOR THE BIG BANG

0 SECONDS TIME ZERO

Birth of the universe, and the appearance of space, time, matter and energy. The universe is a cauldron of high-energy short-lived particles, and photons of radiation. There are equal amounts of matter and antimatter. Everything in the universe today was packed into a volume smaller than an atom.

10^{-35} SECONDS INFLATION

In an instant, the universe swells to an object whose size is measured in inches. Particles and antiparticles annihilate, turning into radiation, but a tiny proportion of matter is left over—the matter we see today.

10^{-12} SECONDS QUARKS COMBINE

Quarks are now moving too slowly to be able to stay out of each other's grasp. Some lump together in threes to form protons and neutrons, which are found in the heart of atoms today. Possibly a tiny proportion survive singly, and might one day be found in cosmic rays.

100 SECONDS ATOMIC NUCLEI BUILT

The temperature of the universe has fallen to a billion degrees. Neutrons and protons bind together, building up the light nuclei including helium (two protons and two neutrons) and deuterium (one proton, one neutron).

300,000 YEARS FOG CLEARS

The temperature falls to that of the surface of the Sun today. The first atoms are born when electrons start to orbit protons and other nuclei. Suddenly the universe becomes transparent, as light can travel more easily through the uncharged atoms than it could through the "soup" of charged particles.

1 MILLION YEARS BIRTH OF GALAXIES

There are slight variations in the density of the gas. At thicker points, the gas starts to form lumps that are pulled together by their own gravitational attraction. These clouds, or "protogalaxies," will develop into galaxies. Already the very first stars have formed and begun to shine.

15 BILLION YEARS UNIVERSE TODAY

The universe has thinned out to the point where, on average, there is only one atom in every cubic foot. But nearly all this matter is gathered together into the galaxies in the form of star patches of interstellar gas and dust, and planets. The galaxies are gathered into clusters tens of millions of light years across, and the clusters still rushing apart from each other. Away from the warmth of the stars, the universe is cold—just a few degrees above absolute zero.

TRUE STORY

What's in a Name?

IN THE 1950s, BRITISH ASTRONOMER SIR FRED HOYLE CLAIMED THAT THE UNIVERSE HAS ALWAYS EXISTED AND WOULD EXIST MUCH THE SAME AS IT IS TODAY. TO RIDICULE THE IDEA THAT IT HAD BEEN CREATED IN A CATASTROPHIC EXPLOSION, HE CALLED IT THE "BIG BANG" THEORY. ALTHOUGH HE WAS BEING SARCASTIC, THE NAME STUCK.

