

# Big Bang Theory

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## History of the theory:

Physical concepts from centuries to the beginning of the 20th century describe the universe as a massive dome that is no more than our galaxy the (Milky Way). No one has imagined that there were a very large number of galaxies that reaches today (more than 400 billion galaxies, ie  $4 \times 10^{11}$ ). In another estimate, it is  $10^{10}$  galaxies within a distributed distance which is currently estimated at about  $10^{23}$  km, or the distance between us and the most distant galaxies is about  $10^{40}$  times the size of the proton. The first astronomer who was able to show that our universe was not confined to the Milky Way galaxy, is Edwin Hubble, who revealed many galaxies during the 1920s. But increased the discovery of spacing between them and their velocities increases up to seven speed of light, as some of them were examined and tested to identify the distances; relying on the intensity of their lighting, the more light coming from them is dimmed, it indicates that it is far, and in terms of Accuracy, the brightness is inversely proportional to the distance squared. Hubble has classified his discovered galaxies into two main categories: regular and irregular, the regular one is divided into helical and elliptical. There are also very distant galaxies, which are not evenly distributed, but rather in the form of a grid model on the surface of huge bubbles; composed of seemingly empty spaces.

The perception of the universe has changed according to these discoveries, from being static to one galaxy only to a dynamic universe that does not settle down and carries hundreds of billions of galaxies. This radical change is considered as the second greatest change in physics after the Copernican revolution.

The universe is showing a continuous divergence and expansion, as astronomical observations have shown, it must suggest that it began

from a compressed point called singularity, as it was the start point of the universe to be formed by assuming a huge explosion that made the universe become wider and expand, so the big bang theory was launched depending on this idea that says that the universe is expanding since the beginning of its manifestation in existence. The theory initially showed the cosmic expansion, but it has been modified since the 1980s to point to cosmic inflation, not merely expansion.

The cause of this great explosion is unclear until now. It is a special explosion, not an ordinary one, as it is not like the explosions we usually hear about or see every moment through the media. I don't mean the specificity of the enormity of the explosion, which is indescribable, as it is difficult to call it an explosion, because it's an explosion that contains all the good in it, incompatible with our concept of the explosion accompanied by death and destruction. It is, according to some people, a very soft explosion, or the resulting radiation is surprisingly regular. It is very regular, despite of the violent beginning of the universe. According to this regularity, the stars are grouped into galaxies, galaxies are grouped into clusters, these clusters are grouped into super clusters and then these super clusters are grouped into combined super clusters. This has been inferred by the similarity between cosmic background radiation and the black-body radiation. It predicts that the primitive universe was very regular with tiny variations, which are part of a hundred thousand differentials and variant waves, as we shall see. The cosmic background radiation carries these remaining ripples and disturbances that echo quantum fluctuations during the initial universe phase. If these quantum fluctuations, expressed by the symbol ( $Q$ ), are lower, then the formation of galaxies and stars will be prevented. Also, if they are higher, galaxies will become more intense causing star collisions, and may form black holes. In both cases, this will prevent the creation of life and our existence as human beings.

However, it's not clear for our minds how could the explosion be smooth and regular? As all the explosions that we see are destructive, coarse, indiscriminate, not smooth and regular, even if they were smooth and already organized, they would seem unclear and encrypted which predicts the great events that the mind still needs to describe and understand, in the same way as the Anthropic Principle which was stated by The Australian theorist physicist (Brandon Carter) during the 1960s.

The article of the big bang has expressed the chaos, as It is not usual for an explosion to create regularity, which, by nature, runs counter to the principle of entropy or the second law of thermodynamics, because the explosion is a random, long-range spread that is not expected to be regular, calm, peaceful and fruitful at the same time.

Imagine that you were told that an explosion was seen reacting very slowly and lasted for a whole day in the midst of rubble of different things. Instead of working on scattering these things in each direction with total randomness; it turns them into something beautiful and organized like a flower that delight the beholders!

It is really interesting that the origin of the term (big bang) came from a strong opposing astronomer, it has been said that he intended, by this term, to exaggerate the theory and ridicule it. It was the famous physicist Fred Hoyle who criticized this theory and expressed it in terms of this expression to degrade the idea of cosmic expansion that presupposes a specific point from which evolution began, but later he denied that it was meant to ridicule the theory, as he was the first to say this term in a radio program on the British Broadcasting Corporation (1949). But this term started spreading until it has stabilized as a sign of that theory till now.

The theory of the Big Bang was not convincing at the beginning of its appearance, and it was not considered until the period after the 1940s, when there was a radical review of measured distances. The most

important reason for making physicists not objecting to it, is related to the Hubble constant estimation measured during the 1930s and 1940s, which was estimated as 170 km per second. Based on this constant, it was concluded that the age of the universe is less than two billion years, according to the law adopted, which is the reciprocal of Hubble constant. While Ernest Rutherford's work on radioactivity showed that the earth's age was about 4.6 billion years old, meaning that the latter was older than the universe. Even when this constant was modified and reduced during the 1950s, the age of the universe approached the earth's age, while other measures which were in progress at the time showed that the life of some galaxies is more than 10 billion years, so it is larger than the age of the universe. It is also shown that the age of some stars approximates modern measurements based on the Hubble constant. This led to doubt about the significance of Hubble's hypotheses about the age of the universe or expansion, whether in relation to his law and constant, or what was adopted on the Doppler phenomenon and red light, and even questioning the origin of the theory of the big Bang as we will see ...

The idea of a stable universe was therefore reliable according to many people even after the spreading of Hubble's discoveries during the 1930s. At the end of the 1940s, another idea that attracted physicists appeared, which is called Steady State theory, created by a number of scientists, headed by Fred Hoyle, Thomas Gold, Hermann Bondi and Jayant Narlikar. Physicists have found their desired destination in this theory and the one that competes with the theory of the Big Bang. The competition between these theories was ended in the mid-1960s after Cosmic Microwave Background was discovered, as the theory of the Big Bang had a decisive victory, although it faced many problems, such as floundering in the estimates of the age of the universe, which could be an evidence of clear randomness. In addition to many questions such as: how could an explosion create a precise system? , How could this theory be reconciled with the principle of entropy and the second law of thermodynamics?. Thus, the idea of the steady state seems more acceptable and logical. This theory assumes that the universe expands

in infinite space and time without explosion, and maintains the same constant cosmic characteristics over time, and the rate of expansion remains also constant. It assumes that there is room for the material to be created at a constant rate so that the density of the universe remains constant during the expansion. This process is called continuous creation, where about one hydrogen per cubic meter is created throughout the life of the universe.

So, according to this theory, creation is continuous without the need for the beginning and the explosion, or the material has no beginning and no end, because the universe has constant means of providing itself with energy forever, so that the average density of the universe remains constant. Thus, galaxies will be formed, ended, then re-formed, and so on. Fred Hoyle has supported this idea theoretically, and it has been considered as the rival of the Big Bang theory for more than a decade.

The theory of the steady state became attractive when the measured age of the universe varies from time to time, until the mid-1960s, when the theory was considered wrong by the discovery of the microwave background radiation (CMB) because of its indications about the difference between the conditions of the universe at the beginning and right Now. The theory was therefore considered to be in contradiction with the standards of astronomy. So, it was abandoned, but Hoyle did not accept the results of the discovery of this radiation, but attributed it to other causes, and kept on his opinion until his death. Today, some people have tried to find, in it or in another similar model, an alternative to the Big Bang theory, such as the theory of cosmic plasma.

It is no wonder that some Western theologians support the theory of the steady state in defense of the constant creation by God without interruption or beginning, while ignoring the atheism of its owners. On the Islamic level, it is consistent with the idea of the doer God: ((do what he wants)). Ibn Taymiyyah al-Harani, a Muslim theologian, believed in this idea, that God is active and creative and always without

interruption, as he always the god who gives life or take it away, and this theory was Confirmed by ancient philosophers. The previous idea of the constant continuity of creation doesn't conflict with the physical belief in the passage of the universe in various cases from its inception to the present day, the same as shown by the radiation of the cosmic background, as the difference, observed by scientists within a specific time ( 14 billion years), is an evidence of a cosmic cycle preceded by other cycles without a start, and will be followed by endless cycles. This idea may be consistent with what is stated in the Qur'anic text:

**(On that Day, we shall roll up the heaven like a written scroll is rolled. As We originated the first creation, so will We bring it back again. This is a binding promise on Us Which We shall assuredly fulfill.)**

In terms of detail, the evidence adopted by the Big Bang theory can be determined by three basic principles:

## **1 - Doppler shift evidence:**

An evidence of the spans of galaxies steadily apart from one another at an accelerated rate depending on the distance between them, and the observed distance from Earth based on the Hubble discoveries of the late 1920s. Before that, the Russian cosmologist Alexander Friedmann predicted the expansion of the universe (1922), he even saw that the distant regions of the universe were faster than others, and that the world was symmetrical in all directions. These predictions came five years before Hubble's discoveries. Three competing assumptions have been made by him about the shape of the universe, either it is open as a horse's saddle and it will continue to be stretched forever, or closed, on the Einsteinian way, like a potato leading it to be vanished again, or a flat surface ranging between opening and closing.

In his discoveries, Hubble relied on Doppler's shift, a phenomenon discovered by the Austrian physicist Christian Doppler (1842), which he applied to both sound and light as mobile waves, but he wrongly applied it to photonic waves when he wanted to explain why planets seem colored. The Doppler phenomenon is not detected by the naked eye, thus it is different from the acoustic wave application, as according to the latter; the phenomenon is quite familiar. If there is a moving source that carries an acoustic siren, as in the case of hearing the ambulance sound, then we realize that the source is approaching or departing. If the loudness of the voice becomes louder, this will indicate the approach of the source, and when it gradually diminishes, so it departs from us. It is also the case with light, if there is a source that moves away from us very quickly, the light we get from it will look red, and the redness will increase as the distance increases. If the source approaches us, it will appear bluish and become more bluish as it gets closer and closer. The explanation for this phenomenon is that the photonic waves, in case of departing, are getting longer; so, it looks red, while it shrinks as it approaches so it will be blue. Consequently, changing to the red is due to the expansion of light, so it takes a longer time to reach us, while the displacement to the blue is due to the compression of the wavelength of light, so it takes a shorter time to reach us.

The British astronomer William Huggins may be the first to employ this phenomenon to know the dimensions of the stars and the direction of their movements, as in 1868, he proved that the dark lines in the spectra of some of the brightest stars turned to faintly red or blue depending on their natural positions in the solar spectrum, and this was explained by moving away or approaching of the star. For example, the wavelength of each dark line in the spectrum of the Capella star is greater than that of the corresponding dark line in the spectrum of the Sun by 0.01% indicating that it is moving away from us at the same rate of light speed.

Hubble and his young assistant Milton Humason formulated his law

based on this phenomenon. He concluded that there is a steady relationship between velocity and distance between galaxies. The farther the distance, the higher the speed is, To the extent that some of them have a great speed of about seven times the speed of light due to the large distance. It was later found that some of them were more than 90% of the speed of light. Today, the speed of some distant galaxies is estimated to be even greater. Many physicists have assumed that they are violating the speed of light and exceed it, so it is impossible to see them. so Hubble concluded that galaxies are moving away from us at different speeds depending on their distance from us. This called for a fixed ratio between distance and speed, which was called Hubble constant. It is known that this constant changes with the change of time as long as the universe is in evolution and expansion movement. But its change occurs only within very long periods, therefore it's considered constant for us.

According to this constant, the velocity of the galaxy's movement can be measured, as it's equal to the Hubble constant ( $H_0$ ) multiplied by the distance ( $D$ ) between us and the galaxy. From a mathematical point of view, the velocity equation ( $V$ ) is as follows:

$$V = H_0 D$$

What is important is that, despite the importance of Hubble's discoveries, he did not link them with the cosmic expansion, because he didn't imagine that this is a sign of expansion. Everything is steadily diverging from everything. But the first to exploit these discoveries in proving this expansion was the physicist and Belgian priest (Georges Lemaître), who, as a result, said that the universe must have started from a starting point of expansion. In his paper (1927) he interpreted Doppler's optical shift as an evidence of the expansion of the universe. He worked to solve Einstein's general relativity equations and predicted



that the universe was expanding, the idea seemed strange and it was said that Einstein's face became red when he objected by saying: True, but your physics is awful. In (1930) Lemeter suggested that our expanding universe had begun from an infinitesimal point called the primordial atom, which is later called the singularity, from which the great explosion began and then expanded as interpreted by Hubble's Law. Lemeter saw that the beginning of the history of the universe was cold, but a number of physicists such as Ralph Alpher and George Gamow put forward an alternative model of a hot start to the universe, as It represents the first step in nuclear synthesis.

This expansion and its relation to the departing distances are usually represented by a dotted balloon. The British astronomer Eddington was the first to do that (1931). The more it's blown, the greater the distance between points. It means faster spacing of points away from the source of blowing relative to the closer ones within a fixed ratio. This spacing is also referred to as expansion of the universe, not the spacing of galaxies themselves, as in the case of the dotted balloon, it is a misleading idea.

## **2 - The evidence of cosmic microwave background radiation:**

This evidence assumes that the universe was created filled with the very hot gamma rays before the material formed through the atoms. Then, as time passed, the universe gradually cooled. At some point, this radiation passes through and travels freely in the space and its temperature gradually decreased until it arrives to us after a long journey, currently estimated by more than 13 billion light-years, so its temperature became very low and close to absolute zero. The travel of radiation and its spread over these billions of years with its low temperature is indicative of the cosmic expansion.

Based on the background of the theory of cosmic expansion, Ralph Alpher and Robert Herman (1948) foresaw the idea of a strong cosmic

radiation background in the nucleosynthesis era. If there had already been an expansion, we would have expected a very cold radiation reaching to us which was estimated by these two physicists at a temperature of 5 Kelvin, before it was discovered during the 1960s by chance. It has drawn the attention of these two scientists that there is plenty of helium that is higher than the expected to be produced by hydrogen in the stars, as helium made inside the stars remains locked in it, though it is everywhere. Therefore, they assume that helium is created primarily before the formation of stars and galaxies, and it is expected on this basis that there is evidence of this process through radiation coming to us from that primitive period. So, it was assumed that there was a background bearing the fingerprints of the origin of the universe at the beginning, that means, bearing the fingerprints of hydrogen and helium.

The story of the discovery of these radio waves or microwaves begins with a kind of noise (1965), when the young astronomers Penzias and Wilson were using a radio wave antenna to communicate with the first modern communications satellite. When they found a mysterious group of confused waves, initially thought there might be a radio near New York, or bird droppings covering the antenna. After months of confusion in research and scrutiny, they were able to detect the most important cosmic phenomenon after Hubble discovery of the expansion of the universe, even though they did not know the importance of this discovery.

Cosmic background radiation has been interpreted as a black body radiation that has a temperature of less than 3 Kelvin. It has a long wavelength, a very cold thermal radiation emanating from a black body because as it has all the characteristics of thermal radiation released from an oven with very low temperature, as it has a spectrum reflects the way of changing the brightness of light according to the change of energy, so applies to the characteristics of this body.

As the universe expands, the wavelength of each ray stretches, or the

wavelength of each photon increases as the universe expands. Since the temperature of the black body radiation is inversely proportional to the length of the radiation wave, this temperature will decrease during the universe expansion as the wavelength increases. It is, therefore, possible to calculate the previous amount of the universe temperature and time after measuring the temperature of the background radiation to be approximately (3 Kelvin) and the length of the radiation wave to be (7.35 cm). The energy of the photon that reaches us is very small compared to that of the nuclear body mass. Its energy at (3 Kelvin) is (0.0007 electron volts). In the higher temperatures of the early times of the universe, the photon energy was much larger. However, the energy of the proton and the neutron did not change from what it was in the past as it is currently, which is equal to (939 million electron volts).

In the early 1990s, the cosmic background measurement reached its peak via the NASA's Cosmic Background Explorer (COBE). Physicists and astronomers have confirmed with high accuracy that the universe is full of microns with a temperature of about 2.7 degrees above absolute zero (-270 degrees Celsius). So, cosmic background radiation is the coldest thing in nature, according to physicist Marcus Chown, although scientists have been able to reach much lower temperatures.

Generally, microwaves are an invisible light that characterizes very cold bodies. Which made it characterized by this is the long journey that started since the inception of the universe, as it represents the echo of the moment of the big Bang, and therefore it exists everywhere as an archetype that predicts the origin of the universe and its evolution. Each cubic meter of the universe contains an average of about 400 million photons. One of the effects of this radiation is what appears in the old television as a noticeable disruption before and after the live broadcast, where about (1%) of them are within this disruption that is similar to ice.

Physicists did not find a better hypothesis than the explanation of the

nature of microwaves according to the assumption that they are like a fossil effect that had traveled a long journey a long time ago till it came to us, this was within 13 billion years. It reveals that the universe began hot and then expanded and grew in size until it gradually cooled as indicated by this cosmic radiation that have reached to us, as It is the cold effect of the last radiation dispersed by electrons in the atomic reunion era.

But why have not we received this radiation since the start of the Big Bang? This is due to the fact that it was not possible for it to move freely at the beginning of the creation of the universe due to the impediments of radioactive fragmentation, this was before the formation of atoms and matter. It is known that in the limited minutes of the age of the universe nuclei of light elements were formed within the so-called primitive nuclear synthesis (Primitive nucleosynthesis). The heat and particle density at the time of the Big Bang was very high, and the photons encountered a problem in their movement as a result of the intensity of their collision due to this particle density, where the photon finds in its way, many free or ionized electrons that either work on its absorption or dispersion. It was like a black hole that prevents light photons from being free. Because they have a huge energy; they are characterized by violent random fevers that prevented any opportunity to synthesize the atoms, due to their violent collisions with electrons and others. So, the radiation predominant, as it causes the material dispersion and prevent it from gathering and cohesion. But as time went on, the photons' energy becomes too weak to prevent the accumulation of matter and to stop ionization, so the free electrons disappeared after the nuclei of the light elements acquired them to form the first neutral atoms.

This era is usually dated to about (380,000 years) after the explosion, at a low temperature of about (3000 Kelvin). This time is considered an articulating time after the finite minutes of the universe's time, since it refers to the transition from the age of tyranny of the radiation to the age of tyranny of the matter. According to the physical

estimates, there was nothing of significance that could be referred to after these minutes until this articulating era has appeared in which the universe was about a thousand times smaller than it is today and one billion times more intense. Before that, the universe had been dark and full of ionized matter and a mixture of matter and radiation of massive energy without any distinction. Then the universe, ever since this era, became transparent against the rays released from the stifling darkness, which reached us energy exhausted in the form of cosmic background radiation, leaving behind the primary atoms to gather and cohere depending on the attraction among them, through which the galaxies and then their clusters were gradually formed. Thus, the predominance of the matter has occurred due to the abundance of the produced galaxies and their clusters.

The cosmic background radiation is considered to be the strongest evidence of the Big Bang Theory. It is unlikely that its source comes from our galaxy, as it is regular, whereas the radiation of our galaxy is not regular, and its degree of uniformity is not evenly distributed in the sky. Thus, physicists concluded that this radiation comes from outside our galaxy and considered identical in all points of the earth and is not affected by either seasons, night or day.

Although physicists saw the discovery of this radiation during the mid-1960s as the greatest evidence of the theory of cosmic expansion, they later found it difficult to explain the state of the heterogeneous universe. Although the properties of this radiation are considered as an evidence of cosmic expansion, they are at the same time inconsistent with the heterogeneity of the universe, as there are areas filled with galaxies and their clusters, while there are other empty areas, so how can we explain the existence of these large gatherings without having anything of the impact on the radiation background, in the sense that there must be some variation in density at the beginning of the universe which explains the existence of Galaxies and their huge clusters, and this variation must have been transmitted by the radiation background with some variation as well.

It is thus noted that the radiation background itself, that physicists have made the greatest evidence of the expansion theory, has raised - later - problems that they could not solve. At first, they found the background radiation homogeneity to be desired; they followed this discovery as the guide they were waiting for, so as to take them back to the beginning of the great explosion before galaxies and matter. But they later faced a problem that this evidence foreshadowed an early homogeneity as long as the radiation they detected was homogeneous, so it's unable to explain how large galaxies emerged from a homogeneous universe? This has led astronomers to look for something other than what they wanted at first, as homogeneity of the background radiation was their destination for cosmic expansion. Later, they wanted to find a background radiation showing some differences by which galaxies could be explained.

The features of the Big Bang theory have changed from their old framework of cosmic expansion to a new assumed framework called cosmic inflation. This new framework was introduced in the early 1980s and predicts such differences in cosmic background radiation. But when astronomers search through satellites and others, they find that the radiation background still predicts the homogeneity with very small differences that cannot explain these galaxies and their huge clusters, as we will know later.

### **3- The evidence of light elements:**

Is an evidence of the manufacture of light elements within a few minutes of the life of the universe, they are : hydrogen, helium and lithium, but the heavier elements were all created after the emergence of the stars, as the Big Bang theory assumed that the universe was composed primarily of hydrogen and (about 23%) of the helium mass. The physicist Stephen Hawking estimated that this calculation is true, but we will find some differences in estimation and calculation.

According to physicist Jim Peebles, the universe in the first three minutes was full of radiation, which prevents a significant increase in the heavier elements from hydrogen. This radiation filled the universe with a very high equivalent heat, and the length of its wave is very short. But its equivalent temperature has fallen with the expansion of the universe continuously; until now it appeared in the form of a radio background noise that fills all directions with the same intensity. Peebles noted that if there was no strong radiation background during the first few minutes of the universe, then the nuclear reactions would become fast enough for a large part of the hydrogen to become heavier, which is the opposite of reality, because hydrogen forms about three-quarters of the universe.

It was assumed that some isotopes of the light elements were formed long before the galaxies and stars were formed according to their fragmentation and they needed a strong heat to form, as with deuterium, which is low in the universe compared to other light elements, it is a heavy hydrogen composed of a united neutron with a proton. It is observed that the nucleus of deuterium is fragile and its creation does not settle in the stars, unlike helium and lithium. What happens in the stars is the destruction of deuterium at a rate that exceeds the rate of its production, because the strong radiation fields within these stars break down deuterium into its original components of protons and neutrons, so the abundance of this element must have been created before the birth of stars and galaxies. When the universe was very hot, the nucleus of deuterium was torn apart by radiation into separate protons and neutrons. Thus, these nuclei are destroyed once it has been created. This is called the deuterium bottleneck. As long as this nuclear traffic jam exists, no helium atom can be synthesized or created. According to physicist Peter Coles, when the radiation temperature was less than 1 billion degrees, radiation did not have enough power to decompose deuterium. But in another consideration, made by Steven Weinberg, that this happened when the temperature was at least three billion Kelvin. It is possible that the deuterium atoms bind to form helium-3 with the release of a neutron. Then this helium

can capture the nucleus of deuterium and form a helium-4 atom with the release of a proton, this is the helium available in nature with a mass of about 25% with Simple traces of deuterium and helium-3 remain.

The effect of strong nuclear force during the first two minutes of the universe was prominent in the formation of hydrogen and other nuclei. A minute later, the universe began to cool enough to combine protons and neutrons into the nuclei of atoms. The first that created nuclei is those related to deuterium, where there is one proton with a single neutron. As the temperature became lower the threshold of nuclear fusion, one helium was produced versus 10 nuclei of hydrogen and very few others. Which mean that the process resulted in the formation of (90%) of hydrogen with (10%) of helium and very few of deuterium, tritium and lithium. The reason for the prediction of this estimate is due to the presence of this proportion in the stars, the ten components of helium. But the latter, is still being created in very little amounts in these stars by the hydrogen fusion, where deuterium tends to quickly merge into helium if not broken by sequential star radiations.

## The reference

<https://www.philosophyofsci.com/index.php?id=119>