

Scientific Theories and the Origin of the Universe

David Bensoussan

The author is a science professor at the University of Quebec

Scientific theories aim to provide frameworks that attempt to explain the origins or ultimate purpose of the universe. However, hypotheses about the first cause are frequently challenged.

The Origin of the Universe

The question of the universe's ultimate origin is unavoidable for any inquisitive mind: What do we know about the origin of the universe? If the universe has a creator, it is natural to wonder what existed before its creation or whether the creator exists outside the universe.

The evolution of the universe seems to follow a temporal arrow, often explainable through causal chains, but its first origin remains enigmatic. Newton questioned why universal gravitation would not eventually cause all celestial bodies to collapse into each other. Yet, it has been demonstrated that the universe is expanding, with matter spreading through space, tending toward maximum entropy and a uniform, lower temperature. The observation that galaxies move apart at an increasing rate suggests the universe began from a single point—a singularity known as the Big Bang. Einstein also hypothesized a universal repulsive force to ensure cosmic stability.

A theory is a set of interconnected and coherent hypotheses, tested and validated by experimentation or observation. The Big Bang theory, supported by evidence of the universe's expansion, proposes that everything began from a single point around 13.8 billion years ago. Before this singularity, neither space nor time existed, rendering the laws of physics inapplicable. Based on general relativity (excluding non-gravitational

forces), it is deduced that mass, energy, and temperature would have been infinite. The Big Bang marks the beginning of everything that followed. At its earliest moment, space was so compressed it nearly disappeared, and time itself was nearly absent. Could time have been born with the Big Bang?

The Planck Wall

In everyday life, time and space are distinct. Yet, they merge in relativity theory, separating only after the Big Bang. This distinction is dated to the Planck time, 10^{-43} seconds after the Big Bang, when the universe's size equaled the Planck length, 10^{-33} centimeters. The Planck wall defines the boundary where our models fail to explain the universe. This transition raises further questions: Did time emerge gradually or suddenly? Was the universe created or self-created? By what physical law or blueprint could this occur?

The Event Horizon

A black hole is a region in space where gravity is so intense that it absorbs all matter and prevents even light from escaping. Predicted by Einstein in 1915 as part of general relativity, black holes' existence was indirectly confirmed in 1971, and the first direct image was captured in 2019.

The event horizon is the boundary of an imaginary sphere around a black hole. It can be likened to a canoe being pulled toward a waterfall – once past the edge, return becomes impossible. The sphere's radius, dependent on the black hole's mass, is called the Schwarzschild radius. Beyond the event horizon, no information or light escapes.

From Black Hole to Big Bang

Similarities between black holes and the Big Bang have inspired bold hypotheses. Both involve a central singularity where gravity plays a crucial role. While black holes are "local" phenomena in space, the Big Bang marks the expansion of space-time itself across the universe.

Gravitational Waves

Predicted by Einstein in 1915, gravitational waves are ripples in space-time caused by the intense acceleration of massive objects, like merging black holes. These waves propagate at light speed, carrying energy across space-time without needing a material medium. They exist outside event horizons. After two black holes merge, the resultant black hole is surrounded by its own event horizon, beyond which no information escapes.

Hawking Radiation

Hawking showed that black holes not only absorb matter but also emit thermal radiation, known as Hawking radiation. Over time, this radiation causes black holes to lose mass and eventually evaporate. This gives rise to the information paradox: General relativity suggests information crossing the event horizon vanishes, yet quantum mechanics insists that information cannot be destroyed. Could this information be encoded in Hawking radiation? Progress has been made in reconciling quantum mechanics and general relativity, but whether information is preserved in Hawking radiation remains unresolved.

This paradox touches the foundations of our understanding of the universe and the interplay between gravity and quantum mechanics. As Richard Feynman wryly noted: "Don't try to understand quantum mechanics, or you'll fall into a black hole and never be heard from again." Nevertheless, exploring these hypotheses deepens our understanding of the universe's origins.

Hypotheses

One idea is a cyclical universe alternating between contraction and expansion. Alexander Friedmann demonstrated that such a model is mathematically viable under general relativity, as is infinite expansion. However, Thomas Gold argued that a contracting universe implies traveling back in time and remembering the future. While expansion remains the dominant hypothesis, other theories, such as continuous matter creation, also exist.

Another bold idea posits the Big Bang as an inverted black hole, characterized by rapid expansion rather than gravitational collapse. Observations from the James Webb Telescope, which studies signals from 13.5 billion years ago, revealed "premature" galaxies existing when matter density seemed insufficient. This challenges existing theories and raises questions: Were there multiple Big Bangs? Could our universe be merging with an older one?

Understanding the Real World

In seeking to understand the universe's origin and fate, we encounter the limits of human knowledge. Current theories, though powerful, leave significant gaps and existential questions. Deists believe in an initial Creator who set the universe in motion, while theists accept an active God intervening throughout. Materialists limit reality to the physical and deny any spiritual dimension.

Every discovery spawns new questions, demonstrating the human mind's ability to grasp part of cosmic order through mathematical concepts and laws. This aligns with Einstein's intuition that "pure thought can grasp reality." Yet, each answer leaves a shadow of mystery, reminding us that our expanding understanding still falls short of unraveling existence's ultimate enigma.

Physicists trust in an underlying order expressible in mathematics. Eugene Wigner famously called this the "unreasonable effectiveness of mathematics in the natural sciences." While a "theory of everything" might reduce the universe's complexity to a single formula, the infinite dimensions of this complexity might elude such reduction.

Do mathematics reflect nature's inherent logic, or are they a human invention fitting observed facts? Does understanding nature's laws mean decoding an objective order or projecting our mental framework onto reality? Science remains dedicated to rational explanations, seeking harmony between physical laws and analytical thought. Yet, questions about paranormal and mystical experiences remain largely unexplored.

Before the Big Bang

Theories like string theory and loop quantum gravity propose frameworks for understanding gravity on both large and quantum scales. String theory envisions particles as vibrating strings within a 10 or 11-dimensional space-time, while loop quantum gravity suggests space-time is composed of tiny "grains."

Both theories remain hypothetical, with no direct experimental validation. String theory sees the Big Bang as the emergence of compressed multidimensional space, while loop quantum gravity views it as a "bounce" following a prior contraction. The multiverse theory posits infinite universes arising from quantum superposition. However, communication between universes remains untestable.

Does an infinite series of universes imply an "original" universe?

The mathematician John Russel illustrates the limits of science and the necessity of a creative force as follows: science can explain through causal relationships how heat affects the agitation of water molecules in a kettle, but it overlooks the fact that it was the decision to heat the water that led to the production of hot water. Regarding the first cause that led to the creation of the universe, he adds: "Either human intelligence ultimately originates in a mindless matter, or there exists a Creator. It is strange that some people claim it is their intelligence that leads them to prefer the first hypothesis over the second."

Metaphysical Questions

Science continually pushes back the boundaries of knowledge, but it never reaches the ultimate frontier. The mystery of the first origin, as well as that of the ultimate end of the universe, remains beyond the reach of human intellectual investigation. It is within these spaces of uncertainty that metaphysics and spirituality step in, attempting to answer questions that lie beyond scientific rigor.

Metaphysics addresses the great questions that physics cannot resolve: the purpose of the universe, the relationship between mind and matter, or the question of free will. Independent of scientific discoveries, these

fundamental inquiries persist, demonstrating that metaphysics continues to challenge us.

These metaphysical questions gain particular significance when one realizes that the emergence of life on Earth rests on an improbable series of circumstances. Can the complexity of the world, with its living organisms and countless differentiated cells that make life possible, be attributed to mere contingency? The precise alignment of their millions of parameters appears so well-organized that it resembles a gigantic machine or a supercomputer. This may lead one to consider the possibility of intelligent design, a near-miraculous coincidence, or even the idea that life and consciousness are the culmination of a cosmic Darwinism, whether planned or not.

Max Planck, one of the fathers of quantum physics, contributed to this reflection by stating: “All matter originates and exists only by virtue of a force... We must assume behind this force the existence of a conscious and intelligent mind. This mind is the matrix of all matter.”

Human Perspectives: Empiricism vs. Innate Structures

Nevertheless, at the human scale, the relationship between mind and the physical world is far from unanimous. For instance, the philosopher David Hume, a leading figure in empiricism, rejected the notions of substance and spirit, claiming that only sensory experience or what could be deduced by rigorous logical reasoning was real. For Hume, our ideas are merely weakened copies of our sensory impressions, and anything that cannot be empirically verified belongs to the realm of speculation.

In contrast, Immanuel Kant argued that the human mind is not a mere blank slate but possesses innate structures, an a priori framework. These categories and forms of understanding – such as space, time, and causality – allow the mind to make sense of experience and engage in analytical thought. For Kant, while knowledge begins with experience, it does not end there; it also depends on these mental structures that organize reality. Thus, where Hume reduces knowledge to the empirical, Kant asserts that the mind plays an active and necessary role in the very constitution of our understanding of the world.

Cosmic Determinism, Chaos, and Contingency

What perspective can we take on physical phenomena on the cosmic scale? A deterministic interpretation of physical phenomena leads to the conclusion that, in a strictly deterministic view, the Creator might no longer have the freedom to intervene in the universe, except to create other universes.

If the Creator is the initiator of a contingent world—contingency being understood as that which could be otherwise, as opposed to what is necessary—then He must leave free will to His creatures.

Between these two approaches, a third vision can be formulated, leading to a mixed view of creation inspired by chaotic systems. These systems exhibit unpredictable behaviors and are highly sensitive to external influences. However, to the great surprise of researchers, chaotic systems, though indeterministic, can display ordered and regular behavior, while still being susceptible to seemingly random external perturbations.

For example, weather illustrates a chaotic system that, although governed by physical laws, is sensitive to minimal variations in pressure or temperature, which can lead to major long-term changes. It is conceivable that the behavior of phenomena in the universe might be a blend of determinism and chance, while still preserving specific evolutionary vectors, leaving room for destinies shaped by consciousness, free will... or external intervention.

The Human Condition and Spiritual Dimensions

Human beings integrate into a single whole the physical, intellectual, emotional, and spiritual dimensions. Physical sciences are primarily existentialist; they focus on the first dimension and disembodify the body from the soul it hosts and that hosts it, as Teilhard de Chardin expresses: “We are not human beings having a spiritual experience but spiritual beings having a human experience.”

The quest for knowledge about the origin of the universe involves scientific, philosophical, and spiritual considerations, leading to the formulation of

original hypotheses. For instance, a quantum event belonging to a set of probable events could generate a quasi-deterministic reality at a non-quantum scale.

This domain of uncertain events is one of the areas that intrigues those who attempt to identify the causality of causalities. It is possible to imagine that the probabilistic nature of quantum physics acts as an intentional disturbance, integrated into a global model that is partially observable through intuitive and deductive judgments.

The duality between what is temporal and what is extratemporal is beautifully illustrated by Angelus Silesius, a 17th-century German theologian and mystic, who wrote :

“Man has two eyes: one sees only what moves in fleeting time, the other what is eternal and divine.”