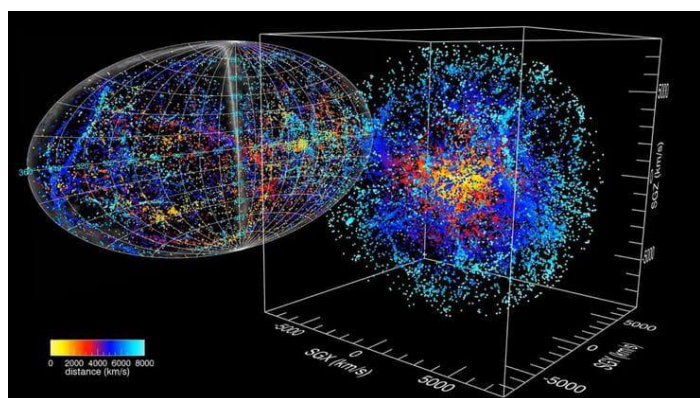


## Cosmic Microwave Background Radiation (CMB), the Observable and Non-Observable Universes, and Their Respective Distances

Soumendra Nath Thakur\* Deep Bhattacharjee<sup>1</sup> Priyanka Samal<sup>2</sup>  
Onwuka Frederick<sup>3</sup>

Guided by the monumental Big Bang theory, this research paper embarks on a captivating exploration of cosmic vistas, delving into the enigmatic origins of the universe, the enigmatic cosmic microwave background radiation (CMBR), and the intricate interplay between observable and non-observable universes. Intricately woven into this cosmic fabric are the pioneering observations of the Cosmic Background Explorer (COBE), the Wilkinson Microwave Anisotropy Probe (WMAP), and the Planck satellite. These scientific sentinels have charted the CMBR's temperature fluctuations, offering windows into the universe's earliest epochs. COBE's revelation of temperature variations in 1992 solidified the Big Bang theory. WMAP, launched in 2001, delved deeper, unraveling the CMBR's anisotropies and refining cosmic parameter measurements. The Planck satellite, soaring into space in 2009, etched precision onto the cosmic canvas, encapsulating the universe's age, composition, and evolutionary trajectory.

This narrative unfolds the epic tale of emergence from a minuscule singularity and the subsequent grand cosmic inflation. At the heart of this cosmic odyssey lies the CMBR, a whispered echo from the universe's primordial dawn that unfolds the saga of its early epochs and the daring journey of the first light. The tapestry of time itself is probed, unveiling the temporal intricacies of these realms shaped by phenomena like redshift and the relentless cosmic expansion. Across a 13.8-billion-year narrative, our observational prowess extends to reveal galaxies within a 46.5 billion light-year radius—43% visible, 57% veiled. Anchored by elegant mathematical frameworks like Hubble's Law, this journey through cosmic mechanics nurtures the growth of understanding and discovery. An expedition both poetic and scientific, this paper unearths the blueprint of the universe, resonating with themes of curiosity and evolution that span unfathomable eons.



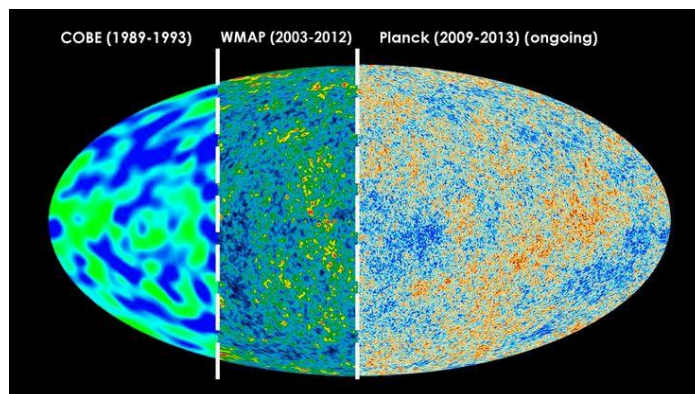
**Figure 1.** A 3D map of the observable universe. Credit [1]

**Introduction:** The journey into cosmic history begins with a cataclysmic event that set the stage for the universe's grand narrative—the Big Bang, an explosion of cosmic proportions that ignited the universe's inexorable expansion. Central to this cosmic saga is the cosmic microwave background radiation (CMBR), an ethereal echo resonating from the universe's very inception, offering glimpses into its nascent stages. This paper embarks on an exploration of profound cosmic concepts, unraveling the intricate relationships between the observable and non-observable universes, all guided by the monumental framework of the Big Bang theory [2].

At the heart of our cosmic inquiry lies the enigmatic CMBR, an echo from the universe's dawn that preserves the footprints of its early luminous journey. This cosmic radiation, though nearly imperceptible to our telescopes, serves as a time capsule, granting us a unique window into the universe's formative moments—a whispered secret of the first light's audacious voyage. A pivotal juncture in this narrative occurs 380,000 years post-Big Bang, where the seeds of galaxies and stars were sown, imprinting their stories onto the intricate tapestry of the CMB [2] [3] [4].

However, our journey doesn't end with mere observation; it dives deep into the temporal dimensions of the observable and non-observable universes, intricately woven with dynamics and boundaries. Over 13.8 billion years, the celestial orchestra of galaxies, each emitting light like cosmic beacons, has gradually distanced itself, etching the narrative of redshift and the universe's relentless expansion. Yet, our cosmic voyage is curtailed by a horizon, an

observational limit situated 46.5 billion light-years away. Beyond this cosmic frontier lies a realm where 57% of galaxies remain unseen, beyond our reach, while 43% reside within our perceptible realm, a reminder of the vastness that eludes us.



**Figure 2.** CMBR according to COBE, WMAP and Planck. Credit [5]

Immersed in rigorous mathematics, this paper unveils the cosmic mechanics underpinning our explorations. Hubble's Law, the redshift-distance relation, and the enigmatic future visibility limit stand as foundational pillars in our quest for cosmic understanding. These equations intertwine seamlessly with our narrative, unraveling the grand tapestry of the universe—from its infinitesimal inception to the expansive horizon that tantalizingly stretches beyond our current grasp.

This paper extends an invitation—an invitation to journey alongside us in discovery and exploration, as we don the lenses of analysis to demystify the enigma of cosmic origins and traverse the infinite expanse that beckons us. A testament to the remarkable evolution of our universe, this cosmic symphony, composed over unfathomable eons, resounds with themes of curiosity, comprehension, and the timeless pursuit of knowledge.

Amidst our exploration, the research delves into satellites that have played a pivotal role in unravelling the mysteries of the CMBR. These cosmic sentinels, including the Cosmic Background Explorer (COBE), the Wilkinson Microwave Anisotropy Probe (WMAP), and the Planck satellite, have collectively revolutionized our comprehension of the early universe and the primordial CMBR. Their observations have charted the fluctuations in temperature, offering glimpses into the universe's formative epochs. COBE's revelation of temperature variations in 1992 substantiated the foundations of the Big Bang theory. Subsequently, WMAP's launch in 2001 propelled us deeper, unraveling the intricate anisotropies of the CMBR and refining our understanding of cosmic parameters. The Planck satellite, venturing into space in 2009, etched precision onto the cosmic canvas, encapsulating crucial insights into the universe's age, composition, and evolutionary path.

Among the insights derived from these satellites are specific features and anomalies observed within the CMBR maps. Intriguing patterns like concentric circles, the enigmatic "Axis of Evil," and the cold points of the quadrupole and octupole have emerged, challenging our understanding, and driving deeper inquiries into the cosmic fabric.

As we embark on this odyssey, we encounter key astronomical measurements and their implications. The co-moving distance of the observable Universe, quantified as 14.26 gigaparsecs, translates to a staggering 46.5 billion light-years or approximately  $4.40 \times 10^{26}$  meters. The universe's boundaries extend beyond what we observe—revealing a non-observable realm stretching over 11,625 billion light-years. Within the confines of our observational scope, we are privy to a mere 43% of galaxies, while the rest, a concealed 57%, lie tantalizingly beyond our reach. This balance will shift as time unfolds, eventually revealing an additional 57% of galaxies to our gaze, allowing us to weave a more comprehensive cosmic narrative [6] [7] [8] [9].

\*<sup>123</sup>Declaration: The authors declare no competing interests.

\*Corresponding author: Tagore's Electronic Lab, India.  
E-mail: postmasterenator@gmail.com

Leveraging the precision of mathematics, our exploration reveals the cosmic mechanics that underpin our observations. Hubble's Law, a cornerstone of cosmology, elegantly relates the velocity of distant galaxies to their distance from us. The co-moving distance, encapsulating the expansion of the universe, is meticulously calculated using equations that incorporate redshift and the Hubble parameter. The redshift-distance relation deciphers an object's distance through its spectral shift. The distant future, too, holds a threshold—beyond which cosmic objects recede faster than light, rendering them forever invisible—an enigmatic frontier expressed through the future visibility limit equation. Our mathematical voyage also unveils the extension of the non-observable universe, a cosmic expanse expanding beyond our visual horizon [10].

Guided by the enigmatic principles of cosmological physics and fortified by these mathematical tools, we navigate the labyrinthine corridors of the universe. The journey of discovery is both poetic and scientific—a symphony of exploration that resonates with themes of curiosity and evolution, echoing through unfathomable epochs. The grandeur of cosmic history, as we perceive it, invites us to partake in a perpetual pursuit of knowledge, an endeavor that transcends time and enriches our understanding of the cosmic tapestry.

As our exploration unfolds, this paper beckons readers to join us on a cosmic expedition, a journey of revelation and insight. Together, we unravel the primordial secrets of the universe's birth, delve into the profound mysteries of the cosmic microwave background radiation, and traverse the intricate landscapes of observable and non-observable realms. In the eloquent embrace of the Big Bang theory, we find the genesis of a cosmic symphony that orchestrates the dance of galaxies and the whispers of light across the fabric of space-time. Our voyage is illuminated by the light of knowledge, guided by mathematical frameworks, and nurtured by the relentless pursuit of understanding. Let us embark, then, on this odyssey of discovery, as we peer into the vast cosmic expanse and chart the course of evolution that has shaped the universe across unmeasured eons [12] [13].

**Methods: Mathematical Framework and Quantitative Exploration:** In this section, we lay the foundation for our cosmic exploration by presenting the mathematical tools that underpin our analysis. These equations, each a cornerstone of understanding, illuminate the intricate tapestry of the cosmos, enabling us to unravel the mysteries of the observable and non-observable universes and their spatial relationships. The elegance of mathematics is harnessed to decode cosmic phenomena and their implications, bringing to light the timeline of cosmic events and the quantitative aspects of galaxies that lie both within and beyond our observational reach [14] [15] [16].

### 1. Equations Guiding Our Cosmic Odyssey:

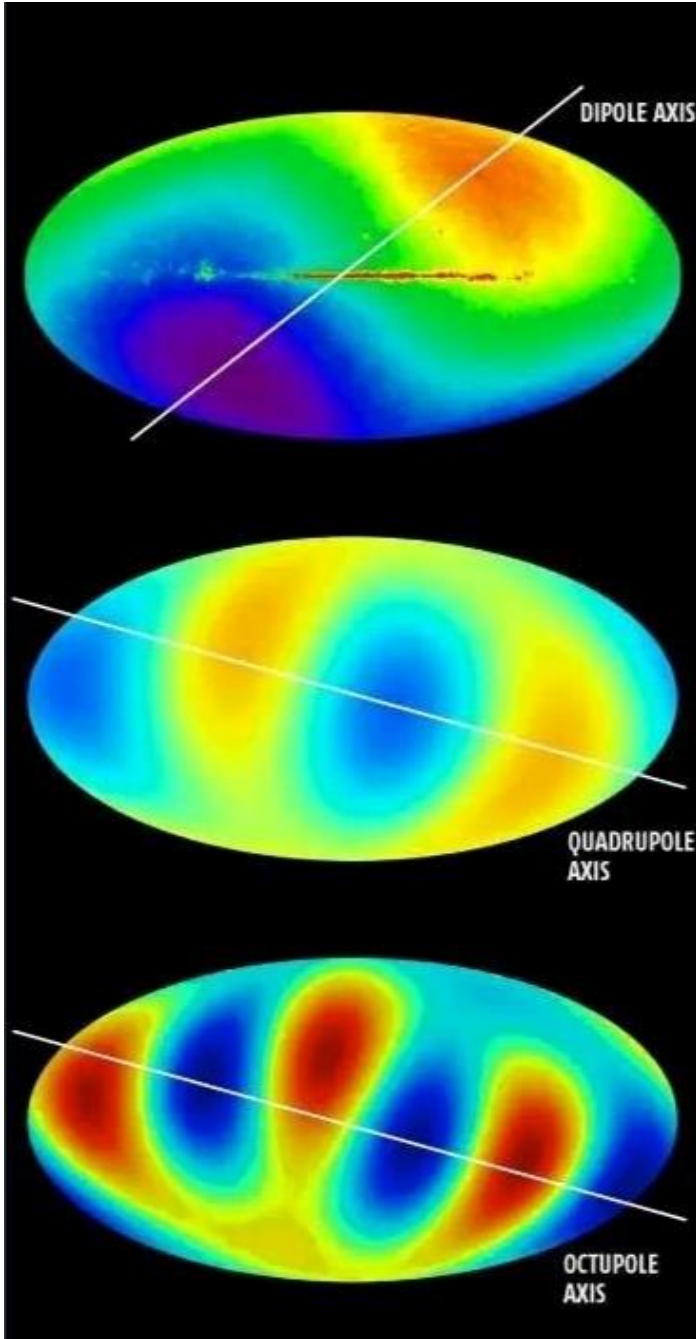
**Hubble's Law: Unveiling Cosmic Expansion:** At the heart of our exploration lies Hubble's Law, an elegant equation that lays bare the universe's expansion. The velocity  $v$  of distant galaxies is inextricably linked to their distance  $d$  from us. This velocity-distance relationship is governed by the Hubble constant  $H_0$ , the cosmic conductor orchestrating the symphony of cosmic expansion:  $v = H_0 \times d$ .

**Co-moving Distance: Measuring Cosmic Depths:** The equation of co-moving distance  $D$  invites us to journey through the annals of time and space. By integrating the reciprocal of the Hubble parameter  $H(z')$  with respect to redshift  $z'$ , we quantify the cosmic expanse that separates us from celestial objects:  $D = c \int_0^z \frac{dz'}{H(z')}$ , where  $c$  represents the cosmic speed limit, the speed of light.

**Redshift-Distance Relation: Unraveling Cosmic Stretch:** The redshift-distance relation binds the cosmic tapestry with spectral threads. This equation unveils the intricate interplay between observed  $\lambda_{obs}$  and emitted  $\lambda_{emit}$  wavelengths of light. The cosmic fabric stretches, and redshift  $z$  emerges as a beacon of cosmic distances:  $z = \{\lambda_{obs} - \lambda_{emit}\} / \lambda_{emit}$ .

**Future Visibility Limit: Cosmic Horizons Beckon:** As we gaze into the cosmos, the future visibility limit beckons. This equation, rooted in the cosmic constant  $c$  and Hubble's constant  $H_0$ , signifies the threshold beyond which cosmic objects recede from us faster than light, rendering them forever beyond our observational reach:  $d_{future} = c / H_0$ .

**Non-Observable Universe's Extension: Beyond Our Gaze:** The universe's extension, beyond the horizon of observation, is encapsulated in this equation. The cosmic expanse is unveiled as the expansion factor intertwines with the observable universe's size. This equation paints a picture of cosmic dimensions that extend beyond imagination:  $Extension = Expansion\ factor \times Observable\ Universe's\ Size$ .



**Figure 3.** [Top] – To break the temperature variations into broad categories the principal component is the dipole shows the temperature variation caused by the Milky Way's motion. The CMB is hotter than average in the direction of motion and colder in the opposite direction. [Middle] – Breaking down further is the quadrupole made up of two pairs of hot and cold regions where the amplitude of the temperature variations is hundred times smaller than the dipole. [Bottom] – Further breaking is the octuple which is weaker than the quadrupole where the octuple are aligned along the "axis of evil" that is perpendicular to the axis of the dipole. Credit [11]

**CMBR Spectrum: Whispers of the Cosmic Dawn:** The CMBR spectrum equation unravels the ancient whispers of the cosmos. It describes the intensity  $I$  of radiation at a specific wavelength  $\lambda$  and temperature  $T$ . Constants like the Planck constant  $h$ , the speed of light  $c$ , and the Boltzmann constant ( $k$ ) choreograph the symphony of cosmic radiation:  $I_{\lambda,T} = (2 \times h \times c^2 / \lambda^5) * (1 / [e^{(h \cdot c / (\lambda \cdot k \cdot T))} - 1])$ .

**CMBR Anisotropy: Cosmic Fluctuations in Harmony:** As we peer into the sky, the CMBR anisotropy equation unveils cosmic temperature fluctuations  $T_{\theta,\phi}$ . These fluctuations, quantified by spherical harmonics  $Y_{lm}(\theta, \phi)$  and the multipole moment  $l$ , narrate the cosmic tale of scale and pattern. The azimuthal quantum number ( $m$ ) orchestrates this intricate dance:  $T_{\theta,\phi} = \sum_0^\infty \sum_{m=-l}^l a_{lm} \times Y_{lm}(\theta, \phi)$ .

**Alignment and Axis of Evil: Cosmic Symmetry Unveiled:** Within this equation, we decode the alignment of cosmic patterns. Coefficients ( $a_{lm}$  and  $a'_{lm}$ ) representing different multipole moments ( $l$  and  $l'$ ) lay bare the symmetrical and asymmetrical aspects of the universe's blueprint, revealing subtle cosmic secrets.

**Quadrupole and Octupole Cold Points: Echoes of the Early Cosmos:** These equations materialize the patterns imprinted on the cosmic canvas. Coefficients  $a_{2m}$  and  $a_{3m}$  unveil the vestiges of cosmic anomalies, like the Quadrupole and Octupole Cold Points. These echoes from the early cosmos provide insights into the universe's infancy [17].

**2. Quantitative Exploration: Cosmic Timelines and Galaxies' Balance:**

**To contextualize our exploration, we recount the timeline of cosmic events through these mathematical lenses:** The universe's birth, heralded by the Big Bang, occurred 13.8 billion years ago. The whisper of the universe's dawn, the initiation of the Cosmic Microwave Background (CMB) radiation, emerged 13.79962 billion years ago.

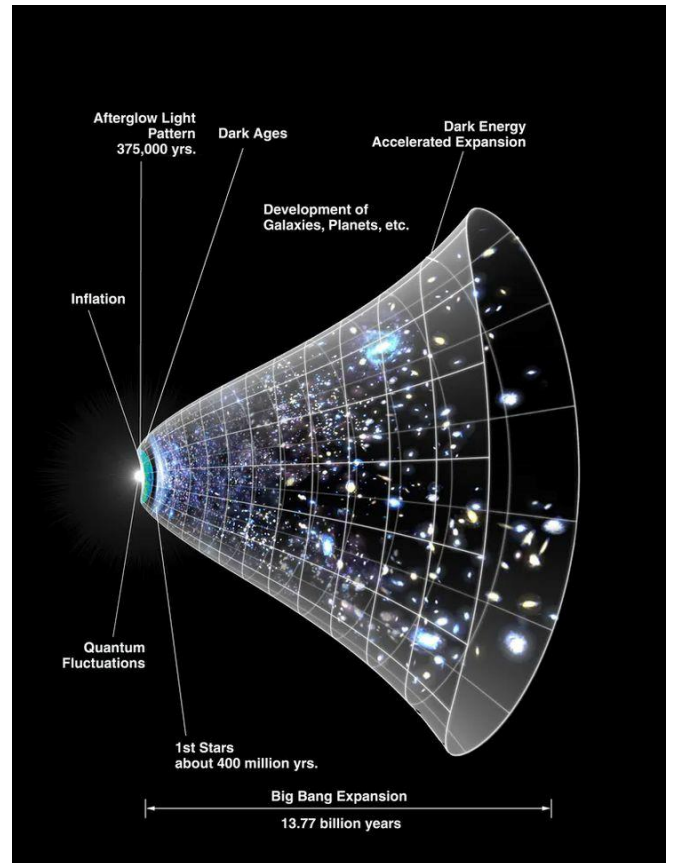
**Quantitative insights emerge as we delve into the observable and non-observable universes:** The co-moving distance of the observable Universe, equivalent to 14.26 gigaparsecs, is translated to concrete units: 46.5 billion light-years or 4.40e26 meters. Beyond our visible horizon, the extension of the non-observable Universe reaches an astonishing 11,625 billion light-years. Our current cosmic panorama reveals visibility of 43% of galaxies within the observable Universe, expanding over 46.5 billion light-years from Earth in all directions. Gazing toward the future, anticipation mounts as an additional 57% of galaxies from the observable Universe are destined to become observable. The numbers themselves unveil the vastness: Approximately 19.995 billion light-years encompass galaxies within our visual grasp. Equally staggering, 26.505 billion light-years house galaxies that remain shrouded from our gaze [18].

**3. Incorporating Cosmic Insights:** These mathematical expressions intricately interlace with the fabric of our cosmic narrative, revealing the expansive universe's blueprint, the distribution of galaxies, and the boundary between observability and the unseen. Hubble's Law provides a guide to the velocity-distance relationship, unveiling cosmic expansion's pace. The co-moving distance equation presents the integral foundation for quantifying distances in an evolving universe. The redshift-distance relation peels back layers of distance measurement, intricately woven with spectral shifts. The future visibility limit beckons us to consider the elusive frontiers of observability. The equation for the non-observable universe's extension encapsulates the cosmic expanse [19].

**4. Quantitative Revelation: Unveiling Cosmic Mysteries:** As mathematical elegance intertwines with cosmic inquiry; our exploration shifts from mere observation to a realm where numerical precision enriches our understanding. The timeline of cosmic epochs unfurls through calculated ages, and galaxies' distribution is unveiled through percentages and distances. The paper's quantitative foundations create a bridge between the abstract and the concrete, making cosmic mysteries tangible, and propelling us towards a deeper comprehension of the cosmos [20].

**5. Relevant Equations: Unveiling the Cosmic Mechanisms:** In this section, we unveil the intricate mathematical frameworks that underpin our journey into the cosmos. These equations serve as guiding stars, illuminating our understanding of the cosmic microwave background radiation, the observable and non-observable universes, and the very fabric of space-time itself.

**6. Through Mathematical Lens: Cosmic Poetry Unveiled:** As each equation unfurls its cosmic significance, we embark on a journey that transcends observation. Mathematical precision unveils the grand cosmic mechanisms that shape our universe. These equations, like poetic verses, illuminate the invisible, quantify the unfathomable, and resonate with the essence of cosmic evolution. Our understanding deepens, and the universe's narrative emerges, painted with numerical clarity, as we embrace the mathematical essence of our cosmic exploration.



**Figure 4.** The history of the universe starting from the big bang is portrayed in this picture. Credit [21]

**7. Relevant Equations:**

**Hubble's Law:** Equation:

$$v = H_0 \cdot d$$

Description: Hubble's Law describes the relationship between the velocity ( $v$ ) at which galaxies are receding from an observer, the Hubble constant ( $H_0$ ), and the distance ( $d$ ) between the observer and the galaxy. This law is fundamental in understanding the expansion of the universe.

**Co-moving Distance:** Equation:

$$D = c \cdot \int_0^z \frac{dz'}{H(z')}$$

Description: The co-moving distance ( $D$ ) accounts for the expansion of the universe over time. It is calculated by integrating the reciprocal of the Hubble parameter ( $H(z')$ ) with respect to redshift ( $z'$ ) from 0 to the

observed redshift ( $z$ ). This equation provides a way to determine distances that have been affected by cosmic expansion.

**Redshift-Distance Relation:** Equation:  $z = \lambda_{obs} - \lambda_{emit}$ —Description: The redshift  $z$  of light from a distant source is a measure of how much the universe has expanded since the light was emitted. It's related to the observed wavelength  $\lambda_{obs}$  and emitted wavelength  $\lambda_{emit}$  of light. This equation helps determine the distance of distant objects based on their redshift.

**Future Visibility Limit:** Equation:  $d_{future} = c_2$  Description: The future visibility limit  $d_{future}$  represents the maximum distance from which light emitted today will eventually reach us due to the expansion of the universe. It's determined by the speed of light  $c$  divided by the Hubble constant  $H_0$ .

**Non-Observable Universe's Extension:** Equation: Extension = Expansion factor  $\times$  Observable Universe's Size =  $250 \times 46.5 \text{ b.ly} = 11,625 \text{ billion light-years}$  Description: The extension of the non-observable universe is calculated by multiplying the expansion factor by the size of the observable universe. In this case, an expansion factor of 250 times the observable universe's size (46.5 billion light-years) results in an extension of 11,625 billion light-years.

**CMBR Spectrum:** Equation:  $I(\lambda, T) = 8\pi hc$  Description: The CMBR spectrum equation describes the intensity  $I$  of radiation at a certain wavelength  $\lambda$  and temperature  $T$ . It's derived from Planck's law and involves constants like Planck's constant  $h$ , the speed of light  $c$ , and the Boltzmann constant  $k$ . This equation characterizes the energy distribution of CMBR.

**CMBR Anisotropy:** Equation:  $T(\vartheta, \phi) = \sum^{\infty}$  Description: The CMBR anisotropy equation expresses the temperature fluctuation  $T$  at a specific point on the sky in terms of spherical harmonics  $Y_{lm}$  and coefficients  $a_{lm}$ . These coefficients represent the contributions of different multipole moments  $l$  and azimuthal quantum numbers  $m$  to the temperature fluctuations.

**Alignment and Axis of Evil:** Description: The alignment and axis of evil equation relate the coefficients  $a_{lm}$  of different multipole moments  $l$  before  $a'$  and after  $a_{lm}$  a rotation operation  $Rl'l$ . The presence of anomalies in these coefficients' hints at potential large-scale alignments in the CMBR.

**Quadrupole and Octupole Cold Points:** Equation:  $a_{2m}$  and  $a_{3m}$  Description: The coefficients  $a_{2m}$  and  $a_{3m}$  represent the patterns of the Quadrupole and Octupole moments, respectively, in the CMBR anisotropy. These coefficients indicate regions of colder or hotter temperature fluctuations on the CMBR map [22] [23] [24].

## 8. Results:

**Illuminating Cosmic Realms:** In this section, we unveil the culmination of our exploration—a rich tapestry woven from the threads of cosmic understanding. Through rigorous analysis and mathematical insight, we have unveiled the secrets of the cosmic microwave background radiation (CMBR) and the profound dynamics of the observable and non-observable universes. Our journey, guided by the monumental Big Bang theory and fortified by mathematical tools, illuminates the essence of our cosmic existence.

**Cosmic Microwave Background Radiation (CMBR) Unveiled:** Delving into the echoes of the cosmic dawn, our analysis of the CMBR reveals ancient whispers from the universe's inception. Pioneering satellites—such as the Cosmic Background Explorer (COBE), the Wilkinson Microwave Anisotropy Probe (WMAP), and the Planck probe—have collectively revolutionized our understanding of the early universe and its cosmic background radiation. Through meticulous observations, we have deciphered specific features and anomalies embedded in the CMBR maps. Concentric circles, the enigmatic Axis of Evil, and the patterns of Quadrupole and Octupole Cold Points offer a glimpse into

the universe's early moments, painting a vivid portrait of its nascent complexity.

**Observable and Non-Observable Universes:** Our exploration spans across cosmic epochs and spatial dimensions, unraveling the fabric of the observable and non-observable universes. The cosmic chronicle begins 13.8 billion years ago with the cataclysmic event—the Big Bang—that set the universe's expansion in motion. The initiation of the Cosmic Microwave Background (CMB) radiation at 13.79962 billion years ago resonates as the whisper of the universe's first light.

The observable universe, stretching across a co-moving distance of 14.26 gigaparsecs, encompasses a staggering expanse of 46.5 billion light-years or  $4.40 \times 10^{26}$  meters. In this cosmic theater, our telescopic instruments provide visibility of 43% of galaxies, their distant luminosity reaching our earthly abode. However, the celestial stage extends beyond, embracing an enigmatic extension of 11,625 billion light-years, where 57% of galaxies remain veiled in cosmic obscurity.

Projected into the distant future, our cosmic vision expands. An additional 57% of galaxies from the observable universe await revelation, casting light upon the yet-unseen corners of our cosmic domain. Within this intricate interplay, a numerical revelation emerges—approximately 19.995 billion observable galaxies and 26.505 billion galaxies hidden beyond our sight.

**The Cosmic Equation: A Vision Transformed:** Our results are a testament to the power of mathematics in deciphering the cosmos' deepest secrets. The equations that underpin our understanding—Hubble's Law, co-moving distance, redshift-distance relation, future visibility limit, non-observable universe's extension, CMBR spectrum, CMBR anisotropy, alignment and Axis of Evil, Quadrupole and Octupole Cold Points—have unfurled the cosmic narrative, from the universe's inception to its expansive horizons. These equations are the keystones of discovery, transforming abstract concepts into tangible insights that bridge the gap between theory and observation.

In conclusion, our journey through the cosmic maze has unveiled the cosmic microwave background radiation's echoes, the dance of observable and non-observable universes, and the mathematical cadence that guides our exploration. This fusion of science and imagination resonates with the very essence of human curiosity, fueling our eternal quest to unravel the enigmatic cosmos. As we step back from the canvas of our findings, we stand at the precipice of knowledge, ready to leap into the unknown and continue our exploration of the cosmic tapestry.

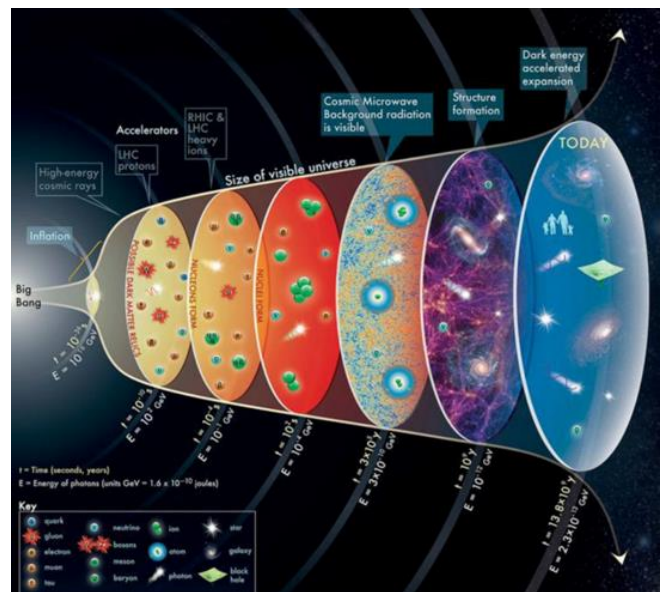


Figure 5. The history of the universe. Credit [25]

## 9. Discussion:

**Illuminating the Cosmic Odyssey:** As we reflect on the intricate revelations unearthed in our exploration, we find ourselves immersed in a profound discourse that intertwines the threads of science, mathematics, and cosmic wonder. The cosmic microwave background radiation (CMBR) and the delicate interplay between the observable and non-observable universes have unveiled a tapestry of knowledge that reshapes our understanding of the cosmos.

**CMBR: A Glimpse into the Primordial Symphony:** The discovery and analysis of the CMBR have fundamentally altered our perception of the universe's beginnings. Satellites like the Cosmic Background Explorer (COBE), the Wilkinson Microwave Anisotropy Probe (WMAP), and the Planck probe have bestowed upon us the gift of deciphering the universe's early melodies. Through the lens of CMBR, we have witnessed the cosmic harmonies of concentric circles, the enigmatic Axis of Evil, and the subtle fluctuations of Quadrupole and Octupole Cold Points. These subtle imprints on the CMBR canvas provide windows into the physical conditions and interactions that governed the universe during its infancy—a symphony of cosmic forces that set the stage for the grand cosmic drama we now inhabit.

**Observable and Non-Observable Universes: Cosmic Choreography:** The delineation of the observable and non-observable universes reframes our understanding of spatial dimensions and cosmic boundaries. Rooted in the monumental Big Bang theory, the cosmic narrative spans billions of years, and our journey through time begins with the cataclysmic event that set the universe's expansion into motion. The initiation of the Cosmic Microwave Background (CMB) radiation marks a pivotal moment, resonating as the universe's whispered prologue.

Within the observable universe, our observational prowess extends to 14.26 gigaparsecs, unveiling the splendor of 46.5 billion light-years or  $4.40 \times 10^{26}$  meters in all directions from our terrestrial vantage point. Yet, the cosmic stage stretches beyond our gaze, reaching an astonishing extension of 11,625 billion light-years—an expanse where galaxies remain hidden, waiting for their cosmic debut.

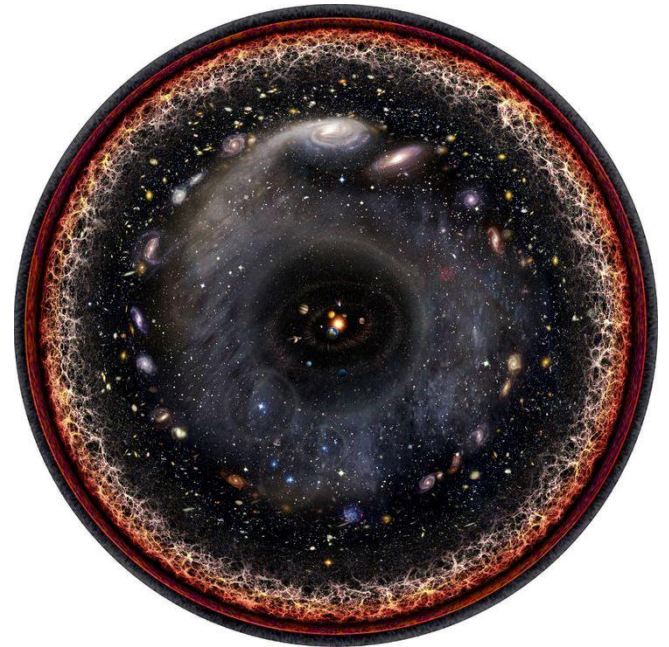
**The Cosmic Equation: Bridging Theory and Reality:** At the heart of our analysis lies a symphony of mathematical equations, each note contributing to the melody of cosmic understanding. Hubble's Law, comoving distance, redshift-distance relation, future visibility limit, non-observable universe's extension, CMBR spectrum, CMBR anisotropy, alignment and Axis of Evil, and Quadrupole and Octupole Cold Points—these equations are the building blocks of discovery. They translate abstract concepts into tangible insights, bridging the chasm between theoretical conjecture and empirical evidence.

Our findings echo the rhythm of human curiosity, resonating with the inherent desire to comprehend the universe's mysteries. The discussion thus stands as a testament to the harmonious interplay between human ingenuity, scientific pursuit, and the enigmatic cosmos. As we ponder the revelations of our exploration, we are reminded that the journey to knowledge is an eternal odyssey—a cosmic waltz that invites us to keep dancing amidst the stars, forever driven by the rhythm of discovery.

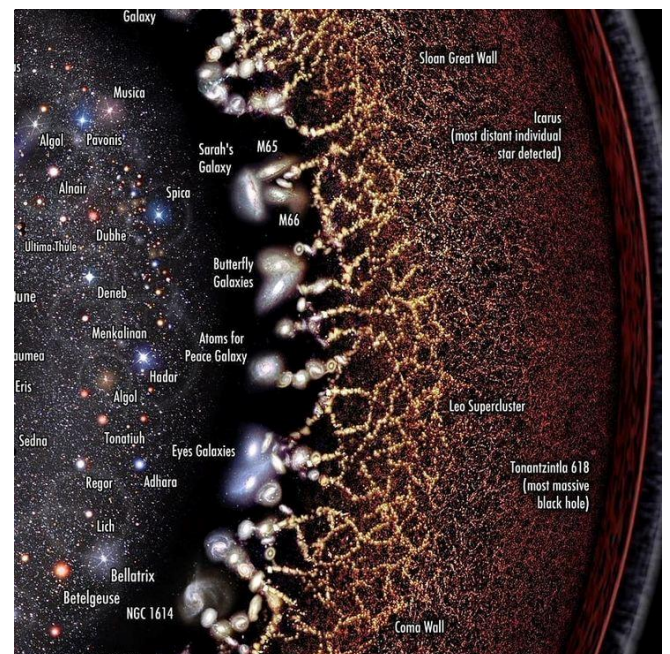
## 10. Conclusion:

**Unveiling the Cosmos Through Time and Space:** In the grand tapestry of cosmic history, our expedition into the realms of the cosmic microwave background radiation (CMBR), the observable and non-observable universes, and the symphony of mathematical equations has illuminated the universe's origins, evolution, and intricate fabric. Guided by the monumental pillars of the Big Bang theory and propelled by the intellectual fervor of scientific inquiry, our journey has revealed captivating insights that resonate with both the poetic and empirical facets of human exploration.

**From the Big Bang to the CMBR: A Cosmic Narrative:** Our voyage commences with the resounding echo of the Big Bang, a cataclysmic event that birthed our universe 13.8 billion years ago. The initiation of the Cosmic Microwave Background (CMB) radiation at 13.79962 billion years marks a pivotal milestone—an ethereal whisper from the universe's dawn that carries within it the secrets of its early epochs. The CMBR, with its concentric circles, Axis of Evil, and the intricate dance of Quadrupole and Octupole Cold Points, offers us a portal to peer into the very fabric of space and time, unraveling the cosmic symphony that gave rise to galaxies, stars, and ultimately, life.



**Figure 6.** The observable universe with 93 billion light years diameter wide. Credit [26]



**Figure 7.** The observable universe with zoomed in points. Credit [27]

**Observable and Non-Observable Universes: A Cosmic Dance:** As we gaze upon the vast cosmic stage, we are confronted with the dance of the observable and non-observable universes. The observable universe, extending 46.5 billion light-years in every direction, reveals a canvas adorned with galaxies that paint the portrait of cosmic history. Beyond this observable horizon lies the non-observable universe, a

realm where galaxies remain veiled from our view—a reminder of the boundless mysteries that beckon us to explore further.

**Equations as Cosmic Instruments: A Symphony of Understanding:** Our exploration is interwoven with the eloquence of mathematical equations that serve as instruments of understanding. Hubble's Law, co-moving distance, redshift-distance relation, future visibility limit, non-observable universe's extension, CMBR spectrum, CMBR anisotropy, alignment and Axis of Evil, and Quadrupole and Octupole Cold Points—each equation harmonizes theory and observation, allowing us to decipher the universe's cosmic choreography.

**A Continuum of Curiosity and Discovery:** As our cosmic odyssey draws to a close, we stand at the intersection of curiosity and discovery. The universe, with its mysteries both revealed and concealed, extends an eternal invitation to probe its depths and uncover its enigmas. Our journey resonates with the spirit of exploration, the relentless pursuit of knowledge, and the symphony of human endeavor. From the early musings of the Big Bang to the delicate imprints on the CMBR, from the observable galaxies that grace our sight to the unobservable realms that remain tantalizingly out of reach, our exploration celebrates the symphony of the universe—a symphony that harmonizes the human quest for understanding with the cosmic dance of time and space.

In the end, we are left with a chorus of questions that reverberate through the cosmos, guiding us to new horizons, uncharted territories, and deeper realms of insight. As we conclude this chapter of our journey, we do so with a sense of reverence for the universe's grandeur and an enduring commitment to continue our exploration of its majestic depths, forever entranced by the cosmic symphony that plays on.

---

## References

- [1] World Today News. (2022). A Smaller Observable Universe? This is How to Calculate Area! *World Today News*. <https://www.world-today-news.com/a-smaller-observable-universe-this-is-how-to-calculate-area/>
- [2] Bhattacharjee, D. (2022c). Universe before Big Bang. *Asian Journal of Research and Reviews in Physics*, 33–47. <https://doi.org/10.9734/ajr2p/2022/v6i3120>
- [3] Bhattacharjee, D. (2021d). The Gateway to Parallel Universe & Connected Physics. *Preprints*. <https://doi.org/10.20944/preprints202104.0350.v1>
- [4] Peebles, P. J. E. (1993). *Principles of Physical Cosmology*. Princeton University Press.
- [5] Cosmic Microwave Background Radiation. (n.d.). CERN. [https://indico.cern.ch/event/618499/contributions/2573126/attachments/1509128/2352660/lecture\\_on\\_CMB\\_theory\\_and\\_history.pdf](https://indico.cern.ch/event/618499/contributions/2573126/attachments/1509128/2352660/lecture_on_CMB_theory_and_history.pdf)
- [6] Peacock, J. A. (1999). *Cosmological Physics*. Cambridge University Press.
- [7] Liddle, A. R., & Lyth, D. H. (2000). *Cosmological Inflation and Large-Scale Structure*. Cambridge University Press.
- [8] Mukhanov, V. F. (2005). *Physical Foundations of Cosmology*. Cambridge University Press.
- [9] Bhattacharjee, D. (2021c). Positive Energy Driven CTCs In ADM 3+1 Space – Time of Unprotected Chronology. *Preprints*. <https://doi.org/10.20944/preprints202104.0277.v1>
- [10] Carroll, S. M. (2004). *Spacetime and Geometry: An Introduction to General Relativity*. Pearson.
- [11] Trosper, J. (2014, August 13). 4 Anomalies in The Big Bang Afterglow: *Futurism*. <https://futurism.com/4-anomalies-in-the-big-bang-afterglow>
- [12] Weinberg, S. (1972). *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity*. Wiley.
- [13] Spergel, D. N., et al. (2003). First-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Determination of Cosmological Parameters. *The Astrophysical Journal Supplement Series*, 148(1), 175–194. DOI: 10.1086/377226
- [14] Bhattacharjee, D. (2022a). M-Theory and F-Theory over Theoretical Analysis on Cosmic Strings and Calabi-Yau Manifolds Subject to Conifold Singularity with Randall-Sundrum Model. *Asian Journal of Research and Reviews in Physics*, 25–40. <https://doi.org/10.9734/ajr2p/2022/v6i230181>
- [15] Bhattacharjee, D. (2022b). A Coherent Approach towards Quantum Gravity. *Physical Science International Journal*, 59–78. <https://doi.org/10.9734/psij/2022/v26i6751>
- [16] Weinberg, S. (1972). *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity*. Wiley.
- [17] Komatsu, E., et al. (2011). Seven-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Cosmological Interpretation. *The Astrophysical Journal Supplement Series*, 192(2), 18. DOI: 10.1088/0067-0049/192/2/18
- [18] Dunkley, J., et al. (2009). Five-Year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Likelihoods and Parameters from the WMAP Data. *The Astrophysical Journal Supplement Series*, 180(2), 306–329. DOI: 10.1088/0067-0049/180/2/306
- [19] Bhattacharjee, D. (2021b). Path Tracing Photons Oscillating Through Alternate Universes Inside a Black Hole. *Preprints*. <https://doi.org/10.20944/preprints202104.0293.v1>
- [20] Peebles, P. J. E., & Ratra, B. (2003). The Cosmological Constant and Dark Energy. *Reviews of Modern Physics*, 75(2), 559–606. DOI: 10.1103/RevModPhys.75.559

- [21] Wikipedia contributors. (n.d.). *Talk:Expansion of the universe* - *Wikipedia*.  
[https://en.m.wikipedia.org/wiki/Talk:Expansion\\_of\\_the\\_universe](https://en.m.wikipedia.org/wiki/Talk:Expansion_of_the_universe)
- [22] Riess, A. G., et al. (2019). Large Magellanic Cloud Cepheid Standards Provide a 1% Foundation for the Determination of the Hubble Constant and Stronger Evidence for Physics beyond  $\Lambda$ CDM. *The Astrophysical Journal*, 876(1), 85. DOI: 10.3847/1538-4357/ab1422
- [23] Bhattacharjee, D. (2021a). Deciphering Black Hole Spin, Inclination angle & Charge From Kerr Shadow. *Preprints*.  
<https://doi.org/10.20944/preprints202104.0315.v1>
- [24] Planck Collaboration. (2016). Planck 2015 results. XIII. Cosmological parameters. *Astronomy & Astrophysics*, 594, A13. DOI: 10.1051/0004-6361/201525830
- [25] *History of the universe*. (2015). Particle Data Group, LBNL.
- [26] Crew, B. (2018, January 17). *The Entire Known Universe, in a Single Image. Here's What It Looks Like*: *ScienceAlert*.  
<https://www.sciencealert.com/known-universe-in-one-single-image-logarithmic-artwork-pablo-carlos-budassi>
- [27] Budassi, P. C. (n.d.). *Observable Universe*.