13.7 Billion Years | Future 9 Billion Years Big Bang Timeline 380,000 Years | 1 Billion Years Chopter 30,4 3 Minutes < 1 Second Beginning

Big Bang Theory

History of the Universe



seconds after the Big Bang

The universe began with a vast explosion that generated space and time, and created all the methar and energy in the universe. Exactly what triggered this sudden expension remains a mystery. Astronomers believe it involved a runaway process called "inflation," in which a peculiar type of energy that existed in the vacuum of space was suddenly mobilized. The inflationary expansion ended only when this energy was transformed into more familiar forms of matter and energy.



Ultimate High-Energy Lab 1 second after the big bang

After inflation ended in the first tiny fraction of a second, the universe continued to expand but not nearly so quickly. As the universe cooled, the most basic forces in nature emerged: first gravity, then the strong force, which holds nuclei of atoms together, followed by the weak and electromagnetic forces. In its first second of existence, the universe was made up of fundamental particles, including quarks, electrons, photons, and neutrinos. Protons and neutrons then began to form.



Basic Elements Form 3 minutes after the big bang

In the next few minutes, the universe as we know it took shape. Already incomprehensibly large, its protons and neutrons came together to form the nuclei of simple elements. That the universe remains largely made up of these elements—hydrogen and helium—is considered strong evidence of the validity of the big-bang model.



From Hot to Cold 500,000 years after the big bang

For the next 300,000 to 500,000 years or so, the universe remained an enormous cloud of hot expanding gas. When this gas had cooled to a critical threshold, electrons were able to combine with hydrogen and helium nuclei. Photons no longer scattered, but rushed outward. We can still see the photons emitted from this period, but time and distance have shifted them into microwave wavelengths. Today, this cosmic microwave background radiation gives astronomers a window onto the early universe.



Birth of Stars and Galaxies 1,000,000,000 years after the big bang

As time moved forward, the pull of gravity exerted its As time moved forward, the pull of gravity exerted its influence on the early universe. It amplified slight irregularities in the density of the primordial gas. Even as the universe as a whole continued to expand, pockets of gas became more and more dense. Stars ignited within these pockets. Groups of stars then became the earliest galaxies. Nodern telescopes can detect these primordial galaxies as they appeared when the universe was only one billion years old, just 7 percent of its present age.



The Era of Ouasars 3,000,000,000 years after the big bang

From one billion to three billion years after the big From one billion to three billion years after the big bang many smaller galaxies merged into larger ones, forming an array of shapes resembling spirals and spheres (known as elliptical galaxies). Often the merger was so violent that stars and gas collepsed into a common center, becoming so dense they formed gigantic black holes. The gas flowing into these black holes became hot enough to glow brightly before it disappeared. The light of these "quasare" can be seen scross the depths of the universe.



Supernova 9933 6,000,000,000 years after the big bang

Within galaxies, as stars were being born, others died...often in enormous cataclyamic explosions. These explosions, called supernovae, are important to the evolution of galaxies because they distribute all the common elements such as oxygen, carbon, nitrogen, calcium, and iron into intenstellar space. Explosions of especially massive stars also create and distribute heavier elements such as gold, silver, lead, and uranium. The supernova pictured here is of

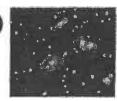


Birth of the Sun

5,000,000,000 years before the present

The sun formed within a cloud of gas in a spiral arm of the Milky Way galaxy. A vast disk of gas and debris that swiried around this new star coalesced into planets, moons, and asteroids.

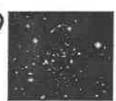
The image on the left, from the Hubble Space Telescope, shows a star in the throes of birth. Powerful jets of radiation roar out of its poles, lighting up the surrounding environment.



Galaxies Collide

3,000,000,000 years in the future

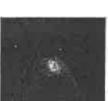
Astronomers estimate that in about three billion years, our Milky Way galaxy will be swallowed up by one of its nearest neighbors, a large galaxy named Andromeda that lies 2.2 million light-years away. Andromeus trat lies 2.2 minion light-years away. Depending on their pathways, these two galaxies will alther merge into a single gigantic galaxy or rip each other apart, sending millions of stars like our sun hurling into space. One such titanic collision involving four galaxies, 300 million light-years away, is pictured at left.



Galaxies Disappear

100,000,000,000 years in the future

If recent observations of cosmic acceleration are correct, then the "vacuum energy" that is emerging in the universe will continue to overtake the pull of gravity from matter. This means that, in the future, gravitationally bound clusters of galaxies will survive but galaxies in general will fly ever more rapidly apert. Eventually our nearest unbound neighbors will be so far sway that they will no longer be seen, even with big telescopes. But this will be so far in the future that our sun will have long since burned out and our Berth died with it.



Stellar Era Ends

1,000,000,000,000 years in the future

During this era, which will last from 100 billion years to one trillion years after the big beng (and is the ara we are currently in), most of the energy generated by the universe will be in the form of stars burning hydrogen and other elements in their cores. This long period will give way to an even longer, lingering death for our universe.

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The Degenerate Era 10,000,000,000,000,000,000,000, 000,000,000,000,000 years in the future

This are extends to ten trillion trillion trillion years This are extends to ten trillion trillion trillion years after the big bang. Most of the mass that we can currently see in the universe will be contained in stars that have blown up and collapsed into black holes and nautron stars. Or it will be locked up in brown dwarfs and planats that never triggered nuclear fusion, or in stars that withered into white dwarfs. With stars no longer actively burning, energy in this era is generated through proton decay and particle annihilation.



The Black Hole Era 10,000,000,000,000,000,000,000, 000,000,000,000,000,000,000,000, 000,000,000,000,000,000,000,000, 000,000,000,000,000,000,000,000, 000,000 years in the future

This era extends to ten thousand trillion years after the big bang. After the epoch of proton decay, the only star-like objects remaining are black holes of widely varying masses. Their energy is steadily evaporating.

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The Dark Era

>10,000,000,000,000,000,000, ,000,000,000,000,000,000,000,000, ,000,000,000,000,000,000,000,000, 000,000,000,000,000,000,000,000, 000,000,000 years in the future

At this labe stage, protons will have decayed and black holes will have almost completely evaporated. Only the byproducts of these processes remain: mostly neutrinos, electrons, positrons, and photons of enormous wavelengths. For all intents and purposes, the universe as we know it will have come to an end