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Big Bang Theory: Origin of Our Universe

Susmita Karan[1], Mamta Panjiyar[2] and Jasbir Singh[3]

Faculty, Department of Basic Science and Humanities, Narula Institute of Technology, Kolkata, India[1]

Student, Department of Mechanical Engineering, Narula Institute of Technology, Kolkata, India[2,3]

Abstract: The article is devoted to the history of the emergence of the Big Bang theory and attempts to modernise it from the notion of the explosion of a hypothetical elementary particle with incomprehensible properties that occurred 15 billion years ago, to the idea of an explosion of space itself between distant galaxies. This explosion, according to the theory of the Big Bang, gave birth to the universe. The weaknesses of this theory are shown. We proposed a new hypothesis of the Big Bang, in which the centre of the explosion is absent. Because of the interaction of the atoms of the baryonic substance with the dark matter of the surrounding space, the growth of their mass, size and speed of rotation occurs over time. As a result of counteracting of the centrifugal forces that increase with time and the restraining forces of pressure in the dark matter of the surrounding space, a moment comes when the centrifugal forces tear apart the atoms. This can occur throughout the universe at the same time by astronomical measures. This will be a big explosion that will stir up the substance of the whole universe. This explosion will be followed by a quiet period of organization of baryons from dark matter, cosmic bodies, growth of their mass and sizes up to the next Big Bang. The age of the modern universe is estimated and the time period until the next Big Bang is estimated.At present, the astrophysics claims that our universe was formed as a result of the "Big Bang". This belief arose from the astronomical observations of distant galaxies, in the spectra of which a large redshift was observed, which meant an increase in the wavelength of light coming from these galaxies to the observer on Earth. The Hubble's law related the increase in wavelength with the distance to these galaxies. On the basis of the Doppler law, physics linked the cosmological redshift in the spectra of distant galaxies with their Active removal from each other, including from the observer on Earth. In addition, the belief that in the distant past there was a Big Bang is confirmed by the detected relic radiation and gravitational waves that have survived to our time after the explosion.

Keywords: Explosion, Hypothesis of big bang, Baryonic substance, Dark matter, Doppler law, Cosmological redshift

I. INTRODUCTION

In 1927, an astronomer named Georges Lemaitre had a big idea. He said that a very long time ago, the universe started as just a single point. He said the universe stretched and expanded to get as big as it is now, and that it could keep on stretching. The Big Bang Theory is a widely accepted scientific theory about the origin of the universe. It suggests that the universe began as a single point and has been expanding ever since. The theory has been developed through a combination of observations, mathematical modelling, and experimental evidence. In this article, we will explore the key concepts behind the Big Bang Theory, its history, and the evidence that supports it. When the universe began, it was just hot, tiny particles mixed with light and energy. It was nothing like what we see now. As everything expanded and took up more space, it cooled down.

The tiny particles grouped together. They formed atoms. Then those atoms grouped together. Over lots of time, atoms came together to form stars and galaxies [1-3]. The first stars created bigger atoms and groups of atoms. That led to more stars being born. At the same time, galaxies were crashing and grouping together. As new stars were being born and dying, then things like asteroids, comets, planets, and black holes formed!

The Big Bang theory is a fundamental concept in cosmology that explains the origin and evolution of the universe. It proposes that the universe began as an infinitely dense and hot point, known as a singularity, around 13.8 billion years ago. This singularity then underwent an explosive event called the Big Bang, which initiated the expansion of space, time, matter, and energy. The theory suggests that the universe was initially in an incredibly compact and high-energy state, and it has been expanding and evolving ever since. As the universe expanded, it cooled down, allowing subatomic particles, atoms, and eventually galaxies to form. The remnants of this early, hot phase can still be observed today in the form of the cosmic microwave background radiation, a faint afterglow of the Big Bang.

The Big Bang theory not only explains the formation of matter and the structure of the universe but also provides a framework for understanding the origin of stars, galaxies, and the cosmic structures we observe today. It has been supported by a wealth of observational evidence, including the redshift of galaxies, the abundance of light elements, and the distribution of cosmic microwave background radiation. The theory has revolutionized our understanding of the cosmos and remains a cornerstone of modern astrophysics and cosmology [5, 6].

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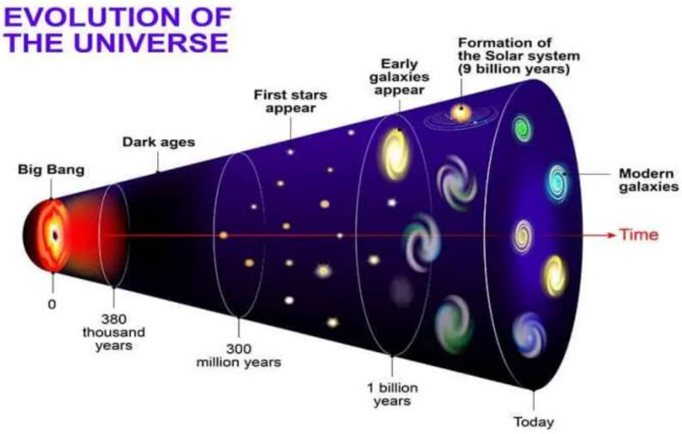

Fig. 1 Evolution of big bang theory [4]

II. HISTORY OF BIG BANG THEORY

The history of the Big Bang theory is a journey that spans centuries and involves the contributions of many scientists and thinkers. Here's a brief overview of key moments and figures in the development of the theory:

A. Early Concepts

- Ancient Cosmological Ideas: Throughout history, various cultures and civilizations developed cosmological ideas about the origins of the universe. These ranged from creation myths to philosophical speculations.
- Georges Lemaître: A Belgian priest and physicist, Lemaître proposed the idea of an expanding universe in the late 1920s. He suggested that if the universe is expanding now, it must have been smaller and hotter in the past. He called this initial state the "primeval atom."

B. Hubble's Discovery

Edwin Hubble: In the 1920s, American astronomer Edwin Hubble made groundbreaking observations of galaxies and their redshifts. He discovered that galaxies were moving away from us, and the more distant galaxies were moving faster. This observation provided strong evidence for the expansion of the universe.

C. Formalization of the Big Bang

George Gamow: In the 1940s, physicist George Gamow developed the first detailed model of the Big Bang, incorporating the idea of a hot, dense early universe and the subsequent expansion. He also predicted the existence of the cosmic microwave background radiation as a remnant of the initial explosion.

D. Discovery of Cosmic Microwave Background (CMB)

Arno Penzias and Robert Wilson: In 1964, astronomers Penzias and Wilson accidentally discovered the cosmic microwave background radiation—a faint glow of microwave radiation that fills the universe. This discovery provided strong support for the Big Bang theory and the early, hot phase of the universe.

E. Confirmation and Refinement

In the following decades, observations of the cosmic microwave background radiation became more precise, matching the predictions of the Big Bang theory with remarkable accuracy. The theory continued to be refined, incorporating concepts like inflation to explain the uniformity of the universe on larger scales.

F. Modern Developments

- Advances in Observations: Observational techniques, such as measuring the redshifts of galaxies and mapping the large-scale structure of the universe, provided further confirmation of the Big Bang theory's predictions.
- Dark Matter and Dark Energy: In the late 20th century, the discovery of discrepancies between observed and predicted galactic motions led to the proposal of dark matter. Additionally, observations of the accelerated expansion of the universe led to the concept of dark energy, which drives this acceleration.

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The Big Bang theory has evolved from early philosophical pondering to a well-supported scientific framework explaining the origin and evolution of the universe. It has been tested through various observations and experiments, and its success in explaining a wide range of cosmological phenomena has solidified its status as the leading explanation for the universe's history [7-10].

III. WAS THERE THE HOT BIG BANG PHASE?

The Hot Big Bang theory is the prevailing scientific explanation for the origin and evolution of the universe. It suggests that the universe began as an extremely hot, dense, and infinitely small point known as a singularity. This singularity underwent a rapid expansion event called cosmic inflation, causing the universe to expand and cool down over time. As the universe expanded, it also began to evolve and develop into the vast and complex structure we observe today [10,11].
Here is a step-by-step breakdown of the Hot Big Bang theory:

A. Singularity

The universe started as a singularity—an infinitely dense and hot point with all the matter, energy, space, and time compressed into it.

B. Inflation

In a very short period of time, known as cosmic inflation, the universe underwent a rapid and exponential expansion. This expansion smoothed out the distribution of matter and energy and set the stage for the universe's subsequent evolution.

C. Particle Formation

As the universe expanded and cooled down, it reached a point where subatomic particles like protons, neutrons, electrons, and their antiparticles could form. This process occurred within the first fraction of a second after the Big Bang.

D. Nuclear Fusion:

Within the first few minutes after the Big Bang, the universe was still extremely hot and dense. Nuclear reactions occurred, primarily involving protons and neutrons, leading to the formation of light elements like hydrogen and helium. These reactions were responsible for creating the initial abundance of these elements.

E. Photon Decoupling

As the universe continued to expand and cool, it reached a point where atoms could form—electrons combined with protons to create neutral hydrogen atoms. This allowed photons (particles of light) to travel freely without scattering off charged particles, resulting in the release of the cosmic microwave background radiation.

F. Structure Formation

Over millions of years, the slightly uneven distribution of matter and energy in the early universe led to the formation of cosmic structures—galaxies, clusters of galaxies, and large-scale cosmic filaments. Gravity played a crucial role in pulling matter together to form these structures.

G. Cosmic Microwave Background (CMB)

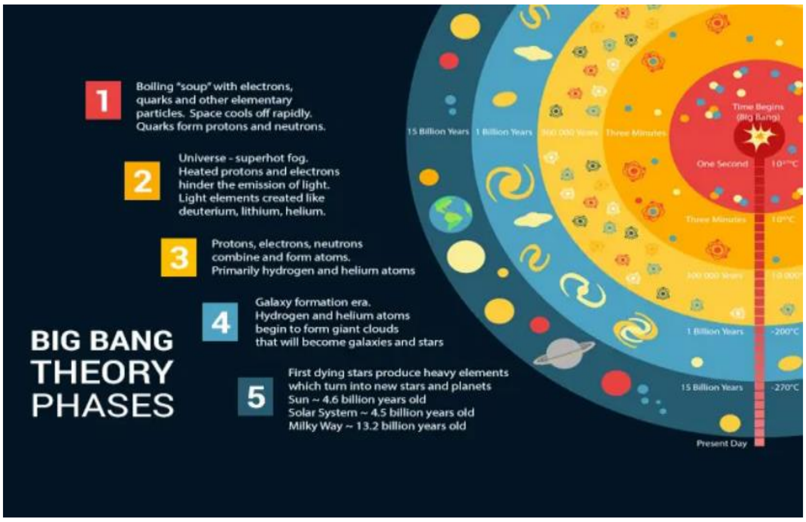

Fig. 2 Big Bang Theory Phase [12]

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The cosmic microwave background radiation is a faint glow of microwave radiation that permeates the universe. It is a remnant of the extremely hot and dense state of the early universe. The CMB was discovered in 1965 and provides strong evidence for the Big Bang theory.

The Hot Big Bang theory is supported by a wide range of observations, including the cosmic microwave background radiation, the observed abundance of light elements in the universe, the distribution of galaxies, and the overall expansion of the universe. These pieces of evidence collectively provide a robust framework for understanding the origin and evolution of our universe [13-18].

IV. EVIDENCE / PROOF FOR THE BIG BANG

According to the Big Bang theory, there was a phase known as the "hot Big Bang" phase. This phase refers to the early moments of the universe shortly after the initial singularity, when the universe was extremely hot and dense. During this phase, the universe expanded and cooled, allowing various fundamental particles to form and interact with one another.

As the universe expanded and cooled, it underwent a series of transitions that are described by different eras:

A. Planck Era
This is the earliest phase of the universe, lasting from time zero (the moment of the singularity) to approximately 10^{-43} seconds. During this time, the fundamental forces of nature were unified, and the conditions were so extreme that the laws of physics as we know them today break down.

B. Grand Unified Theory (GUT) Era
From around 10^{-43} seconds to 10^{-36} seconds after the Big Bang, the universe entered the GUT era. During this phase, the strong force, weak force, and electromagnetic force were likely combined into a single unified force.

C. Electroweak Era
Around 10^{-36} seconds after the Big Bang, the universe cooled down further, and the electroweak force (a combination of the electromagnetic and weak forces) separated from the strong force.

D. Quark-Gluon Plasma Era
Between about 10^{-12} seconds and a few microseconds after the Big Bang, the universe was filled with a state of matter known as quark-gluon plasma. During this era, quarks and gluons, which are usually confined within particles like protons and neutrons, were free to move independently due to the high temperatures and energies.

E. Hadron Era
As the universe continued to expand and cool, quarks and gluons combined to form protons, neutrons, and other hadrons (particles composed of quarks). This era lasted from a few microseconds to a few minutes after the Big Bang.

F. Nucleosynthesis Era
Around 3 minutes to 20 minutes after the Big Bang, conditions were such that nuclear reactions could occur, leading to the formation of light elements like hydrogen, helium, and trace amounts of lithium. This era is responsible for the abundance of these elements in the universe today.

G. Cosmic Microwave Background Era
After the universe had expanded and cooled sufficiently, around 380,000 years after the Big Bang, atoms formed and photons (particles of light) were no longer constantly scattering off charged particles. This allowed the universe to become transparent to light, and the cosmic microwave background radiation—the afterglow of the hot Big Bang—was emitted. This era marks a crucial turning point in the universe's evolution.

These various eras collectively make up the "hot Big Bang" phase of the universe's history. The observations of the cosmic microwave background radiation and the abundances of light elements are key pieces of evidence that support the existence of this hot Big Bang phase and the overall framework of the Big Bang theory.

V. COSMIC MICROWAVE BACKGROUND RADIATION (CMBR)

According to the Big Bang theory, the Universe was initially very hot and dense. As it expanded, it cooled (your refrigerator works on the same idea, expanding a liquid into a gas to cool the inside). Cosmologists were able to calculate the theoretical temperature of today’s Universe and began to search for evidence of it. It was eventually discovered by accident in 1964 by Arno Penzias and Robert Wilson as ‘noise’ in an antenna they had built to research how radio signals could be reflected off orbiting satellites.

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They first thought it was radio interference from nearby New York City, but eventually recognised it as radiation from beyond the Milky Way. The cosmic microwave background radiation (CMBR) that Penzias and Wilson observed is leftover heat radiation from the Big Bang. Today, CMBR is very cold due to expansion and cooling of the Universe. It's only 2.725 Kelvin (-270.4 °C), which is only 2.725 °C above absolute zero. Cosmic microwave background radiation fills the entire Universe and can be detected day and night in every part of the sky.

A. Studying CMBR

The Cosmic Background Explorer satellite (COBE) was launched in 1992 to look for small variations in CMBR temperature. The Wilkinson Microwave Anisotropy Probe spacecraft (WMAP) was launched in 2001 to measure variations more accurately. Cosmologists believe that tiny temperature variations in the CMBR are caused by differences in the density of matter in the early Universe. Areas of different density led to the formation of galaxies and stars.

B. The WMAP Survey

After nine years of observation the WMAP survey produced a detailed temperature map of the entire sky. Colours indicate tiny variations in the temperature of background radiation. These correspond to places where galaxies formed. The WMAP survey shows CMBR is almost the same in all directions. Red spots are slightly warmer and blue spots are slightly cooler, but the difference is only about ±0.0002 of a degree. The WMAP survey provides strong evidence that supports the Big Bang theory. The pattern of radiation is similar to what astrophysicists predict it would be if the Universe started from a very dense state and expanded to its present size.

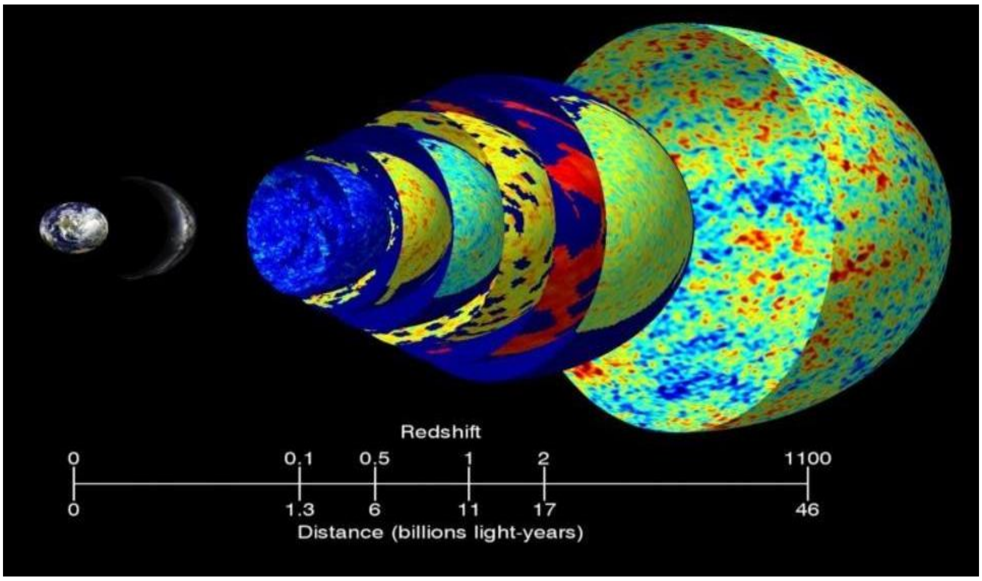

Fig. 3 Cosmic Microwave Background Radiation [19]

VI. WHAT ARE THE WEAKNESSES OF THE BIG BANG THEORY AND OUR CURRENT CONCEPTION OF THE ORIGIN OF THE UNIVERSE?

While the Big Bang theory is the leading cosmological model and has successfully explained many observed phenomena, there are some questions and challenges that it doesn't fully address. Here are some of the weaknesses and unanswered questions associated with the Big Bang theory and our current understanding of the origin of the universe:

- Initial Singularity

The Big Bang theory describes the expansion of the universe from an initial singularity, but it doesn't explain what caused the singularity or what conditions were like at that moment. The theory breaks down at the point of singularity, raising questions about the nature of space and time at that extreme state.

- Horizon Problem

The universe appears to be remarkably uniform on large scales, but different regions of the universe are too far apart to have directly influenced each other. This poses the "horizon problem"—how did these regions achieve such a uniform temperature and structure when they shouldn't have had enough time to communicate and equilibrate?

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- Flatness Problem

The universe is very close to being "flat" on a large scale, meaning that the angles of a triangle add up to 180 degrees and parallel lines don't diverge. However, the theory suggests that the universe's curvature should have changed over time due to the effects of matter and energy. The question of why the universe is so close to flatness is known as the "flatness problem."

- Matter-Antimatter Asymmetry

According to the theory, equal amounts of matter and antimatter should have been produced in the early universe. However, we observe a universe dominated by matter, and the asymmetry between matter and antimatter isn't fully explained.

- Dark Matter and Dark Energy

The Big Bang theory doesn't provide a direct explanation for dark matter and dark energy, which together make up the majority of the universe's mass-energy content. While these components are included in cosmological models, their nature and origins are still unknown.

- Inflation's Cause

While the concept of cosmic inflation helps explain certain observations, such as the uniformity of the cosmic microwave background radiation, the exact cause of inflation and the physical mechanism driving it remain theoretical and unproven.

- Cosmic Structures and Formation

While the Big Bang theory explains the overall expansion and large-scale structure of the universe, the details of how galaxies, galaxy clusters, and other cosmic structures formed from the initial conditions are complex and not fully understood.

- Dark Matter Particle

While dark matter is postulated to exist based on its gravitational effects, the nature of the dark matter particle itself remains unknown. Efforts to directly detect dark matter particles have not yet been successful.

- Quantum Gravity

The Big Bang theory doesn't account for the effects of quantum mechanics and gravity at extremely high energies and temperatures. A complete theory of quantum gravity is still an active area of research.

- Multiverse Hypotheses

Some theories suggest the possibility of a multiverse—a collection of multiple universes, each with its own set of physical laws. While these hypotheses are interesting, they are currently speculative and difficult to test.

Despite these weaknesses and unanswered questions, the Big Bang theory remains the most widely accepted framework for understanding the origin and evolution of the universe. Ongoing research, advancements in observational technology, and theoretical developments continue to shed light on these challenges and may lead to a more comprehensive understanding in the future.

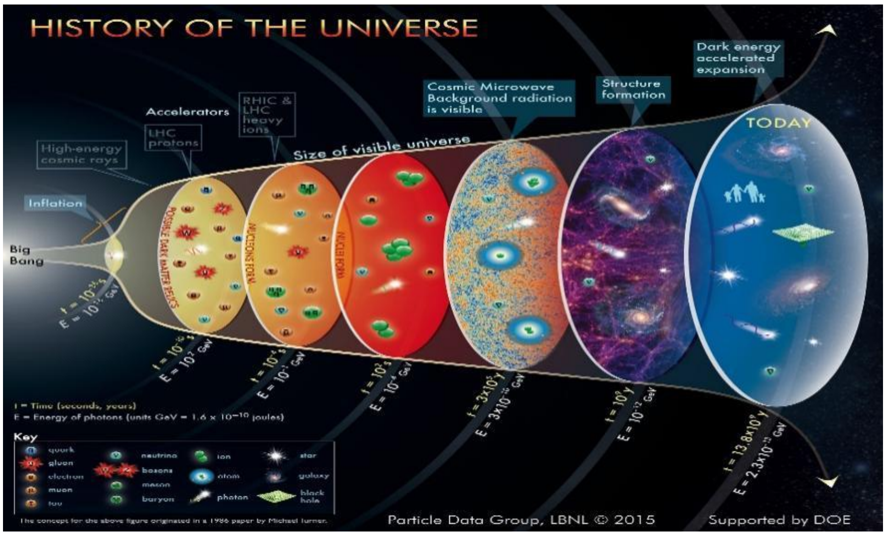

Fig. 4 Current concept of big bang theory [20]

VII. HOW DO YOU PREDICT THIS THEORY WILL EVOLVE, OR BE ADJUSTED, WITH TIME?

The evolution of scientific theories, including the Big Bang theory, is a dynamic process that is shaped by new observations, technological advancements, and theoretical developments. While I can't predict the exact future of the theory, I can offer some general trends and possibilities for how the Big Bang theory might evolve or be adjusted over time:

➢ Fine-Tuning and Precision

As observational technology improves and cosmological measurements become more precise, scientists may refine various parameters and constants associated with the Big Bang theory. This could lead to a more accurate understanding of the early universe's conditions and evolution.

➢ Early Universe Physics

The current theory doesn't fully account for the interactions of fundamental forces and particles at extremely high energies and temperatures, where both quantum mechanics and gravity play significant roles. Efforts to develop a comprehensive theory of quantum gravity could provide insights into the earliest moments of the universe.

➢ Unifying Fundamental Forces

The Big Bang theory is based on the assumption that the four fundamental forces (gravity, electromagnetism, weak force, and strong force) were once unified. Future developments might involve finding deeper connections between these forces and explaining their unification.

➢ Dark Matter and Dark Energy

As research progresses, we might gain a better understanding of the nature of dark matter and dark energy. Identifying the particles responsible for dark matter and elucidating the properties of dark energy could lead to adjustments in our understanding of the universe's evolution.

➢ *Multiverse and String Theories*

Concepts like the multiverse and string theory propose that our universe might be one of many, and that extra dimensions could exist beyond the ones we currently perceive. These ideas could influence our understanding of the early universe and the conditions that led to its formation.

➢ Inflation and Early Universe Dynamics

Inflation remains an important but still theoretical component of the Big Bang theory. Future research might uncover more details about the mechanisms driving inflation and provide stronger evidence for its occurrence.

➢ Observations of Cosmic Structures

Ongoing observations of galaxies, galaxy clusters, and cosmic microwave background radiation could provide more insights into the behavior of matter and energy in the early universe. Advanced surveys and telescopes might reveal patterns and anomalies that require adjustments to the current theory.

➢ Interdisciplinary Connections

As our understanding of particle physics, quantum mechanics, and gravity improves, we may see greater integration between these fields and cosmology, leading to a more complete and unified description of the universe's history.

➢ Experimental and Observational Breakthroughs

New discoveries, unexpected observations, and breakthrough technologies can significantly impact the evolution of scientific theories. Unanticipated findings could prompt the need for adjustments or entirely new models.

It is important to note that the evolution of scientific theories is a gradual and iterative process. As new data is collected and new theories are proposed, the scientific community engages in rigorous debate and testing to refine, adjust, or potentially replace existing models. While the core principles of the Big Bang theory might remain, its specific details and the ways in which it's understood could certainly evolve with time.

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