

A Speculative
Reexamination
of the Fermi Enigma

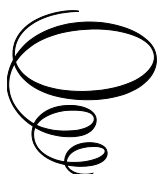
A Speculative Reexamination of the Fermi Enigma:

The Cosmic Silence

By

Iñaki del Amo Castillo

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ABSTRACT

This book explores one of the most haunting questions at the intersection of astrophysics, metaphysics, and ethics: the Great Silence. In a universe that is both ancient and vast, why do we detect no trace of intelligent civilizations? Is it absence—or something deeper?

Rooted in cutting-edge data from missions like the James Webb Space Telescope and theories of early-universe cosmology—including the Big Bounce, false vacuum decay, and cyclic models—this work reconceives the Fermi Paradox through the lens of emergent time and informational geometry. It asks not merely where the others are, but when they are—and whether their ontological trajectories are synchronized with ours.

The hypothesis is bold: time may not be a passive coordinate but a property that emerges under specific thermodynamic and quantum conditions. In this framework, civilizational silence is not necessarily absence or extinction, but a phase misalignment—a failure to resonate across temporal geometries. Advanced beings might operate in topological domains or entropy regimes invisible to our observational window.

From quantum camouflage and curvature-based stealth to the risks of vacuum manipulation and interstellar signaling, this book weaves physical theory with philosophical insight. Could intelligence, when untethered from conscience, be a vector for self-erasure? Are we, unknowingly, approaching the very filter we seek to understand?

The Fermi Enigma ultimately proposes that cosmic contact is not a matter of detection, but of readiness. It is not technology, but epistemic and ethical maturity, that will define our next leap—not only across stars, but across the deeper thresholds of being.

Rather than invoking fear, this work encourages reflection. It invites us to rethink intelligence not as domination over nature, but as the capacity to harmonize with the temporal fabric of existence itself.

SYNOPSIS

A Speculative Reexamination of the Fermi Enigma: The Cosmic Silence is a bold philosophical and scientific exploration of one of humanity's greatest unresolved questions: the profound stillness of the universe. If the cosmos is teeming with life, as probabilities suggest, why does no one answer our calls?

Bridging astrophysics, speculative cosmology, and moral philosophy, this book proposes that silence is not absence—but a threshold. Perhaps civilizations do not vanish through war or collapse, but through the unbearable gravity of their own knowledge. From quantum curvature and entropy asymmetry to the eerie possibilities of false vacuum decay and emergent time, the text explores whether intelligence itself may be a self-erasing trajectory.

Recent data from the James Webb Space Telescope and theories of cyclic cosmology suggest that advanced life may operate in informational regimes beyond our detection—hidden by thermodynamic misalignment, geometric camouflage, or ontological dissonance. In this frame, time is no longer a linear flow, but a property that emerges under specific physical and cognitive conditions.

The Fermi Enigma challenges us to rethink the nature of intelligence in a universe where even curiosity might destabilize reality. It calls for cosmic humility, epistemic caution, and a renewed ethical framework—one that sees intelligence not as domination, but as resonance with the delicate architecture of existence.

AUTHOR'S NOTE

This book is not a scientific treatise, nor a work of science fiction. It stands as a speculative essay grounded in contemporary scientific ideas, philosophical reasoning, and historical analogies. The proposals set forth here are not doctrines, but hypotheses—offered not as certainties, but as invitations to think, to question, and to wonder.

The reader is encouraged to challenge these ideas, contrast them with their own, and above all, to reflect on what it truly means to be an intelligent species in a universe that may be not only fragile, but also fundamentally unready—or unwilling—to be perceived.

Perhaps the silence we interpret as emptiness is simply a mirror of our own perceptual limitations. What if reality is not absent, but misaligned? What if our tools of observation, our concepts of time, space, and consciousness, are not yet tuned to what truly exists?

This book does not aim to reveal answers, but to open a space of inquiry. In a cosmos where visibility may not equal existence, and contact may require more than technology, the greatest frontier may lie not in space—but in our own capacity to see.

PROLOGUE

The universe holds a secret. A secret so profound that, if true, it would shatter our understanding of reality forever.

From the moment humanity looked up at the stars, we have asked the same question: are we alone? Throughout history, we have searched, calculated, sent signals, and sought answers. And yet, all we have encountered is a vast, unbroken silence. A silence that feels unnatural.

The Fermi Paradox suggests the universe should be teeming with civilizations. If that is the case, why do we see none?

Perhaps the answer is not that they never existed, but that they have chosen to disappear. Or worse—perhaps every civilization that has reached the peak of its technological development has encountered a danger so insurmountable that the only logical path was to vanish. Not due to external threats, but as a consequence of their own knowledge, their own evolution. The real question we should ask is not whether we are alone, but: *should we even be searching?* What if, in our relentless curiosity, we stumble upon echoes of warnings we do not yet understand?

The Intelligence Trap

Every species that reaches self-awareness will inevitably face a final test. History shows that once a civilization acquires the ability to control its surroundings, it simultaneously gains the power to annihilate itself. We have seen this before—with gunpowder, with nuclear fission. And soon, we may witness the emergence of something even more catastrophic: *quantum curvature weapons.*

Is intelligence inherently self-destructive? If every sufficiently advanced civilization reaches a point where it can manipulate the quantum vacuum, collapsing the very structure of spacetime, then the only question that truly matters is: **when?**

If hyper-advanced civilizations discover that they can create a weapon capable of erasing existence itself, perhaps they all inevitably vanish—not by war, not by conquest, but by the inevitable consequences of their own knowledge.

And if that is true, then maybe this is not the first universe. Maybe we have existed before. Maybe intelligence, in all its forms, collapses its own reality and resets the cycle over and over again. *Maybe the Big Bang was not the beginning—but the last act of a forgotten civilization.*

The Final Dilemma

Humanity is advancing at an accelerating pace. In mere centuries, we have leaped from classical mechanics to relativity, to quantum theory. We now manipulate particle accelerators and probe the very nature of the quantum vacuum. But if we continue on this trajectory, are we approaching the same threshold that countless others may have faced before us?

Can we avoid the trap, or are we destined to repeat the fatal mistake of civilizations long forgotten?

The silence of the universe is not just the absence of sound. It is the echo of long-lost warnings. And we are dangerously close to discovering why.

“Civilization is a race between education and catastrophe.”

—H.G. Wells

CHAPTER 1

INTRODUCTION

“The universe holds a secret. A secret so profound that, if true, it would shatter our understanding of reality forever.”

From the moment humanity first gazed at the stars, we have been driven by one inescapable question: *Are we alone?* Throughout millennia, we have searched, calculated, sent messages, and scoured the skies for signs of other intelligences. Yet, despite our technological triumphs and relentless curiosity, all that greets us is a vast, unbroken silence—a silence that seems both eerie and deliberate. The Fermi Paradox challenges our expectations by suggesting that the universe, given its boundless expanse and age, should be teeming with civilizations. If so, why does our cosmic radio remain mute?

Is this silence a coincidence of timing? A limitation of our instruments? Or is it something deeper—something unsettling that lies at the heart of intelligent life itself?

Perhaps the answer lies not in the absence of life, but in its disappearance. It is conceivable that every civilization reaching the pinnacle of technological prowess encounters an insurmountable existential peril—a danger so great that the only logical recourse is to vanish, not because of external threats, but as an inevitable consequence of their own advancement.

This danger might not wear the face of invasion or cosmic disaster, but instead arise from within: the weaponization of quantum physics, irreversible climate feedback loops, artificial general intelligence run amok, or the subtle unraveling of social cohesion in the wake of hyperconnectivity. These are not hypothetical terrors—they are shadows already stretching across our horizon. And what if other civilizations, long before us, encountered the same dilemmas? What if the silence of the

cosmos is not passive, but purposeful—a quiet forged not from emptiness, but from retreat?

A Cosmic Silence and the Risk of Knowledge

Every species that attains self-awareness must confront a final, defining test. History teaches us that when a civilization gains the power to shape its surroundings, it simultaneously acquires the means to destroy itself. From the discovery of gunpowder to the era of nuclear fission, technological progress has always been a double-edged sword. Today, we stand on the brink of an era in which quantum curvature weapons might one day render entire realities void. Is intelligence, then, inherently self-destructive? If every sufficiently advanced civilization reaches the point of manipulating the quantum vacuum—thereby collapsing spacetime itself—the crucial question becomes: *When?*

If hyper-advanced societies eventually unlock the power to erase existence, they may all vanish—not through conquest or war, but as an unavoidable outcome of their own intellectual evolution. Perhaps this cycle of rise and reset suggests that our universe is not a singular, linear event but a recurring phenomenon—a cosmic reboot in which intelligence collapses its own reality time and again. In this light, the Big Bang might not have been the true beginning, but rather the final act of a civilization long forgotten.

Scope and Objectives

Humanity is advancing at an accelerating pace. In mere centuries, we have leaped from the era of classical mechanics to the realms of relativity and quantum theory. We now wield particle accelerators and peer into the fabric of the quantum vacuum. Yet, as we press forward, one must ask: are we nearing the same threshold that has doomed countless civilizations before us? *Can we sidestep this peril, or are we destined to repeat the fatal mistakes of our predecessors?*

In this book, we delve into the paradox of cosmic silence through the intertwined lenses of astrophysics, philosophy, and the history of

technological evolution. We examine why civilizations might choose—or be compelled—to remain silent, assess the existential threats that loom on a cosmic scale, and ponder whether broadcasting our presence is an act of hope or a perilous gamble. By the end, our aim is to shed light on critical ethical and philosophical dilemmas that will shape our cosmic future:

- Should we actively send signals into the void, boldly announcing our existence?
- Could it be that advanced civilizations have uncovered universal truths so dangerous that remaining silent is the only rational strategy?
- How might recent observations—such as the James Webb Space Telescope’s early detection of mature galaxies—force us to rethink our understanding of cosmic expansion and the cyclical nature of existence?

Recent discoveries by the James Webb Space Telescope have revealed mature galaxies forming much earlier than conventional models predict. This breakthrough challenges the prevailing Big Bang paradigm and bolsters alternative models like cyclic or bounce cosmologies. The urgency to reconsider our cosmological and philosophical frameworks has never been greater, as these observations hint at a universe far more dynamic and enigmatic than previously imagined.

The silence of the universe is not merely the absence of sound; it may be the reverberation of ancient warnings. Perhaps we are perilously close to uncovering the truths behind this cosmic hush.

1.1 Interstellar Communication

Since the latter half of the 20th century, humanity has undertaken deliberate efforts to establish communication beyond Earth. One of the earliest and most emblematic of these was the **Arecibo Message** (1974), a binary radio transmission crafted by Frank Drake and colleagues to demonstrate our technological capabilities. Beamed toward the M13 globular cluster, it included information about human biology, mathematics, and our solar system (Drake, 1975). While its scientific

value was largely symbolic—given the tens of thousands of years required for any round-trip communication—it marked a turning point in humanity’s desire to reach out into the cosmos.

This act was soon followed by the more poetic gesture of the **Voyager Golden Records** (1977), curated by Carl Sagan and his team. These phonograph discs, affixed to the Voyager 1 and 2 spacecraft, contained sounds, music, greetings in 55 languages, and images portraying Earth’s culture and biodiversity (Sagan, 1978). The Records were not merely messages—they were declarations of identity. They embodied the hope that, someday, someone—or something—might find them and know that we existed.

1.1.2 From Passive Listening to Active Messaging

For much of its history, the Search for Extraterrestrial Intelligence (SETI) focused on **passive listening**: scanning the skies for anomalous radio signals or optical pulses that might indicate an intelligent source. This method, rooted in caution and scientific conservatism, has produced candidate signals—such as the famous “Wow! Signal” in 1977—but no confirmed detections to date.

In contrast, the more recent METI (Messaging to Extraterrestrial Intelligence) movement advocates for a proactive stance. Proponents argue that, given the vast distances involved, waiting for others to speak first may be a losing strategy. Instead, METI posits that intentional, structured, and ethically framed outreach is a natural extension of our technological maturity and an act of cosmic diplomacy.

1.1.3 Risks, Ethics, and Controversies

However, active messaging is not without controversy. Critics argue that METI ignores a central tenet of contact ethics: **we do not know who is listening**. In a cosmos where civilizations may be vastly older, more advanced, or culturally divergent, broadcasting our presence could be perceived as naïve—or even reckless (Gertz, 2016).

Stephen Hawking, for instance, famously warned that initiating contact with advanced civilizations could mirror historical encounters between European colonial powers and indigenous populations—encounters that rarely ended well for the less technologically developed society (Hawking, 2016). Hawking’s caution was not rooted in xenophobia, but in historical precedent: asymmetries of power have consequences.

Other researchers (Benford, 2022; Lingam & Loeb, 2021) have provided scientific arguments against indiscriminate messaging, highlighting potential misinterpretations, risks of technological exposure, and the irreversible nature of such transmissions. Once sent, a signal cannot be recalled. It is a permanent artifact of our existence—broadcast without knowing the rules of the game, or whether the game is even safe to play.

1.1.4 Toward a Global Protocol

Calls have grown louder for an international, interdisciplinary framework to govern interstellar communication. Ćirković and others have advocated for a global consensus on METI activities, suggesting that such actions represent a form of planetary-scale decision-making and should be subject to open deliberation and ethical review (Ćirković, 2021).

Key questions remain: Who speaks for Earth? What message should we send—and in what language or format? Should we reveal our location, our biology, our culture? What risks are we willing to take on behalf of future generations?

Some scholars propose a **Precautionary Principle**—that until we understand the potential consequences of interstellar messaging, we should refrain from transmitting. Others counter that silence may signal fear or insularity, and that a thoughtful, coordinated outreach may invite reciprocity from similarly cautious civilizations.

1.1.5 Cultural Reflections and Public Imagination

The debate over interstellar communication also resonates in the cultural sphere. Films like *Contact*, based on Carl Sagan’s novel, explore the philosophical and emotional stakes of receiving a message from the stars.

Conversely, works like *Arrival* or *Prometheus* present first contact as a source of existential disruption, misunderstanding, or danger. These narratives reflect our ambivalence—our simultaneous yearning for connection and fear of the unknown.

Public engagement with these ideas, from online forums to artistic projects, suggests that the question of whether we should communicate is not limited to scientists. It is a question that touches every domain of human meaning: ethics, risk, identity, and the future of civilization.

1.1.6 A Question Without Precedent

Ultimately, interstellar communication is not just a scientific challenge. It is a philosophical riddle and an ethical dilemma. It forces us to ask: what kind of species are we? What values do we want to express to the cosmos? And what are we willing to risk in doing so?

As our technologies grow more powerful and our reach extends farther into the universe, the choice becomes clearer—and more consequential. To speak or to remain silent is no longer a technical decision. It is a moral one.

1.2 Modern Cosmology: From the Big Bang to the Big Bounce

Contemporary cosmology is characterized by diverse theoretical frameworks aimed at explaining the origins, evolution, and ultimate fate of the universe. The predominant cosmological model, the Big Bang theory, describes the universe as originating from an immensely hot and dense state approximately 13.8 billion years ago, subsequently expanding and cooling over time (Weinberg, 2008).

However, alternative theories have emerged, challenging and complementing this traditional view. Among these, the concept of the multiverse posits that our observable universe might be merely one of an infinite array of universes, each governed by potentially different physical laws (Tegmark, 2003). Another provocative hypothesis is the false vacuum theory, suggesting that the current vacuum state of the universe is metastable and

might eventually transition to a more stable state, resulting in catastrophic consequences for existing cosmic structures (Coleman & De Luccia, 1980).

Recent observations by the James Webb Space Telescope (JWST) have introduced additional complexities, presenting substantial challenges to standard cosmological models. JWST has observed galaxies formed far earlier and more mature than predicted, questioning existing assumptions about cosmic reionization, galaxy formation, and the timeline of the universe's evolution (Adams et al., 2023). These findings suggest that conventional cosmological paradigms may need significant revision or even replacement by models accommodating cyclical or bounce-like processes, such as those proposed by the Big Bounce theory—suggesting the universe undergoes infinite cycles of collapse and re-expansion (Steinhardt & Turok, 2002).

1.3 The Fermi Paradox and Its Implications

The Fermi Paradox remains one of the most profound unresolved issues in astrobiology and cosmology, encapsulating the contradiction between the high likelihood of extraterrestrial civilizations in our galaxy and the complete absence of observable evidence (Hart, 1975).

One influential resolution to this paradox is the “Great Filter” hypothesis, introduced by Robin Hanson and further explored by Nick Bostrom. It suggests that civilizations encounter insurmountable barriers at various stages of their technological or biological development, preventing their longevity or detection by others (Hanson, 1998; Bostrom, 2008). Related theories propose the existence of “guardian civilizations,” highly advanced societies deliberately remaining hidden to monitor or regulate the behavior of emerging intelligent species, thereby preventing destructive outcomes like interstellar warfare or catastrophic technology misuse (Brin, 1983).

Prominent thinkers including Carl Sagan and Stephen Hawking have contributed significantly to the discourse surrounding these hypotheses. Sagan often highlighted the potential for both wonder and existential danger in encountering extraterrestrial life, advocating cautious optimism

(Sagan, 1985). Hawking, however, expressed reservations, emphasizing caution given humanity's historical experiences of encountering technologically superior civilizations (Hawking, 2016).

Recent ethical studies further stress that the decision to broadcast our presence should be preceded by a global debate and ethical review, considering the potential irreversible implications of contact (Ord, 2020; Ćirković, 2021).

CHAPTER 2

CONCEPTUAL FRAMEWORK SPECULATIVE METHODOLOGY

2.1 Theoretical Foundations: *Technological Intelligence and the Ethics of Existential Risk*

Technological intelligence, defined as the capacity of a civilization to manipulate its environment through advanced technological means, stands as both humanity's greatest achievement and most profound risk. As civilizations progress technologically, their potential for self-inflicted existential threats escalates exponentially (Bostrom, 2008). The unique duality of technological advancement—its capacity for extraordinary progress juxtaposed against catastrophic potential—demands rigorous ethical consideration and philosophical scrutiny.

The concept of existential risk, extensively analyzed by Nick Bostrom and other contemporary philosophers, refers to threats capable of causing the extinction of intelligent life or irreversibly curtailing its potential (Bostrom, 2013). Technological civilizations inevitably confront these risks as a byproduct of their own progress. Historically, humanity has already navigated critical existential thresholds, notably nuclear technology and biotechnology, each offering considerable benefits alongside perilous potential outcomes.

Philosophically, existential risk poses significant ethical dilemmas. Traditional ethical frameworks often emphasize immediate and tangible consequences, but existential risk involves probabilistic threats with catastrophic but uncertain outcomes (Beck, 1992). Ethicists argue that our moral responsibility extends to future generations and that it is ethically incumbent upon current societies to ensure their preservation and flourishing (Parfit, 1984).

The ethics surrounding existential risk further challenge the anthropocentric perspective that often dominates ethical discourse. Scholars advocate for expanding our ethical considerations beyond immediate human concerns to encompass a broader spectrum of life and the long-term survival of intelligence itself (Persson & Savulescu, 2012). This shift in perspective is crucial when considering interstellar communication or advanced technological interventions such as geoengineering, artificial intelligence, and quantum manipulation.

Given the escalating capabilities of contemporary technologies, some philosophers and scientists advocate for the Precautionary Principle—an ethical stance recommending restraint and thorough risk assessment before deploying potentially hazardous technologies (Hansson, 1997). In this context, technological intelligence is viewed not merely as a capability but as a profound moral responsibility, requiring careful management, global cooperation, and informed consensus.

Theorists also emphasize the ethical implications of technological singularity—a hypothetical future point at which technological growth becomes uncontrollable and irreversible, potentially resulting in profound and unforeseeable changes to human civilization (Kurzweil, 2005). This notion underscores the urgency for proactive ethical frameworks and international policies designed to mitigate existential threats before technological capacities exceed societal control.

Ultimately, addressing the ethics of existential risk involves fostering global dialogues that integrate multidisciplinary perspectives from science, philosophy, ethics, and public policy. Such holistic approaches are vital not only for safeguarding humanity's future but also for ensuring that technological intelligence remains aligned with the long-term sustainability and ethical integrity of civilization itself.

2.2 Interdisciplinary Speculative Methodology

This study adopts an interdisciplinary speculative methodology, justifying extrapolation as a valid epistemological tool when empirical evidence is incomplete or inaccessible. In fields such as cosmology and existential

risk, traditional empirical methods encounter inherent limitations, necessitating speculative reasoning to explore plausible scenarios beyond current observational constraints. By integrating philosophical inquiry with recent empirical findings—particularly those emerging from the James Webb Space Telescope (JWST)—this methodology provides a robust framework for hypothesizing and evaluating cosmic phenomena such as cosmic loops, universal indeterminacy, and strategic silence (Adams et al., 2023).

2.3 Epistemological Management of Scientific Uncertainty

Scientific inquiry at the frontiers of knowledge is inevitably shaped by uncertainty. Rather than treating this uncertainty as a limitation, our speculative methodology embraces it as a productive force for theoretical development. The unexpected early detection of mature galaxies by the JWST, for example, directly challenges the assumptions of standard cosmological models. Such anomalies highlight the fragility of our current paradigms and underscore the need for open-ended epistemological frameworks.

In response, this study adopts a reflective posture that prioritizes conceptual flexibility and philosophical rigor over premature consensus. By critically analyzing observations that disrupt established narratives—such as the linear expansion of the universe or the singularity-based origin model—we use uncertainty as a lens through which to interrogate the foundational assumptions of modern science. The speculative approach is not an abandonment of scientific discipline, but a structured method for reasoning beyond the empirical frontier. It allows for the formulation of hypotheses that, while not immediately testable, are grounded in existing data and logically coherent frameworks.

This approach seeks to balance empirical constraint with imaginative reach. It acknowledges the provisional nature of current knowledge while encouraging interdisciplinary collaboration to refine, challenge, and expand the boundaries of what can be known. Ultimately, epistemological humility becomes an essential companion to scientific ambition, especially

in a cosmos where silence may signify either emptiness—or an unspoken warning.

2.4 Key Authors and Theoretical Justification

Several influential philosophers and scientists provide foundational support for the speculative framework of this research. Friedrich Nietzsche’s concept of “Eternal Return” offers a philosophical grounding for cosmological cycles and repetitive universes, suggesting a framework where existence recurs infinitely, each iteration bearing ethical implications (Nietzsche, 1882).

Karl Popper’s philosophy of science underscores falsifiability and critical rationalism as cornerstones of theoretical advancement, validating speculative propositions as legitimate if they can be empirically tested or critically challenged, even indirectly (Popper, 1959). Immanuel Kant’s ethical imperative, emphasizing universalizable moral principles, provides a foundational ethical guideline for assessing existential risks and the moral responsibilities of advanced technological societies (Kant, 1785).

Imre Lakatos’s philosophy regarding the progressive nature of scientific theories further supports speculative methodology. According to Lakatos, theories progress by addressing anomalies and integrating novel predictions, thus justifying speculative cosmological models as part of legitimate scientific discourse (Lakatos, 1978).

Finally, Bertrand Russell’s analytical philosophy contributes critical tools for evaluating logical coherence and ethical consistency in speculative propositions, ensuring philosophical rigor within interdisciplinary approaches (Russell, 1945).

Collectively, these thinkers provide the philosophical legitimacy, ethical clarity, and scientific rationale essential for employing speculative methodologies in exploring complex issues surrounding technological intelligence, existential risk, and cosmic phenomena.

CHAPTER 3

RESULTS: COSMOLOGICAL DIALOGUES, CIVILIZATIONAL BEHAVIORS, AND ETHICAL IMPLICATIONS IN LIGHT OF FERMI’S GREAT SILENCE

“Envision the night sky as a vast cosmic amphitheater. Billions upon billions of stars glitter, each potentially hosting its own unfolding story. Yet the silence that suffuses our vantage point suggests more than mere emptiness. It beckons us to wonder whether this stage has been arranged to mute our voices in the void.”

In this section, we present an accessible yet intellectually stirring analysis of three leading contemporary cosmological paradigms—Big Bang, Big Bounce, and Conformal Cyclic Cosmology (CCC)—and explore how each framework conditions the emergence, persistence, and prospect of communication among intelligent civilizations. We then introduce three hypothetical civilizations, categorized by the Kardashev Scale (I, II, and III), and investigate how they might behave in each cosmic scenario. Finally, we analyze the ethical ramifications accompanying each level of technological advancement.

We refrain from inundating the reader with impenetrable equations; instead, we aim to spark a shift in perspective by immersing the audience in the mindset of beings shaped by these cosmic narratives, evoking their hopes and anxieties. The question that ultimately emerges is not simply “Where is everybody?” but rather, “Why does the universe itself seem to conspire to keep us silent, despite its prodigious potential for life?”

3.1 Cosmological Frameworks at a Glance: Three Visions of the Universe and Their Implications for Life

Every cosmological model provides a distinct origin story for the universe and, by extension, a unique set of parameters determining the likelihood that life will appear, flourish, and perhaps even attempt interstellar communication. We begin by delineating each paradigm, emphasizing its essential features and consequences for the “life cycle” of civilizations.

3.1.1 The Big Bang Universe: Expansion, Temporal Limits, and the Fading Beacon of Civilization

Overview of the Big Bang Narrative

Approximately 13.8 billion years ago, our universe emerged from a state of extreme density and temperature—a singular “Big Bang” event. Within the first fractions of a second, a brief but stupendously rapid inflationary phase smoothed out any preexisting irregularities, yielding a large, nearly uniform cosmos. Over time, as temperatures dropped, primordial particles combined to form nuclei, and roughly 380,000 years later, electrons and nuclei formed neutral atoms; this decoupling produced the Cosmic Microwave Background (CMB) we observe today (Bennett et al. 2013; Planck Collaboration 2018). Subsequent gravitational collapse forged the first stars and galaxies within a few hundred million years, seeding heavier elements through supernovae, which in turn enabled the formation of rocky planets. Billions of years later, on at least one such world—ours—life took hold, eventually culminating in a technological species capable of reflecting upon its own origins.

Windows of Opportunity for Life

Within the Big Bang framework, the formation of complex life hinges on a sequence of astrophysical and chemical prerequisites. Massive stars must forge heavier elements via nuclear fusion and then disseminate them through cataclysmic supernovae (Harari 2015; Shields, Ballard & Johnson 2016). Those enriched elements coalesce into second-generation planetary systems, where liquid water, an energy source, and suitable elemental chemistry converge to create the conditions for life. The timescale for this

entire sequence is measured in billions of years. For intelligent, spacefaring life—civilizations capable of interstellar communication—the path is even longer: at least several gigayears must elapse before sufficient planetary evolution, biogenesis, and cultural-technological progress.

The Role of Accelerating Expansion

A particularly pernicious factor in a Big Bang cosmos is the accelerated expansion driven by dark energy (Riess et al. 1998; Perlmutter et al. 1999; Freedman et al. 2020). This acceleration implies that, beyond a growing “horizon,” distant galaxies recede from us at superluminal “recession velocities.” In effect, they become forever unreachable: any signal we emit—even at the speed of light—will never arrive once the galaxies cross the critical threshold. Simultaneously, the cosmic microwave and radio backgrounds, along with interstellar and intergalactic gas and dust, attenuate and scatter our electromagnetic emissions, so that beyond a few tens of thousands of light-years, any radio transmission becomes enmeshed in noise. Consequently, as more regions slip beyond the cosmological horizon, the “listening distance” and “speaking distance” shrink. In due course—on the order of tens of billions of years—even our Local Group of galaxies will become effectively isolated (Riess et al. 1998; Weinberg 2008).

Signal Dispersion and Detectability

Electromagnetic signals weaken in intensity following the inverse square law with respect to distance. This means that the farther a signal travels, the more its energy spreads out across a wider area. For example, imagine a civilization transmitting a powerful radio burst intended to reach another civilization located one thousand light-years away. By the time that signal reaches that distance, its strength is reduced to just one millionth of its original intensity.

If the destination were ten thousand light-years away, the signal would be reduced to only one hundred-millionth of its initial power. And at one hundred thousand light-years—the approximate diameter of the Milky Way—the signal would retain only one ten-billionth of its original flux.

Furthermore, the interstellar medium complicates the picture. Plasma clouds, cosmic scintillation, and background radiation such as synchrotron noise can blur, distort, or completely erase the intricate patterns encoded in the signal. This forces any civilization attempting long-distance communication to use increasingly large antenna arrays and much shorter, more intense signal bursts to have any chance of detection (Tarter, 2001; Benford, Benford & Benford, 2022).

In practical terms, once the distance exceeds several tens of thousands of light-years, standard technosignatures—such as conventional radio transmissions—become essentially undetectable with any realistic telescope or listening technology. This limitation becomes even more severe in a universe with accelerating expansion, where the very fabric of spacetime stretches the distance between sender and receiver, further diluting the signal as it travels (Freedman et al., 2020).

Temporal Windows for Two-Way Contact

If Civilization A sends a radio message today to Civilization B located 50,000 light-years away, it takes 50,000 years to arrive. If B were to reply immediately, that reply would take another 50,000 years to return—totaling a 100,000-year round trip. Over such geologically vast intervals, both civilizations might undergo immense cultural, political, or technological transformations; either side could become extinct or revert to a pre-technological state before any acknowledgment arrives. The accelerated expansion also means that, by the time the reply is in flight, the cosmological horizon may shift, potentially placing B out of A's reachable region altogether (Weinberg 2008; Lin et al. 2014). Thus, true two-way dialogues become virtually impossible unless civilizations arise within a few hundred light-years of each other—a very small fraction of the galaxy's volume.

Summary: The Big Bang's Communication Paradox

- **Shrinking Accessibility:** Dark energy–driven acceleration ensures that galaxies beyond a certain threshold recede forever, severing potential communication channels.

- **Severe Signal Attenuation:** Interstellar scattering and inverse-square dilution render signals beyond tens of thousands of light-years indistinguishable from background noise.
- **Unrealistic Round-Trip Times:** Messaging across tens of thousands of light-years demands timescales longer than most civilizations can survive or remain stable.
- **Inevitable Isolation:** Even if an extraterrestrial civilization receives our brief signal, the reply may never return before galaxies slip beyond reach.

“In a classic Big Bang universe, the cosmic clock ticks relentlessly, propelled by dark energy’s invisible hand. As distant stars disappear over the horizon, every civilization faces the stark reality: shouting into the void for a response that may vanish forever.”

3.1.2 The Big Bounce Universe: Cyclic Renewal and the Quantum Wall That Erases Memories

Overview of the Big Bounce Narrative

Contrary to the classical Big Bang’s singular origin—where space and time cease to have meaning at a finite “zero”—Big Bounce models propose that the universe undergoes an infinite sequence of expansions and contractions. In particular, Loop Quantum Cosmology (LQC), an application of Loop Quantum Gravity (LQG) techniques to homogeneous, isotropic spacetimes, replaces the singular big crunch/big bang with a quantum bounce when densities approach the Planck scale ($\rho \sim 10^{94} \text{ g/cm}^3$) (Ashtekar, Pawłowski & Singh 2006; Bojowald 2008). In this picture, when the cosmos becomes incredibly small and dense, quantum-gravitational repulsion counteracts classical gravity, reversing contraction into expansion. Each cycle includes:

1. **Classical Contraction:** Matter and radiation densities increase as the universe shrinks.
2. **Quantum-Dominated Regime:** Planck-scale physics emerges. Discreteness of spacetime and quantum geometry produce an effective repulsive force.

3. **Bounce:** Contraction halts at a minimal volume, and the universe transitions to expansion.
4. **Classical Expansion:** A hot, dense state resembling a Big Bang emerges; structure formation, star formation, and potential life development proceed similarly to a standard Big Bang scenario.

Erased Records of Previous Cycles

One of the most striking consequences of the quantum bounce hypothesis is the total erasure of classical information at the moment of maximal compression.

In loop quantum cosmology and related theories, the universe does not end in a singularity as in the classical Big Bang model. Instead, it contracts to an extremely dense and hot state, and then “rebounds” or bounces into a new expanding phase. At the very heart of this process—called the bounce—the density of matter and energy reaches values so extreme that space itself is compressed down to scales approaching the Planck length, which is approximately 1.6×10^{-35} meters.

To grasp how small this is: the Planck length is about 20 orders of magnitude smaller than the diameter of a proton. At that scale, our everyday understanding of physics no longer holds. The familiar structures of matter—atoms, molecules, planets, and even stars—cease to exist as coherent entities. Instead, they dissolve into a quantum “foam,” a turbulent background of probabilistic fluctuations governed by the laws of quantum gravity.

As a result, no organized, macroscopic structure can survive this compression. All traces of civilizations, biospheres, or any form of recordable history are effectively wiped out.

Moreover, no signal can pass through this bottleneck unchanged. Whether a message is carried by photons (light), neutrinos, or gravitational waves, the extreme curvature and turbulence of spacetime at the bounce scrambles or absorbs it beyond recognition. It would be like trying to preserve a document in a black hole made of boiling probabilities: the information dissolves in the quantum churn.