A Scientific Inquiry to the Infinity of The Universe

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Abstract

This paper examines common misconceptions about the origin of the universe and questions the limitations of the widely accepted Big Bang theory. While the Big Bang explains much about the early universe, it does not fully address deeper questions—such as what existed before the event or what caused the universe to exist in the first place. By combining key ideas from classical physics, Einstein's relativity, and quantum mechanics, the paper proposes a theory of an infinite and randomly generated universe—one that may have always existed under certain physical conditions. Drawing heavily from Stephen Hawking's A Brief History of Time, along with both ancient and modern perspectives, this work argues that the universe may not have a singular beginning, but instead could be one of many in an eternal system. The aim is to encourage a broader understanding of the cosmos and inspire deeper curiosity about the nature of reality.

1 Introduction

Boom! Upon trillions of pieces of matter and particles shatter away from each other in all directions, expanding with a speed that is even faster than the speed of light seconds after the Big Bang occurred. But you wouldn't be able to hear anything, first, because you weren't there when it happened, and second, since sound waves can't be transferred to your ear because the universe is a vacuum, and it hasn't been created yet. No one can hear, feel, or observe it, but how do we know how the universe came to exist? The answer is hidden among the theories that explain the history of the universe in which every element required for life "accidentally" qualified. Those theories have been proposed by extraordinary human beings in history including physicists, cosmologists, and philosophers who dedicate their lifetime trying to understand such a fundamental problem of reality.

Many people think that the universe must have a beginning, meaning that our timeline has a starting point which they believe was the Big Bang. However, the issue with that theory is that they cannot interpret how everything would look before that. Was there anything that existed before the beginning of time? Acknowledging the importance of such a mystery, theoretical physicists have been able to modify their ideas by searching for evidence in the present and by logical thinking; coming up with a theory that explains the history of the universe in which it is self-contained and will infinitely exist.

2 The Big Bang Theory

The Big Bang theory is the most famous and well-known explanation proposed by scientists in the journey to understand the secrets of the cosmos. According to Andrew May and Elizabeth Howell's article on Space.com, scientists describe the universe that we know started with an infinitely hot and dense single point called the singularity that inflated and stretched at an unimaginable speed, then slowed down as it is now after 13.7 billion years [1]. The majority of people think the Big Bang is the explosion of a singularity that started our universe, without truly knowing how everything came to exist, while some think it is a false theory due to a misunderstanding of Newton's first law of motion and Newton's universal law of gravitation.

2.1 A Scientific Definition of the Big Bang

In the beginning, there was an explosive expansion of the singularity, a point with a size of a fraction millimeter or zero in diameter, which experts describe as "suddenly" happening, pushing matter and radiation away from each other and forming the universe in the early stages. According to theories of physics, if we were to observe the universe just one second after the Big Bang, we would see a bundle of extremely hot subatomic particles such as neutrons, protons, electrons, positron, photons, and neutrinos moving in all directions [1]. As time passed, those particles would start to cool down to the point that protons, electrons, and neutrons begin to combine and eventually form an atom. Then it took hundreds of millions of years for the first star to form and light began to shine and even longer for the universe to start to resemble what we see today.

To this day, we still haven't been able to conclude whether the Big Bang was true and whether its theory reflects everything about the beginning, but the evidence that we have found, so far, strongly supports the event. From the expansion of the universe to noting that the universe is still in its cooling down

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process, indicates that there are early stages of existence. Even though mathematical calculations and logic prove things, scientists still cannot positively conclude if the event happened in the way they think and many factors can causing inaccurate results. Some communities in the world don't believe the Big Bang started our universe because according to Newton's first law, matter in space after being exerted by force will remain in motion at a constant velocity if no other force acts upon it, so particles will never come together to form an atom or even a planet. This argument is correct at the level of describing Newton's first law but ignores the fact that the universe is still expanding, and and it misses a whole part of Newton's extraordinary work which is gravitational force.

In his law of universal gravitation, Newton describes an attractive force exerted between two objects in space that draws them close together. The force is calculated by

$$F = G\frac{m_1 m_2}{r^2} \tag{1}$$

where F is the force acting, G is gravitational constant, m_1 the mass of the first object, m_2 is the mass of the second object, and r is the distance between them - as F is proportional to the total mass of the two objects divided by the square of distance between them multiplied by the gravitational constant which is $6.67E-11$.

This implies F is extremely small if the mass of the objects is small and if they are far away from each other. For this to make logical sense, we have to apply Einstein's energy and mass relation $E = mc^2$ to the moment right after the Big Bang when matters are moving faster than the speed of light, it must have an unimaginable mass and the closest distance. But the explosive force exerted on each matter was out power the gravitational force, so they have moved away from one another. As time went by, the gravitational force started pulling matters closer together and slowed down the universe's expansion to the point that an atom was formed, and so on. That is the reason why it took a long period to produce an atom by subatomic particles.

The outstanding of Newton's law of universal gravitation has helped humans to better understand about the universe, explains why the Earth travels around the Sun and other moons that travel as an orbit in our galaxy. But the great characteristic of a genius is acknowledging the weakness of their work and being willing to fix it. Newton could not explain why there is such a force applied on two objects at a distance when there isn't any connection between them. This mystery was left unsolved over many years until a physicist, James Clerk Maxwell, and his partners discovered the electromagnetic field.

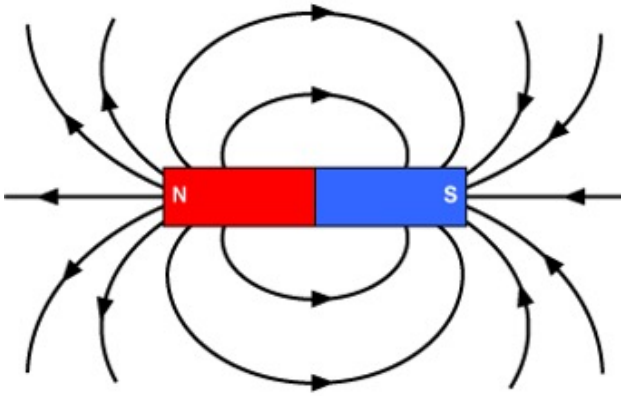

Figure 1: *Magnetic Field on Compass. This figure illustrates the magnetic vectors acting around a magnet which started on the north side (N) and ended on the south side (S). From Northeastern University, Magnetism Basis. (n.d.). Magic of Magnetism. https://ece.northeastern.edu/fac-ece/nian/mom/work.html.*

2.2 Electromagnetism

J. C. Maxwell was a Scottish physicist who was famously known for his theory of electromagnetic radiation (1865), a theory that can answer Newton's question about the structure of space in which two objects interact with each other. Maxwell's theory describes a field that he called magnetic, a vector field surrounding every object in the universe, that influences the motion of moving electric charges, and magnetic materials like compasses. He explained the reason forces are acting on two objects from a distance in Newton's theory is because the gravitational force was transferred through this field, which consists of magnetic fluxes as shown in (1), to the other object and causes its change in motion. Another brilliant idea proposed by Maxwell and many other scientists at the time including Michael Faraday was the electric field.

The electric field is an alteration of space caused by the presence of an electric charge. The electric field meditates the electric force between a source charge and a test charge [2]. An object or particle with either positive or negative electric charge will interact with this field and exert an electric force on each another. This is basically how a particle accelerator works, accelerating particles in both a magnetic and electron field.

3 Enstein's Work

3.1 Special Relativity

According to CERN (the European Organization for Nuclear Research), the first research paper Einstein

wrote was about his theory of special relativity which was sent to the journal *Annalen der Physik* on 30 June 1905, explaining the relationship between space and time-energy and mass-electron and magnetic field [3]. He claimed that the magnetic and electron fields are parts of one thing: the electromagnetic field, a field on which satellite, telephone, internet, and radio signals communicate. The accuracy of special relativity has been proven many times through experiments, and it is the source of our technology nowadays. Humans can even create weapons by manipulating his equation. However, special relativity wasn't the best theory of Einstein yet. About ten years after this work was published, Einstein sent another paper to the journal with a wider range of knowledge of the universe, the most beautiful theory in science history, general relativity.

3.2 General Relativity

Harvard Center for Astrophysics says that general relativity explains that the concentration of mass and energy curves the structure of space and time, affecting the motion of anything passing nearby, including lights [4]. When a light beam passes by a planet, its trajectory first altered, and then return to straight as it escapes out of a certain radius of the planet. Eddington, an astronomer, and physicist in the 1900s, observed during a total solar eclipse of gravitational lensing of light passing near the Sun that agreed exactly with the prediction of general relativity and confirmed Einstein's equations of what happens to a beam light when it travels by a planet with great mass [5]. To understand this idea, one must imagine a small circle ball being thrown in a straight line until it reaches the inside of a downward cylinder cone, the ball will then travel in a curved direction and then fly outside if the initial velocity is big enough, otherwise, it will continue to travel around the cylinder as its rotational radius decreases and eventually get to the bottom. This remarkable idea has also answered the question of why the Earth and other planets travels around the Sun in an eclipse and the moon around the Earth. Since space can be curved, an object with more mass will bend the space around it more than the lighter one, and that object becomes the center of a curved space around it, making other objects fall into it. The Sun is the heaviest star in our solar system, which is why it would have such a large bent region around it, making the stars around fall into this area, and this matches Newton's law of gravitation! Turns out, Einstein has modified Newton's idea in a more accurate way which included the missing elements that cause the stars' motion in the universe.

Although Einstein's theory of general relativity seems to perfectly describe the structure of space, there is still one major problem that at first, he did not agree with but later changed his equations to fit with the solution. That is, if gravitation were the only active force, Einstein's universe would collapse. We know that the universe doesn't just consist of our galaxy, and the sun or any star that has the greatest mass will become the center of our universe. As other stars move around it, they would eventually get together and collide, causing the whole universe to collapse at one single point just like multiple balls in the downward cylinder cone will get to the bottom and stop moving. To prevent this from happening, there is one solution that Einstein, in 1931, had adopted: that the universe expands from every direction. The expansion of the universe has been observed by many scientific instruments as NASA HUBBLESTIE states "In 1929, Edwin Hubble provided the first observational evidence for the universe having a finite age. Using the largest telescope of the time, he discovered that the further a galaxy is from us, the faster it appears to be receding into space. This means that the universe is expanding uniformly in all directions" [6]. To this day, scientists still don't know what causes the expansion of the universe since gravitational force is supposed to slow down its inflation process, but instead, it continues expanding as time goes on. One possible answer to this is the universe consists 68% of dark energy, a kind of "energy" that we don't know exactly how to interpret, but physicists know it causes the expansion. NASA explains dark matter as a property of space as we know space is not actually "empty" but has many properties. One of them is that space can possess its energy and more space can come into existence resulting in more energy of space appearing causing the universe to expand faster. This discovery is magnificently important because if the universe is expanding, the time arrow would be pointing from left to right, this explains why the past will always remain itself, the present becomes the past, and the future will soon become the present and then the past. That means if we are to reverse the arrow of time from right to left, billions upon billions of years, the cosmos used to be extremely small and dense. That is how the Big Bang theory was produced.

But human curiosity doesn't stop there, one more question is needed for an answer, one that is much more fundamental, and beyond the boundary. If we continue to go back even further in time, passes the moment of the singularity, what was in the universe before that? In other words, what did the universe look like before the beginning of time? Or was there a beginning? The Big Bang theory itself does not explain anything about this mystery, but certainly, there

must be something that existed before the singularity that caused the existence of the universe. To find an answer to this question, we must look at the possible solutions proposed by intelligent humans in history, starting with ancient times.

4 Ancient Theory on the Beginning

Throughout our history, humans have never stopped seeking the answer to the origin, how time started, and what happened before that, and many philosophers from ancient times have come up with multiple ideas about how the universe began. Their theories though could not be proven at the time, but later be considered as one of the fundamental explanations that have a high possibility to be precise when scientists discovered more evidence of it.

4.1 The Greek Philosophers

Hawking says that in 340 B.C, the Greek philosopher Aristotle was able to put forward a good argument for believing that the Earth was a rounded sphere rather than a flat plate by observing the eclipse of the Moon was caused by the Earth coming between the Sun the Moon, and the Earth's shadow is always rounded which can only be true if the Earth is spherical [7]. Aristotle thought the Earth was stationary and that the Sun, the Moon, the planets, and stars moved in circular orbits around the Earth. This idea was elaborated into a complete cosmological model in the second century A.D. [7]. He created the idea that the universe has a boundary and is rounded by the furthest fixed star and was later adopted by the Catholic Church as the picture of the universe that matched the scripture description because it had left a great space for heaven and hell. The Library of Congress explained Aristotle's cosmological system in which he argued that there were four fundamental elements, fire, air, water, and earth. The combination of those four things produces matters as we see today and all of them have their weight. The lighter substances moved away from the center of the universe while the heavier ones like the Earth, according to Aristotle, settled into the center [7]. Even though his arguments are not necessarily true compared to modern science, they withstood for centuries because they made logical sense at the time and couldn't be tested by any credible instrument. Nonetheless, as Hawking states "Aristotle, and most of the other Greek philosophers, on the other hand, did not like the idea of a creation because it smacked too much of divine intervention. They believe, therefore, that the human race and the world around it had existed, and would exist forever." The other ancient philosophers at the time have considered these arguments and responded with multiple periodic floods or other disasters that have set the human race back to the beginning.

On the other hand, the beginning of the universe has been discussed for a while at the time. To the number of early cosmologies and Jewish/Christian/Muslim traditions, the universe started at a finite, and not very long ago in the past. One argument that they had was the "First Cause" which is within the universe, everything that exists has a cause for its existence. The universe exists; therefore, it must have a cause, and this cause is God who is preferred as the creator of the universe. But that doesn't mean He created it at a specific time in the past. God could create the universe at an infinite time. The question of whether the universe had a beginning in time and whether it is limited in space was later brought back to discussion by philosopher Immanuel Kant in 1781. He said it was a contradiction to say either the universe does or does not have a beginning because if there was not a beginning, the universe would have existed forever, and if there is a beginning in a specific time, there would be an infinite period of time before any event, which he considered absurd. These arguments are based on the assumption that time continues forever. According to Hawking, "The concept of time has no meaning before the beginning of the universe. This was first pointed out by St. Augustine. When asked: 'What did God do before he created the universe?' Augustine didn't reply: 'He was preparing hell for people who asked such questions.' Instead, he said that time was a property of the universe that God created, and that time did not exist before the beginning of the universe" [7].

The question of the origin of the universe at the time was a metaphysic or theological question that couldn't be proven scientifically but by logical thinking and religious belief. However, we know certainly that it does not make sense to say the universe began at some time in the past because that would mean there were events before the beginning and that time would infinitely exist. One may say time started when God created the universe, and time is a property that came along with it, but it would be meaningless to say He created at some time in the past because there would be events that happened before His creation that do not have any effect on reality. The assumptions from the ancient and classical philosophers were a great contribution to modern cosmology in the journey of looking for the fundamental answer to whether or not there was a beginning of the universe.

5 Stephen Hawking and His Theory of an Infinite Universe

5.1 A Brief Biography of Stephen Hawking

According to Britannica, Stephen W. Hawking was born on January 8, 1942, in Oxford, England. He studied physics at University College, Oxford where he got his bachelor of art in 1962, and was later transferred to Cambridge University for his Ph. D in 1966. He was an outstanding graduate student at Cambridge where he came up with multiple theories that describe the universe. One of his significant ideas at the time which was the thesis for his Ph. D - "Properties of expanding universe" - a theory where he explained the universe began from a black hole that he later disproved. Throughout his career, Hawking studied the basic laws that govern the universe including general relativity, quantum mechanics, and black holes. Diagnosed with amyotrophic lateral sclerosis (ALS) at the age of twenty-one, Stephen Hawking was given only two years to live but was able to maintain life for way more than that. As Bushnell states, "As his body degenerates, he explores time in reverse searching for origins, for explanations and the meaning inherent in beginnings." Hawking rejected Einstein's previous idea that "God does not play dice" about a universe that was intentionally created by God and indicated that the existence of the universe is "an unavoidable element of unpredictability or randomness into science" or in other words, God is "an inveterate gambler and that He throws the dice on every possible occasion" [8]. Stephen Hawking's contributions to physics are uncountable, he earned a Royal Society in 1974 and became a professor of gravitational physics at Cambridge in 1979.

5.2 Hawking's Radiation

One of Stephen Hawking's all-time famously known works is called Hawking's Radiation which according to Dr. Gunn, was trying to answer the question of whether or not black holes have a temperature [9]. To understand this, one must know how a black hole formed and what its properties are that affect the universe. A black hole can be known as the result of a large star supernova explosion when the total mass is large enough . Eventually, when the star had shrunk to a certain radius, the gravitational field at the surface became so strong that not even light could escape. In the theory of general relativity, Einstein states that nothing can travel faster than light so if light cannot escape, nothing else would be able to. This is what we call a black hole, and the boundary of

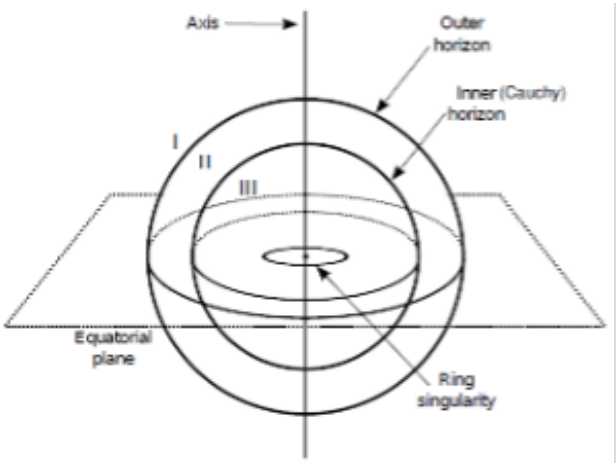

Figure 2: *Structure of black hole. This is an illustration of the black hole structure in three-dimensional, with an axis through the center and an equational plane that separates the black hole in half to represent the x and y-axis that form a rectangle as shown. From Romero, G. E. (2022, March 25). Black Hole Philosophy. SciELO, 53(159). https://doi.org/10.22201/iifs.18704905e.2021.1294.*

it is called an event horizon. In the center of a black hole is a point called the singularity as suggested in the theory of general relativity where everything is infinite density (Figure 2). This may sound odd when the singularity our universe primarily came from is similar to the one created in a black hole. So did the universe begin from a black hole? The answer is possibly, but scientists are still concerned about this idea because the two singularities seem like the same but they still haven't been able to ensure this theory.

In Hawking's radiation, the boundary of a black hole, the event horizon, is formed by the light rays that cannot escape from the black hole and hover just on the edge. The paths of these light rays could never approach one another because if they did, they must run into each other and fall into the black hole. If the boundaries of the black hole never run into each other, the size of the event horizon would stay the same or increase over time but would never decrease. As Hawking states, "If two black holes collided and merged to form a single black hole, the area of the event would be greater than or equal to the sum of the areas of the event horizons of the original black holes" [7]. This theory was later confirmed by physicists at Cornell and MIT Universities in 2015 by observing the GW150914, the first gravitational wave signal detected by the Laser Interferometer Gravitational-wave Observatory (LIGO) that the before and after the cosmic collision, the total event horizon area did not decrease after the merger. This is one of the important ideas of Hawking radiation and it has been proven to be accurate so it will lead to a chain of following conclusions and predictions

of the universe from Stephen Hawking. One of them being the most fundamental and greatest theory of all time, the infinite universe. In order to talk about the beginning or end of the universe, one must understand what a scientific theory is. Any physical theory is always provisional and it would always remain a hypothesis, which means you could never prove it no matter how many times a result of an experiment agrees with the thesis. A good theory satisfies two requirements: it must be accurate and stand for a large number of testifications, and it must make definite predictions about the result of future observation.

5.3 The Theory of Everything

Hawking was once pursuing to complete the one single theory that explains all the physics of the universe, and also the ultimate purpose of science. To produce this theory, Hawking had to combine both general relativity and quantum mechanics since they describe the universe on the largest and smallest scales. Although mathematics equations have become more precise over time, Hawking still could not unify all the equations for a complete picture of the physical world. According to Pultarova, "The situation is so exasperating that some of the greatest physicists of today concede that they might not live to see it all fall into place" [10]. Today, there are still missing pieces to plug in the potential theory of everything that scientist believe can be found in the particle accelerator like the Large Hadron Collider at CERN. However, we would need to comprehend the nature of dark matter and dark energy and combine them with the String theory, a theoretical framework that describes the particles in physics that are replaced by one-dimensional objects called strings.

5.4 A Brief History of Time

A Brief History of Time: From the Big Bang to Black Holes is a book on theoretical cosmology first published in 1988 by Stephen Hawking and is one of the most famous books in the world of physics. In his book, Hawking explains the physics theories that about the beginning of the universe to create a base for his idea of an infinite universe which is also included in the book. Bushnell says "Hawking is widely known by scientists and non-scientists alike-may be a more convincing platform on which to stage an exploration of the personal, subjective, autobiographical nature of science" [8]. The major theme of the book that Hawking describes is the search for a quantum theory of gravity. Stating that "if there is a complete unified theory, it would also presumably determine our actions" and even "the outcome" of our search for it.

In A Brief History of Time, Hawking says that the picture of the universe that started very hot and cooled down agreed with all the observational evidence that we have today but it also leaves many unanswered questions such as why was the early universe so hot? Why is the universe so uniform on a large scale? Why does it look the same in all points of space and all directions? What was the origin of the density fluctuations? General relativity cannot answer these questions because it explains that the universe began with infinite density at the Big Bang singularity. Einstein couldn't explain what would come out of the singularity, this meant he would have to cut the Big Bang out of the theory because it does not affect what we observed. Science seems to have discovered many laws that within the limits set by uncertain principles, these laws may have been created by God, but it appears that He had left the universe to function in accordance with it and did not intervene with anything since then. He had chosen a way to start the universe that human is not able to understand. But if He started in such an incomprehensible way, why did He let it evolve with laws that we can all understand? Hawking suggested that the whole history of science has been the gradual realization that events do not happen in any manner but they reflect a certain order which may or may not be divinely inspired. It would only be natural to suppose that this order should apply not only to the laws but also to the conditions at the boundary of spacetime that specify the initial state of the universe [7]. So many of the laws of physics were being applied at the early stage of the universe that remained unchanged over a period of time. This could not make sense if one said all the laws were created after the beginning of time because the beginning itself started by following those laws. Therefore, only one possible reason for this is that the universe exists spatially infinitely without a beginning or there are infinite numbers of universes. This explanation answers the earlier question of how the universe began and what was in space before that. Interestingly, there could be many more universes existing parallel to us that may produce our universe with its own laws, and that universe was originally created by another universe, and so on. As Hawking states "However, the laws do not tell us what the universe should have looked like when it started-it would still be up to God to wind up the clockwork and choose how to start it off. So as long as the universe had a beginning, we could suppose it had a creator. But if the universe is really completely self-contained, having no boundary or edge, it would have neither beginning nor end: it would simply be. What place, then, for a creator?" [7].

His theory of an infinitely existing universe implies that our universe is an unavoidable result that happened in a reasonably low probability like throwing dice but thousands of times until all the condition is qualified, this has proven the statement that God is "an inveterate gambler and that He throws the dice on every possible occasion." This also means that there could be a "bigger God" who had created a universe before ours and that would be an infinite sequence that has no beginning and no end.

6 Conclusion

The complexity of our universe is far beyond what a normal person thinks about, and there are many more mysteries that need to be solved to achieve more scientific discoveries not just in the field of cosmology but among every other part of one branch of knowledge that we call "science," the branch that describes everything that we learn about the natural world. As the scientific world is rapidly developing, more tools are being invented to help us in the journey of unlocking the unanswered questions, Stephen Hawking's theory of the beginning of time has been proven to be accurate by many experiments with advanced scientific instruments. There was no such thing as a starting point and no beginning of time, our world has been the same way it has always been, and with extremely small probability, under the conditions that have met, we existed. That also means we are not alone in this universe. In addition, whether or not Stephen Hawking's theory is complete and explains almost everything, we must accept the fact that there are many more puzzles to solve so that we will never stop pursuing our passion for the universe.

Disclosure Statement

This paper was originally written by Khang Luong during high school for College Prep Writing (Semester 1) and has been revised currently. Please note that some information presented may not be fully accurate or up to date. This paper is intended for general interest and entertainment purposes only. The author declares no affiliations, memberships, funding, or financial interests that could be perceived as influencing the objectivity of this work.

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