

Big Bang

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The Big Bang is a physical theory that describes how the universe expanded from an initial state of high density and temperature. Various cosmological models based on the Big Bang concept explain a broad range of phenomena, including the abundance of light elements, the cosmic microwave background (CMB) radiation, and large-scale structure. The uniformity of the universe, known as the horizon and flatness problems, is explained through cosmic inflation: a phase of accelerated expansion during the earliest stages. Detailed measurements of the expansion rate of the universe place the initial singularity at an estimated 13.787 ± 0.02 billion years ago, which is considered the age of the universe. A wide range of empirical evidence strongly favors the Big Bang event, which is now widely accepted. Extrapolating this cosmic expansion backward in time using the known laws of physics, the models describe an extraordinarily hot and dense primordial universe. Physics lacks a widely accepted theory that can model the earliest conditions of the Big Bang. As the universe expanded, it cooled sufficiently to allow the formation of subatomic particles, and later atoms. These primordial elements—mostly hydrogen, with some helium and lithium—then coalesced under the force of gravity aided by dark matter, forming early stars and galaxies. Measurements of the redshifts of supernovae indicate that the expansion of the universe is accelerating, an observation attributed to a concept called dark energy. The concept of an expanding universe was introduced by the physicist Alexander Friedmann in 1922 with the mathematical derivation of the Friedmann equations. The earliest empirical observation of an expanding universe is known as Hubble's law, published in work by physicist Edwin Hubble in 1929, which discerned that galaxies are moving away from Earth at a rate that accelerates proportionally with distance. Independent of Friedmann's work, and independent of Hubble's observations, in 1931 physicist Georges Lemaître proposed that the universe emerged from a "primeval atom," introducing the modern notion of the Big Bang. In 1964, the CMB was discovered. Over the next few years measurements showed this radiation to be uniform over directions in the sky and the shape of the energy versus intensity curve, both consistent with the Big Bang models of high temperatures and densities in the distant past. By the late 1960s most cosmologists were convinced that competing steady-state model of cosmic evolution was incorrect. There remain aspects of the observed universe that are not yet adequately explained by the Big Bang models. These include the unequal abundances of matter and antimatter known as baryon asymmetry, the detailed nature of dark matter surrounding galaxies, and the origin of dark energy.