SCHODINGER'S CAT HAS SIBLINGS: a guide to infinite alternate realities

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ABSTRACT - The topic of parallel universe make us think about the vast creativity of our human mind. This concept existed even in our ancient texts. Many theories revolve around this concept suggesting infinite possible universes. This paper reviews theories that explore its existence such as quantum mechanics, string theory etc. and we will also explore philosophical, scientific and experimental challenge of validating the concept of parallel universes. With the help of recent studies and advancements we are going to reshape our understanding of reality and our place in this infinite and mysterious space we call our universe.

KEYWORDS

General relativity; Shloka; Zoroastrianism; Greiger counter; Superposition

INTRODUCTION

Have you ever felt that something about the universe seems… different? Or wondered if, somewhere, there's another version of you, living a slightly different life? This is the essence of parallel universes—a fascinating concept that has captivated scientists, philosophers, and storytellers alike. In this paper, we'll explore the theories surrounding parallel universes, uncovering the science and the myths, and sharing insights to feed your spirit of inquiry. What comes in to your mind when you hear the magical words "parallel universe". Many of you will surely conjure images of science fiction films. Now we will know what parallel universe really from an imaginative view for better understanding first. Now let's imagine your mom told you to eat the cake on the dinner table after finishing your food. What will you do? Some of you will eat it instantly and if you are obedient you will listen to your mother. Whatever you do in your universe the opposite will happen in the other universe. This is how multiple universes originate for you when you choose an option. Every option is an answer when it comes to the topic of parallel universes. At first we will learn the history of this topic then we will go on a wild journey of exploring some mind bending theories. Now let's jump to some theories which give us a scientific approach to the topic we will discuss in this paper.

- SCHRODINGER'S CAT
- STRING THEORY
- QUANTUM SUPERPOSITION
- COSMIC INFLATION
- MANY WORLDS INTERPRETATION

This paper is written for all, a kid of age five to a long living adult, anyone who is willing to know about parallel universes can understand this paper. So let us delve deeper in this realm of parallel universes which may no longer remain only on paper and science fiction, but also in our understanding, questioning, and curious mind.

TOPIC
HISTORY OF PARALLEL UNIVERSES • MYTHOLOGICAL ORIGINS • ANCIENT AND PHILOSOPHICAL ORIGINS
SCHRODINGER'S CAT • THE EXPERIMENT SETUP • QUANTUM SUPERPOSITION • OBSERVATIONS • IMPLICATIONS
STRING THEORY
QUANTUM SUPERPOSITION
COSMIC INFLATION
MANY WORLD INTERPRETATION
OVERALL CONCLUSION

HISTORY OF PARALLEL UNIVERSES

MYTHOLOGICAL ORIGINS

क्षित्याक्षिक्षिरे ष क्षिलावृतः सप्तक्षि◌िद शगुणोत्तरै रण्डिोशः यत्र
पतत्यणु◌िल्पः सहाण्डिोक्षि◌ि◌ोक्षिक्षिस्तिनन्तः

kṣity-ādibhir eṣa kilāvṛtaḥ saptabhir daśa-guṇottarair aṇḍa-kośaḥ
yatra pataty aṇu-kalpaḥ sahāṇḍa-koṭi-koṭibhis tad anantaḥ

Bhagvtama – Skanda 6 –Chapter 16 –shloka 37

Every universe is covered by seven layers — earth, water, fire, air, sky, the total energy and false ego and each layer is ten times greater than the preceding one. There exists infinitely many universes beside our universe, although they are infinite in itself, they resembles to atom in our bodies. Therefore **You** (we human beings) are unlimited.

This shloka from the ancient text of Hinduism glorifies the existence of parallel universes. Many more mythologies like Norse, Japanese, Mesoamerican, Greek, Egyptian, Celtic mythologies also have mentions of parallel universes.

ANCIENT AND PHILOSOPHICAL ORIGINS

In the ancient Greece during the 5th century BCE, Greek philosophers Leucippus and Democritus proposed the theory of atomism. They argued that every atom moves through an infinite void. So there can be infinite combinations of atom which could lead to infinite universes where even different beings can exist. Plato's theory of Forms suggested the concept of dual realities. He imagined that every object that exists in this physical world exists as their ideal form in the higher realm.

Zoroastrianism which is also one of the world's oldest religions proposed the existence of spiritual world (good – Ahura Mazda) and material world (bad – Angra Mainyu) each influenced cosmic struggle, thus introduced a form of cosmological dualism.

Jewish mysticism, speaks of the "Four Worlds" – Atzilut, Beriah, Yetzirah and Assiah. The soul is believed to ascend or descend through these worlds in its journey toward spiritual enlightenment.

Egyptians believed that like us humans universe also goes through the cycle of life, death and rebirth. Same for Hinduism also as they believe in this cycle of life of universe. In Hinduism this cycle is divided into four yugas – Satyayuga, Tretayuga, Dvaparayuga and lastly Kaliyuga.

There are numerous mentions of parallel universes in different religious, ancient texts. But our understanding in this topic also evolved through scientific advancements. So now we are going to know about some modern theories in this topic.

SCHRODINGER'S CAT

No worries! We really don't need a real cat to understand this. This is actually a thought experiment designed by Physicist Erwin Schrodinger in 1935. This experiment highlights the concept of superposition and the strangeness of quantum mechanics.

THE EXPERIMENT SETUP

- Imagine a cat inside a sealed box.
- Small amount of a radioactive substance in the same box.
- A Greiger counter (a device to detect radiation).
- A vial of poison.
- A hammer connected to the Greiger counter.

Now this setup listed above works as follows: If the Geiger counter detects radiation from the decay of a radioactive atom, the hammer activates and breaks the vial of poison, the cat dies and if no radiation is detected, hammer is not activated, poison remains intact, the cat lives.

QUANTUM SUPERPOSITION

According to quantum mechanics, subatomic particles can exist in multiple states at once. The chance of the cat dying is 50% and the cat living is also 50%. Until is box is opened and an observation is made, quantum mechanics suggests that the atom exists in both decayed and non-decayed states simultaneously. We will know more about this topic in later chapters.

OBSERVATIONS

Collapse of the wave function takes place when an observation is made. The superposition collapses and we get a specific outcome. Opening the box and observing what is inside, forces the quantum system to choose a state. So when we look inside the cat is alive or dead, not both.

IMPLICATIONS

1. The role of the observer - Until the cat is observed by an observer it is both dead and alive or none. It makes us question whether the act of observation determines our reality.
2. The measurement problem – It challenges how, why and when quantum superposition collapse into a single state upon measurement.

STRING THEORY

String theory is a modern and active concept because it unifies all fundamental forces and explains the true nature of particle, space-time and gravity. It is a theoretical framework that attempts to reconcile general relativity and quantum mechanics. This theory proposes that the fundamental particles, such as quarks and electrons are one-dimensional ‘strings’ rather than point-like entities. Varied frequencies cause these strings to vibrate, and the varied vibrational modes represent the different kind of particles. This offers a possible unified theory, commonly called a "theory of everything," which could describe all forces and particles within one framework.

One of the main motivations for string theory is the incorporation of gravity into the quantum mechanical description of the universe. Standard quantum mechanics, paired with Einstein's theory of general relativity, consistently fails with quantum theory in certain regions where gravity is strong, such as black holes or the Big Bang. String theory promises to provide such a possibility by establishing the quantum description of gravity through the virtual particle "graviton," which mediates gravitational force. Within string theory, graviton is realized by a certain vibration pattern of a string.

String theory further postulates the presence of some extra dimensions beyond the conveniently-presumed three dimensions of space and one of time. The version of string theory specifies that the number of dimensions may vary between 10 and 26. These extra dimensions are compacted, meaning that they are curled up to such an extent that they cannot be observed at everyday scales. The precise structure of these additional dimensions carries profound implications for the laws of physics and the types of particles that exist. Certain distinct versions of string theory like Type I, Type IIA, Type IIB, heterotic-SO (32), and heterotic $E_8 \times E_8$ are known in the literature so far. The essential premise supports duality which states that under certain transformation cohorts, theories that appear to be separately distinct are actually equivalent to one another. M-theory, one of the big breaks in string theory, is more general and incorporates the five string theories and has been proposed to be an 11-dimensional theory.

The framework of string theory describes parallel universes, or multiverses, via the notion of extra dimensions. String theory postulates that the particles we perceive are in actuality tiny vibrating strings-oriented coining into existence in a higher-dimensional space, higher particularly than our familiar three-dimensional space and single-dimension time. Some realizations of string theory possessed 10 or 11 altogether dimensions.

In essence, out of all these dimensions, our universe could actually be just one of many "branes," short for "membranes," these are multi-dimensional objects that may be thought as separate, coexisting universes. Each brane can have its own physical laws and properties. While our universe lies within a three-dimensional brane, others may be included in any configuration with various dimensions, each proposing a separate universe with its distinct attributes.

These parallel worlds might be oriented next door in the higher-dimensional individual space but each remains inaccessible to us. They are able to influence each other in limited cases but would never be experienced at least by us since they belong to higher dimensions. The notion of parallel universes in string theory is linked with the idea of "brane collisions," where the two branes could collide and potentially give birth to a baby universe, or perhaps explaining the nature of an event like the Big Bang.

QUANTUM SUPERPOSITION

Quantum superposition is a principle of quantum mechanics that means particles exist in many states at once until they're measured. Objects in classical physics are said always to possess definite properties-that their position, for example, or their velocity-at any given time. But if electrons or photons-or even atoms and even larger pieces of matter-are the particles in question, quantum theory holds that they do not exist in definite states until observed. This runs contrary to our intuition because it appears as though a particle might be in more than one place or that it may have more than one value for energy or spin orientation.

One of the most discussed and famous thought experiments, which shows the concept of superposition, is Schrödinger's cat. Erwin Schrödinger devised this paradox to show how quantum mechanics can eventually lead to quite absurd scenarios on the macro level. His experiment involves a sealed box containing a cat, a radioactive atom, a Geiger counter, poison, and a hammer. If the Geiger counter detects radiation, it crushes the cat with the hammer, killing it. Quantum mechanics insists that until the box is opened, the cat is in a superposition of being alive and also dead. In reality, though, the act of observation causes the wave function to collapse to one of the two possibilities: the cat alive or the cat dead. This is where the "paradox" of quantum theory really comes into play concerning the application of quantum concepts to larger systems.

The mathematical structure underlying the superposition is described by wave functions and encompasses many possible states. As an example, in a two-state system (such as a photon polarized in two ways), a wave function can be written as a combination of both states. When a measurement is taken, the system "collapses" into one of these states, and the probabilities are calculated from components of the wave function. This is one of the principal ideas in the quantum phenomena and applications, such as in computing. The computer uses this premise for each qubit to have a possible superposition to represent 0 and 1 at the same time, which leads to quantum processors capable of doing enormous computations much faster than their classical counterparts.

Superposition is also important in phenomena like interference and entanglement. Interference arises because of the partial overlap of a superposed wave function, which, through constructive or destructive interference, leads to patterns that are reliable in experiments, such as the double-slit experiment. Entanglement relates particles with a shared state even when they are widely spaced apart. Superposition serves as the basis of both these phenomena, illustrating just how intuitively unnatural quantum systems are. However, direct experimental verification of superposition is difficult due to decoherence, which has the effect of casting quantum systems into pure states by coupling to the environment. Superposition needs to be maintained in specially designed environments and with complete isolation in the laboratory to prevent this collapse. Superposition, of course, is increasingly being shown to be an important ingredient in uses of quantum technology that are finding growing applications in areas such as quantum cryptography-for methods of secure communication and in quantum sensors that achieve accuracy orders of magnitude beyond state-of-the-art.

In summary, quantum superposition means that the classical explanation of a particle in a single state no longer holds because particles can exist in many states simultaneously. Its implications for quantum computing, cryptography, and fundamental research in physics are sure to continue pushing the boundaries of our understanding of reality and reveal how much is not yet seen of the quantum world.

COSMIC INFLATION

Cosmic inflation is a theory in cosmology describing very rapid, exponential expansion of the universe in its earliest moments, strictly within a fraction of a second after the Big Bang. The idea was first advanced in the early 1980s by physicist Alan Guth as a solution to several puzzling problems in the standard Big Bang model: the horizon, flatness, and magnetic monopole problems. It proposes the stage of hyper-fast expansion to explain how one can understand the uniformity and large-scale structure of today's universe through inflation.

- The Horizon Problem: One of the greatest puzzles of early cosmology was explaining how the universe was uniformly hot and dense. Such regions of the universe are separated by billions of light-years and have been outside causal contact since the Big Bang. Still, they appear to possess almost identical properties-such as temperature-within billions of years. This is puzzling because, by the speed of light limitation, insufficient time has passed for regions to exchange information or energy, so we are left with the question of why CMB radiation is so homogeneous. The theory of cosmic inflation implies that the universe was much more compact previous to this inflation, making it possible for the farthest regions to be in thermal equilibrium and almost close to one another. When inflation occurred, the differences in distances of these regions were far scaled apart, explaining their current uniform temperature.

- The Problem of Flatness: In the empirical spatial geometry of the universe, its problem is known as the flatness problem. According to general relativity by Einstein, the average density of the universe would decide whether it happened to be one of the three geometries-classical open, closed, or flat. A closed universe eventually collapses, and anopen universe expands forever. Observations have shown the universe to be incredibly flat with a critical density that is almost perfectly balanced. A balance such as this is very fragile in the standard Big Bang model and a small discrepancy would lead to extreme curvature that governs evolution. Inflation, however, pushes the universe toward flatness as it expands so fast that all initial curvature should become negligible, much like the surface of a balloon which appears flatter as it is inflated; hence the flatness of the universe today is a natural result of inflation.

- The Magnetic Monopole Problem: particle physics theories predict that the universe contains magnetic monopoles - hypothetical particles carrying a single magnetic charge. In the hot early universe, they would have been copiously produced. However, none have been observed and it was a mystery why. Cosmic inflation provides an explanation: such monopoles would be diluted to a statistically insignificant density and dispersed th roughout an exponentially expanding universe, so they become effectively unobservable.

Mechanics of Cosmic Inflation: Inflation relies on the existence of a theoretical field, known as the "inflaton" field, similar to other quantum fields; this field is believed to carry a form of energy that would lead to rapid expansion. Now, when the universe was in an extremely high-energy regime just after the Big Bang, this field would have had a phase transition, sort of like the water freezes into ice. In that process, the inflaton field would have the universe expand exponentially under intense repulsive gravity. Following this short inflationary epoch, the inflaton field decayed into particles and radiation and thus initiated the hot Big Bang epoch where the standard matters and radiation began to dominate.

Quantum Fluctuation and the Emergence of Structure: While inflation goes on, the quantum fluctuations-the minute variations in the energy scale of the inflaton field were enhanced through enormous expansion of the universe. These in turn eventually led to the great macroscopic scale of our universe and matured into galaxies, clusters and cosmic voids. Regions with slightly higher energy densities would attract matter through gravity and thus give birth to stars and galaxies, while lower-density regions turned into the large cosmic voids that we observe today. Inflation thus not only explains the large-scale uniformity of the universe but also accounts for its small irregularities, which are necessary for structure formation.

Observational Evidence for Inflation: Observational support for inflation comes primarily from studies of the CMB and large-scale structure. The CMB’s detailed measurements, especially from the Wilkinson Microwave Anisotropy Probe (WMAP) and the Planck satellite, reveal a pattern of tiny temperature fluctuations that align with predictions of inflation. The statistical properties of these fluctuations, known as the power spectrum, fit the inflationary model remarkably well. Inflation also predicts a nearly “scale-invariant” spectrum, meaning the same kind of variations are observed on different scales, another prediction confirmed by CMB observations.
Additionally, inflation predicts the existence of primordial gravitational waves—ripples in space-time caused by the extreme expansion. While these have not been directly observed yet, efforts to detect them through CMB polarization measurements, like those by the BICEP and Keck experiments, are on-going and would provide further support for inflation.

Extensions and Alternatives: While inflation is a widely accepted theory, certain aspects remain unresolved, leading to alternative theories and refinements. One area of focus is the nature of the inflaton field itself, which remains hypothetical. Another question involves what stopped inflation and allowed the universe to transition to the traditional Big Bang expansion. Proposed refinements, like “eternal inflation,” suggest that inflation could be an on-going process in certain regions of the universe, with our universe being just one “bubble” among many in a larger multiverse. Alternatives to inflation, such as the “ekpyrotic” and “cyclic” models, draw from different mechanisms like cosmic “bouncing” or extra-dimensional collisions to explain the early universe’s characteristics.

Implications for Cosmology and Future Research: Cosmic inflation greatly affects our view of the cosmos; it is that branch of physics, which links quantum mechanics with cosmology, providing insight into the structure and geometry of the universe, and may be hypothesised to connect with multiverse theories. Inflation remains an inspiration that sparks debates and research, mainly concerning its finer details, such as how the inflaton field actually originated. Future work on observational cosmology, for example, the detection of gravitational waves, may add to our understanding or alternative explanations for this role or underscore inflation's role in cosmology.

Conclusion Cosmic inflation, therefore, forms the cornerstone upon which modern cosmology has come to be based, explaining many features of how the universe began and its broad structure. The theory of inflation resolves critical problems in cosmology, like the horizon problem and the flatness problem. It also proposes a means to generate cosmic structure. As this study progresses and science picks up with the advancement in technology, our understanding of inflation, it’s very complicated mechanisms, and their grander implications are most probably set to increase multifold.

MANY WORLD INTERPRETATIONS

The Many-Worlds Interpretation (MWI) of quantum mechanics, brought forward by Hugh Everett in 1957, offers a radical solution to the measurement problem. In the context of MWI, every time a quantum event happens, the universe splits into various branches, each a possible outcome. In this paper, we review the core concepts of MWI, its philosophical implications, mathematical foundations, and interdisciplinary connections. Some of the core concepts are -

1. Wave Function Collapse: The MWI deletes wave function collapse. Instead, the universe splits into various branches.

2. Branching Processes: The MWI uses branching processes. This explains world splitting by every branch to underscore an outcome.

3. Many-Worlds: The MWI states that there exist many worlds that have a separate version of history.

Philosophical Implications

1. Ontological Implications: The MWI brings in question the traditional ontologies regarding reality and existence.

2. Epistemological Reflections: The interpretation reflects on what we know, see and measure.

3. Free Will vs. Determinism: Critics have argued that the interpretation is unclear regarding the free will and determinism.

Mathematical Foundations

1. Hilbert Space Formalism: Quantum mechanics is described in the framework of MWI by Hilbert space formalism.

2. Theory of Probability: The theory of probability is reinterpreted in the context of MWI; it gives a number to branching outcomes.

Critics and Challenges

1. Conceptual Problems: Some Puzzles that the conceptual framework of MWI raises.

2. Empirical Evidence: There is a lack of empirical evidence for the credibility of MWI.

3. Computational Method: Computation of MWI is outside the scope of current computers.

Innovative Applications

1. Quantum Computing: Implication of MWI for quantum computing.

2. Quantum Information: MWI's implication on quantum information theory.

3. Black Hole Physics: Implications of MWI on black hole physics.

Conclusion

The Many-Worlds Interpretation is the philosophical solution to the measurement problem in quantum mechanics, but it also borders on the bizarre. This does not shy away from critique and challenges. Implications for philosophy and cosmology make MWI a very important area of research.

OVERALL CONCLUSION

In tracing the journey related to the concept of parallel universes, we find a path that starts with ancient myths and philosophical inquiries, ending in the most recent progressions in quantum mechanics and cosmology.
Stories and theories of ancient philosophy stand witness to humanity's long and strong curiosity regarding other worlds, forming early speculative thoughts about worlds beyond ourselves. These would become creative fancies that were developed over the centuries into the scientific thrusts of contemporary thinking.

With the advent of quantum mechanics, Schrödinger's cat and the Many-Worlds Interpretation presented a more complex framework for the idea of multiple realities-the possibility that every choice and any number of quantum events created worlds branching off in each direction. Such cosmic inflation and string theory ideas further expanded this idea and posited a universe comprising an infinite number of "bubble" or multidimensional realities existing together but with different specific physical laws and constants.

But they are scientific theories full of promise yet some speculation and unwarranted, yet awaiting validation from empirical study. These theories question what we have learned thus far, give us a peek at possible structures of existence, and for the time being are imaginative frameworks rather than proven realities. This is the nature of ground-breaking scientific exploration: it pushes boundaries but often takes years, even centuries to yield definitive answers.

In conclusion, the search for parallel universes is a spectacular example of the depth of human drive to investigate beyond the known; mythology, philosophy, and science are all woven into a single quest to find understanding. Even if such answers lie far in the future, every step tends to deepen our perception of what reality may be. It reminds us that curiosity and imagination are as important as the science that might one day build on these possibilities into certainties.