



## Fascinating Tale of Universe and Human Exploration

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**Abstract.** The evaluation of space missions and their influence have started with the space race of the 20th century, as a result of humans have boarded on a journey through time and space with some of the most groundbreaking and life-changing space missions. NASA's astrophysics division is dedicated to exploring the universe, pushing the boundaries of what is known of the cosmos, and sharing its discoveries with the world. The division continues growing humanity's understanding of how the universe began and progressed. NASA researchers are making advancement towards addressing the appealing questions of life in the universe, the early beginnings of the universe, and how it all works with leading-edge technologies and groundbreaking science. Space missions investigate outer space through telescopes and spacecraft to gather data, understand the universe, and search for life. These missions, both human and robotic, have explored the solar system, with early efforts like the Pioneer and Voyager programs leading the way and current missions like the International Space Station (ISS) conducting experiments in Earth's orbit. Future plans include sending humans back to the Moon via the Artemis program and eventually to Mars. Missions gather data to study the origins of the universe, the formation of galaxies, and the potential for life on other planets. Space exploration drives the development of new technologies that have practical applications on Earth in fields like telecommunications, medicine, and transportation.<sup>1</sup> Robotic spacecraft have been sent to orbit planets like Venus, Mars, Jupiter, and Saturn, while telescopes like the James Webb Space Telescope (JWST) observe distant objects. It is a review article to explore and appraise the human effort to discover the unknown story of universe.

**Key words.** Voyager, Apollo, NASA, ISS, JWST, CMB, dark energy, black hole

### 1. Introduction

Primordial humans in ancient times, studied the night sky with their naked eyes. They tracked stars and planets for navigation, farming, and calendars. Galileo used a telescope to study the moon at first.<sup>2</sup> On November 30, 1609, Galileo Galilei of Italy used his improved telescope to observe the Moon and made the first detailed drawings of its rugged, uneven surface, composed of mountains and craters, not a perfect sphere as previously thought.<sup>3</sup> His detailed sketches and observations were published, helping to usher in the era of modern astronomical observation and contributing to the rejection of Aristotelian ideas about the heavens. Galileo's observations demonstrated the power of the telescope to reveal new scientific truths and supported the new astronomy, leading to his recognition across Europe. He also observed Jupiter's moon and Saturn's rings, and later, Newton and Kepler also explained planetary motion.<sup>4</sup> On October 4, 1957, the Soviet Union (USSR) launched Sputnik 1, which was the first human-made satellite to orbit Earth. This event, the first of the Sputnik program, marked a significant achievement for the USSR and is considered a pivotal moment in the Space Race.<sup>5</sup> On April 12, 1961, Soviet cosmonaut Yuri Gagarin became the first human to travel into space, orbiting Earth aboard the Vostok 1 spacecraft. This historic achievement was a major milestone in the Space Race and marked the beginning of human spaceflight.<sup>6</sup>



Figure 1: President John F. Kennedy and his vision to space mission<sup>7</sup> and Buzz Aldrin on the Moon photograph taken by Neil Armstrong.<sup>8</sup>

The primary objective of Apollo 11 was to complete a national goal set by President John F. Kennedy on May 25, 1961: perform a crewed lunar landing and return to Earth. Neil A.<sup>9</sup> Armstrong was one of nine men chosen of NASA's second astronaut group in 1962, and flew to space on the Gemini 8 mission in 1966 before being assigned to the Apollo 11 mission.<sup>10</sup> In 1969, the United States' Apollo 11 mission was the first to successfully land humans on the Moon. American astronauts Neil Armstrong and Buzz Aldrin were the first to walk on the lunar surface, with Armstrong taking the historic first step.<sup>11</sup> The mission marked a monumental achievement in human history and a major milestone in the Apollo program. As he stepped onto the lunar surface, Neil Armstrong famously said, "That's one small step for man, one giant leap for mankind"<sup>12</sup>. Now there will be discussion of the five most remarkable space missions in recent history, each representing significant scientific, technological, and human accomplishments.<sup>13</sup> These missions-spanning telescopes, solar probes, deep space explorers, and comet landers have expanded our understanding of the universe and demonstrated the power of persistence, collaboration, and innovation in space exploration.<sup>14</sup> Again, the James Webb Space Telescope (JWST), launched on December 25, 2021, is the most advanced space telescope ever built. It features a massive 6.5-meter mirror that collects more light than its predecessor, the Hubble Space Telescope. JWST observes the universe in infrared light, which helps scientists see through dust clouds and detect distant objects, such as early galaxies and exoplanet atmospheres.<sup>15</sup> The James Webb Space Telescope (JWST), a successor to the Hubble Space Telescope, was launched on December 25, 2021, and is the most powerful and complex space observatory ever built.<sup>16</sup> It operates by observing in infrared light from the second Lagrange point (L2), 1.5 million kilometers from Earth, to study the early universe, the formation of stars and galaxies, and exoplanets with unprecedented sensitivity.<sup>17</sup> The mission is an international collaboration involving NASA, the European Space Agency (ESA), and the Canadian Space Agency (CSA). One of its most powerful tools, the Mid-Infrared Instrument (MIRI), enables deep exploration of the early universe. Early images from JWST have revealed hidden binary stars, galaxy collisions, and the most distant galaxies ever observed, marking a new era in astronomy.



Figure 2: NASA's James Webb Space Telescope picture of moon<sup>18</sup>Stellar Jet on Outskirts of Our Milky Way.<sup>19</sup>

The Parker Solar Probe, launched in 2018, is the first mission designed to "touch" the sun. It aims to study the Sun's outer atmosphere (the corona) and the winds and streams of charged particles that affect Earth's space weather. To survive the Sun's intense heat, the probe uses a special carbon-composite heat shield.<sup>20</sup> Operating primarily autonomously due to its extreme environment, the probe uses gravity assists from Venus to move closer to the Sun with each orbit. It has already passed through the solar corona and discovered magnetic "switchbacks"-sudden reversals in the Sun's magnetic field-that may explain how solar wind accelerates. Its final and closest approach happened in 2024.<sup>21</sup> By studying the Sun up close, scientists gain invaluable data to better understand phenomena like solar storms and the processes that affect Earth's

atmosphere and climate.<sup>22</sup> This research can lead to more accurate space weather predictions, improving the safety and reliability of critical infrastructure, including radio communications, satellites, and power grids.<sup>23</sup> However, the Voyager 1 and 2 spacecraft, launched in 1977, took advantage of a rare planetary alignment to explore the outer planets. Voyager 1 provided new insights into Jupiter and its moons, while Voyager 2 gave us the first close-up views of Uranus and Neptune.<sup>24</sup> After completing their planetary missions, both spacecraft continued into deep space. Voyager 1 entered interstellar space in 2012, followed by Voyager 2 in 2018.<sup>25</sup> Despite being over 45 years old and operating on minimal power, they still send data, helping scientists with their study at the edge of the Sun's influence, known as the heliosphere.<sup>26</sup> Voyager 2, the only spacecraft to ever conduct close-up flybys of Uranus and Neptune, completed its unique trajectory through the outer solar system after its initial planetary encounters. Following its planetary missions, Voyager 2 also headed into interstellar space, continuing to collect valuable scientific data.<sup>27</sup> This "Grand Tour" allowed the spacecraft to use gravity assist to gain speed and trajectory, traveling to subsequent planets with minimal propellant. These missions remain iconic examples of the endurance and reach of human-made technology.

The Hubble Space Telescope, launched in 1990, faced an early crisis when its primary mirror was discovered to be slightly misshapen, resulting in blurry images. This was fixed during a 1993 servicing mission, where astronauts installed a corrective device called COSTAR. After the repair, Hubble began producing sharp, detailed images that transformed astronomy. Over its decades in space, Hubble has helped measure the universe's expansion, observed distant galaxies, and provided stunning views of planets and nebulae.<sup>28</sup> In 2021, engineers resolved another major issue when Hubble's computer system failed, again proving the dedication and ingenuity required to maintain such long-term missions. The flaw was corrected by an in-orbit servicing mission in December 1993.<sup>29</sup> Astronauts installed corrective optics that functioned like eyeglasses for the telescope. The repairs transformed the Hubble into an astronomical powerhouse, enabling it to deliver the high-quality images that were initially anticipated.<sup>30</sup> On the other hand, the Rosetta mission, launched by the European Space Agency in 2004, was the first to orbit and land a probe (Philae) on a comet. After a ten-year journey, Rosetta arrived at comet 67P/Churyumov-Gerasimenko. Philae's landing in 2014 was historic, although it bounced and landed in a shaded area, which limited its solar power. Still, it gathered valuable data in 72 hours, revealing that the comet contained complex organic molecules such as amino acids, key ingredients for life.<sup>31</sup> Rosetta continued to orbit the comet until 2016, when it was deliberately crashed onto its surface, marking the end of a mission that changed how we understand comets and the early solar system.<sup>32</sup> Philae's landing was complicated by the comet's weak gravity, which caused the lander to bounce upon initial contact. It eventually settled in a shadowed location, hindering its primary solar-powered functions. The mission provided a wealth of data, including the discovery of molecular oxygen in the comet, and offered unprecedented insights into the composition and behavior of comets.<sup>33</sup> Together, these missions show the evolution of space exploration from close solar system studies to profound space observations. They demonstrate that scientific discovery is a lengthy and intricate process that involves risk, failure, and innovation. Each mission not only answered major questions but also opened new ones, keeping the spirit of exploration alive for the next generation of scientists, technologists, and engineers.

In the future, the Moon could serve as a launch pad for more ambitious missions. Crewed missions to Mars are planned for 2030 or later by NASA, USA. The strategy, known as "Moon to Mars,"<sup>34</sup> involves establishing a sustainable human presence on and around the Moon to develop the necessary technology and experience for future deep-space exploration, including Mars.<sup>35</sup> NASA plans to send astronauts to Mars in the 2030s, leveraging the lunar environment as a stepping stone for these more ambitious missions. Robots are already scouting landing sites and resources.<sup>36</sup> Asteroid mining is a potential future industry where humans will extract metals and water for use in space. In the near future, next-generation telescopes may detect Earth-like planets and possible biosignatures.<sup>37</sup> In the future, tiny spacecraft will be propelled by lasers to nearby stars, such as Proxima Centauri. Cryogenic travel will be possible for an interstellar Journey in the far future by humans. Future Artemis missions will involve building a new space station in lunar orbit and establishing a habitable Moon base.<sup>38</sup> The knowledge gained from the Artemis missions will pave the way for crewed missions to Mars, which are planned for the 2030s. NASA plans for at least two delivery missions with large cargo. The agency intends for SpaceX's Starship cargo lander to deliver a pressurized rover, currently in development by JAXA (Japan Aerospace Exploration Agency)<sup>39</sup>, to the lunar surface no earlier than fiscal year 2032 in support of Artemis VII and later missions. The agency expects Blue Origin to deliver a lunar surface habitat no earlier than fiscal year 2033.<sup>40</sup> With the Artemis campaign, NASA will explore more of the Moon than ever before, learn how to live and work away from home, and prepare for future exploration of Mars.<sup>41</sup> NASA's SLS (Space Launch System) rocket, exploration ground systems, and Orion spacecraft, along with commercial human landing systems, next-generation spacesuits, Gateway lunar space station, and future rovers are NASA's foundation for deep space exploration.<sup>42</sup> There are many questions, have no clear explanation or proof or solid evidence of truth. Likes: What keeps Galaxies together? What are the building blocks of the Universe? What makes the Universe look the way it looks today? Physicists or researchers have tried to answer these questions. We know today that approximately a quarter of the universe is filled with a mysterious glue and that is dark matter. We know, it is out there. But we don't know, what it is made out of.<sup>43</sup>

We are the first species to comprehend the cosmos and our role within it. This understanding offers us an opportunity to influence the future. By carefully and intentionally guiding our era, we have the potential to establish stable governments, develop safe interplanetary colonies, and create defenses against natural threats like asteroids and super-volcanoes, drastically lowering existential risks. Overcoming this pivotal moment could enable billions of years of thriving life and civilizations. The stars nearby could host trillions of future beings, and this chance far surpasses the fragility of our current

situation. Our decisions now matter beyond our lifetimes—success could make us pioneers, while failure might end the pursuit of life and consciousness that began on Earth. If we succeed, we ignite a chain of intelligence that fills the universe. This period is both the most perilous and the most significant in our history, exposing us to existential threats but also positioning us to secure an extraordinary future on an astronomical scale.

What we perceive as the force of gravity is actually objects (like planets or light) following the straightest possible path (a geodesic) through this curved spacetime. Planets orbit stars because they are following the curves in spacetime created by the star's mass, not because of a direct pull. Again, Light from distant stars bends as it passes massive objects, confirming the curvature of spacetime. The famous summary 'matter tells spacetime how to curve, spacetime tells matter how to move,' captures the dynamic interaction, where mass dictates the geometry, and the geometry dictates motion. According to scientists, the expansion of the universe began with the Big Bang. This expansion was completely uniform everywhere. Matter was distributed equally everywhere. Then stars, planets and galaxies came into existence in the universe from them. NASA scientists were shocked when in 1981, Sir Robert Kirchner discovered a void in the constellation of Boötes, 800 million light years away from Earth, which was completely uninhabited. It was given this name because of this "constellation". If we calculate the expansion of the universe since the Big Bang and then. So, based on the expansion that has occurred so far, there should be at least ten to twelve thousand galaxies in this empty space, but there is nothing like that there. Although there are other empty spaces in the universe, such a vast area and that too completely empty is beyond "understanding". In this review article author will try to explore and appraise the human effort to discover the unknown story of universe on the basis of existing and latest concepts, theories and propositions of physicists, astronomers and scientists.

## 2. Literature Review

**2.1 Death Universe and Other Theory of Universe.** The Dead Universe theory posits that our universe is not expanding, inflating, or undergoing cycles of rebirth. Instead, it is gradually diminishing and has been in a state of decay for perhaps trillions of years. This model suggests that the universe is slowly entering a state of total death, with galaxies continuously forming and then fading away under the influence of the dead universe's remnants. Rather than growing or regenerating, our universe is progressively winding down, moving towards a silent and complete cessation of cosmic activity. Our entire observable universe may exist within a distinct brane that floats in a higher-dimensional space. This brane represents a segment of the dead universe that is transitioning into a state of death. However, the creative remnants of the dead universe could lead to the formation of new galaxies within this brane. These galaxies are formed as the dead universe's remnants exert their influence, leading to the creation of progressively smaller galaxies. Explosions and other cosmic events within this decaying process contribute to the formation of these new galaxies (Randall, 2005).<sup>44</sup> Randall said, "The universe may be governed by hidden dimensions, beyond the familiar three of space and one of time, opening up new avenues for exploration and understanding."

So, it can postulate that the entirety of our dead universe exists within a brane, which floats in a larger dimensional space. Within this volume, our universe exists as a membrane distinct from other potential universes, entering a state of death. This brane could be influenced by the physical laws and remnants of the dead universe, leading to the continuous creation of galaxies. These galaxies, as part of the cosmic memory of the dead universe, are generated by the interactions and remaining energies of the dead universe's structures. This model suggests that the gravitational anomalies and the curvature of time and space observed in our universe are the result of the dead universe's physics influencing the observable universe. The Dead Universe's decaying remnants, particularly supermassive bodies and dark energy, are key elements in shaping the structure and behavior of our observable universe. To substantiate Dead Universe theory, it would be appropriate to refer to various recognized physical principles and discoveries:

Newton's Law of Universal Gravitation: As a basis for understanding gravity on a large scale.

- Einstein's General Relativity: This theory updated the understanding of gravity as the curvature of space-time. The role of singularities and event horizons in black holes could be explored in relation to the "Dead Universe".
- Hubble's Laws and Observations from the Hubble Space Telescope: They provide empirical evidence of the expansion of the universe, which could be interpreted in light of the attraction of a massive "Dead Universe".
- Quantum Cosmology: Investigating the implications of quantum mechanics on cosmological scales, this area could provide insights into how a "Dead Universe" could influence matter and energy in our universe.
- Research on Dark Energy and Dark Matter: Studies on these mysterious components of the universe could be useful in understanding the forces that are competing with or interacting with gravity in the "Dead Universe".

Prominent scientists for reference could include:

- Stephen Hawking: For his work on singularities and the properties of black holes.
- Roger Penrose: Who collaborated with Hawking and developed theories on the nature of space-time.

- Saul Perlmutter, Brian P. Schmidt, and Adam G. Riess: Astronomers who were awarded the Nobel Prize for their discoveries regarding the acceleration of the expansion of the universe.
- Kip Thorne: A theoretical physicist who made significant contributions to the understanding of gravitational waves and the nature of gravity.

## 2.2 Problems of Existing Theories.

The horizon problem becomes apparent when researchers examine the uniformity and consistency of cosmic microwave background radiation. CMB radiation is the thermal radiation left over from our universe's formation when it was about 380,000 years old. This radiation occurred shortly after the Big Bang, when visible light could first move freely without obstruction.<sup>45</sup> The apparent consistency of CMB and that reflects temperature variations at a scale of one part in 100,000 – indicates that the furthest reaches of outer space were once in thermal equilibrium. In other words, the universe's most distant parts were once the same temperature, suggesting that heat was evenly distributed in all directions. However, these regions are far apart. Considering our universe's age and the speed of light (approximately 186,000 miles per second), it should be physically impossible that these regions could have ever been close enough to interact and equilibrate directly since the inception of the Big Bang. To put it more simply, the horizon problem raises a compelling question of how the universe's distant parts could somehow end up with such similar temperatures and characteristics.<sup>46</sup>

The flatness problem, on the other hand, deals with the universe's shape and overall curvature. According to Einstein's Theory of Relativity, the universe's shape is determined by mass and energy, which is described by a curvature measure called Omega ( $\Omega$ ). A universe with " $\Omega = 1$ " is flat – indicating no curvature and meeting the critical density requirement where the universe's expansion rate should eventually slow down and approach zero without actually ever reaching zero. It means that a gradual slowing down of the universe's expansion over time never stops. Initially, the original Big Bang Theory suggested that immediately after the Big Bang, the universe should have been very close to critical density ( $\Omega \approx 1$ /flat in shape). But as time passed and the universe's expansion continued, even a minor deviation from critical density would magnify over time, resulting in a universe that is significantly curved, either "open" ( $\Omega < 1$ ) or "closed" ( $\Omega > 1$ ). But the universe that we observe with our scientific instruments today is flat. So, the question is: How is that possible?

To solve these kinds of problems, modern cosmologists have put forth several theories to better explain the universe's properties and phenomena.<sup>47</sup> One of the most sobering and empirically supported theories is the cosmic inflation theory, first proposed by physicist Alan Guth during the 1980s. According to Guth's cosmic inflation theory, there was an exponential expansion within a fraction of a second after the Big Bang. This period of inflation set the stage for the universe's observable structure and composition that we see today. Guth's theory is consistent with observable scientific evidence. It also resolves several enduring cosmological mysteries, including the horizon problem and the flatness problem. In regard to the horizon problem, cosmic inflation theory theorizes that the universe experienced an exponential expansion in the first fraction of a second after the Big Bang. This inflation period stretched the universe beyond its visible horizon, enabling distant regions to come into causal contact and achieve thermal equilibrium. This theory means that the expansion allowed the universe's distant areas to interact and influence each other, resulting in them reaching the same temperature. In other words, the physics described by the cosmic inflation theory would allow the present universe to have expanded faster than the speed of light during this early inflationary period.<sup>48</sup> That would have eliminated the problems of distance and time preventing thermal equilibrium.

Regarding the flatness problem, cosmic inflation theory suggests that the period of rapid and significant expansion led to an increase in the scale factor of the universe, which determines the relative sizes of spatial dimensions (the size of space itself). As a result, any slight deviations from a flat geometry in the early universe would have been greatly stretched out and weakened during this inflationary period. In other words, the rapid expansion would have smoothed out these deviations, making the universe more uniformly flat. During the universe's growth, the energy density linked to the inflation field became dominant over other forms of energy like radiation and matter. This dominance would have had a leveling effect on the entire universe's geometry, moving it closer to a flat configuration. So inflationary cosmology from the 1980s provides compelling resolutions to these kinds of questions about the origin of the universe. It reshapes our comprehension of early dynamics and lays the foundations for modern cosmological theories. This inflation is thought by researchers to have been triggered by quantum fluctuations within the fabric of space-time – a phenomenon foreseen by quantum mechanics.<sup>49</sup> At these quantum levels, tiny fluctuations are believed to have been magnified during inflation, which introduced irregularities and differences that eventually developed into the first galaxies, clusters of galaxies, and macro-level cosmic formations.

With advancements in cosmology, scientists are considering the concept that our universe might just be one among many in an extensive "multiverse." This theory suggests that an infinite number of universes might exist, each with its own distinct physical laws, constants, and characteristics. While this hypothesis is still speculative and beyond today's empirical testing capabilities, the multiverse hypothesis presents a captivating explanation for some of the universe's most puzzling aspects. For example, the precise tuning of constants and parameters in our universe to support life could find justification in a multiverse scenario where each region possesses unique properties. In such a case, our own universe would not be designed to support the existence of life as we know it, but is rather the product of chance and coincidence.<sup>50</sup> There could be many other universes within the multiverse that are not capable of supporting such life. Now that we've

talked about the earliest origins of the universe, a fair question you might be thinking is, “How will it end?” There’s no way to know for sure, but scientists have some theories. The concepts of accelerating expansion, as well as the Big Rip theory and the Big Freeze theory, offer insights into the universe's potential futures.

After the Big Bang Theory for the universe’s beginning was firmly established, researchers inferred that the force of gravity would slow the universe's expansion over time, as all matter contained in the universe pulls on itself to reunite. They believed that gravity would eventually stop the expansion. Then, a recoil would occur and cause everything to slowly coalesce back together, perhaps all the way back to a single point. Researchers called this theory the Big Crunch. It even gave rise to the notion that perhaps the universe experiences a repeating cycle of rebounds as it expands and contracts over and over again as a result of competing forces trying to dominate each other. But scientific observation of the universe’s rate of expansion revealed that it is not slowing. Instead, it is actually increasing. This unexpected finding, drawn from studying supernovae in the late 1990s, suggests that a mysterious force called dark energy is opposing gravity on a cosmic scale and accelerating the universe's expansion. The presence of dark energy propelling this accelerated expansion has significant implications for what lies ahead for our universe. It suggests that galaxies will continue drifting apart at an ever-increasing pace.

Taking the accelerating expansion of the universe to its inevitable conclusion, the Big Rip Theory provides a vivid and dramatic picture of one possibility for our universe’s fate. This theory suggests that dark energy’s repulsive force grows stronger over time and can overpower all other forces, including the gravitational pull within galaxies, stars, and subatomic particles.<sup>51</sup> As the universe expands faster and faster under this scenario, the Big Rip theory foresees galaxies moving away from each other, which is already happening today.<sup>52</sup> Eventually, the gravitational forces that bind galaxies, stars, planets, and atoms together may also succumb to the overpowering influence of dark energy. This catastrophic event would result in the destruction of cosmic structures, causing matter to break down into its basic components and leading to the tearing apart of spacetime itself at the most fundamental level. Simply put, dark energy would “rip” everything in the universe to pieces.

The Big Freeze Theory (also known as the Heat Death Theory) presents a more gradual and subdued fate for the universe. According to the Big Freeze, the universe will continue expanding at an increasing pace due to dark energy, causing matter and energy to gradually thin out over immense periods of time. As galaxies drift apart and the universe grows colder and more barren, new stars will stop forming and existing ones will slowly burn out. Eventually, the universe will reach a state of maximum entropy, where all energy is uniformly dispersed with no potential for matter interaction.<sup>53</sup> In this state, called Heat Death by some theorists, the universe would become a cold, dark void. There would be no life, light, or any recognizable structure or activity.<sup>54</sup>

Despite strides in unraveling the origins and evolution of the universe, cosmology continues to pose obstacles, uncertainties, and unresolved inquiries. For example, dark matter and dark energy collectively account for about 95% of the universe’s total mass energy, but these components of our universe remain a complete mystery in modern astrophysics and cosmology. Even though we can infer their existence and even measure them to a degree, we know almost nothing about them.<sup>55</sup> Additionally, the elusive origin of the singularity itself, as the starting point from which the universe appears to have emerged, continues to puzzle researchers. Current scientific hypotheses such as loop quantum gravity and string theory have attempted to merge Einstein’s relativity with quantum mechanics to create a unified theory of the universe. Still, this work is incomplete at best so far.

The beginning of our universe is one of humanity’s mysteries that have captivated mythologies, philosophies, and scientific endeavors. From cosmological myths depicting primal chaos to contemporary cosmological theories formulated through intricate mathematical study and calculation, our comprehension of how the universe came to exist has evolved over time. This evolution reflects our curiosity, imagination, and determination to unravel the mysteries surrounding our own existence in our vast cosmos. As we delve deeper into cosmic dynamics through scientific exploration, we are humbled by the vastness, intricacy, and splendor that define our ever-expanding understanding of the cosmos.<sup>56</sup> Every cosmological theory, whether about the Big Bang, Cosmic Inflation, or the idea of a multiverse filled with realities, provides a fascinating perspective of the birth and evolution of the universe. It sparks curiosity, amazement, and a deep feeling of connectedness to the cosmos at large and to each other on Earth. So, we should continue the work of our understanding the universe and see where the truth leads us.<sup>57</sup>

The Dead Universe theory suggests that what we perceive as our cosmos is the legacy of an ancestral reality whose grandeur has long faded into the mists of time. The universe we inhabit may be akin to a cosmic aftermath, a diluted echo of a once vibrant and expansive cosmic past. Rather than being the catalysts of genesis, the black holes that populate our night sky are posited as remnants of a previous cosmic end, markers of the graves of galaxies and stars that have long since perished. Each star system, every nebula we capture through our telescopes, might be a manifestation of cosmic memory, a lingering whisper from a universe that has run its course. In this view, dark matter and dark energy are reimagined as the residual hallmarks of this ancient epoch, perhaps the last vestiges of a once dynamic cosmic framework. The young galaxies we witness are not born from a void but are conceived from the vestiges of a pre-existing structure in a state of stately and measured dissolution. Similarly, to the birth of stars from the dense cosmic nurseries, our universe may have been partially shaped from the detritus left by its predecessor.

The vibrant stars and galaxies we observe, in their billions of years of existence, could very well be the ultimate creations of a bygone universe. On the verge of its cessation, it still possessed the capacity to engender new celestial structures, intimating that the end of one cosmic cycle and the inception of another are intrinsically interconnected, leading to a culmination projected to be in about 200 billion years. These phenomena, observable in our present universe, abide by the unalterable laws of conservation and transmutation that govern all of natural reality. These fledgling galaxies might be interpreted as the final echoes or gleaming reminiscences of a cosmos that exists no more. They are fragments of a vast stellar heritage, the ultimate murmur of a universe that once thrived in scale and energetic wealth. We are thus residing in the twilight of a glorious cosmic history, witnessing what may be deemed the “last dance” of light and matter sourced from a universe that has ebbed away. What we discern as our stellar reality is merely the residue—a modest yet still animated segment of an existence far grander than we can grasp, extending beyond our temporal and spatial reach. Essentially, all that exists, all that we behold, and all that we may come to understand are but the enduring fragments in time and space, the everlasting signature of the dead universe. “Space tells matter how to move, and matter tells space how to curve.” As said by Brian Greene in “The Fabric of the Cosmos: Space, Time, and the Texture of Reality.”<sup>58</sup>

As this process unfolds, the density and complexity of the universe wane. Where once there were dense clusters of matter and energy, now there are increasingly vast and empty spaces, dotted with isolated islands of stellar activity. The observation of young galaxies by the James Webb Space Telescope thus serves as a glimpse into this process of decline, revealing the final stages of a cosmos we are just beginning to understand. In this picture, the death of the ancestral universe was not an abrupt event but a prolonged phenomenon that allowed the gradual emergence of new structures from its ruins. Black holes, rather than being the catalysts of a new birth, are the final guardians of the cosmic memory of the preceding universe, storing in their gravitational abysses the history of all that once was. Indeed, black holes have mass. The mass of a black hole can be comparable to that of the Earth, the Sun, or even vastly greater, depending on the type of black hole. There are stellar black holes, which generally have masses ranging from a few to tens of times that of the Sun, and supermassive black holes, which can have masses equivalent to millions or billions of times the mass of the Sun.

The term “black hole” refers to the fact that these objects are regions of space where gravity is so intense that nothing, not even light, can escape from them. The word “hole” is a way to describe this “trapping” feature, although it is not a hole in the traditional sense of a cavity or opening. The adjective “black” is used because, since light cannot escape from a black hole, it is completely dark, neither emitting nor reflecting light, rendering it “black” to any observer. When certain stars, much more massive than the Sun, reach the end of their lives, they can undergo a process known as gravitational collapse. After exhausting all their nuclear fuel, the pressure that supports the star against gravity disappears, and it collapses in on itself. Depending on the original mass of the star, this collapse can result in a supernova, and the remaining core may form a stellar black hole. This is an example of a black hole that originates from a “dead star”. In this way, we advance toward the theory of a dead universe with dimensions greater than our observable universe.

If the Sun were to cease to exist, that is, if it suddenly stopped emitting light and heat, the consequences would be dramatic, but the orbits of the planets in the solar system, including Earth, would initially remain unchanged, at least for some time. This is because gravity, not light, is the force that keeps the planets in orbit around the Sun. Gravity is a consequence of an object’s mass, and light is a form of energy emitted by it. If the Sun suddenly stopped emitting light, it would mean that it is no longer performing nuclear reactions in its core, but its mass would still be present, and therefore, its gravity would continue to influence the planets. However, the absence of light and heat would have catastrophic effects on life on Earth and the planet’s climatic conditions. Over time, if the Sun were to transform into a white dwarf or undergo some other process that significantly altered its mass, the orbits of the planets could be affected. Changes in the Sun’s mass would alter its gravitational force, which, in turn, would affect the trajectory of celestial bodies orbiting it.

It is not strange to postulate the existence of a universe without the activity of light emission but still composed of galaxies, supermassive black holes, dark matter, dark energy, and where the laws of physics remain active. I can affirm, based on the theoretical argument developed, that such a universe exists and that, soon, it may be revealed to the light of scientific knowledge. From a scientific viewpoint, however, the claim to the existence of a fundamental reality such as a “dead universe” requires a substantial set of empirical and theoretical evidence that can be verified through independent observations and experimentation. Until such evidence is provided and validated by the scrutiny of the scientific community, such a concept should be considered with caution, currently residing in the realm of theoretical speculation, similar to many hypotheses and theories that have preceded it. These black holes are found at the centers of almost all large galaxies, including our own Milky Way. They have masses ranging from millions to billions of times that of the Sun. It is believed that they grow by accumulating matter and other black holes over time, but their exact origin is still a subject of research. They are not considered “dead galaxies,” but they are a fundamental part of the dynamics and evolution of galaxies.

The term “dead galaxy” typically refers to a galaxy that has ceased star formation. Galaxies can “die” in terms of stellar production due to various processes, such as the loss of gas (the fuel for star formation) or interactions with other galaxies. These galaxies do not transform into black holes, although they may harbor supermassive black holes at their centers. The “dead universe” theory is legitimized and worthy of study by proposing that the collective deaths of celestial bodies

converge in the formation of a singular predecessor universe, as opposed to the concept of multiverses suggested by various speculative theories. These theories often deviate from the mathematical models and the rigorously tested and proven scientific evidence. In contrast, the dead universe theory, which harmonizes with established discoveries and laws of physics, offers a perspective that integrates into the contemporary understanding of the universe while providing a potential platform for future investigations.

Currently, the consensus around the Big Bang theory appears to be weakening, while, on the other hand, the Dead Universe theory not only conforms to the already established physical laws but also proposes alternative explanations that can be readily subjected to verification through observation and experimentation. Thus, the “expansion of the universe” can be interpreted not as an indicator of dynamic growth but rather as a gradual separation driven by the laws of gravity from a preceding universe, a relic still influencing the current cosmos. This phenomenon could be regarded as the final exhale of a universe that is gradually surrendering its energies. We are witnessing a process of cooling and quiescence, where matter and energy are smoothly redistributed, and space-time stretches, aspiring to a state of enduring serenity. As this process progresses, the formation of new galaxies will tend to decrease and eventually cease, resulting in a universe filled with contemplative silence and the true quiet that follows the luminous interlude of the stars. Just as its parent universe died, so too shall its offspring, the observable universe, pass away.

**2.3 Observational Evidence from the James Webb Space Telescope.** Habitually, the Big Bang theory has been the backbone of cosmology, providing us with a model of a universe born from a singularity, expanding for approximately 13.5 billion years. However, in light of new evidence, it becomes increasingly clear that this narrative faces significant challenges, making room for a new perspective: the theory of the “dead universe” that I propose. The Dead Universe theory suggests a radically different approach. Instead of conceiving the universe as the result of an explosion, it proposes that the universe is a vast and possibly eternal continuum, where concepts of beginning and end are relativized. This is not just a vague hypothesis; the discoveries of the James Webb offer concrete evidence that challenges the fundamental premise of the Big Bang. Ancient galaxies that should display signs of interactions and mergers, as predicted by the standard model, remain surprisingly intact, suggesting a much more complex and less linear cosmic history.

The observation of astronomical objects that appear to be older than the age of the universe defined by the Big Bang model represents a significant challenge for contemporary cosmology. How can the existence of these mature structures be reconciled with a universe that, according to current estimates, is approximately 13.5 billion years old? The hypothesis of the Dead Universe seeks to address this contradiction by proposing that such galaxies are not mere discrepancies, but rather clues to an ancestral universe, whose timeline extends beyond the temporal scale demarcated by the event of the Big Bang. This theory suggests that conventional cosmological timelines may need to be revised in light of new evidence, possibly expanding our understanding of the history and evolution of the cosmos. Moreover, the supposed uniform expansion of the universe, a cornerstone of the Big Bang model, is called into question by recent observations. Distant and ancient galaxies do not behave in a way that would corroborate constant and accelerated expansion. This raises a fundamental question as what if the universe is not expanding uniformly, or even if it is not expanding at all? Scientist in their new theory suggests that the cosmos may be in a more complex and static or inverse state than previously imagined, a state where time and space are not absolute, but relative and interconnected in a way that we are still beginning to understand.

This is not just a challenge to the dominant narrative; it is an invitation to radically rethink our understanding of the cosmos. The theory of the Dead Universe offers a path to explore these questions, proposing a “timeless” universe or one that generates its own strange body, light, as its primordial nature was not light but rather the darkness of dark matter and supermassive bodies, where beginning and end are human concepts, not universal realities. In the perspective of the dead universe, the fusion of black holes and the consequent creation of stars may be considered incomprehensible events for beings inhabiting this universe. Let imagine a civilization evolving amidst eternal darkness, where light is an abstract, almost mythological notion. For them, the sudden emergence of bright spots in the sky would be beyond comprehension, an anomaly in a predominantly dark environment. Perhaps the equation of UNO matter also resembles a window tint or solar control film, so that when we are inside, we perceive the existence of light, but if we look from outside in, we perceive no light at all and everything appears to us as lightless and in darkness. Therefore, a universe immersed in death within a dark fabric may present a reality of splendid light that we cannot see because of the presence of a matter that I describe as neutral.

The theory of the Dead Universe proposes a new interpretation of the observational boundaries of the universe through an analogy with window tint. We argue that dark matter and other cosmic anomalies may be analogous to layers that, although transparent from within, are opaque when viewed from outside. We explore how this metaphor can be applied to the study of astrophysics and offer insights into the properties and behavior of dark matter. Just as an internal observer perceives light through a layer of window tint, while from the exterior transparency is obscured, our visibility of the cosmos may be limited by material layers that are not immediately apparent to our conventional detection methods. The theory of the Dead Universe proposes that we live in a remnant of a previous cosmic reality, where dark matter acts as a “cosmic window tint” that distorts our perception of the universe. This matter not only influences the trajectory and speed of galaxies but may also be the reason why we observe the universe in such a dark and enigmatic manner. Gravitational waves and other observations can be seen as the light that permeates this dark layer, offering glimpses of the underlying

structure of the universe. Our understanding of the expansion of the universe and the distribution of dark matter may be enriched by considering the idea that, just as light passing through window tint, there is inherent luminosity and active phenomena beyond our current vision awaiting discovery. Therefore, future research should focus on penetrating this layer of “cosmic window tint,” see-through the true extent and nature of the universe in which we reside.

Cosmological theories that propose various forms of “barriers” or transition zones in the universe. For example, the event horizon of a black hole acts as a point of no return where gravitational attraction is so strong that not even light can escape, making it invisible from the outside. This is somewhat like looking at a dark window from the outside; you cannot see through, suggesting an absence of light or activity when, in reality, there is hidden wealth. Extending this to our notion, if there were a “UNO matter” that acted as this kind of cosmic hue, it could be something that exists within the structure of the universe and a hypothetical substance or field that interacts with light and other forms of energy in a way that masks the activity or underlying structure of the cosmos when seen from a certain perspective. Such material could theoretically be responsible for the phenomena we observe, like the effects attributed to dark matter, which influences the movement of galaxies and yet emits no detectable light or radiation, remaining “UNOI” or “invisible” to our current methods of observation.

The notion of a “domain wall” in cosmology is a hypothetical structure that could act as a boundary between different phases or types of vacuum states in the universe, similar to the interface between two bubbles. It’s a speculative concept, but one that could potentially explain cosmic separation or transition areas, much like our concept of “UNO matter” film. However, while analogies can be useful for illustrating concepts, in scientific publications, they are typically used sparingly and always anchored in rigorous argumentation and empirical evidence. Besides, the very nonexistence of light as a primordial element may challenge the fundamental laws of this dead universe. While they inhabit a domain, in which darkness reigns supreme, the presence of light could be seen as an intrusion or even as a metaphysical impossibility. These reflections lead us to question whether we can truly comprehend the totality of the universe from our limited perspective as observers of the cosmos. What we consider as universal truths may be just a small fraction of cosmic reality, and the dead universe may represent a spectrum of existence that escapes our full understanding.

Perhaps the very nature of light is indeed opposed to the essence of the dead universe. The mergers of supermassive bodies and black holes, which were the original nature of this universe, gave birth to light, an object strange to its reality. This universe will persist forever, immersed in its own eternal darkness, while light shines in contradiction. However, this does not mean that our observable universe is the essence of this dead universe. The unions and irregular behaviors of particles altered the original order of this universe, giving rise to strange bodies, such as the galaxies we observe. In this sense, we are mere intruders of chance in this reality, unless there exists a creator entity for the dead universe. Light is something strange to the reality of the dead universe, if we may say so, as it will always exist with its nature and its own laws, and it is calling this strange universe that has light as a primordial factor to its nature and essence. In this sense, it is not up for discussion the existence of humanity and life as we know it. “No one can deny that the universe is more for darkness, chaos, and obscure mystery than for a reality of light,” as the Abrahamic religions said.<sup>59</sup> It’s an exciting moment to question, explore, and perhaps discover the true nature of the cosmos. Our time will always be the present because we are within the eternal time of the dead universe (Thorne, 1994). “A single understanding that unifies the quantum and classical worlds would sweep through cosmology like a wind, stirring up all the old questions and many new ones, answering some but leaving most unanswered.”<sup>60</sup>

Physics deals with the paradox of dark matter. It is conjectured that such matter may consist of compact and supermassive objects, such as primordial black holes, or perhaps of hypothetical and indescribable particles, known as sterile neutrinos. However, the very concept believed to elucidate dark matter finds a stronger resonance within the scope of the Dead Universe theory than within the confines of the Big Bang paradigm. The existence of a past and extinct universe, devoid of all luminance, supports the belief that this process generated energy, similar to the unexplained cosmic enigma of dark energy. According to this theory, dark energy is not the agent of universal expansion, but rather the residual laws of the preceding universe still in effect (Lee Smolin 2006). The Dead Universe Theory takes into account dark matter, radio waves, and particle behavior. But a creative agency does not nullify the Dead Universe theory for purely scientific purposes. Science does not strive to substantiate the existence of the divine. It only seeks to investigate natural phenomena and elucidate them through the lens of empiricism. Likewise, it does not exist to deny the divine. So let us set aside what escapes explanation and channel our energies into what can be explained into the Theory of the Dead Universe (Carroll, 2010). “Imagine a universe in which any one of these numbers was different. It would be a universe without atoms, stars, or planets; a universe without people, or any other form of life as we know it. It would be a universe without history. Yet such a universe would be entirely consistent with the laws of physics as we understand them. Why then do we find ourselves in a universe that is just right for us?”<sup>61</sup>

**2.4 Explanation for the Cold Spot in the Universe.** The “Cold Spot” in the universe is a large, unusually cool patch in the Cosmic Microwave Background (CMB), the afterglow of the Big Bang, best explained by a massive, under-dense region called a super-void that CMB photons travel through, losing energy (integrated Sachs-Wolfe effect).<sup>62</sup> While a super-void is the leading idea, its immense size and the depth of the spot challenge standard models, with some even speculating exotic origins like another universe’s imprint, though most evidence points to a huge void. It was discovered through observations made by the WMAP (Wilkinson Microwave Anisotropy Probe) satellite in 2004 and later confirmed

by data from the ESA's Planck mission. This spot is about 70 microkelvins colder than the average CMB, which challenges the standard explanation based on the homogeneity of the universe predicted by the Big Bang theory.<sup>63</sup> This perspective implies that abnormalities like the Cold Spot are not just statistical fluctuations or effects of unknown cosmic superstructures, but rather direct manifestations of the extreme conditions and laws of the prior universe. Gravitational influences or other residual forces from this dead universe may be causing the temperature variations observed in the cosmic background radiation. Temperature is a condition inherent to the dead universe and not the observable universe due to its state of cosmic demise. The notion that multiverses are colliding with this universe seems improbable over a history of billions of years; certainly, various other cold spots would have been encountered, yet they do not exist because this cold spot was the link between this universe and the mother universe over trillions of years of its existence.

**2.5 Limitation of Big Bang Theory.** The Big Bang theory, while successful in explaining most of the observed features of the universe, such as cosmic expansion and the abundance of light elements, struggles to fully explain anisotropies like the Cold Spot. According to the standard model, temperature fluctuations in the CMB should be relatively uniform across large scales due to cosmic inflation. The Cold Spot, due to its scale and depth, does not easily fit into this model without requiring more complex descriptions, like rare statistical fluctuations or huge, undetected cosmic superstructures. So, the Big Bang theory explains much of cosmology but has key limitations, including the Horizon Problem (uniform CMB temperature)<sup>64</sup>, Flatness Problem (universe's geometry)<sup>65</sup>, and Monopole Problem (lack of magnetic monopoles)<sup>66</sup>, which are addressed by the Inflation theory, but this introduces its own issues like explaining the initial conditions and the nature of dark matter/energy.<sup>67</sup> The theory also struggles to describe the initial singularity (Planck Epoch) and the matter-antimatter asymmetry. The Inflation Theory proposes a period of extremely rapid (exponential) expansion of the universe during its first few moments. It was developed around 1980 to explain several puzzles with the standard Big Bang theory, in which the universe expands relatively gradually throughout its history.<sup>68</sup> The detailed particle physics mechanism responsible for inflation is unknown. In 1992, a number of inflation model predictions have been confirmed by observation; for example, temperature anisotropies observed by the COBE satellite exhibit nearly scale-invariant spectra as predicted by the inflationary paradigm and WMAP results also show strong evidence for inflation.<sup>69</sup> However, some scientists dissent from this position.<sup>70,71</sup>

The horizon problem is the problem of determining why the universe appears statistically homogeneous and isotropic in accordance with the cosmological principle.<sup>72</sup> For example, molecules in a canister of gas are distributed homogeneously and isotopically because they are in thermal equilibrium: gas throughout the canister has had enough time to interact to dissipate inhomogeneities and anisotropies.<sup>73</sup> In the Big Bang model without inflation, gravitational expansion separates regions too quickly. So, the early universe does not have enough time to equilibrate. In a Big Bang with only the matter and radiation known in the Standard Model, two widely separated regions of the observable universe cannot have equilibrated because they move apart from each other faster than the speed of light and thus have never come into causal contact.<sup>74</sup> The flatness problem (also known as the oldness problem) is a cosmological fine-tuning problem within the Big Bang model of the universe. Observations of the cosmic microwave background have demonstrated that the Universe is flat to within a few percent.<sup>75</sup> The expansion of the universe increases flatness. Subsequently, the early universe must have been exceptionally close to flat. In standard cosmology based on the Friedmann equations the density of matter and energy in the universe affects the curvature of space-time, with a very specific critical value being required for a flat universe.<sup>76</sup> The current density of the universe is observed to be very close to this critical value. Since any departure of the total density from the critical value would increase rapidly over cosmic time,<sup>77</sup> the early universe must have had a density even closer to the critical density, departing from it by one part in  $10^{62}$  or less. This leads cosmologists to question how the initial density came to be so closely fine-tuned to this 'special' value.<sup>78</sup>

**2.6 Discrepancy with Cosmic Radiation Theory.** While cosmic background radiation generally supports a uniform and homogeneous universe as predicted by inflation, the Cold Spot suggests anisotropies that may require new physics or adjustments to current cosmogonic models. In this context, the Big Bang theory does not provide a direct explanation for this anomaly, raising questions about possible revisions or extensions to the model. The Dead Universe theory offers an alternative explanation for the Cold Spot, suggesting that it represents an "umbilical cord" from a previously collapsed universe. This theory proposes that our observable universe is just a remnant of a much larger and older universe and the dead universe. Gravitational laws and influences from this previous universe, now only partially existing, may be responsible for irregularities like the Cold Spot. This approach not only offers an explanation for the anomaly but also expands cosmological understanding by incorporating the idea of a multiverse or cosmic cycles of death and rebirth. The Dead Universe theory provides an intriguing insight into the origin of anomalies like the Cold Spot in the cosmic microwave background radiation. This theory suggests that the Cold Spot is not a mere random fluctuation, but a direct consequence of the thermal state of a now-extinct precursor universe. Imagine a gigantic, aging universe, progressively cooling until it becomes a vast space of low thermal energy and akin to a cold chamber in the cosmos.

This analogy can be likened to opening a small door between an extremely cold environment, such as a freezer, and a warmer area, like a kitchen. The instant thermal exchange that occurs is similar to the effect the dead universe could have on the space around it, especially at points where the interaction is most intense. This thermal interaction results in a noticeably colder area in the context of the observable universe, which we detect as the Cold Spot. This equation seeks to quantify the direct influence of the extreme cold of the dead universe on the observable universe, in a manner similar to how cold air from a freezer mixes with the warmer air of a kitchen. The use of this analogy and the corresponding

equation provides a vivid and scientifically plausible way to explain how an ancient and cold universe can impact the temperature of the cosmos we observe today. Validation of this theory will require detailed observations and rigorous analysis of the anisotropies in the cosmic microwave background radiation, looking for specific patterns that would corroborate this thermal interaction on a cosmic scale.

The theory of immense gravitational magnitude of the predecessor universe may naturally warp space-time, a phenomenon known in astrophysics as a “gravitational well”, responsible, for example, for bending light. The idea that the observable universe is within the womb of a dead mother universe that died trillions of years ago, the same fate as our universe, which emerged from the womb of the previous mother, may explain what astrophysics has not been able to. The gravitational force of the ancient universe may bend the fabric of the universe in such a way that it creates a “slippery” advancing through space without actually moving. The Big Bang theory, while accepted to explain the origin of the Universe, has gaps, such as the lack of explanation for continuous expansion. Studies connecting particle accelerators, which evidence phenomena similar to micro-explosions, can be interpreted as support for this alternative hypothesis. If the observable universe emerged from a “dead universe”, such an event could be interpreted as an expansion driven by the lingering action of the gravity of a previous universe, a concept that could be inferred from the presence and behavior of black holes, which offer indirect evidence of this process. The continuity of gravitational laws, which seem to govern without alteration since the primordial state, may be a testament to the deep connection between the current universe and its possible origin in a previous and broader context.

A pertinent issue in contesting the Big Bang model lies in the observation that expansions resulting from explosive events generally introduce a level of randomness in the movement of the involved particles. However, the expansion observed in the universe suggests a more orderly and systematic progression, possibly guided by principles not yet fully elucidated by contemporary physics. Regarding the characterization of the “Explosion” associated with the Big Bang itself, the term may be deemed inappropriate if interpreted in the light of conventional explosions. If such an event does not fit within the traditional parameters of an explosion, then what would be the physical mechanisms sustaining such a model? The proposition of the Big Bang, which posits the expansion of the spacetime fabric itself, demands a source of energy capable of enabling such a phenomenon. Additionally, the process described by the Big Bang does not correspond to an explosion within a pre-existing space but rather to the expansion of the spacetime structure itself. In this context, the hypothesis of the “Great Dead Universe” offers an alternative explanation that could provide a detailed description of cosmic expansion, filling gaps left by the Big Bang model, which sometimes seems to oscillate in its explanations about the exact nature of the initial event.

Additionally, the regularity and organized structure observed in the cosmos may seem antithetical to a chaotic and random origin suggested by a conventional explosion. Scientific studies, including those based on principles of quantum physics, have indicated that the nature of the universe may incorporate explosive aspects. Consequently, if the observable universe is influenced by a previous cosmic legacy, then the initial conditions and physical laws of this preceding universe could be the regulating keys of the expansion we witness today (Rees 2000). “The theory of everything is an ambitious quest in theoretical physics to unify all four fundamental forces of the universe: gravity, electromagnetism, weak nuclear force, and strong nuclear force.” Said by Sean Carroll, in “From Eternity to Here: The Quest for the Ultimate Theory of Time.”<sup>79</sup> “Every atom in your body came from a star that exploded. And, the atoms in your left hand probably came from a different star than your right hand. It really is the most poetic thing I know about physics: You are all stardust.” As described by Lawrence M. Krauss, in “A Universe from Nothing: Why There Is Something Rather than Nothing.” (Krauss, 2012)<sup>80</sup> The Dead Universe theory not only challenges the foundations of the Big Bang but also offers more cohesive explanations for the existence of celestial phenomena. By proposing a new model for the origin of the universe, this theory paves the way for a deeper and possibly more accurate understanding of the cosmos, transcending the limitations of current science.

**2.7 Modern Cosmology.** Modern cosmology is a dynamic interplay of theoretical and experimental endeavors, continually evolving to surmount novel challenges. The discipline necessitates systematic reconstruction to harmonize theory with emerging observational data at each juncture. A watershed moment in this ongoing debate unfolded with the revelation of supernova dimming,<sup>81</sup> a phenomenon that revealed the limitations of the Friedmann–Lemaître–Robertson–Walker metric (here Friedmann metric). To address this dissonance, the cosmological constant was introduced to align the theoretical predictions with empirical insights.<sup>82</sup> Present-day surveys and astronomical observations indicate that galaxies are increasingly moving away from us. At the core of current cosmological discussions is the significant challenge of understanding the formation of structures and the evolution of galaxies amidst the backdrop of the accelerated expansion in the late-time universe.<sup>83</sup> The Friedmann model, rooted in the cosmological principle, has effectively described the universe’s evolution in line with empirical observations.<sup>84, 85, 86</sup> However, the mystery of dark energy and the force driving cosmic acceleration remains a tenacious challenge in contemporary physical cosmology.<sup>87, 88</sup> Various efforts to explain cosmic acceleration rely on concepts such as the cosmological constant or scenarios dominated by dark energy. However, the puzzlements surrounding the cosmological constant pose significant puzzles.<sup>89, 90, 91</sup> Adding to these difficulties is the potential violation of the cosmological principle when homogeneity or isotropy falters in galaxy structure formation.<sup>92, 93</sup>

As for three-dimensional redshift, surveys delve deeper into the cosmos, revealing structures lacking a transition to homogeneity.<sup>94, 95</sup> Now, questions arise regarding the steadfastness of the cosmological principle.<sup>96</sup> The galaxy

distribution in recent observations (or light) and the simulation of dark matter distribution (or matter) display significant inhomogeneity on the largest statistical scale available.<sup>97</sup> The matter distribution exhibits even greater inhomogeneity, challenging the search for the cosmological principle in the current observed light or matter distribution in the universe.<sup>98</sup> Recent studies on the angular scale of cosmic homogeneity using the Sloan Digital Sky Survey's Sixteenth Data Release (SDSS-IV DR16) of a luminous red galaxy sample based on a model-independent approach found a homogeneity of 60–80  $h^{-1}$  Mpc.<sup>99</sup> This finding was recently challenged through a homogeneity test for the matter distribution based on the Baryon Oscillation Spectroscopic Survey Data Release 12 CMASS galaxy sample.<sup>100</sup> It was found that the observed distribution of matter is statistically unlikely to be a random arrangement up to a radius of 300  $h^{-1}$  Mpc, which is approximately the largest statistically available scale.

The identification of large quasar groups (LQGs) further catalyzes the debate, suggesting an inherent inhomogeneity incompatible with prevailing cosmological paradigms.<sup>101,102</sup> Such revelations underscore the need for a profound cosmological reassessment.<sup>103</sup> Correct testing on the prediction of the standard model on the spatial distributions of luminous astronomical sources needs to be based on cosmological simulations of a high resolution involving a large sample of isolated galaxies using robust data-driven detectors to avoid misinterpretations of the analyzed sources.<sup>104</sup> While two-dimensional predictions appear consonant with isotropy and homogeneity, three-dimensional catalogues unveil a complex picture of inhomogeneous galactic distributions.<sup>105</sup> These divergent findings regarding the transition to homogeneity confound attempts at a unified perspective.<sup>106,107</sup> The contrasting nature of these observations challenges the conventional assumption of cosmic homogeneity and isotropy.<sup>108</sup> The implications have a potential impact on understanding cosmic acceleration and the need for an additional dark energy component.<sup>109,110</sup>

Researchers find it necessary to explore alternative models of dark energy or its modified forms to account for the cosmic acceleration of the universe, considering the observational anomalies of the standard model and its lack of physical motivation.<sup>111,112,113,114</sup> The proposed model includes scenarios where the scalar field replaces the cosmological constant to represent dark energy and modified gravity theories.<sup>115,116</sup> Recent observations, such as the unexplained Hubble parameter tensions, large-scale anisotropies, and massive disk galaxies at higher redshifts, pose challenges to the Friedmann model and the concordance model of cosmology in general. For example, the Hubble parameter determined from the cosmic microwave background (CMB) radiation differs from that determined using Type Ia supernovae and the redshift of their host galaxies.<sup>117,118</sup> While one possible explanation is the incompleteness of the concordance model, alternative theories propose that the standard redshift model, as a distance–scale factor relation, might be incomplete.<sup>119,120</sup> Addressing these observations supports modifications to some foundations of cosmology based on the cosmological principle.<sup>121</sup> Modifying the standard redshift relation may offer a plausible explanation for investigating recent Hubble tensions.<sup>122</sup>

Some other models propose cosmic acceleration as an emergent phenomenon.<sup>123</sup> The fundamental effect of cosmic evolution on photon propagation is cosmological redshift. In the standard model, cosmological redshift is a theoretical function of the scale factor derived from the Friedmann metric. However, researchers are now reconstructing this scale factor–redshift relation from observations rather than relying on its theoretical form.<sup>124,125</sup> One drawback of remapping cosmological models is the unknown function of the observed redshift, increasing the degree of freedom of the equation. This issue has been addressed by introducing function parameterization through Taylor expansion before adopting a parametric approach. Related work includes a cosmological model proposed to explain the accelerated expansion of the universe by modifying the standard redshift relation.<sup>126</sup> It has been demonstrated that combining Friedmann equations with a modification of redshift remapping may lead to a self-consistent framework under the assumption of the inadequacy of the Friedmann model.<sup>127,128</sup> The parametric,<sup>129</sup> non-parametric,<sup>130</sup> and modified standard redshift models,<sup>131</sup> are expected to address the cosmological constant problem.

However, all these ambitious objectives hinge upon an indispensable precondition and an abundance of accurate and expansive cosmological data. Despite the growing body of observational data, persistent limitations require a careful interpretation of the current cosmological models' completeness and accuracy.<sup>132,133,134</sup> The upcoming Vera Rubin Observatory holds the potential for a transformative ten-year exploration, armed with a 3.6 Gigapixel camera,<sup>135</sup> ready to survey the entire visible night sky and delve into cosmic intricacies.<sup>136</sup> Again, in 2015 the parametric model proposed by Bassett et al.<sup>137</sup> introduces modifications to the traditional redshift paradigm, seeking to refine our understanding of cosmic dynamics. This model involves the introduction of parameters that capture modifications in the redshift space, allowing for a more nuanced interpretation of observational data. The model addresses subtle aspects of cosmic phenomena by incorporating specific parameters, providing a more detailed and accurate representation of redshift-related observations. On the other hand, the non-parametric model, as formulated by Wojtak and Prada in 2017, takes a distinct approach by avoiding predefined parameters, allowing for greater flexibility in modeling cosmic phenomena.<sup>138</sup> Unlike parametric models, the non-parametric model refrains from imposing fixed parameters, enabling a more adaptive and data-driven analysis of redshift-related phenomena. This model is precious in scenarios where the underlying dynamics are complex and not easily encapsulated by predefined parameters. It provides a more versatile tool for interpreting observational data.

There are a wide variety of evolved stellar systems in the nearby universe (Norris et al. 2014),<sup>139</sup> from globular clusters (Brodie & Strader 2006; Kruijssen 2014; Renzini et al. 2015)<sup>140,141,142</sup> to compact elliptical galaxies (Faber 1973)<sup>143</sup>,

ultrafaint dwarfs (e.g., Simon & Geha 2007)<sup>144</sup>, and ultra-diffuse spheroids (van Dokkum et al. 2017)<sup>145</sup>, each of which presumably has its own characteristic formation pathway. The high stellar densities in many of these systems in combination with their old ages (Forbes and Bridges 2010)<sup>146</sup> suggest that the majority of their star formation occurred at  $z \gtrsim 1.5$  when the gas densities in the universe were in general much higher. One potentially promising way forward for investigating the formation of these local systems is by obtaining a sensitive, high-resolution view of the distant universe. Luckily, such observations can be obtained by combining the power of long exposures with the Hubble Space Telescope with the magnifying effect of gravitational lensing, as recently implemented in the ambitious Hubble Frontier Fields (HFF) program (Coe et al. 2015; Lotz et al. 2017)<sup>147, 148</sup>. Such sensitive observations allow us to probe to very low luminosities, as it is likely necessary to detect many of the progenitors of local systems. The high lensing magnifications from massive galaxy clusters stretch many galaxies by substantial factors, allowing them to be studied at very high spatial resolution. As it has discussed in Bouwens et al. (2021b)<sup>149</sup>, this stretching can reliably be estimated up to linear magnifications of  $\sim 30\times$  (or total magnification factors of  $\sim 50\times$ ). It is also available in Bouwens et al. 2017a, c<sup>150, 151</sup>, where similar though smaller limits were presented with the then-current models, and Meneghetti et al. (2017)<sup>152</sup>. Given the small inferred sizes of the fainter lensed sources identified by Kawamata et al. (2018)<sup>153</sup> and Bouwens et al. (2021b)<sup>154</sup> It is interesting to place these sources in the context of various stellar systems that they may evolve into today, as well as other small star-forming systems like star clusters or cluster complexes. An initial look at such comparisons was already executed in an earlier unpublished study by our group (Bouwens et al. 2017b)<sup>155</sup> and also by Kikuchihara et al. (2020)<sup>156</sup>. An important early inference from these studies was that lensed  $z = 6-8$  galaxies have sizes and masses that appear to lie in the range of  $\sim 50-500$  pc and  $10^7$  to  $10^8 M_{\odot}$ , lying somewhere between ultracompact dwarfs/globular clusters and compact elliptical galaxies in size/mass space.

There has been enormous progress over the past decade in discovering galaxies which existed early in the history of the Universe (within a billion years of the Big Bang, at  $z > 6$ ). It is great and thanks in large part to images from the Hubble Space Telescope, and confirming spectroscopy from large telescopes on the ground. The next few years will see the “high redshift frontier” pushed even further with the James Webb Space Telescope (JWST) and ground-based Extremely Large Telescopes (ELTs).<sup>157</sup> The Nancy Grace Roman Space Telescope (shortened as the Roman Space Telescope, Roman, or RST) is a NASA infrared space telescope in development and scheduled to launch to a Sun–Earth  $L_2$  orbit by May 2027.<sup>158</sup> The limited field of view of these facilities (especially JWST), and sensitivity only out to the near-infrared (near-IR,  $\lambda < 2\mu\text{m}$ ) for the Roman Space Telescope (formerly WFIRST)<sup>159</sup> and EUCLID wide-field imaging space missions, and which mean that a crucial piece of the jigsaw remains missing. That is a wide-field imaging survey,<sup>160</sup> working at near and mid-IR wavelengths (necessarily from space) is needed to find the very rare most massive and luminous galaxies at the highest redshifts, the progenitors of which are likely to be the first galactic structures to form. NIR spectroscopy at  $\lambda > 2\mu\text{m}$  (corresponding to the rest-frame optical frame) is also mandatory to get complete information (metallicity, stellar mass) for galaxies at  $z > 10$ .<sup>161</sup>

The landscape of astrophysics in the timeframe from 2035–2050 is expected to be very rich as the JWST mission will have been completed, presumably finding a wealth of faint galaxies at high redshift and addressing the role of these early galaxies in the reionization of the inter-galactic medium. Millimeter/submillimeter Array (ALMA), currently the most powerful radio telescope on Earth. The Square Kilometer Array (SKA) is an intergovernmental international radio telescope project being built in Australia (low-frequency) and South Africa (mid-frequency). ALMA will be a very mature facility by then and SKA will have explored the molecular emission and dust re-emission from some of these objects.<sup>162</sup> The re-ionization of the Universe was achieved by low luminosity sources.<sup>163, 164, 165</sup> These low luminosity sources would only be visible if they are in groups or proto clusters. This is likely so for the first galaxies, which were of very low luminosity. Thus, detecting proto clusters from  $z \sim 6$  to  $z \sim 15$  would unveil the history of the Universe’s re-ionization.<sup>166</sup> Rare and bright sources at high redshift as well as transients like distant supernovae will be explored by the Rubin Observatory (previously LSST) on the ground, and EUCLID and the Roman Space Telescope in space, at wavelengths below 2 microns.<sup>167</sup> In the X-ray, after a hiatus of many decades new facilities like Athena will see AGN out to unprecedented distances. But there is a key gap in the parameter space that remains unexploited and a wide-field IR survey mission with spectroscopy and imaging working beyond 2 microns that need to address in future.<sup>168</sup> By this unfinished journey toward mysterious universe will continue further. However, this analytical research work will evaluate and describe the chronological development of ideas and theories of physics to apprise the origin and creation of universe on the basis of contemporary development of concept of physics. Author will also take effort to investigate and narrate and appraise of the creation and future of universe.

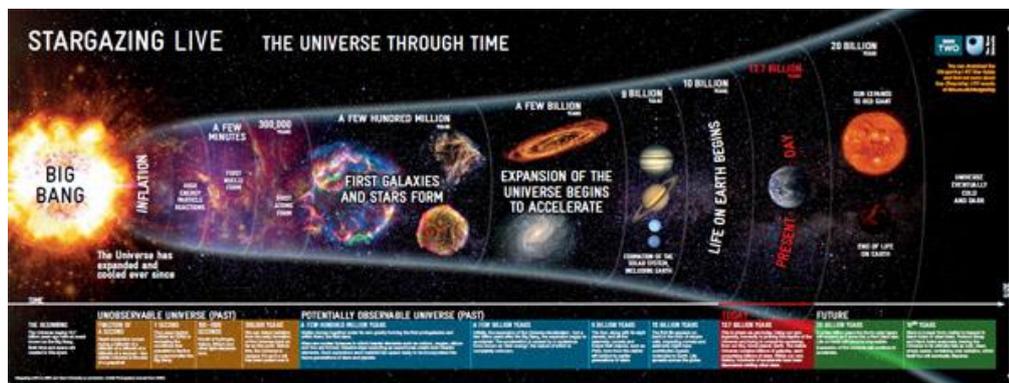


Figure 3: History of universe timeline<sup>169</sup>

### 3. Future Predetermined by Quantum Mechanics

Spacetime unity derived from Einstein's relativity, space and time are inseparable into a single 4D manifold called spacetime. The universe has three spatial dimensions (up/down, left/right, forward/backward) and one dimension of time, making it four-dimensional. All moments (past, present, future) are equally real and exist at once, like different locations on a map. The universe is seen as a fixed, unchanging block, not a dynamic process, with no objective "flow" of time. The philosophical view that all moments in time are equally real, contrasting with Presentism (only the present is real) or Growing Block theories. So, time is just another dimension in the 4D fabric of spacetime, so the past, present, and future at the micro-level are synchronized just like all points on a map. Again, the laws of physics at the micro-mechanical level indicate that the future is not predetermined until events occur. In Bohmian mechanics, the future is determined but hidden from us. But in cosmology, the universe's large-scale fate might be fixed if the laws and constants are interchanged.<sup>170</sup> However, if constants evolve or quantum effects, the time behavior, then even the cosmos' future is still unfolding. Challenges the idea of free will, as the future is already there, suggesting a deterministic universe. Many physicists challenge the idea of free will, as the future is already there, suggesting a deterministic universe.<sup>171</sup> They raise questions about how change and becoming occur if everything already exists. So, the feeling of a moving present is seen as a subjective experience, not an objective feature of reality.

**3.1 Einstein's Special Theory of Relativity and the Block Universe.** Einstein's special theory of relativity revolutionized our understanding of space and time by combining them into a unified four-dimensional structure called space-time. This led to the concept of the "block universe," in which all events- past, present, and future exist simultaneously and permanently as parts of a fixed continuum. In this view, time does not flow; instead, it exists all at once, much like space. A critical consequence is the relativity of simultaneity, meaning that different observers, depending on their relative velocities, can disagree about what events are happening now. Thus, the notion of a universally shared present collapses, and this supports the philosophical idea of eternalism, where every moment in time is equally real.<sup>172</sup> The block universe implies determinism, as the future appears just as fixed as the past, governed by unchanging physical laws.

**3.2 Determinism Versus Indeterminism in Relativity.** Relativity suggests a deterministic universe where the entire timeline, including the future, is predetermined and unchanging. However, this creates a dilemma: if relativity accurately describes the large-scale universe, can the future truly be open to debate? The video outlines two perspectives- either the entire block universe, including the future, is fully defined, or parts of reality outside our "past light cone" remain undefined or indeterminate.<sup>173</sup> This leads to the idea of a "bubble" of defined reality around each observer, particularly near the brain, while the rest of the universe stays undefined until observed. To resolve this tension between determinism and an open future, we must turn to quantum mechanics, which introduces genuine indeterminacy into physical law.

**3.3 Quantum Mechanics and the Indeterminacy of Reality.** Quantum mechanics departs from classical determinism by describing systems with wave functions that encode probabilities for all possible outcomes rather than definite values. Before measurement, quantum systems exist in superposition, a combination of all possible states. Upon measurement, a single outcome emerges, but which outcome occurs cannot be predicted deterministically, only probabilistically.<sup>174</sup> This core aspect of quantum mechanics has been confirmed through countless experiments. However, the mechanism by which the probabilistic wave function collapses to a single result, known as wave function collapse, is still one of the deepest mysteries in quantum theory. Understanding whether this collapse is real and what causes it is crucial for determining whether the future is fixed or open.

**3.4 The Copenhagen Interpretation and Non-Determinism.** The Copenhagen interpretation is one of the oldest and most widely taught views of quantum mechanics. It suggests that a quantum system stays in superposition until a measurement occurs, at which point the wave function collapses to a single definite outcome. This introduces a fundamental element of randomness into the universe, meaning that even with complete knowledge of the present, the

future cannot be predicted with certainty.<sup>175</sup> However, this creates issues when combined with relativity. Since different observers can perceive simultaneity differently, they might disagree on whether a particular event's wave function has already collapsed. This difference challenges the idea of a universally accepted reality and emphasizes the difficulty of reconciling quantum collapse with relativistic space-time.

**3.5 The Many-Worlds Interpretation and Determinism Restored.** The Many-Worlds interpretation presents a radical yet elegant alternative: it completely rejects the idea of wave function collapse. Instead, it proposes that all possible outcomes of a quantum event happen, each in its own parallel universe. The wave function evolves deterministically according to the Schrödinger equation, with every possible result realized in some branch. Observers become entangled with these branches and experience only one outcome, while other versions of themselves experience different outcomes. From a global perspective, the universe is entirely deterministic, with all branches coexisting.<sup>176</sup> This interpretation aligns with Einstein's relativity because the branching respects causal limits like the speed of light. However, from a personal perspective, observers perceive randomness because they are only in one branch.

**3.6 Relativity, Decoherence, and the Propagation of Branching.** In the Many-Worlds framework, branching is not instantaneous across the universe. Instead, it spreads according to the rules of relativistic causality—at or below the speed of light. Entanglement webs form, consisting of interconnected quantum events that define different realities. Decoherence plays a crucial role here by explaining how quantum branches become effectively isolated from each other. As quantum interference between branches diminishes over time, each branch behaves classically. Decoherence provides a physical mechanism for the transition from quantum probabilities to classical experiences.<sup>177</sup> This leads to an objective meaning of the present as the specific entanglement network an observer is part of. However, due to the relativity of simultaneity, each observer's perception of "now" varies depending on their motion through space-time.

**3.7 Pilot-Wave Theory and Its Challenges.** The de Broglie-Bohm pilot-wave theory offers an alternative interpretation of quantum mechanics that restores determinism without needing parallel worlds. It suggests particles follow specific paths influenced by a guiding wave function that evolves according to quantum rules. This provides a clear, non-random description of particle behavior. However, the pilot-wave theory faces major challenges in reconciling with special relativity. Because it involves non-local effects—where changes in one place can instantly affect distant particles—it does not naturally fit into the relativistic framework, which states that no influence can travel faster than light.<sup>178</sup> This incompatibility with relativity weakens its standing as a complete, modern physical theory.

**3.8 Consciousness and the Nature of the Present.** A key philosophical and experiential question emerges from the concept of a block universe: if all events are predetermined, what does it mean to perceive the present? Since consciousness results from neural processes that develop over time, the "now" we feel is not a single moment but a span of time. This expanded sense of the present conflicts with presentism—the idea that only the current moment exists—and with naive notions of a strict boundary separating past and future. Instead, our conscious experience of time suggests a more nuanced, distributed view of the present, which is compatible with relativity's concept of relative simultaneity. This challenges simple interpretations of time and prompts more profound questions about how we subjectively experience the flow of time. The core question: Does the future already exist? — remains unresolved and largely depends on which interpretation of quantum mechanics one accepts.<sup>179</sup> If one adopts the Copenhagen view, the future remains fundamentally indeterminate, shaped only upon observation. If one prefers Many-Worlds, the future is predetermined in a vast multiverse, though each observer experiences a branching, uncertain path. Reconciling the flow of time and the direction of time—why we remember the past but not the future—continues to be an open challenge in physics.<sup>180</sup> This discussion may end by emphasizing the importance of integrating physical theory with philosophical insights and the subjective realities of consciousness to better understand time, determinism, and the structure of reality.



Figure 4: Black holes don't emit light and they are worth considering as a potential dark matter<sup>181</sup>

## 4. Consequence and Ultimate Fate of Universe

Black holes are some of the most extreme objects in the Universe. That is the only locations where there's so much energy in a tiny volume of space that an event horizon gets created. When they form, atoms, nuclei, and even fundamental particles themselves are crushed down to an arbitrarily small volume to a singularity and that is in our three-dimensional space. At the same time, everything that falls past the event horizon is forever doomed, simply adding to the black hole's gravitational pull.<sup>182</sup> The truth of the cosmos may be far more intricate and mysterious than once believed. By addressing open questions about dark matter, magnetic fields, time, neutrinos, inflation, and even the possibility of a simulated reality, this collection illustrates how modern astrophysics and cosmology are increasingly interwoven with cutting-edge physics, speculative ideas, and technological innovation. These subjects not only challenge existing paradigms but also offer glimpses into deeper layers of physical law, potentially reshaping our understanding of existence itself. As observation improves and theory advances, the answers to these questions may unlock entirely new dimensions, both literally and metaphorically, of cosmic awareness. So, astrophysicists and cosmologists study the universe.<sup>183</sup> They are not only asking where it came from but also where the universe is going. Their ideas about the future are based on a mix of theory, observation, and speculation. Since Hubble's work (since 1929), we know the universe is expanding. But today, we know that expansion is accelerating due to dark energy. So, galaxies beyond a certain horizon will move away faster than light, becoming forever invisible to us. Our cosmic neighborhood will become more isolated. So, there may be three possible scenarios:

**4.1 Big Bang nucleosynthesis.** Big Bang nucleosynthesis is considered as the theory of the formation of the elements in the early universe. It has ended when the universe was about three minutes old and its temperature has released below that at which nuclear fusion could occur. It had a brief period during which it could operate, so that the very lightest elements were produced. Starting from hydrogen ions or protons, it primarily produced deuterium, helium-4, and lithium and other elements were produced in only trace abundances. The elementary theory of nucleosynthesis was developed in 1948 by George Gamow, Ralph Asher Alpher, and Robert Herman.<sup>184</sup> Interestingly, which was used for many years as a probe of physics at the time of the Big Bang, as the theory of Big Bang nucleosynthesis connects the abundances of primordial light elements with the features of the early universe.<sup>185</sup> Precisely, it can be used to test the equivalence principle,<sup>186</sup> to probe dark matter, and test neutrino physics.<sup>187</sup> Some cosmologists have proposed that Big Bang nucleosynthesis proposes there is a fourth "sterile" species of neutrino.<sup>188</sup> Understanding the formation and evolution of the largest and earliest structures, like quasars, galaxies, clusters and superclusters and which was one of the largest efforts in cosmology. Cosmologists study a model of hierarchical structure formation in which structures form, from the bottom up, with smaller objects forming first, while the largest objects, like superclusters, are still accumulating.<sup>189</sup> One way to study structure in the universe is to survey the visible galaxies, in order to construct a 3-dimensional picture of the galaxies in the universe and measure the matter power spectrum. This is the approach of the Sloan Digital Sky Survey and the 2dF Galaxy Redshift Survey.<sup>190</sup> Another tool for understanding structure formation is simulations, which cosmologists use to study the gravitational aggregation of matter in the universe, as it clusters into filaments, superclusters and voids.<sup>191</sup> Most simulations contain only non-baryonic cold dark matter, which should suffice to understand the universe on the largest scales, as there is much more dark matter in the universe than visible baryonic matter. More advanced simulations are starting to include baryons and study the formation of individual galaxies. Cosmologists study these simulations to see if they agree with the galaxy surveys, and to understand any inconsistency.<sup>192</sup>

The Big Bang nucleosynthesis indicate that, the cosmic microwave background, structure formation, and galaxy rotation curves suggests that about 23% of the mass of the universe consists of non-baryonic dark matter, whereas only 4% consists of visible, baryonic matter.<sup>193</sup> Today the gravitational effects of dark matter are well understood, as it behaves like a cold, non-radiative fluid that forms haloes around galaxies. As we know that, dark matter has never been detected in the laboratory, as well as the particle physics nature of dark matter remains entirely unknown. However, without observational constraints, there are a number of candidates. Such as: a stable supersymmetric particle, a weakly interacting massive particle, a gravitationally-interacting massive particle, an axion, and a massive compact halo object. Alternatives to the dark matter hypothesis include a modification of gravity at small accelerations (MOND) or an effect from brane cosmology. TeVeS is a version of MOND that can explain gravitational lensing. Again, Modified Newtonian dynamics (MOND) is a theory that proposes a modification of Newton's laws to account for observed properties of galaxies.<sup>194</sup> MOND was developed in 1982 and presented in 1983 by Israeli physicist Mordehai Milgrom. Modifying Newton's law of gravity results in modified gravity, while modifying Newton's second law results in modified inertia.<sup>195</sup> The latter has received little attention compared to the modified gravity version. Its primary motivation is to explain galaxy rotation curves without invoking dark matter, and is one of the most well-known theories of this class.<sup>196</sup>

**4.2 Big Freeze or Heat Death.** As existing stars run out of fuel and cease to shine, the universe will slowly and inexorably grow darker. Eventually black holes will dominate the universe, but they will disappear over time as they emit Hawking radiation.<sup>197</sup> Over infinite time, there could be a spontaneous entropy decrease by the Poincaré recurrence theorem, thermal fluctuations,<sup>198,199</sup> and the fluctuation theorem. The heat death or Big Freeze scenario is compatible with any of the three spatial models, but it requires that the universe reaches an eventual temperature minimum.<sup>200</sup> Without

dark energy, it could occur only under a flat or hyperbolic geometry.<sup>201,202</sup> It could also occur in a closed universe with a positive cosmological constant. Physicist Freeman Dyson<sup>203</sup> has proposed a scenario for the far future in which intelligent life could achieve a form of immortality by processing an infinite number of thoughts in his 1979 paper 'Time Without End: Physics and Biology in an Open Universe'.<sup>204</sup> This concept, known as 'Dyson's eternal intelligence,' and was originally predicated on an open universe, and a cosmological model that expands forever. In the context of a zero cosmological constant (as a flat or open universe without dark energy), the universe would continue to cool as it expands, but at a decelerating rate.<sup>205</sup> Dyson's idea was that intelligent beings could store a finite amount of energy and expend it in increasingly smaller fractions. After each expenditure of energy for thought processes, these beings would enter a state of hibernation for immense periods, allowing the universe to cool further. As the ambient temperature of the universe drops, the minimum energy required for a computation also decreases, theoretically allowing for an infinite number of thoughts to be processed over an infinite subjective time, even with a finite energy reserve. However, this scenario faces challenges, as the discovery of an accelerating expansion, driven by a positive cosmological constant, suggests that the universe will not continue to cool indefinitely and distant regions will become causally disconnected, which would prevent the indefinite survival envisioned by Dyson.<sup>206</sup>

**4.3 Big Rip.** It is a hypothetical, catastrophic end to the universe where the accelerating expansion of space becomes so powerful that, it overcomes all other forces, eventually tearing apart all structures.<sup>207</sup> In this scenario, galaxy clusters, galaxies, solar systems, planets, and ultimately atoms and subatomic particles would be ripped apart. The process occurs if dark energy becomes stronger over time or 'a form sometimes called phantom energy,' leading to a violent and complete dissolution of all matter.<sup>208</sup> The expansion would be strong enough to tear individual galaxies apart, followed by solar systems. In the final moments, planets would be ripped from their stars, followed by stars themselves.<sup>209</sup> Eventually, the forces holding atoms together would be overcome, and even subatomic particles would be torn apart. The current Hubble constant defines a rate of acceleration of the universe not large enough to destroy local structures like galaxies, which are held together by gravity, but huge enough to increase the space between them.<sup>210</sup> A steady increase in the Hubble constant to infinity would result in all material objects in the universe, starting with galaxies and eventually in a finite time all forms, no matter how small, decomposing into unbound elementary particles, radiation and beyond.<sup>211</sup> As the energy density, scale factor and expansion rate become infinite, the universe ends as what is effectively a singularity. In the special case of phantom dark energy, which has supposed negative kinetic energy that would result in a higher rate of acceleration than other cosmological constants predict, a more sudden big rip could occur.<sup>212</sup> The Big Rip is a theoretical possibility and not the most likely outcome, as it requires dark energy to behave in a specific way. Current data suggests dark energy is roughly constant, and a Big Rip is not predicted by this model.<sup>213</sup> However, the exact nature of dark energy is still a mystery, and some experimental evidence has hinted at possibilities that would make this scenario more likely, according to Universe Today.<sup>214</sup>

**4.4 Big Crunch.** The Big Crunch is another hypothetical scenario for the final destiny of the universe, in which the expansion of the universe eventually reverses and the universe re-collapses, ultimately triggering the cosmic scale factor to reach absolute zero. And this is an event potentially followed by a reformation of the universe starting with another Big Bang.<sup>215</sup> The vast majority of current evidence indicates that, this hypothesis may not be correct. In its place, astronomical observations show that, the expansion of the universe is accelerating rather than being slowed by gravity, suggesting that a Big Chill or Big Rip is much more likely to occur.<sup>216,217</sup> Recent evidence suggests that this scenario is unlikely but has not been ruled out, as measurements have been available only over a relatively short period of time and could reverse in the future.<sup>218</sup> Such scenario allows the Big Bang to occur immediately after the Big Crunch of a preceding universe. Again, if this happens repeatedly, it creates a cyclic model, which is also known as an oscillatory universe.<sup>219</sup> The universe could then consist of an infinite sequence of finite universes, with each finite universe ending with a Big Crunch that is also the Big Bang of the next universe. A problem with the cyclic universe is that, it does not reconcile with the second law of thermodynamics, as entropy would build up from oscillation to oscillation and cause the eventual heat death of the universe.<sup>220</sup> Current evidence also detects the universe is not closed rather open ended. This has caused cosmologists to abandon the oscillating universe model. So, a similar idea is incorporated by the cyclic model, but this idea escapes heat death because of an expansion of the branes that dilutes entropy accumulated in the previous cycle.<sup>221</sup>

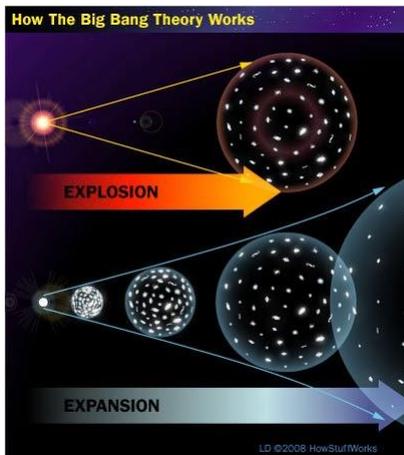


Figure 5: The Ultimate future of Universe- Big Crunch, Big or Freeze Big?<sup>222</sup>

**4.5 Big Bounce.** The Big Bounce may consider as another strong hypothesis and which is a cosmological model for the origin of the known universe.<sup>223</sup> It was initially suggested as a phase of the cyclic model or oscillatory universe interpretation of the Big Bang, where the first cosmological event was the result of the collapse of a previous universe.<sup>224,225</sup> It retreated from serious consideration in the early 1980s, after inflation theory emerged as a solution to the horizon problem, which had arisen from advances in observations revealing the large-scale structure of the universe.<sup>226</sup> The Big Bounce is a theorized scientific model related to the beginning of the known universe.<sup>227</sup> According to one version of the Big Bang theory of cosmology, in the beginning of the universe was infinitely dense. This description seems to be at odds with other more widely accepted theories, especially QM and its uncertainty principle.<sup>228</sup> Therefore, QM has given rise to an alternative version of the Big Bang theory, precisely that the universe tunneled into existence and had a finite density consistent with QM, before evolving in a manner governed by classical physics.<sup>229</sup> In case, where the universe is closed, this theory would predict that once this universe collapses, it will spawn another universe in an event similar to the Big Bang after a universal singularity is reached or a repulsive quantum force causes re-expansion. This theory states that the universe will continuously repeat the cycle of a Big Bang, followed by a Big Crunch. So, here inflation was found to be inevitably eternal, creating an infinity of different universes with typically different properties, suggesting that the properties of the observable universe are a matter of chance.<sup>230</sup> An alternative concept that included a Big Bounce was conceived as a predictive and confirmable possible solution to the horizon problem.<sup>231</sup> Investigation continued as of 2022.<sup>232,233,234</sup> We may get some new explanation or clarification of present concept.

**4.6 Big Slurp.** Big Slurp theory suggests that the universe currently exists in a false vacuum and that it could become a true vacuum at any moment. In order to best understanding, before discussion of the false vacuum collapse theory, one must first understand the Higgs field which permeates the universe.<sup>235</sup> It almost similar to electromagnetic field, it varies in strength based upon its potential. A true vacuum exists so long as the universe exists in its lowest energy state, in which case the false vacuum theory is irrelevant. However, if the vacuum is not in its lowest energy state or a false vacuum, it could tunnel into a lower-energy state.<sup>236, 237</sup> This is called vacuum decay.<sup>238</sup> This has the potential to fundamentally alter the universe: in some scenarios, even the various physical constants could have different values, severely affecting the foundations of matter, energy, and spacetime. It is also possible that all structures will be destroyed suddenly, without any forewarning.<sup>239</sup> However, only a portion of the universe would be destroyed by the Big Slurp, while most of the universe would still be unaffected because galaxies located further than 4,200 megaparsecs or 13 billion light-years away from each other. Again, they are moving away from each other faster than the speed of light while the Big Slurp itself cannot expand faster than the speed of light.<sup>240</sup> To place this in context, the size of the visible universe is currently about 46 billion light years in all directions from earth.<sup>241</sup> The universe is thought to be that size or larger.

One of the newest reports released suggests something ominous as if the Higgs Boson truly exists at the appropriate mass, our universe may be in some serious trouble. At least it is according to a theoretical physicist from the Fermi National Accelerator Laboratory in Batavia, Illinois, who claims, 'If you use all the physics that we know now and you do what you think is a straightforward calculation, it's bad news.' Many physicists have been discussing the possibility of our universe teetering on the edge of stability for many years now. Especially physicists Michael Turner and Frank Wilczek, who published a paper in Nature back in 1982 and that suggested this unfriendly scenario as per their statement 'without warning, a bubble of true vacuum could nucleate somewhere in the universe and move outwards at the speed of light, and before we realized what swept by us our protons would decay away.'<sup>242</sup> According to Lykken calculations (which hinge on the mass of the Higgs being correct, or off by a small margin of 1%), many tens of billions of years from now, the universe would experience some catastrophic event as a bubble formed from quantum fluctuations. That is from some sort of an alternate universe with a lower-energy state might appear in ours, expanding and ultimately destroying us at the speed of light, to boot, they said.<sup>243</sup> Even more interestingly, these calculations brought up a question more philosophical than anything else, bringing him to ultimately wonder if the state of our universe is instrumental in producing stars, galaxies, planets, matter and ultimately, life.

**4.7 Cosmic uncertainty.** It refers to the inherent limits on our ability to know the universe with perfect accuracy, stemming from two main sources: cosmic variance and fundamental physical principles. Cosmic variance is the statistical uncertainty that arises because we can only observe one universe, which is a single sample with random fluctuations. Fundamental principles, such as Heisenberg's uncertainty principle, place a universal limit on how precisely certain pairs of physical properties (like energy and time) can be known at the same time.<sup>244</sup> Actually, Cosmologists can only ever study our one universe. Because of this, our observations of phenomena like the cosmic microwave background or large-scale galaxy distribution are limited to a single realization.<sup>245</sup> The early universe had random quantum fluctuations that grew into the large-scale structures we see today. This means our observable patch is not necessarily a perfectly average representation of the entire universe.<sup>246</sup> Cosmic variance introduces an unavoidable statistical uncertainty in measurements of cosmic properties, such as the density of matter or the characteristics of early universe fluctuations. For example, a region of sky surveyed might have a slightly higher or lower density of galaxies by chance.<sup>247</sup> Each possibility as described in this paper so far is based on a simple form of the dark energy equation of state and the latest theories or hypotheses of physics. However, as the name implies, little is now known about the physics of dark energy or even black holes or vacuums in the universe.<sup>248</sup>

On the other hand, if the theory of inflation is true, the universe went through an event dominated by a different form of dark energy in the first moments of the Big Bang; but inflation ended, indicating an equation of state more complex than those assumed for present-day dark energy. It is possible that the dark energy equation of state could change again, resulting in an event that would have consequences which are difficult to predict or parameterize.<sup>249</sup> As the nature of dark energy and dark matter remain enigmatic, even hypothetical, the possibilities surrounding their role in the universe are unknown. As we investigate further into cosmology, bio-information theory, and the different models of consciousness, we will be able to further hypothesize and validate our last survival resort when the universe dies. A positive cosmological constant is a problem. An accelerating universe means that galaxies and galactic entities eventually “grow” apart. Energy stored in these areas would be inaccessible. Unless, of course, if you bring in the dark house—dark energy. No one really knows what dark energy is and what it does. So, this remains unresolved. The largest obstacle towards achieving Dyson’s eternal intelligence is to pass below the physical threshold necessary to the maintenance of conscious awareness. Granted that organic lifeforms are certainly inefficient in turning energy into computations (and consciousness), perhaps inorganic lifeforms or even alternative molecular structures might require much less energy to give rise to consciousness.<sup>250</sup>

## 5. An Estimation/Prediction of the Journey to The End of the Universe

**Introduction: The Transient Nature of the Cosmos.** As we know that, the universe, and everything within it, is constantly changing, impermanent, and subject to time. Astronomically, this concept involves studying transient events, which are short-lived astrophysical phenomena like supernovas or gamma-ray bursts.<sup>251, 252</sup> Philosophically, it reflects the Buddhist and other spiritual concepts of impermanence and the fleetingness of all existence, encouraging a focus on purpose and meaning rather than attachment to temporary things. If we look to the universe as a demonstration. It reflects on the impermanence of the universe, emphasizing that all matter, from stars and planets to galaxies, emerged from primordial cosmic origins and will ultimately return to a basic, formless state. Earth is described as a rare, life-supporting oasis amid a vast and mostly inhospitable cosmos. Situated in the solar system and part of the Milky Way galaxy, Earth exists within a universe that constantly evolves through cycles of creation and destruction.<sup>253</sup> This ever-changing cosmos spans incomprehensibly long timescales, setting the stage for a forward-looking narrative that explores how celestial bodies- including Earth- will transform and eventually meet their fate. Many spiritual and philosophical traditions, including Buddhism and Islamic teachings specially in the Holly Quran, emphasize that all things are temporary and subject to change.<sup>254, 255</sup> Instead of leading to despair, the transient nature of life is seen as a reminder of the importance of living with purpose and humility, recognizing that even difficult times will fade.<sup>256</sup>

**5.1 Earth and the Solar System's Near Future (2100-3000 AD).** If we consider Earth's projections into the 22nd and 23rd centuries, they highlight major environmental and astronomical changes. Global warming, caused by rising greenhouse gas levels, accelerates ice cap melting and sea-level rise, forcing coastal populations to migrate—mirroring ancient human movements. Solar phenomena such as sunspot cycles, increased solar flares, and coronal mass ejections increasingly disrupt Earth's magnetic field and threaten modern technological systems, including satellites, communication infrastructure, and power grids.<sup>257</sup> By 2200 AD, intensified volcanic activity temporarily cools the planet through the release of aerosols, while solar wind interactions with Earth's magnetosphere continue to produce auroral displays.<sup>258</sup> Around 2300 AD, climate disruptions intensify as polar melting weakens ocean currents, like the Gulf Stream, cooling parts of Europe while heating tropical zones.<sup>259</sup> As Earth approaches 2500 AD, long-term orbital cycles known as Milankovitch cycles start to exert a greater influence on climate. These include variations in Earth's eccentricity (orbit shape), axial tilt, and precession (wobble), leading to minor ice ages and widespread ecosystem disruptions. These changes pose significant challenges for human civilization.<sup>260</sup> At the same time, the solar system's movement through the galaxy impacts cosmic ray levels, which can affect atmospheric chemistry and Earth's climate.<sup>261</sup> By 3000 AD, long-lasting glaciation periods might occur, and slow gravitational shifts between planets will gradually change their orbits, although over much longer timescales. As one of the long-term effects of global warming, the Greenland ice sheet will have completely melted.<sup>262</sup>

**5.2 Geological and Solar Evolution Over Millennia (4000 AD-10,000 AD).** As millennia pass, tectonic forces continue shaping Earth's geography. Mountain ranges, such as the Himalayas, grow taller, while new volcanic activity—mainly from super volcanoes like Yellowstone—poses risks of prolonged climatic cooling or "nuclear winter" conditions.<sup>263</sup> The Sun's gradual increase in luminosity becomes more noticeable, warming Earth slowly and pushing the planet toward a moist greenhouse state—a dangerous tipping point where water begins to evaporate into the atmosphere, threatening ocean stability and biodiversity.<sup>264</sup> Geomagnetic field reversals complete their cycles, potentially weakening Earth's magnetic shield and changing how charged particles are distributed in the atmosphere. These shifts could have cascading effects on climate and technology.<sup>265</sup> As the solar system moves through denser interstellar gas clouds, the heliosphere—the Sun's protective bubble—shrinks, letting in more cosmic rays. This may boost cloud formation through atmospheric ionization and influence climate patterns over geological timescales. These increased radiation levels could also promote biological evolution by raising mutation rates—some harmful, others possibly beneficial. If a failure of the Wilkes Subglacial Basin "ice plug" in the next few centuries were to endanger the East Antarctic Ice Sheet,<sup>266</sup> it would take up to this long to melt completely.<sup>267</sup> Sea levels would rise 3 to 4 metres. One of the potential long-term effects of global warming,<sup>268</sup> this is separate from the shorter-term threat to the West Antarctic Ice Sheet.<sup>269</sup> If humans were extinct, Earth would be midway through a stable warm period with the next glacial period of the Quaternary glaciation due in 10,000 years,<sup>270</sup> but if humans survived and did impact their planet, the greenhouse gas emissions would disrupt this natural cycle.<sup>271</sup> According to research, the carbon dioxide released from burning fossil fuels could cause the planet to skip glacial periods repeatedly for at least the next 500,000 years.<sup>272</sup>

**5.3 Long-Term Geological and Cosmic Changes (10,000 AD-1 million AD).** After 10000 years, the red supergiant stars Betelgeuse and Antares will likely have exploded as supernovae. For a few months, the explosions should be easily visible on Earth in daylight.<sup>273, 274, 275</sup> As Earth's poles precess, Vega, the fifth-brightest star in the sky, becomes the northern pole star. Although Earth cycles through many different naked-eye northern pole stars, Vega is the brightest.<sup>276</sup> By this point, halfway through Earth's precessional cycle, Earth's axial tilt will be mirrored, causing summer and winter to occur on opposite sides of Earth's orbit. This means that the seasons in the Southern Hemisphere will be less extreme than they are today, as it will face away from the Sun at Earth's perihelion and towards the Sun at aphelion; the seasons in the Northern Hemisphere will be more extreme, as it experiences more pronounced seasonal variation because of a higher percentage of land.<sup>277</sup> The oscillating tilt of Earth's poles will have moved the North African Monsoon far enough north to change the climate of the Sahara back into a tropical one such as it had 5,000–10,000 years ago.<sup>278</sup>

After 25000 years, The northern polar ice cap of Mars could recede as the planet reaches a warming peak of its northern hemisphere during the c. 50,000-year perihelion precession aspect of its Milankovitch cycle.<sup>279, 280</sup> The small red dwarf Ross 248 will pass within 3.024 light-years of Earth, becoming the closest star to the Sun.<sup>281</sup> It will recede after about 8,000 years, making first Alpha Centauri (again) and then Gliese 445 the nearest stars.<sup>282</sup> After 50000 years, according to more recent studies in 2016, anthropogenic climate change, if left unchecked, may delay this otherwise expected glacial period by as much as an additional 50,000 years, potentially skipping it entirely.<sup>283</sup> Niagara Falls will have eroded the remaining 32 km to Lake Erie and will therefore cease to exist.<sup>284</sup> The many glacial lakes of the Canadian Shield will have been erased by post-glacial rebound and erosion.<sup>285</sup> Due to lunar tides decelerating the Earth's rotation, a day on Earth is expected to be one SI second longer than it is today. To compensate, either a leap second will have to be added to the end of every day, or the length of the day will have to be officially lengthened by one SI second.<sup>286</sup> It is possible that the current cooling trend might be interrupted by an interstadial phase (a warmer period), with the next glacial maximum of the Quaternary glaciation reached only in about 100 kyr AP.<sup>287</sup>

After 100000 years, the proper motion of stars across the celestial sphere, which results from their movement through the Milky Way, renders many of the constellations unrecognizable.<sup>288</sup> The red hypergiant star VY Canis Majoris will likely have exploded in a supernova.<sup>289</sup> Native North American earthworms, such as Megascolecidae, will have naturally spread north through the United States Upper Midwest to the Canada–US border, recovering from the Laurentide ice sheet glaciation (38°N to 49°N), assuming a migration rate of 10 metres per year, and that a possible renewed glaciation by this time has not prevented this.<sup>290</sup> Cupid and Belinda, moons of Uranus, will likely have collided.<sup>291</sup> Earth will likely have undergone a supervolcanic eruption large enough to erupt 400 km<sup>3</sup> (96 cubic miles) of magma.<sup>292</sup> As one of the long-term effects of global warming, ten percent of anthropogenic carbon dioxide will still remain in a stabilized atmosphere.<sup>293</sup> According to Berger and Loutre, the next glacial maximum of the Quaternary glaciation is expected to be the most intense, regardless of the effects of anthropogenic global warming.<sup>294, 295</sup> After 500000 years, Earth will likely have been hit by an asteroid of roughly 1 km in diameter, assuming that it is not averted.<sup>296</sup> The rugged terrain of Badlands National Park in South Dakota will have eroded completely.<sup>297</sup> After 600000 years, The estimated time for the third super-eruption of the Toba supervolcano by this date. The first super-eruption occurred around 840,000 years ago, after 1.4 million years of magma input, whereas magma fed the second super-eruption at 75,000 years.<sup>298, 299</sup>

Over the next hundreds of thousands to millions of years, Earth's tectonic plates will continue drifting, gradually assembling a new supercontinent. This process, occurring roughly every 300-500 million years, will cause massive changes in ocean circulation, climate zones, and ecosystems. Erosion continues shaping the surface while volcanic activity persists across tectonic boundaries. The Atlantic Ocean may eventually close due to continental drift, leading to

major landmass collisions and the formation of towering mountain chains. Simultaneously, the Sun will continue to brighten. Though still in its main-sequence phase, its increased radiation will slowly evaporate ocean water, turning much of Earth into a desert landscape over time. In the broader cosmic context, the Milky Way galaxy is on course to merge with the Andromeda galaxy, a process already underway and expected to culminate in billions of years. This merger will dramatically reorganize star systems and initiate new waves of star formation while coalescing the central supermassive black holes into one larger entity. These galactic shifts will cause gravitational disruptions, reshuffling planetary systems.

**5.4 The Far Future of Earth and the Solar System (1 million-10 billion Years).** Over this vast timescale, impacts from asteroids the size of the Chicxulub impactor remains possible and could trigger mass extinctions. However, the most significant change will come from the Sun. In about 5 billion years, the Sun will run out of hydrogen fuel and expand into a red giant, engulfing the inner planets, possibly including Earth. If not consumed, Earth will be scorched and lose its atmosphere, making it completely uninhabitable. Afterward, the Sun will shed its outer layers, forming a beautiful yet short-lived planetary nebula, and leave behind a white dwarf, a dense, cooling stellar remnant. Over billions of years, this white dwarf will lose heat and dim further. Meanwhile, the gas giants and Kuiper Belt objects will freeze, and their orbits may shift as the solar system gradually becomes a cold, inert place. By approximately 10 billion years, the white dwarf will cool into a black dwarf, and the solar system will effectively be silent, frozen, and drifting through the dark expanse of the galaxy.

After one million years, Meteor Crater, a large impact crater in Arizona considered the 'freshest' of its kind, will have worn away.<sup>300</sup> Desdemona and Cressida, moons of Uranus, will likely have collided.<sup>301</sup> The stellar system Eta Carinae will likely have exploded in a supernova.<sup>302</sup> Earth will likely have undergone a super-volcanic eruption large enough to erupt 3,200 km<sup>3</sup> (770 cubic miles) of magma, an event comparable to the Toba super-eruption 75,000 years ago.<sup>303</sup> After two million years, The estimated time for the full recovery of coral reef ecosystems from human-caused ocean acidification if such acidification goes unchecked; the recovery of marine ecosystems after the acidification event that occurred about 65 million years ago took a similar length of time.<sup>304</sup> The Grand Canyon will erode further, deepening slightly, but principally widening into a broad valley surrounding the Colorado River.<sup>305</sup> After three million years, Due to tidal deceleration gradually slowing Earth's rotation, a day on Earth is expected to be one minute longer than it is today. To compensate, either a 'leap minute' will have to be added to the end of every day, or the length of the day will have to be officially lengthened by one SI minute.<sup>306</sup>

After ten million years, The Red Sea will flood the widening East African Rift valley, causing a new ocean basin to divide the continent of Africa. And the African plate into the newly formed Nubian plate and the Somali plate.<sup>307</sup> The Indian plate will advance into Tibet by 180 km. Nepali territory, whose boundaries are defined by the Himalayan peaks and the plains of India, will cease to exist.<sup>308</sup> The estimated time for the full recovery of biodiversity after a potential Holocene extinction, if it were on the scale of the five previous major extinction events.<sup>309</sup> Even without a mass extinction, by this time most current species will have disappeared through the background extinction rate, with many clades gradually evolving into new forms.<sup>310,311</sup> After thirty million years, Earth will likely have been hit by an asteroid of roughly 5 km in diameter, assuming that it is not averted.<sup>312</sup>

After fifty million years, the maximum estimated time before the moon Phobos collides with Mars.<sup>313</sup> According to Christopher Scotese, the movement of the San Andreas Fault will cause the Gulf of California to flood into the California Central Valley. This will form a new inland sea on the West Coast of North America, causing the current locations of Los Angeles and San Francisco in California to merge.<sup>314</sup> The Californian coast will begin to be subducted into the Aleutian Trench.<sup>315</sup> Africa's collision with Eurasia will close the Mediterranean basin and create a mountain range similar to the Himalayas.<sup>316</sup> The Appalachian Mountains peaks will have largely worn away,<sup>317</sup> weathering at 5.7 Bubnoff units, although topography will actually rise as regional valleys deepen at twice this rate.<sup>318</sup> After 100 million years, Earth will likely have been hit by an asteroid comparable in size to the one that triggered the K-Pg extinction 66 million years ago, assuming this is not averted.<sup>319</sup> According to the Pangaea Proxima model created by Christopher R. Scotese, a new subduction zone will open in the Atlantic Ocean, and the Americas will begin to converge back toward Africa. Upper estimate for the lifespan of Saturn's rings in their current state.<sup>320</sup> The Sun's luminosity will have increased by one percent.<sup>321</sup>

After one billion years, 27% of the ocean's mass will have been subducted into the mantle. If this were to continue uninterrupted, it would reach an equilibrium where 65% of present-day surface water would be subducted.<sup>322</sup> By this point, the Sagittarius Dwarf Spheroidal Galaxy will have been completely consumed by the Milky Way.<sup>323</sup> The Sun's luminosity will have increased by 10%, causing Earth's surface temperatures to reach an average of around 320 K (47 °C; 116 °F). The atmosphere will become a "moist greenhouse", resulting in a runaway evaporation of the oceans.<sup>324</sup> This would cause plate tectonics to stop completely, if not already stopped before this time.<sup>325</sup> Pockets of water may still be present at the poles, allowing abodes for simple life.<sup>326</sup> High estimate until all plant life dies out, assuming some form of photosynthesis is possible despite extremely low carbon dioxide levels. If this is possible, rising temperatures will make any animal life unsustainable from this point on.<sup>327,328</sup> After 100 billion years, All the galaxies of the Local Group will coalesce into a single large galaxy and an expanded 'Milkmeda or Milkdromeda'. Again, the last galaxies of the Local Group coalescing will mark the effective completion of its evolution.<sup>329</sup> the universe's expansion causes all galaxies

beyond the former Local Group to disappear beyond the cosmic light horizon, removing them from the observable universe.<sup>330,331</sup>

After one trillion years, A low estimate for the time until star formation ends in galaxies as galaxies are depleted of the gas clouds they need to form stars.<sup>332</sup> The universe's expansion, assuming a constant dark energy density, multiplies the wavelength of the cosmic microwave background by  $10^{29}$ , exceeding the scale of the cosmic light horizon and rendering its evidence of the Big Bang undetectable. However, it may still be possible to determine the expansion of the universe through the study of hypervelocity stars.<sup>333</sup> The estimated time by which the universe will have expanded by a factor of more than  $10^{26}$ , reducing the average particle density to less than one particle per cosmological horizon volume. Beyond this point, particles of unbound intergalactic matter are effectively isolated, and collisions between them cease to affect the future evolution of the universe.<sup>334</sup> The estimated time by which the cosmic background radiation cools to a floor temperature of  $10^{-30}$  K and does not decline further. This residual temperature comes from horizon radiation, which does not decline over time.<sup>335</sup>

**5.5 The Degenerate Era and the Dark Universe (10 trillion- $10^{150}$  years).** After ten trillion years, the estimated time of peak habitability in the universe, unless habitability around low-mass stars is suppressed.<sup>336</sup> After 100 trillion years, A high estimate for the time by which normal star formation ends in galaxies. This marks the transition from the Stelliferous Era to the Degenerate Era; with too little free hydrogen to form new stars, all remaining stars slowly exhaust their fuel and die.<sup>337</sup> By this time, the universe will have expanded by a factor of approximately  $10^{2554}$ .<sup>338</sup> The time by which all stars in the universe will have exhausted their fuel (the longest-lived stars, low-mass red dwarfs, have lifespans of roughly 10–20 trillion years). After this point, the stellar-mass objects remaining are stellar remnants like white dwarfs, neutron stars, black holes; and brown dwarfs. Collisions between brown dwarfs will create new red dwarfs on a marginal level: on average, about 100 stars will shine in what was once "Milkomeda". Collisions between stellar remnants will create occasional supernovae.<sup>339</sup> After one quadrillion years, the estimated time until stellar close encounters detach all planets in star systems (including the Solar System) from their orbits. By this point, the black dwarf that was once the Sun will have cooled to 5 K ( $-268.15$  °C;  $-450.67$  °F).<sup>340</sup>

This era, known as the degenerate era, will begin once all stars have exhausted their fuel. No new stars will form due to the lack of hydrogen gas. All remaining white dwarfs will cool into black dwarfs, and red dwarf stars, currently the most long-lived, will eventually burn out. As time stretches into trillions of years, galaxies will disperse as gravitational interactions fling stars and remnants into intergalactic space. Black holes become the dominant cosmic structures, merging and consuming surrounding matter. Over time, even they begin to evaporate via Hawking radiation, a slow process taking up to  $10^{100}$  years or more. Eventually, the universe will be a sparse, dark place filled with low-energy particles, and cosmic microwave background radiation will fade into undetectability. Particle interactions will become so rare that, in any meaningful sense, time will cease to be relevant. The cosmos will reach a state of maximum entropy, complete thermodynamic equilibrium.

**5.6 Speculative Scenarios Beyond the Heat Death (Post  $10^{150}$  years).** After  $10^{20}$  years, The estimated time until the Earth collides with the black dwarf Sun due to the decay of its orbit via emission of gravitational radiation, if the Earth is not ejected from its orbit by a stellar encounter or engulfed by the Sun during its red giant phase.<sup>341</sup> After  $2 \times 10^{36}$  years, The estimated time for all nucleons in the observable universe to decay, if the hypothesized proton half-life takes its smallest possible value ( $8.2 \times 10^{33}$  years).<sup>342</sup> After  $1.16 \times 10^{67}$  years, The estimated time until a black hole of one solar mass today will have decayed by the emission of Hawking radiation.<sup>343</sup> After  $10^{106}$  to  $2.1 \times 10^{109}$  years, The estimated time until ultra-massive black holes of  $10^{14}$  (100 trillion) solar masses, predicted to form during the gravitational collapse of galaxy superclusters, decay by Hawking radiation.<sup>344</sup> This marks the end of the Black Hole Era. Beyond this time, if protons do decay, the universe enters the Dark Era, in which all physical objects have decayed to subatomic particles, gradually winding down to their final energy state in the heat death of the universe.<sup>345</sup>

In this final stage, speculative physics theories propose that quantum fluctuations may occasionally trigger brief events, such as the creation of new particles or even black holes. However, these events are rare. Some theories, like eternal inflation and Poincaré recurrence, suggest that entire universes could be reborn through quantum tunneling or vacuum decay, potentially restarting cosmic evolution with a new Big Bang. Other possibilities include the spontaneous appearance of Boltzmann brains, self-aware entities that emerge briefly due to random fluctuations. These strange entities highlight the paradoxes of time, entropy, and consciousness in infinite universes. On the smallest scales, quantum foam might remain as a dynamic, flickering background-possibly the last sign of physical activity in an otherwise static universe.

**5.7 The Ultimate Fate of the Universe.** After  $10^{161}$  years, A 2018 estimate of Standard Model lifetime before collapse of a false vacuum; 95% confidence interval is  $10^{65}$  to  $10^{1383}$  years due in part to uncertainty about the top quark's mass.<sup>346</sup> After  $10^{200}$  years, The highest estimate for the time it would take for all nucleons in the observable universe to decay, provided they do not decay via the above process but instead through any one of many different mechanisms allowed in modern particle physics. (as we know that, higher-order baryon non-conservation processes, virtual black holes, sphalerons, etc.) on timescales of  $10^{46}$  to  $10^{200}$  years.<sup>347</sup> After  $10^{1500}$  years, assuming that protons do not decay, the estimated time until all baryonic matter in stellar remnants, planets and planetary-mass objects will have either fused together via muon-catalyzed fusion to form iron-56 or decayed from a higher mass

element into iron-56 to form iron stars.<sup>348</sup> After  $10^{120}$  years, the highest estimate for the time it takes for the universe to reach its final energy state.<sup>349</sup> After  $10^{10^{56}}$  years, Around this vast timeframe, quantum tunnelling in any isolated patch of the universe could generate new inflationary events, resulting in new Big Bangs giving birth to new universes.<sup>350, 351</sup> Ultimately, the universe will reach a state of profound darkness and near-absolute stasis. All stars, galaxies, and structures will have either dissipated or collapsed, and entropy will dominate all processes. The dark era of the universe—possibly extending forever—will be characterized by stillness, silence, and timelessness, interrupted only by fleeting, insignificant quantum events. However, the final answer remains elusive. The intersection of quantum physics and general relativity may hold the keys to new beginnings, or the universe may stay forever inert. In either case, the story ends with awe and humility before a vast, mysterious, and still largely unknowable cosmos. And everything in the universe remains unfolded. It is a major limitation of knowledge, science, and philosophy.

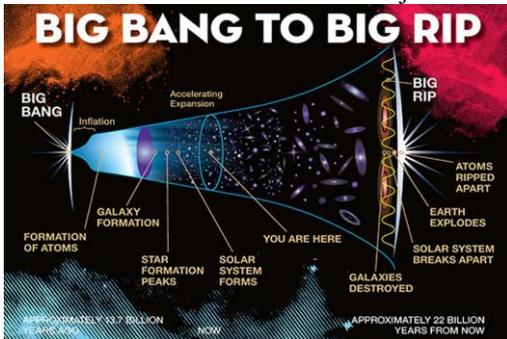


Figure 6: End of everything- Big Bang to Big Rip<sup>352</sup>

## 6. Unsolved and Uncertain Mysteries of the Universe.

Today, we know, cosmic waves or rays are the same. They are high-energy particles coming from outer space. While they are not waving, they exhibit wave-like patterns. Variations in cosmic rays reveal information about the universe's structure. Let's explore a collection of astrophysical and cosmological topics that delve into some of the most intriguing and unconventional frontiers in modern science. These subjects venture beyond the well-charted realms of classical astronomy into areas where theory, observation, and speculation converge. From anomalies in black hole properties and mysterious galactic emissions to hidden dimensions, exotic matter states, and the very nature of time and reality, this discussion explores phenomena that defy standard models.<sup>353</sup> It highlights both puzzling observational data and bold theoretical frameworks, emphasizing the dynamic, evolving nature of our quest to understand the universe at its most fundamental level.

**6.1 The Missing Baryon: Problem and the Cosmic Web.** A major unsolved issue in cosmology is the Missing Baryon Problem, where about half of the expected ordinary matter (baryons) in the universe remains undetected. Theoretical predictions and data from the Cosmic Microwave Background (CMB) suggest baryons should make up around 5% of the universe, yet only half of that has been observed.<sup>354</sup> These missing baryons are believed to exist in the cosmic web's warm-hot intergalactic medium (WHIM), a diffuse, filamentary structure composed of gas at temperatures ranging from 100,000 to 10 million Kelvin. This gas emits weak ultraviolet and X-ray signals, making it hard to detect directly. Modern methods, such as absorption line studies using quasar light, fast radio burst (FRB) analyses, and X-ray detections of ionized oxygen by telescopes like Chandra and XMM-Newton, have provided supporting evidence. Future observatories, such as Athena and the Square Kilometer Array, will likely enhance our understanding of these hidden baryons and their roles in cosmic evolution. Therefore, there is a connection between dark matter and dark energy.<sup>355</sup> The largest "missing variants" make up 95% of the cosmos visible. So, when we talk about it & making sense of it, but even so, we are really talking about the unseen ingredients of the parts we don't see, but make up most of the universe—the universe of the universe—to behave the way it does! For energy.

**6.2 Cosmic Ray Conundrums: Ultra-High-Energy Particles.** Another intriguing phenomenon involves Ultra-High-Energy Cosmic Rays (UHECRs), which have energies far exceeding what human-made accelerators can reach. Their exact origins and acceleration mechanisms remain unknown. Because of interactions with the CMB (Greisen-Zatsepin-Kuzmin or GZK cutoff), such high-energy particles should lose energy over long distances. Since UHECRs are charged, magnetic fields bend their paths, making it difficult to determine their sources. Possible sources include active galactic nuclei, gamma-ray bursts, or even the decay of ancient supermassive particles. Ground-based observatories like the Pierre Auger Observatory and the Telescope Array detect these particles via extensive air showers, while upcoming missions like POEMMA aim to improve source tracking. Studying UHECRs could provide new insights into high-energy astrophysics, quantum gravity, and dark matter.

**6.3 The Hubble Tension: Discrepant Cosmic Expansion Rates.** The Hubble Tension highlights inconsistencies in the measured expansion rate of the universe. Local methods using standard candles like Type Ia supernovae give a higher Hubble constant ( $\sim 73$  km/s/Mpc), while early-universe measurements from the CMB suggest a lower value ( $\sim 67.4$  km/s/Mpc). This mismatch cannot be easily explained by errors, implying potential new physics or revisions to the standard cosmological model.<sup>356</sup> Proposed explanations include evolving dark energy, extra relativistic particles, or

altered gravitational laws. New approaches using cosmic chronometers, gravitational wave "standard sirens," and baryon acoustic oscillations aim to clarify the true expansion rate and improve our understanding of cosmic evolution.

**6.4 Intergalactic Shadows: Unseen Structures of the Cosmic Web.** The Cosmic Web not only consists of visible galaxies but also vast, faint regions of gas and dark matter forming filaments and voids. These intergalactic regions are hard to observe directly, but methods such as studying the Lyman-alpha Forest in quasar spectra and gravitational lensing help reveal their presence. These "intergalactic shadows" may hold clues about galaxy formation and the behavior of dark energy in low-density environments.<sup>357</sup> Understanding the structure and role of these hidden regions is vital for developing accurate models of the universe's growth.

**6.5 Gravity Unbound: Questioning General Relativity on Cosmic Scales.** Einstein's General Relativity encounters challenges on cosmic scales. Although it performs well within our solar system, phenomena like cosmic acceleration and galaxy rotation curves indicate the need for dark energy and dark matter, neither of which has been directly detected. Alternatives such as Modified Newtonian Dynamics (MOND), theories involving extra dimensions, and entropic gravity suggest modifications to gravity itself.<sup>358</sup> Data from black hole mergers and future missions like LISA could offer new insights, potentially transforming our understanding of gravity and spacetime.

**6.6 Quantum Gravity Frontiers: Unifying Macro and Micro Cosmos.** The search for Quantum Gravity aims to unify General Relativity and Quantum Mechanics into one framework. Candidates include Loop Quantum Gravity, which views spacetime as a network of discrete units, and String Theory, which describes particles as vibrating strings in higher-dimensional space. Other theories suggest that spacetime emerges from quantum information.<sup>359</sup> Despite limited experimental access due to high energy demands, gravitational wave studies and high-energy experiments continue to explore these theoretical frontiers.

**6.7 Spectral Riddles: The Enigma of Diffuse Interstellar Bands (DIBs).** Diffuse Interstellar Bands (DIBs) are mysterious absorption lines in starlight caused by unknown interstellar molecules. Possible candidates include complex organic molecules like PAHs and fullerenes, but no definitive identification has been made. Variations in the bands based on environment complicate the search, which now includes laboratory simulations and machine learning. Solving the DIB puzzle would enhance our understanding of interstellar chemistry and the physics of space.

**6.8 Anomalous Trajectories: The Flyby Anomaly and Orbital Oddities.** The Flyby Anomaly refers to unexplained changes in spacecraft velocity during Earth flybys, first observed in the 1990s. Despite considering tracking errors, atmospheric effects, and gravitational irregularities, no definitive explanation has been found. The pattern appears to depend on the trajectory geometry, leading to speculation about unknown physics. Understanding this anomaly is crucial for accurate spacecraft navigation and could have broader implications for gravitational research theory.

**6.9 The Silent Pioneers: The Quest for Population III Stars.** Population III stars—the universe's first stars—remain hypothetical. Formed from pure hydrogen and helium shortly after the Big Bang, they were likely massive, bright, and short-lived, initiating the production of heavier elements. Although never observed directly, researchers look for their signatures in extremely metal-poor stars and distant galaxies. Some may have collapsed directly into black holes, evading detection. Finding evidence of these stars would help explain early cosmic chemical enrichment and galaxy formation.

**6.10 Stellar Genesis Revisited: Metallicity and the Birth of the First Stars.** Early star formation was greatly affected by metallicity, or the lack of it. In the metal-free early universe, gas clouds cooled inefficiently, leading to the formation of very massive stars—possibly hundreds of times the Sun's mass. These stars emitted intense radiation that ionized hydrogen in their surroundings, marking the epoch of reionization. Over time, metal enrichment from supernovae enabled the formation of more diverse stars. Understanding this process is essential for modeling stellar evolution and the development of cosmic structure.

**6.11 Unconventional Black Holes: Anomalies in Mass, Spin, and Behavior.** Recent observations of black holes, including gravitational wave detections, reveal unexpected properties that challenge classical models. Intermediate-mass black holes (~30 solar masses) detected by LIGO are larger than typical stellar black holes but smaller than supermassive ones, raising questions about their formation channels. Spin measurements show some black holes rotating near theoretical limits, while others have unusually slow or misaligned spins, suggesting complex formation histories involving mergers or chaotic interactions. Additionally, black holes found in the "mass gap" (~50-120 solar masses), where pair-instability supernovae predict no remnants, hint at alternative formation scenarios such as direct collapse or primordial origins. Speculative objects, such as gravastars or fuzzballs, have been proposed as alternatives to black holes but lack definitive evidence. These anomalies continue to refine our understanding of black hole physics and the evolution of the cosmos.

**6.12 Microwave Whispers: Probing Anomalous Emission from the Milky Way.** Observations of the Milky Way's microwave emissions have uncovered anomalous components that defy explanation by standard astrophysical processes. Initially detected by COBE and confirmed by WMAP and Planck satellites, these emissions do not align with classical thermal dust emission or synchrotron radiation. Hypotheses include rapidly spinning tiny dust grains (spinning dust),

interactions between cosmic rays and interstellar dust, or magnetized grains emitting microwaves. Exotic particle processes, such as axion decay potentially related to dark matter, have also been proposed. Despite progress, no current model fully explains the observed features. Missions like NASA's SPHEREx and laboratory studies aim to clarify this emission's origins, which could reshape our understanding of interstellar dust and galactic physics.

**6.13 Magnetic Mysteries: Cosmic Magnetic Fields in Shapin, the Universe.** Cosmic magnetic fields permeate galaxies, galaxy clusters, and the intergalactic medium, affecting charged particles, star formation, and galactic dynamics. The origins of these fields are uncertain, possibly initiated by early-universe plasma fluctuations and later strengthened by galactic dynamos. Observations show that magnetic fields align with features like spiral arms and influence structures such as jets from supermassive black holes. They are studied indirectly through polarization and cosmic ray deflections. Magnetic fields may even interact with dark matter and dark energy, potentially impacting cosmic structure formation and expansion. Despite their importance, their elusive nature makes them one of the most underexplored forces in the field of cosmology.

**6.14 Relativity Extreme: Time Dilation and Cosmic Chronology Challenges.** Einstein's relativity shows that time is a flexible dimension, slowing down under high velocities (special relativity) or intense gravity (general relativity). Experiments confirm time dilation, as evidenced by differences observed in atomic clocks on fast-moving jets or adjustments made for GPS satellites. Near black holes, time dilation becomes significantly pronounced, causing falling objects to appear "frozen" from a distance. On cosmic scales, redshifted galaxies record the passage of time, shaping our understanding of the universe's age and development. Quantum theories propose that time may be emergent rather than fundamental, possibly breaking down near singularities. These insights challenge traditional ideas of past, present, and future, with significant implications for cosmology.

**6.15 Neutrino Enigmas: The Ghostly Messengers of the Cosmos.** Neutrinos are nearly massless, neutral particles produced in stars, supernovae, and the Big Bang. Their weak interaction with matter allows them to travel long distances, carrying unique astrophysical information. Large detectors, such as Ice-Cube at the South Pole, capture rare neutrino events in ice. The 1987A supernova neutrino burst provided key insights into the death of stars. Neutrino oscillations, or flavor changes during travel, require physics beyond the Standard Model. Detecting the cosmic neutrino background could uncover secrets of the early universe, helping to reveal fundamental forces and astrophysical phenomena.

**6.16 Gamma Ray Surprises: Unexplained Emissions from the Galactic Center.** The Fermi Gamma-ray Space Telescope has detected an excess of gamma radiation from the center of the Milky Way, exceeding what is expected from known sources, such as the central black hole. The diffuse emission pattern suggests an extended origin. Possible sources include dark matter annihilation, cosmic ray interactions with gas, or unknown astrophysical objects such as micro-quasars. None of these fully explains the signal. Investigating these emissions could lead to breakthroughs in particle physics, galactic structure, and the indirect detection of dark matter.

**6.17 Rethinking Inflation: Alternative Scenarios for the Universe's Birth.** Inflation theory suggests a rapid expansion of the universe right after the Big Bang, which helps explain puzzles like flatness and homogeneity. However, the inflation field responsible for this expansion is hypothetical and has not been detected. Alternatives include ideas like cyclic universes, eternal pre-Big Bang states (emergent universes), or quantum fluctuations that create universes within a multiverse. Some models propose that inflation varies in different regions. Testing these theories requires precise cosmological observations, and a successful theory could change our understanding of how the universe was born.

**6.18 Cosmic Strings and Topological Defects: Traces from the Early Universe.** Topological defects such as cosmic strings may be remnants from symmetry-breaking phase transitions in the early universe, similar to cracks in cooling crystals. Cosmic strings, if they exist, would be thin but extremely dense, causing unique gravitational lensing effects. Other defects include domain walls and magnetic monopoles, although none have been definitively observed. While inflation remains the leading theory for structure formation, ongoing efforts aim to detect such relics through gravitational waves, gamma rays, or CMB anomalies. Discovering them would shed light on the physics of the early universe.

**6.19 Baryogenesis and Beyond: The Puzzle of Matter-Antimatter Imbalance.** The dominance of matter in the universe contradicts the expectation that matter and antimatter were produced in equal amounts. This imbalance likely results from baryogenesis processes that involve CP violation, baryon number violation, and nonequilibrium conditions. The CP violation seen in the Standard Model is not enough, leading to theories like electroweak baryogenesis, lepton genesis, and other new physics. Experiments at particle colliders and astrophysical research aim to uncover the fundamental cause, which remains one of the most challenging questions in cosmology.

**6.20 Ghostly Galaxies: The Enigma of Ultra-Diffuse Structures.** Ultra-diffuse galaxies (UDGs) are puzzling objects as large as the Milky Way but with very few stars. Some appear nearly devoid of dark matter, while others seem dominated by it. Found in clusters and isolated areas, their formation may involve tidal stripping, inefficient star formation, or remnants of ancient starbursts. Their diversity challenges traditional theories of galaxy formation and highlights gaps in our understanding of baryonic and dark matter interactions.

**6.21 Challenging Constants: Are Nature's Numbers Truly Universal.** Physical constants such as the speed of light, the gravitational constant, and the fine-structure constant form the foundation of the laws of nature. Some research investigates whether these constants might change over time or across space, which would significantly shift our understanding of physics. Observations of quasars and atomic clock experiments are used to test for such variations. Although no definitive changes have been found, the potential implications are considerable. Theoretical models like string theory propose that these constants could arise from more fundamental geometric properties of space or additional dimensions.

**6.22 Phantom Dimensions: Unveiling Hidden Realms Beyond Perception.** Theories like string theory suggest there are more spatial dimensions beyond the three we see. These extra dimensions are probably compactified and hard to detect with current technology but could explain why gravity is so weak if it "leaks" into them. Brane cosmology suggests our universe is a 3D surface within a higher-dimensional space. These concepts might help us understand dark matter, dark energy, and the multiverse. Experiments at particle colliders and astrophysical observations are trying to test these ideas, but clear evidence still hasn't been found.

**6.23 Time's Labyrinth: Temporal Anomalies and the Possibility of Cosmic Time Travel.** Relativity confirms time dilation, but more speculative models allow for closed time-like curves through spacetime that enable backward time travel. Theoretical structures, such as wormholes or cosmic strings, might permit such loops if negative-energy matter exists. However, paradoxes like the grandfather paradox make these ideas controversial. The question is paradoxical, and debates about causality also fuel controversy. While future-directed time travel aligns with current physics, reverse time travel remains speculative but conceptually interesting. In time travel logic, if a grandson presents his grandfather to meet his grandmother, then he/you will never be born, as his/your father was never born. However, if the grandson never travels back because he does not exist, then the conversation remains incomplete.

**6.24 Artificial Gravity: Speculative Technologies for Navigating Cosmic Frontiers.** Long-duration space missions require artificial gravity to counteract the adverse effects of microgravity. The most feasible method is spacecraft rotation to simulate gravity via centrifugal force. Other speculative approaches include electromagnetic manipulation or exotic matter-based gravity control. While these remain theoretical, rotating habitats are being considered in current mission planning, offering practical steps toward sustained human exploration in space.

**6.25 The Simulation Hypothesis: Are We Living in a Cosmic Construct.** The simulation hypothesis proposes that our reality might be a highly realistic simulation created by an advanced civilization. If such simulations are common, we might statistically be one of them. Quantum mechanics anomalies and precisely tuned constants are seen as possible clues. Some suggest experiments to find signs of computational limits in the universe. However, critics argue that such simulations could be impossible and that the hypothesis might be impossible to test. Still, it raises important questions about the nature of reality and the nature of consciousness.

**6.26 Exotic States of Matter: Beyond the Known Frontier.** Beyond solids, liquids, gases, and plasma, extreme conditions reveal exotic matter states. Bose-Einstein condensates form when atoms behave as a single quantum entity at near-zero temperatures. Quark-gluon plasma replicates the early universe's hot, dense state. Neutron stars might contain strange matter. Hypothetical forms include super solids, time crystals, Planck stars, and matter with negative mass. These states challenge known physics and offer novel insights and technologies, driving both experimental and theoretical research. Some cosmologists suggest that our universe might be part of a multiverse. If so, the future of our universe could be an ending, but universes may continue endlessly. In quantum cosmology, some properties break the rules of space. transformations never.



Figure 7: Many ways universe may destroy<sup>360</sup>

## 7. Distant Future of Consciousness in the Universe

For billions of years, Earth's life may be evolved without the capacity for self-destruction. However, with nuclear weapons, man-made pandemics, and climate change, humanity has acquired technologies that could potentially wipe out civilization. Humans are still a relatively young species, having existed for only a few hundred thousand years. Civilizations tend to collapse before reaching full technological maturity, making this period potentially the most dangerous point of failure. For humanity, Earth remains the only planet we inhabit, and all our achievements and future prospects are confined to this small, vulnerable biosphere. The term 'the Precipice' is often used in philosophy, cosmology, and extraterrestrial studies particularly by Toby Ord—to describe humanity's current position in cosmic history, standing on the edge between destruction and unprecedented opportunity. Let's discuss Ike's vision of humanity's potential future, from our current existential vulnerabilities to the farthest reaches of cosmic evolution. It begins with the idea of 'the Precipice,' a moment when humanity faces both catastrophic risks and unprecedented opportunities for advancement. It explores Earth's long-term habitability, the necessity of interstellar migration, and the feasibility of colonizing the Milky Way. It considers the implications of discovering extraterrestrial life and proposes that advanced civilizations may exist beyond our detection capabilities. The narrative moves into deep time, examining the fate of galaxies, the role of life in shaping the universe, and the philosophical idea that consciousness may be central to cosmic purpose. It concludes with reflections on transhumanism, the future of consciousness, and ethical frameworks based on unity and compassion, emphasizing that the survival and flourishing of sentient life depends critically on the choices made in our current era.

**7.1 Cosmic Reach.** Toby Ord characterizes the current era as 'the Precipice,' a unique historical moment marked by humanity's unprecedented capacity for self-annihilation alongside tremendous potential for cosmic scale survival and expansion. This patch is defined by existential risks-nuclear war, climate change, unaligned AI, and mass extinction-but despite these threats, the likelihood of overcoming them remains real. Crucially, humanity's potential can be bifurcated into its physical potential as space exploration and settlement and its mental potential as the development of consciousness and cognition. Scientifically, Earth is projected to remain habitable for 500 million to 1 billion more years, despite natural cataclysms such as super-volcanic eruptions or asteroid impacts, which, although devastating, are unlikely to permanently terminate complex life on Earth. Eventually, our star, the Sun, will become the primary existential threat. As it ages and brightens, it will render Earth inhospitable by evaporating water and destabilizing life-sustaining conditions. However, advanced civilizations may mitigate or delay this through technological interventions, such as blocking a portion of solar radiation using space-based solar collectors or harnessing solar energy on a large scale, possibly extending Earth's habitability for another billion years or more.

Ultimately, Earth will be uninhabitable when the Sun reaches the red giant phase, expanding beyond Earth's orbit before finally dying. Humanity's survival as it currently depends on migration to other star systems, with Alpha Centauri being the nearest stellar neighbor at roughly four light-years, making it a prime candidate. The discovery of Proxima B, an Earth-sized rocky planet within Proxima Centauri's habitable zone, offers a tangible target for future interstellar migration. While interstellar travel remains a formidable technical challenge, no known physics impedes its feasibility across the necessary time scales (millions of years, or even multiple attempts). If humanity achieves such interstellar travel, it could spread life and civilization across multiple star systems, drastically reducing vulnerability to local natural disasters, such as disasters or cosmic events. Within our local stellar neighborhood of roughly 15 million stars, with an average interstellar distance of about six light-years, colonization of the entire Milky Way becomes conceivable. Traveling at one percent of the speed of light and allowing adequate time for settlement, the whole galaxy could be colonized in 100 million years a short cosmic interval relative to Earth's geological lifespan. The Milky Way's stars and future star "generations provide a nearly inexhaustible source of energy and opportunity, emphasizing the cosmic significance of humanity's current moment as the dawn of history and knowledge on a cosmic scale.

**7.2 Life Beyond Earth.** The discovery of extraterrestrial life would profoundly impact humanity's understanding of its place in the cosmos. Even a single confirmed instance of extraterrestrial life implies that life is widespread, given the vast age of the universe over 14 billion years and its rich supply of life-essential elements. The Fermi Paradox, the apparent contradiction between the high likelihood of Extraterrestrial civilizations and the lack of detectable evidence, highlights the mystery of our seemingly solitary existence. One explanation for this paradox is that our observational efforts have been minimal, with only around 1000-star systems examined, akin to sampling a single glass of water from the entire ocean. Another possibility is that advanced civilizations have evolved beyond detectable physical forms or electromagnetic signatures. As physicist Michio Kaku posits, future intelligence might encode consciousness as pure information conveyed via light 'laser porting' that can be transmitted over vast distances and instantiated in remote avatars. Such information-based cognition would evade traditional detection methods, potentially explaining the universe's apparent silence. This hypothesis further suggests a cosmic convergence point where life evolves into beings of pure, transmitted light, avoiding the risks inherent in sending biological entities through space. While any contact or communication with alien intelligences should be treated cautiously, speculation points to potentially shared cosmic values like intelligence, benevolence, and compassion among advanced civilizations. Humanity's destiny may be entwined with this trajectory toward higher forms of consciousness and connectivity.

**7.3 Deep Time.** Expanding beyond the Milky Way, our Local Group of galaxies includes about 50 galaxies, among which Andromeda is the nearest and largest. Although intergalactic travel is astronomically more challenging than interstellar travel, it cannot be ruled out, given humanity's historical precedents of overcoming seemingly impossible

challenges. Moreover, cosmic evolution itself may facilitate eventual contact: gravity is causing the Milky Way and Andromeda to collide in approximately 4 billion years. This galactic merger will not destroy individual star systems. Still, it will create a larger, more massive galaxy, eventually culminating in a single enormous galaxy formed from the coalescence of the Local group over hundreds of billions of years. However, cosmic acceleration, driven by dark energy, predicts that galaxies beyond the Local Group will eventually recede beyond observable horizons, isolating galaxy systems in cosmic loneliness. This cosmological isolation implies a future of galactic solitude, unless alternative cosmological models provide a more accurate description of the ultimate cosmic fate (e.g., eventual collapse or cyclical universes). From the vantage point of deep time, life and consciousness may come to play an active role in shaping the universe's destiny, potentially guiding or transforming cosmic evolution itself. Thinkers like Freeman Dyson and David Deutsch hypothesize that life might eventually control matter and energy, and will acquire all knowledge and potentially giving rise to a universal consciousness. Paul Davies expands on this idea, imagining a universal superintelligence that combines mind and cosmos, suggesting that life and consciousness are fundamental to the universe's core nature. This philosophical view indicates that humanity's current moment could be an early phase in a universe that is eventually realizing its own mental potential through conscious life.

**7.4 More Than Human.** Humanity's evolutionary trajectory inevitably intersects with emerging technologies capable of profoundly transforming our physical bodies and mental faculties—a movement collectively known as transhumanism. Despite resistance stemming from fears of losing human essence or values, it appears likely that future generations will employ technologies to enhance intelligence, memory, compassion, concentration, and imagination. Toby Ord highlights that such enhancements promise the creation of entirely new cultural forms, integrating emotion and cognition in unprecedented ways, thus opening vast new realms of human experience. David Pearce envisages that advanced consciousness could transcend suffering entirely by redesigning mental architectures to sustain gradients of bliss, replacing pain with refined states of well-being and mental richness. This raises critical ethical and philosophical questions/Should humanity transcend its evolutionary limitations or preserve traditional human nature? Consciousness, identified as the vessel of all value, far exceeds what present humans experience. The immense "possibility-space" of conscious states represents a vast frontier, analogous in scale and richness to the universe itself, awaiting exploration by future minds.

**7.5 The Universal Self.** Philosophical discourse increasingly questions traditional notions of individual identity, suggesting that the self is an illusion and that consciousness itself is the accurate continuity among experiences. This view, termed Open Individualism, posits that consciousness alone is the fundamental bearer of identity through time, irrespective of physical substrate or evolutionary changes. Maintaining consciousness across transformative stages/biological or artificial, is essential to preserving actual value and identity. Advanced civilizations, as they pursue the evolution and protection of consciousness, may converge on universal ethical principles that transcend human cultural particularities. Such universals likely emphasize creativity, cooperation, compassion, and knowledge. Suppose consciousness is the essential metric for moral concern. In that case, advanced beings may regard others as extensions of themselves, fostering a cosmic fraternity of minds that shares common values and goals. This ethical convergence offers hope that the historical consequences of tribalism, including conflict, hatred, and exploitation, will give way to cooperation and peace as humanity and other intelligent species expand into space. David Pearce further argues that advanced civilizations may undertake cosmic missions to alleviate suffering across the universe, carefully seeding life on new worlds in compassionate, non-Darwinian ways that minimize predation and suffering. This implies future biospheres may be profoundly different in character from Earth's.

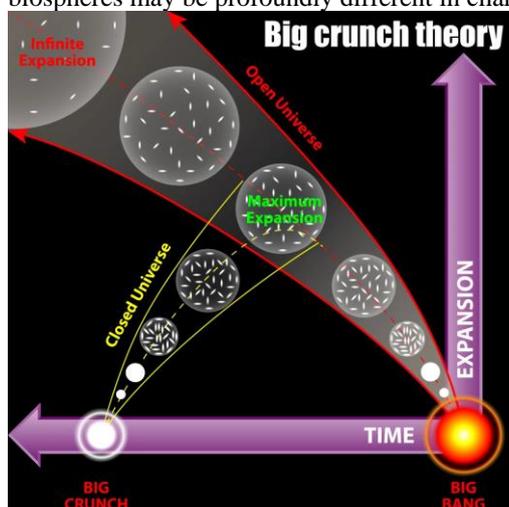


Figure 8: Diagram comparing the possible trajectories of the universe's expansion, towards either a Big Freeze/Rip model (red) or a Big Crunch (yellow) model<sup>361</sup>

## 8. Conclusion

Today, humanity stands at a crucial crossroads as our historical moment is extraordinarily significant cosmically. With tens of thousands of preceding generations behind us and potentially hundreds of millions to come, the decisions and actions of current generations carry disproportionate weight. We inhabit a time of actual cosmic vulnerability and opportunity, known as 'the Precipice,' when the survival and flourishing of consciousness is not just human life. It could be secured for the unfathomably long future. As we stand at 'the Precipice,' a rare and consequential moment in time, our choices carry extraordinary weight. The trajectory of our species may lead to extinction or to a flourishing civilization that spans stars, explores new realms of consciousness, and embodies universal ethical principles rooted in shared sentience. The future may bring about the colonization of galaxies, the emergence of transhuman minds, and the creation of compassionate biospheres. At its core, the preservation and elevation of consciousness emerge as the guiding thread that connects all meaningful futures. Whether we embrace this role with wisdom and foresight will determine not only the destiny of humanity but also the unfolding story of life and intelligence across the cosmos.

Now the core question is, does the future already exist? Interestingly, it remains unresolved and largely depends on which interpretation of quantum mechanics one accepts. If one adopts the Copenhagen view, the future remains fundamentally indeterminate, shaped only upon observation. If one prefers Many-Worlds, the future is predetermined in a vast multiverse, though each observer experiences a branching, uncertain path. Reconciling the flow of time and the direction of time-why we remember the past but not the future-continues to be an open challenge in physics. This discussion may end by emphasizing the importance of integrating physical theory with philosophical insights and the subjective realities of consciousness to better understand time, determinism, and the structure of reality. So, our thinking should be based on philosophy and physics together for a better understanding of philosophy. Actually, time is a part of spacetime. It is a coordinate that mixes with space under motion. There is no absolute universal 'Now.' Different observers slice spacetime differently. In quantum mechanics, time is usually a parameter, not an operator, in the Schrödinger equation; quantum evolution is unitary and reversible until measurement. In philosophy, time is often explained as 'Only the present exists.'

If we consider the universe is flat, then there must be an additional component, which making up 73% of the energy density of the universe in addition to the 23% dark matter and 4% baryons. And which is known as dark energy. In order not to interfere with Big Bang nucleosynthesis and the cosmic microwave background, it must not cluster in haloes like baryons and dark matter. There is strong observational indication for dark energy, as the total energy density of the universe is known through constraints on the flatness of the universe. However, the amount of clustering matter is tightly measured, and is much less than this. The case for dark energy was strengthened in 1999, and measurements demonstrated that the expansion of the universe has begun to gradually accelerate.<sup>362</sup> Apart from its density and its clustering properties, nothing is known about dark energy. Quantum field theory predicts a cosmological constant (CC) and that is similar to dark energy, but 120 orders of magnitude larger than that observed.<sup>363</sup> Steven Weinberg and a number of string theorists have appealed the 'weak anthropic principle.'<sup>364</sup> Here, the reason that physicists observe a universe with such a small cosmological constant is that 'no physicists or life could exist in a universe with a larger cosmological constant.'<sup>365</sup> However, many cosmologists find this an unsettled explanation, as the weak anthropic principle is self-evident- it does not attempt to explain the context of that universe. As we know that where living observers exist, there must be at least one universe with a cosmological constant (CC) which allows for life to exist.<sup>366</sup> A better understanding of dark energy is likely to solve the problem of the ultimate fate of the universe. Again, in the current cosmological epoch, the accelerated expansion due to dark energy is avoiding structures larger than superclusters from forming. It is not known whether the acceleration will continue forever, perhaps even increasing until a Big Rip, or whether it will eventually reverse, lead to a Big Freeze, or may follow something else.<sup>367</sup>

Still today physics has no satisfactory answer, whether primordial black holes were formed in our universe, and what happened to them.<sup>368</sup> So, cosmologists need to perceive cosmic rays with energies above the GZK cutoff, and whether it signals a failure of special relativity at high energies.<sup>369</sup> Again, the Greisen-Zatsepin-Kuzmin (GZK) limit or cutoff is a theoretical upper limit on the energy of cosmic ray protons traveling from other galaxies through the intergalactic medium to our galaxy. They need to find out the equivalence principle,<sup>370</sup> whether or not Einstein's general theory of relativity is the accurate theory of gravitation,<sup>371</sup> and if the fundamental laws of physics are the same everywhere in the universe.<sup>372</sup> Additionally, cosmologists need to clear the explanation of Biophysical cosmology and which is a type of physical cosmology that studies and understands life as part as well as an inherent part of physical cosmology. It stresses that life is inherent to the universe and therefore frequent.<sup>373, 374</sup> Several possible futures have been predicted by different scientific hypotheses, including that the universe might have existed for a finite or infinite duration, or towards explaining the manner and circumstances of its beginning.<sup>375</sup> The fate of the universe may be determined by its density. The preponderance of evidence to date, based on measurements of the rate of expansion and the mass density, favors a universe that will continue to expand indefinitely, resulting in the Big Freeze scenario below.<sup>376</sup> So, the observations are not conclusive, and alternative models are still possible. Choosing among these challenging scenarios is done by 'weighing' the universe, for example, measuring the relative contributions of matter, radiation, dark matter, and dark energy to the critical density. More precisely, contending scenarios are evaluated against data on galaxy clustering and distant supernovas, and on the anisotropies in the cosmic microwave background.<sup>377</sup>

The thinking of physicists should be based on philosophy and physics together for a better understanding of philosophy. Actually, time is a part of spacetime. It is a coordinate that mixes with space under motion. There is no absolute universal "Now." Different observers slice spacetime differently. In quantum mechanics, time is usually a parameter, not an operator, in the Schrödinger equation; quantum evolution is unitary and reversible until measurement. In philosophy, time is often explained as 'only the present exists.' However, past, present, and future all equally exist as a 4-D block in the Block Universe or Eternalism. However, the 4D Block Universe, or Eternalism, is a concept in physics and philosophy where time is treated as a fourth dimension alongside space, forming a static, unchanging 4D "block" where all past, present, and future moments exist simultaneously and equally, challenging our perception of a flowing "now" and suggesting reality is a fixed whole, like a film reel existing all at once, rather than a frame-by-frame progression. According to Einstein's equations in relativity, reality is a 4D manifold with geometry determined by mass and energy. Again, if the block universe is true and everything is 'already there,' does that eliminate free will? Philosophers distinguish between determinism (or the idea that the future exists) and epistemic or practical freedom, as we can still act knowingly within constraints. Some thinkers have suggested that reality is a processing of information; physical laws act as constraints on the flow of information. So, the structure of reality may be spacetime plus layers of fields, where the information or causal structure gives rise to spacetime. Interpretations vary, including presentism, many-worlds, collapse, emergent gravity, and fundamental geometry. So, the universe and its happenings remain mysterious, like the block universe.

Some interpretations of quantum mechanics, like Many-Worlds theory posits that it is only apparent randomness, and the world as a whole is deterministic. Some others, like the Copenhagen Interpretation, hold that it is true randomness. Again, the standard quantum theory considers the deterministic evolution of the quantum state. It is only the process of measurement that introduces indeterminism. Until the measurement problem is resolved, this measurement-induced indeterminism cannot be used to prove fundamental indeterminism. After all, the principle of determinism is otherwise known as the principle of causality. There is nothing in the theory that gives rise to an effect without a cause. Regardless of which is the case, quantum randomness becomes insignificant at larger scales, like in biological systems. Physicist, enlightenment thinkers and scientist believed the universe's ultimate truths could be discovered through human reason and observation. Although we may not always recognize it, this new world view has had a profound effect not only on science, but on art, literature, philosophy, and societal relations. Choosing among these rival scenarios as describe in this paper is done by 'weighing' the universe, for example, measuring the relative contributions of matter, radiation, dark matter, and dark energy to the critical density. More concretely, challenging scenarios are evaluated against data on galaxy clustering and distant supernovas, and on the anisotropies in the cosmic microwave background. The 21st century now begins with a humble acceptance of uncertainty. From Certainty to Uncertainty traces the rise and fall of the deterministic universe and shows the evolving influences that such disparate disciplines now have on one another. Michio Kaku's latest universe predictions focus on advanced AI, interstellar travel, Brain-Net or mind-internet, quantum computing and which revealing cosmic secrets.<sup>378</sup> He foresees potential universe endings like the Big Crunch, and that emphasizing that future technology could solve big problems, and enable human expansion like Mars colonization, and even allow direct experience sharing via brain interfaces, though climate change remains an immediate threat.

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