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# A Study on the Nature and Form of Zero - The Fundamental Principles of Cosmic Origin Philosophy

*Samo Liu*

## ABSTRACT

Zero is the last number invented by humankind and a truly marvellous one. At first glance, its existence appears meaningless—it represents nothing. Yet, when placed before any digit, it changes nothing; when added after, it increases the number tenfold. Multiplying any number by zero results in zero; dividing zero by any number still yields zero; but dividing any number by zero leads to infinity. Zero symbolises the origin of the cosmos—the beginning of all things. While other numbers express the existence and transformation of matter, only zero represents the primordial origin of the universe and the beginning of phenomena.

The cosmic origin is a state of non-material or immaterial existence—not absolute nothingness, but rather the foundational basis of all being. All things arise from such a base point, and that point is zero. Yet, this is a living, yin-yang 阴阳 zero. Let us begin at the beginning and reflect upon the profound significance of this number. The invention of information and knowledge by humanity may indeed serve to explain just this—perhaps it exists for precisely that reason.

Expressed in the language of human-created information: zero is the beginning of the universe and of all things. Returning to zero symbolises balance and the perfect of human knowledge and informatio.

*Keywords:* zero; cosmic origin; energy, information and matter; force, thermodynamics and existence.

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## ABSTRACT

*Zero is the last number invented by humankind and a truly marvellous one. At first glance, its existence appears meaningless—it represents nothing. Yet, when placed before any digit, it changes nothing; when added after, it increases the number tenfold. Multiplying any number by zero results in zero; dividing zero by any number still yields zero; but dividing any number by zero leads to infinity. Zero symbolises the origin of the cosmos—the beginning of all things. While other numbers express the existence and transformation of matter, only zero represents the primordial origin of the universe and the beginning of phenomena.*

*The cosmic origin is a state of non-material or immaterial existence—not absolute nothingness, but rather the foundational basis of all being. All things arise from such a base point, and that point is zero. Yet, this is a living, yin-yang 阴阳 zero. Let us begin at the beginning and reflect upon the profound significance of this number. The invention of information and knowledge by humanity may indeed serve to explain just this—perhaps it exists for precisely that reason.*

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## I. LITERATURE REVIEW: CREATIO EX NIHILO? YES, LET US BEGIN ANEW

Humans emerged within the creation of the universe. That humanity exists is, at the very least, a good thing—from our own perspective. Yet how were we created? That remains unknown. However, humans have invented language, script, and numerical systems, from which knowledge and information have arisen. With these tools, and through philosophical reasoning, let us begin our reflection from the very start.

From current scientific understanding, we know that humans arise from the union of sperm and egg—an integration of yin and yang substances through physical and chemical reactions. These cells originate from the bodies of the parents, sustained and formed through the energy and information derived from food, sunlight, air, and water—a thermodynamic transformation of energy and information in another yin-yang combination (Liu Hongjun & Samo Liu, 2020; 2021a). This process may be described as a physical-chemical reaction, but more fittingly as a thermodynamic causal reaction of "being" and "non-being" (Samo Liu, 2025d), aligning with the philosophy of cosmic origins (Samo Liu, 2025f).

By extrapolation, our parents came from their parents—our ancestors—and so on, back to the very beginning. That origin marks the formation of human cells from a primordial "spatial formal cause"

through processes of accumulation and natural selection. Whose design was this? The god of the cosmos, perhaps.

The formation of cells traversed stages: from plant cells, to animal cells, to human cells (Samo Liu, 2025d). The formation of cells arises from atoms and molecules, whose origins are explained by quantum mechanics and relativity—showing their creation from the equivalence of energy and matter, via particles and quarks that resemble non-material energy and material energy, structured by strong force, weak force, and electromagnetism. Notably, gravity is absent at this stage—it is a secondary force emerging from mass (Samo Liu, 2024i).

Physics tells us: without mass, there is no positionality or distance between material entities (Leibniz, 1996), and thus no gravity. The philosophy of cosmic origins and quantum mechanics reveal that particles may possess mass—or not. This reflects the chaotic initial state from which matter is created (Samo Liu, 2024i).

Every form of existence, whether material or immaterial, possesses a structure. This structure is composed of structural information and information about forces, forming a yin-yang nature of being. Every existence must be accompanied by a process of temporal measurement beginning from zero (a human-made concept), as well as a structural form of existence, movement, transformation, evolution, and change—all measured from zero (also human-made). (Samo Liu, 2025f)

*Note:* Without human-created knowledge and information, the universe cannot be expressed—but regardless of human expression, the universe exists as it is.

Each form of existence carries with it a system of measurement and expression that begins from zero. Without the number zero, the expression of human knowledge and information would lack a point of origin—a coordinate zero-point—from which to begin.

*As stated in the first chapter of the Dao De Jing:*

“无名天地之始;有名万物之母。(untranslation” (Laozi, 2019; Liu Hongjun & Samo Liu, 2021d)

*And in the Heart Sutra:*

“观自在菩萨行深般若波罗蜜多时,照见五蕴皆空,度一切苦厄(untranslation” (Sakyamuni, 2020; Liu Hongjun & Samo Liu, 2024).

These teachings mean that the fundamental origin of humanity and all things is “nothingness无” and “emptiness空” (*wu* and *kong*), and that the initial state of their creation is “being有” (*you*). “Being有” includes quarks, particles, atoms, molecules, cells, and more. The emergence of humanity is a comprehensive result of both material and immaterial forms of existence. Of course, this also includes forces, time, and informational elements. All forms of being possess soul灵魂 and mind心灵.

Those who are alive possess soul灵魂 and mind心灵 all the more. (Samo Liu, 2025d)

Zero is the foundation of the universe—the point of origin, the basis and balance point of philosophical inquiry. Humanity and all beings arise from it. Even in the material world, a coordinate system must have a zero-point origin. All existence begins from this point of zero. In daily life, when we begin something, we often say: “Let’s start.” In the end, we return to zero or a final figure. Zero is a monumental invention of human knowledge and information systems.

Admittedly, with the limits of current human knowledge, we do not know exactly how humanity began—nor do we know how the universe began. Nevertheless, humans have invented language, script,

numbers, mathematics, coordinate systems, and scientific methods—tools of knowledge and information that allow us to explore these questions. We can use philosophy to contemplate them—or even exaggerate and imagine freely through art—because humans possess soul and mind, senses感觉 and perception感知, and a unique capacity for dialectical reasoning. Other animals and forms of matter do not possess such faculties.

Before Aristotle, several great thinkers had already told humanity that both humans and material things originate from the primordial conditions of “nothingness无” and “emptiness空” Many people found this difficult to believe, leading to contradictions. Aristotle launched the tradition of material philosophy, telling us that we should consider humanity and matter to have emerged from material substance, and should study them by category and classification. As for the older philosophical ideas that humans and matter arose from “nothingness” and “emptiness,” he left those to theology. (Aristotle, 2019; 2016)

More than two thousand years later, humanity has reached the scientific pinnacle of quantum mechanics and relativity. Scientific discoveries have verified that matter and life indeed originate from fundamental conditions of "nothingness" and "emptiness." As a result, we are compelled to revisit the ancient cosmological views of our pre-Aristotelian ancestors—this time through the lens of dialectical materialism. (Samo Liu, 2025f)

British author Jeremy Webb edited a volume titled " *Nothing: From Absolute Zero to cosmic oblivion amazing insights into nothingness* "—a collection of essays on scientific philosophy. This work offers substantial inspiration for thinking about the cosmic origin and the philosophy of zero. (Jeremy Webb, 2018).

It is an excellent work of scientific philosophy. The book employs dialectical materialist logic to investigate the meaning of "emptiness," "nothingness," and zero. Rather than reviewing the book in detail here, we may integrate it with Daoist, Buddhist, and Ancient Greek philosophies of cosmological origins, alongside conclusions from modern physics. From this, we can assign to zero a new philosophical significance:

Zero is the informational foundation of the philosophy of cosmic origin.

The book includes a number of essays on zero and "emptiness"/"nothingness," such as:

- Richard Webb's *The Birth of Zero* (pp. 25–32)
- Paul Davies' *The Beginning of Time* (pp. 47–57)
- Ian Stewart's *The Mathematical Magic of Zero* (pp. 129–136)
- Paul Davies' *A Space of Nothing* (pp. 139–145)
- Ian Stewart's *The Ubiquity of Emptiness* (pp. 175–180)
- Michael de Podesta's *Absolute Zero* (pp. 183–193)
- Michael Brooks' *The World of Supermatter* (pp. 233–242)

Richard Webb's research suggests that in 628 AD, the Indian astronomer Brahmagupta published the *Brāhmasphuṣasiddhānta* (*The Correct System of Brahma*), in which the concept of zero made its first clear mathematical appearance. Later, the notion of zero experienced various fluctuations in acceptance and use. In the 17th century, French philosopher and mathematician René Descartes established the Cartesian coordinate system, placing zero firmly and irrevocably at the central and irreplaceable position of all spatial and mathematical representation. (Jeremy Webb, 2018, pp. 25–32)

Who exactly discovered or invented the number zero is not the crucial matter here. What truly matters is that this was one of humanity's greatest contributions across mathematics, philosophy, science, and theology—a pivotal creation in the development of knowledge and information.

Paul Davies posed the question of "*the beginning of time*", though he offered no definitive answer within his article. At the very outset, Davies points out that merely suggesting that science might explain the origin of the universe is enough to provoke passionate responses from both theists and atheists. (Jeremy Webb, 2018, pp. 47–57) Why such strong reactions?

I have written extensively on this issue: because the human mind and its cognitive "software" have long been imprisoned by the material philosophy of Aristotle. For over 2000 years, material philosophy has become a trap for human thought, causing humanity to forget that "*time and space*" are themselves philosophical constructs—creations of human cognition in response to natural phenomena. (Samo Liu, 2025c) This issue will be further explored below, along with a suggested answer.

Ian Stewart, in his article *The Mathematical Magic of Zero*, argues that dealing with zero requires strong conceptual flexibility. Zero represents *emptiness* and *nothingness*. It has brought both anguish and joy to mathematicians. Stewart also notes that *nothingness* is one of mathematicians' favourite themes—a kind of Pandora's box, filled with curiosity and contradiction, sitting at the very heart of mathematics.

Pandora's box has been opened, and what flew out was "emptiness and nothingness." This concept is dazzling, unruly, and provocative—yet essential. The "infinity" introduced by zero can undermine the integrity of mathematical calculations. (Jeremy Webb, 2018, pp. 129–136)

The article shows that the allure of zero is not limited to mathematics—it permeates all of humanity's philosophical thinking. Although it analyses zero from a materialist philosophical perspective, it does not fully explore the deeper meaning of this fascination. This paper aims to offer such an interpretation.

In *A Space of Nothing*, Paul Davies raises the question: *How can "emptiness" separate objects in space or possess attributes such as volume and boundaries?* A possible answer will be offered later, with reference to earlier works I have published.

*Davies points out that the ancient Greeks held two primary conceptions:*

There is a view represented by the perspective of Parmenides, believed that the vacuum was actually filled with an invisible medium—a view inherited and developed by Aristotle. However, from my own study of Aristotle's works, I have found no such development; rather, Aristotle left the concept of "void" to theology and Simplify 'philosophy' into the logical framework of material philosophy and material science.

Another concept is atomism, which believed that the universe was an infinite void filled with innumerable, indivisible particles—*atoms*—which aggregated in various combinations to form matter and physical entities.

The article also discusses the opposing views of Newton and Leibniz on *absolute space*. From my reading, however, I believe that their views were fundamentally aligned. (Samo Liu, 2021c) Leibniz did not deny the existence of absolute space—he simply approached it from a different analytical perspective and ultimately proved its existence. (Leibniz, 1996).

Davies' article touches on the concepts of *fields* and *aether*, as well as the quantum mechanical phenomenon that particles and electrons do not obey Newtonian concepts of space-time. Notably, the article describes quantum theory's astonishing calculation: that an empty box of given volume contains *infinite energy*. Thus, it concludes that a vacuum is not truly empty but is instead filled with boundless energy.



The article ends with the conclusion that *the fate of the universe lies in the nature of the vacuum*. (Jeremy Webb, 2018, pp. 139–145)

This is an excellent piece of science writing that popularises physics and cosmology, though it ultimately leaves the core questions unanswered. These are addressed in my work.

In *The Ubiquity of Emptiness*, Ian Stewart argues that the concept of "emptiness" is, in mathematical terms, an *empty set*. He asserts that zero is a number—the foundation of the entire numerical system. The secret of mathematics lies in the fact that everything reduces to "emptiness."

The article explains the concepts of "nothingness" and zero from a purely mathematical standpoint. (Jeremy Webb, 2018, pp. 175–180) Here, I offer a complementary analysis from the perspective of philosophy.

In *Absolute Zero*, Michael de Podesta proposes that absolute zero is an ideal—unattainable, perfect, and ultimate cold. He asserts that heat is a naturally inherent form of energy. Since the mid-19th century, scientists have tried everything imaginable to get ever closer to this limit. In the process, they discovered a realm of extraordinary beauty and order, enriching the core of science—especially deepening our understanding of temperature and of matter itself.

In my previous writings, I raised a regrettable point: the scientific and technical communities have not yet explored the transformation between non-material and material states from the perspective of the *mass* and *structure* of matter itself.

The article explains how Lord Kelvin established the absolute temperature scale. While scientists typically use the Celsius and Fahrenheit scales, absolute zero corresponds to  $-273.15^{\circ}\text{C}$  on the Celsius scale, and the melting point of ice is represented as  $273.15\text{K}$  on the Kelvin scale.

From this foundation, humanity began the liquefaction of gases and advanced steadily toward absolute zero. Scientists began to recognise the strange transformations that matter undergoes near this limit—phenomena such as superconductivity and superfluidity emerged. It was also discovered that cooling matter near absolute zero reveals its fundamentally quantum-mechanical nature.

(Jeremy Webb, 2018, pp. 183–193)

However, the article does not apply the philosophy of *cosmic origin* to its analysis. It remains grounded in materialist philosophy, using quantum mechanics and relativity to describe the transformations observed near absolute zero—but fails to examine these as possible traces of the transformation between material and non-material realms. This issue will be explored further below.

In *The World of Supermatter*, Michael Brooks writes that cooling matter to absolute zero is equivalent to removing all of its thermal energy—bringing it closer to an ultimate state. At this threshold, a door opens to an entirely new world in which all the familiar laws of physics begin to break down.

This statement closely mirrors the language used to describe quantum mechanics—and, intriguingly, also echoes the metaphysics that Aristotle once handed over to theology.

The article describes how, at extremely low temperatures near absolute zero, many metals lose their electrical resistance and become superconductors. This transformation is not gradual but occurs suddenly—at a critical temperature—where extraordinary phenomena take place.

Brooks extends the discussion by introducing a profound idea: when temperature nears absolute zero and all thermal energy is removed, particles are left with very few allowable energy states. The only

change that can then occur is the swapping of positions among particles, resulting in a change in phase. He introduces bosons and fermions.

(Jeremy Webb, 2018, pp. 233–242)

He also discusses a seemingly single-matter state known as Bose-Einstein Condensate, or BEC for short. In such states, physics appears to transform matter into *energy-matter states* or *information-matter states*—a concept that is undeniably strange.

It is worth noting: once physics begins to describe "*information-matter states*", it steps perilously close to a philosophical dead end. Both science and information science have already clearly defined that information is neither energy nor matter. (Samo Liu, 2024i)

This introduces a monumental philosophical paradox into physics. There is, however, one known exception: the discovery that *hormonal substances* may exhibit target-specific informational properties. (Liu Hongjun & Samo Liu, 2020).

The article, while exploring *the world of supermatter* from the standpoint of materialist philosophy, does not offer concrete answers. It discusses phenomena, not principles. In this paper, I attempt to provide a response through the lens of *cosmic origin philosophy*.

Philosophical foundations of this work:

Daoist philosophy, Buddhist philosophy, Ancient Greek philosophy, and dialectical materialism.

*Scientific foundations discussed:*

Modern physics, systems science, and mineral processing science.

*Core theme*

The mathematical and philosophical functional principles of "*zero*", as a creation of humanity—serving as the philosophical foundation of *cosmic origin*.

## II. DISCUSSION

Humanity has created language, numbers, characters, mathematics, coordinate systems, science, and a wide array of information tools. In the quest for survival and existence, knowledge and information were created, which are now used to study the universe and the existence within it—including the existence of humanity itself. (Samo Liu, 2025g)

The defining characteristic of such knowledge and information is that it is built upon *philosophical reasoning* and represents a standardised, formatted, and unified system of information. The object of study is the universe and all forms of existence within it, including human society. What is sought is *cosmic truth*, and what is used are tools of human information. The information and knowledge generated through these tools are inherently incomplete, evolving, exploratory, and non-absolute.

Humans pursue truth, but the knowledge and information we create can only represent *relative truth*, never absolute truth. Humanity's current mode of thought follows the tradition of *post-Aristotelian material philosophy*—treating the universe, all within it, and human society itself as fundamentally *material* existences to be studied scientifically. Similarly, the "universal truths" uncovered by science are not absolute but relative and always subject to change through exploration.

The cosmological ideas of our ancestors concerning the *origin of the universe*—due to the limited information available in ancient times—were deferred by Aristotle into the realm of *theology*. He set aside the ideas of *emptiness and nothingness* as the cosmic origin, and instead boldly developed the



disciplines of *material philosophy* (First Philosophy) and *material science* (Second Philosophy), leading to tremendous advancement in human knowledge and information.

However, upon reaching the peak of scientific development, humanity has now found that what was once deemed metaphysical and relegated to theology is being *validated* by modern physics. The phenomena emerging from modern physics can no longer be adequately explained using only the frameworks of materialist philosophy. Thus, we must revisit and re-integrate the ancient philosophies of *cosmic origin* to *supplement and complete* the current systems of knowledge and information. We are now required to take the fruits of materialist philosophy and material science, and—together with ancestral philosophies of cosmic origin—reconstruct or re-invent human knowledge and information... starting from zero.

## 2.1. The Philosophical Foundations of the Study of Zero

Ancient Greek philosophy's study of cosmic origin is most clearly reflected in Parmenides' ontology of origin. In *Physics*, Aristotle once provided a detailed logical critique of this ontological framework. He believed that denying such a "void-based ontology" was relatively easy, yet he did *not* deny it outright. Instead, he acknowledged its form of "existence" but felt insufficiently informed. (Aristotle, 2019)

As a result, in *Metaphysics*, he solemnly assigned this "void-based ontology" to the domain of theology. (Aristotle, 2016) He then earnestly designed a logical classification: material philosophy as *first philosophy*, and material science as *second philosophy*—thus beginning a new intellectual journey for humanity. (Garrett Thomson & Marshall Missner, 2019)

Whether one praises or criticises Aristotle's philosophical concepts, it remains a fact that Western philosophy and science evolved within the framework he designed.

Modern humans have created the digital, mathematical concept of zero. Meanwhile, modern physics and modern science have introduced the yin-yang notion that matter—atoms—originate from nothingness, energy, and information. We must now begin to sort through this concept starting from zero.

The conceptual roadmap includes several yin-yang domains, as follows:

### 2.1.1 First Yin-Yang Domain

*Absolute Zero and Absolute Space –*

Zero-dimensional absolute space, with zero time. Time cannot be defined. Spatial form is infinite—no length or distance units can be specified. Energy and information exist as infinite *void and nothingness*. This is the cosmic origin, the starting point of the material universe, and the *existence* referred to by Parmenides.

### 2.1.2 Second Yin-Yang Domain

*Dark Matter and Dark Energy –*

The concept of non-material energy and information. These forms lack materiality but possess *structural spatial form*. Though their exact structures are unknown, they are non-material and non-three-dimensional. They do not correspond to absolute zero temperature. They could be termed "zero-dimensional," or given alternative nomenclature. Structure implies process; while the time unit is currently unknown, a new physical time unit could be invented.

### 2.1.3 Third Yin-Yang Domain:

#### Quantum Mechanical Energy and Information –

Here begins the emergence of *materialised energy*. The categories of *fermions* and *bosons* have been named. These structures exist in a liminal state—between material and immaterial. For bosons, they should be treated based on information about time and force. (Samo Liu, 2024b; 2024i; 2025c).

Fermions can be interpreted with reference to Prof. Edward Witten's M-theory, though the boundary between material and non-material, as well as gravitational mass, must be clearly defined. *Mass* gives rise to *position* and *gravity*; *structure* gives rise to *charge position* and *electromagnetic force*. Time can be measured in Planck time, and distance in Planck length. (Samo Liu, 2025c)

### 2.1.4 Fourth Yin-Yang Domain:

#### Matter –

Here, matter formally emerges in a *trinary yin-yang duality*—the Tai Chi of yin and yang. (Samo Liu, 2025g) In this realm, the study of time and mechanics is well-established. Both mechanics and time reflect the dynamics of thermodynamic motion and transformation. (Samo Liu, 2024i; 2025c; 2025e).

Space is described using a three-dimensional coordinate system, while time uses standard human-defined units of time and length. These time and space units are *inflexible, irreversible, and fixed* within the framework of physics.

### 2.1.5 Fifth Yin-Yang Domain:

#### Motion and Energy Conversion of Matter –

Thermodynamics explains all mechanical and temporal processes of existence. The transformation between matter and energy takes place in three-dimensional space. Through the interplay of time and force, these transformations occur as *yin-yang exchanges*. In this domain, spatial units may be measured in light-years or parsecs; time may be measured in kalpas (“劫”, a cosmological time unit). (Samo Liu, 2025c)

From the second to fifth domains, we define the realm of thermal energy-based material existence. The total energy of the universe is expressed as negative entropy:

- E = Total energy of the created universe
- E1 = Energy of material mass
- E2 = Energy of material motion and transformation
- E3 = Quantum mechanical energy involved in creating material mass
- Ex, Ey = Dark matter and dark energy

If the total energy of the universe is represented as 100%, then:

$$\begin{aligned} E_x + E_y &= 95.1\% \\ E_1 = E_2 = E_3 &= 4.9\% \text{ (Samo Liu, 2024g; 2024h)} \end{aligned}$$

E1, E2, E3, Ex, and Ey undergo mutual transformation under thermodynamic conditions of force and time—forming a Tai Chi of yin and yang. (Samo Liu, 2025g)

*The first domain is named:*

The Infinite—Wu Ji of Yin and Yang. (Samo Liu, 2025g)

The previous article, “*Wu Ji*无极 and *Tai Ji*太极, *Yin–Yang*阴阳 and *Heaven–Earth*乾坤”, outlined a model of the physical universe based on the philosophical thinking of *cosmic origin*. (Samo Liu, 2025g; 2024h; 2024i) This article, in contrast, begins from zero to explore the framework of *existence* itself.

In Buddhist philosophy, ideas of cosmic origin are concentrated in the *Diamond Sutra* and the *Heart Sutra*. (Sakyamuni, 2020) It holds that the world is material, and that the origin of matter lies in “emptiness空” (*śūnyatā*). Emptiness does not mean nothing at all; rather, to comprehend emptiness is to attain enlightenment, known as *Anuttara-Samyak-Sambodhi*阿耨多罗三藐三菩提. (Liu Hongjun & Samo Liu, 2024)

Regarding *space*, true space cannot be defined by humanity. The space humans understand is the three-dimensional coordinate system of physical matter.

Regarding *existence within space*, everything is expressed in terms of ‘Cause’ 因 and ‘factor’s因素 “conditions” 缘—a binary nature. When conditions change under a cause, this process is termed *pratitya-samutpāda*缘起 (dependent origination), or *causal relationship*因果关系. The direction and pathway of transformation is called *du*度 (degree/measure/process), and the means and purpose of this transformation is called the *Middle Way*中道. (Liu Hongjun & Samo Liu, 2024)

Different forms of existence correspond to different time scales. In Buddhist philosophy, the time unit for understanding the universe is *kalpa* (劫). In contrast, human-created time units are exceedingly brief when viewed from this perspective.

The last words of Sakyamuni Buddha in the Diamond Sutra are:

“一切有为法，如梦幻泡影，如露亦如电，应作如是观 (*untranslation*).”  
(Sakyamuni, 2020; Liu Hongjun & Samo Liu, 2024)

All forms of existence have structure and form, and can be represented through process. From emptiness they arise, and to emptiness they return. In other words, whether in form or in process, all things begin at zero, undergo a structured journey (expressible through numbers or mathematics), and eventually return to zero—only to begin again.

This cyclical existence and transformation corresponds with the five *yin–yang* domains previously defined.

*Emptiness* is the origin 本原—and the beginning—which is zero.

Daoist philosophy systematically explores cosmic origin. The roots of this philosophical system begin with the *I Ching*, or *Book of Changes* (Samo Liu, 2025e), and are systematised in Laozi’s *Dao De Jing*, as well as in the *Wenzi*, *Liezi*, and *Zhuangzi*. (Laozi, 2019; Liu Hongjun & Samo Liu, 2021d)

In the *Dao De Jing*, space and existence are described comprehensively:

“道可道，非常道；名可名，非常名。无名天地之始，有名万物之母 (*untranslation*).”

Here, “无名天地之始” describes the primordial existence of space and the universe. “有名万物之母” describes material existence within space. The opening lines tell us that humanity will *always* need to explore space and its contents—the limitations of language, mathematics, coordinate systems, and even science mean we will never fully explain them. The universe is a fusion of “*being*有” and “*non-being*无.”

In the *Wenzi*, Space and the existence within is described as:

“四方上下谓之宇，往古来今谓之宙. (*untranslation*).” (Wenzi, 2019)

This implies that space may be understood as a three-dimensional realm (“above and below, left and right”), and the material within it exists with beginnings, changes, and movements. Every existence will eventually end. One must consider both the *structure* and the *process* of existence—*form* and *time*—to perceive life itself. This is the cosmic-origin method of observing all phenomena.

This view of spatio-temporal existence is remarkably similar to Einstein’s four-dimensional spacetime. All things have a beginning and an end, moving and transforming from zero to some value, and then returning to zero—manifesting the states of *yin* and *yang*.

Perhaps the most poetic expression comes from *Zhuangzi*, in *Gengsang Chu*:

“有实而无乎处者宇也；有长而无乎本剽者宙也。(untranslation”

(*Zhuangzi*, 2017)

“有实而无乎处者宇也。”Interpreted through cosmic origin philosophy: tangible matter—like Earth, the solar system, or the Milky Way—occupies *somewhere* in space. But without a coordinate system constructed by humans, we cannot describe where. Furthermore, it suggests that tangible matter originates from *emptiness*. To represent such material existence, a coordinate system must be established—and the *origin* of this system is zero. This is the existence of *yang*阳.

“有长而无乎本剽者宙也。”*Zhou*宙 is a form of *yin*阴 existence. It governs the motion and transformation of *yang*阳 entities. It is an informational existence that cannot act upon itself—like *force*, which cannot affect force itself; or *time*, which cannot affect time itself. This force acts only on *yang* entities and is beyond self-perception. In *Dao De Jing* Chapter 21, it is referred to as *jing*精 (spirit 精神) and *xin*信 (information 信息)—the *soul*灵魂 of the cosmos. It is what animates and transforms the universe and all things within space and time.

The *spirit, mind, and soul of the universe* governs all creation, motion, change, and cycles—beginning from zero.

In *Dao De Jing* Chapter 38, it is said:

The highest benevolence of the cosmic mind is balance. Balance remains the origin of the coordinate system, zero. This *balance* is again the origin of the coordinate system—zero. (Liu Hongjun & Samo Liu, 2021d)

The origin of all things is zero. The end may not always be balance, but it is always the conclusion of a structured process—followed again by a return to zero.

The *Liezi* describes the creation of the universe in four stages:

太易、太初、太始和太素 (untranslation. (*Liezi*, 2016)

Each stage represents a structured process beginning from zero—corresponding to the first to the fourth domain outlined earlier.

Later scholars such as Zhang Zai (*Qi Theory*), Zhou Dunyi (*Tai Ji Diagram Theory*), Zhu Xi (*Neo-Confucian Principle Theory*), and Wang Yangming (*Mind Theory*) further systematised and enriched the Daoist philosophy of cosmic origin—retelling the Philosophical Stories of all existence beginning from zero and striving toward balance.

Zero represents *nothingness* and *emptiness*. It does not signify non-existence, but rather the *origin* of the universe—the beginning of all things and their continual cycles of change. Ultimately, the purpose of the cosmos is still balance, and its *essence* remains the origin point of the coordinate system: zero.

In the language of physics:

The universe is a thermodynamic process.

Therefore, relativity in physics is not only Einstein's *Relativity of Mass and Motion*, but also Lord Kelvin's *Thermodynamic Relativity of Absolute Zero*. (Samo Liu, 2024e)

Einstein's special relativity represents the limit and infinity of material motion—that is, zero. There is no speed beyond light, no curvature of space-time—only *perception, life, and transformation of existence*.

Lord Kelvin's theory of *absolute zero* similarly points to one truth: *The beginning and end of the universe is Absolute Zero*.

Note: "*Absolute Space*" was proposed by Newton, but it was Leibniz, who *opposed* the idea, that ultimately *proved* it. (Samo Liu, 2020b; 2021c)

Thus, it may be referred to as the Newton–Leibniz Absolute Space.

The author calls it the Zero-Dimensional Universe—the origin of all things. It can exist without matter, distance, or velocity, but within it lie the yin-yang forces of Wu Ji (Infinite Nothingness Existence) and Tai Ji (Limited Yin and Yang Existence)—a living existence, which we call Zero.

The above presents a philosophical response to the questions posed by the essays in *Nothing: From Absolute Zero to the Forgotten Corners of the Universe* (Jeremy Webb, 2018), including:

Richard Webb's *The Birth of Zero* (pp. 25–32)  
 Paul Davies' *The Beginning of Time* (pp. 47–57)  
 Ian Stewart's *The Mathematical Magic of Zero* (pp. 129–136)  
 Paul Davies' *A Space of Nothing* (pp. 139–145)  
 Ian Stewart's *The Ubiquity of Emptiness* (pp. 175–180)  
 Michael de Podesta's *Absolute Zero* (pp. 183–193)  
 Michael Brooks' *The World of Supermatter* (pp. 233–242)  
 It is offered as a contribution for academic discourse.

## 2.2. The Physical Foundations of the Philosophical Study of Zero

American author and physicist Professor Lawrence M. Krauss wrote a book titled "*A Universe from Nothing*", applying the logic of materialist philosophy and conclusions from material science to depict, in the language of physics, a material universe originating from *emptiness* and *nothingness*. (Lawrence M. Krauss, 2022) From the perspective of materialist thought, it is a popular science work that seeks to explain the philosophy of cosmic origin through scientific reasoning.

Undoubtedly, Professor Krauss is a staunch defender of materialism. The book is replete with a tone of debate against religion—a tone I do not admire, nor participate in.

My own philosophical standpoint draws from religious philosophy, modern physics, and mineral processing science and technology. I have written several books and articles on this subject. I understand that all current human knowledge and information is built upon the foundations of post-Aristotelian materialist philosophy and science. (Samo Liu, 2025g) Whether in religious or scientific circles, human-created systems of knowledge—constructed from language, text, and numbers—remain confined within the paradoxes of Material Philosophy.

The problem of truth demands more than debate—it requires *verification, supplementation, and refinement* through scientific knowledge and information.

Modern physics itself is rife with contradictions. For example, the theoretical tension between quantum mechanics and relativity is a result of confinement within Material philosophy. But this is ultimately a



philosophical problem—not one to be debated with religion. Ironically, while Professor Krauss declares that we no longer need philosophers, *he himself is a remarkable philosopher of physics*.

The book is professionally written. As an outsider, I would not presume to critique its technical content. Yet from the standpoint of *cosmic origin*, I believe Professor Krauss has provided a scientific explanation of a "*universe from nothing*." The book comprises 11 chapters, each insightful and expertly articulated. (Lawrence M. Krauss, 2022)

*Chapter 1* discusses the origin of the universe and presents *the Big Bang* as the starting point. This aligns well with the thermodynamic interpretation within the philosophy of cosmic origin.

*Chapter 2* examines how the universe might end. Rather than indulging in various speculative end-of-universe theories common in cosmology, Krauss introduces the concept of *dark matter*. On page 25, he posits: *If we can determine the nature and abundance of dark matter, then we will be able to ascertain the fate of the universe*.

Clearly, Professor Krauss does not seem to engage with religious cosmology or the cosmic origin philosophies found in Aristotle, nor those proposed by Descartes, Newton, Kant, Schelling, or Hegel. In his rejection of a *personal God*, he also implicitly dismisses Schelling's idea of *God as the spirit of nature*. Nor does he appear to consider the perception of existence, the dialectical *yin–yang* nature of life in the universe, or the interplay between *information and energy*. He seems to overlook the philosophical foundations of space and time. (Samo Liu, 2024i)

On page 25, he discusses Einstein's general theory of relativity and the idea of *spacetime curvature*. Krauss praises this theory and accepts the confirmation of spacetime curvature through the bending of light around the Sun.

I have written nine papers analysing the philosophical contradictions between quantum mechanics and relativity from the perspective of cosmic origin. In them, I critique the fallacy of *spacetime reversal*, which I see as a materialist misjudgement of the nature of space and time. (Samo Liu, 2024g–2025f)

In my own study of Einstein's writings, I have found no evidence that he deeply investigated the *philosophical origins* of space and time. From the standpoint of cosmic origin thinking, I conclude that *spacetime reversal* and *higher-dimensional space physics* are philosophical absurdities. I urge the academic community to evaluate these conclusions with the tools of scientific philosophy.

*Chapter 3*, titled *Light from the Beginning of Time*, resonates—at least in name—with the present article. Here, I propose that *light* is the zero point of time, and likewise the zero point of natural form. This *light* is not the conceptual light known in human language, but a synthesis: the *light of physics*, the *light of theology*, and the *light of philosophy*, all emanating from *absolute zero* within the *absolute space of cosmic origin*.

Evidently, Professor Krauss does not approach it from this angle. Instead, he discusses how to *measure the total mass of the universe* and *calculate its curvature*. Yet this chapter still offers insights into space, time, and existence within space. It inspires reflection on why Einstein proposed *spacetime curvature* in the first place, Einstein's books does not provide a basis for *spacetime reversal*, and opposes theories of *faster-than-light* travel.

*My reflection on relativity is this*: when the velocity of matter approaches the speed of light, we must *re-examine the original nature of time and space*—and liberate ourselves from the constraints imposed by Aristotelian Material Philosophy.



*Chapter 4*, titled *Nothing Comes from Nothing*, is where Professor Krauss, after summarising the achievements of relativity and quantum mechanics, confronts the questions of *the origin of matter and existence within space*. His answer is clear:  
The origin is “Nothingness and Emptiness”—that is, Zero.

This chapter introduces the concept of antimatter. From the perspective of cosmic origin philosophy, I argue that the existence of antimatter represents a misjudgement within the philosophy of physics. (Samo Liu, 2025e) It may in fact be a physical manifestation of *yin-type informational existence*—that is, the “living” informational dimension of the universe. I invite the academic community to explore and debate this interpretation.

This chapter also raises the issue of the “*non-emptiness of vacuum*”. From the standpoint of cosmic origin philosophy, *emptiness* or *nothingness* does not equate to non-existence. Instead, it refers to the presence of *yin and yang* in the form of *energy and information*. This is a form of existence in a *non-material* state—a manifestation of the *infinite yin–yang Wu Ji*, the very essence of zero.

On page 56, Professor Krauss makes a profound statement:

“Particles can emerge from nothing.”

This is a *foundational principle* of cosmic origin philosophy. It extends beyond particles: dark energy and dark matter, quarks and particles, atoms and molecules, cells and humans—all originate *ex nihilo* (from nothing), and are then followed by *being generated from being*.

The “non-doing that does 无为而为” of the *cosmic Dao* 道 governs the creation, motion, transformation, and cyclical processes of all things in space and within space.

*Chapter 5*, titled *The Runaway Universe*, discusses the expansion of the cosmos and the role of *dark energy*, touching upon the *unknowable* aspects of physical cosmology. From a cosmic origin philosophical viewpoint, I argue that if physics and cosmology persist in following a purely Material Philosophy framework, they will inevitably encounter more *unknowable phenomena*. These may, however, be solvable if re-approached through the lens of *cosmic origin philosophy*.

In *Chapter 6*, Professor Krauss applies materialist philosophical reasoning to debate whether the universe is *flat or curved, open or closed*. This is a classic Material Philosophy framework, and in my view, *cannot yield definitive answers*. According to cosmic origin philosophy, the universe is a union of emptiness and existence. Therefore, a synthesis of cosmic origin philosophy and materialist reasoning is required to approximate a more accurate answer.

The final sentence of this chapter reflects a recognition of this perspective. On page 77, he concludes:

"The universe emerged from nothing. Indeed—so it did."

Chapter 7 presents a melancholic reflection on the *future of the universe*—collapse, expansion, the Big Bang, black holes. These are not hopeful metaphors for cosmic destiny. So what should we do?

The emotional tone of this chapter mirrors my own when writing the sixth article for Great Britain Journals Press. (Samo Liu, 2024f) I was moved to tears as I wrote it.

In truth, *there is nothing to be done*. This is simply the nature of the universe—its natural existence, natural transformation, and natural cycles. Humanity is a form of intelligent matter, having created language, writing, numbers, and other informational tools. With these tools, we explore truth, express existence, and express emotion. Yet human information-processing capabilities can easily amplify or distort natural phenomena.

Consider the dinosaurs—once the rulers of Earth. They disappeared without such emotions, because they lacked the cognitive framework to possess them.

In my writings, *The Origins of the Universe*, *The Origins of Humanity*, and *The Survival of All Things*, I discuss this question. There is no need for humanity to resent the universe.

From the perspective of *cosmic time* measured in kalpas, the current state of the material universe we inhabit is one of *temporary equilibrium*. We have assigned this balance to human time units—years, months, days. These units may be cosmologically imprecise, but for our present moment, they remain relatively stable.

This relative temporal equilibrium has been *solidified* into our everyday time: years, months, days, hours, minutes, seconds.

However, the philosophical stance of modern physics has made the mistake of imagining these time units as capable of *bending* and *reversing*. This is impermissible. (Samo Liu, 2025e)

What matters now is how humanity survives and exists. We must use our own achievements to protect ourselves, rather than facilitate our own demise.

This calls for *collective human reflection*, and such reflection must be guided by cosmic origin thinking. In *Chapter 8*, Professor Krauss uses rigorous physics to explore the concept of vacuum energy. However, it may be inaccurate to describe the presence of yin and yang in space merely as *energy*. While physics translates matter into energy through equations (and can precisely express it as  $E_1 = E_2 = E_3$ ), (Samo Liu, 2024h)—the reverse process of expressing *energy as matter* requires *new terminology* in physics to describe the "zero-existence" of *emptiness with perception*.

This chapter also touches upon the *multiverse* and the *centre of the Milky Way*. Professor Krauss discusses *Professor Witten's M-theory* with a degree of satire. Personally, I both *admire* and *oppose* this theory. I admire its *mathematical brilliance*, but I oppose its philosophy of higher-dimensional space, which violates the foundational principles of cosmic origin, breaking through the fundamental truths of space and time.

*This will be further discussed later.*

This chapter also delves into *extra dimensions* and a possible *grand unified theory*, exposing many of the contradictions and dilemmas within modern physics. While Professor Krauss claims to have no need for philosophers, his search suggests a deep longing for philosophical insight.

*Chapter 9* presents a key conclusion: *the laws of nature are everything*. Professor Krauss avoids the concept of a *cosmic deity*, but he nevertheless emphasises the importance of the idea that the universe emerged from nothing, posing the fundamental philosophical question:

*"Why is there something rather than nothing?"*

This is a question that cosmic origin philosophy is well equipped to address. I have written several books and numerous articles in an attempt to answer precisely this question.

Chapter 10 attempts to resolve this question using the methodology of physics and materialist philosophy.

On page 110, Krauss states:

Given the right conditions, not only can something arise from nothing—it inevitably must.

On page 111, he asserts:

*Vacuum instability leads to the production of matter.*

Cosmic origin philosophy offers a parallel but deeper view: imbalance is a vital phenomenon of the *yin-yang* cosmos and a core principle of its origin. Imbalance initiates *thermal motion* between yin and yang—thermodynamics is the foundational logic of creation in the universe. Thermodynamics governs the full cycle of creation—from *information to energy*, to form, and back again. This cycle entails a *mutual process of perception—time*—which is inherently tied to *balance*.

One may find this same logic in *Daoist, Buddhist, and Ancient Greek* philosophies of cosmic origin, as I have explored in my published works.

On page 117, Professor Krauss proposes a bold idea: (in Chinese)

The total energy of the universe is precisely zero, and the net charge in a closed universe must also be zero.

On page 120, he concludes:

“Quantum mechanics not only permits a universe to arise from nothing—it *requires* it.”  
He argues that “*nothing*” means the absence of space, time, and everything else, because *nothing* is unstable.

Cosmic origin philosophy holds a different stance: *space and time* are *human-created philosophical constructs*, invented to describe the *form* and *process* of existence. If quantum mechanics and relativity have indeed demonstrated that the universe can emerge from nothing, then we must *break free* from the constraints of Material Philosophy, and *reconceptualise space and time* from their origins—establishing a new coordinate origin, *beginning at zero*.

*Chapter 11* deals with the notion of creation. On the surface, Professor Krauss appears to oppose religion, but in reality, he is paying it a kind of respect. He proposes that God is best invoked to explain the origin of *morality*.

I do not claim to be a scholar of religion, but I do admire the cosmic origin philosophies of *Daoism and Buddhism*.

Human beings invented the concept and vocabulary of *morality* to regulate their behaviour and thoughts.

I believe that *Laozi* used the term *Dao De* (道德, the Way and its law) to express the laws and principles that govern the universe.

The *personified God* is a beautiful human creation—and has become the object of faith for many. In my view, the reason humanity created a personified deity was to express *awe and reverence toward the natural universe*.

I believe in a “*God of Cosmic Nature*”—a form of existence long ago conceived by our ancestors—and that modern physics has already *proven the existence* of this god, albeit unknowingly.  
(Samo Liu, 2024g)

Physicists have discovered and confirmed the existence of such a “god,” yet remain unaware of it—just as Leibniz proved the existence of absolute space, while many still misunderstood him as its opponent. The *credit or fault* for this confusion lies with Aristotle, who 2,000 years ago constructed the *Material Philosophy framework* that continues to shape human thought.

*This issue, too, deserves academic reflection.*

This chapter also references *Aristotle's definition of God* as the "*Prime Mover*". Reading Aristotle, one can interpret him from multiple perspectives. In my view, Aristotle's "Prime Mover" corresponds with the totality of forces studied by modern physics. These forces are the *angels* of the *God of Cosmic Nature*.

(Liu Hongjun & Samo Liu, 2020; 2021a; 2021b)

Two thousand years ago, Aristotle lacked the scientific knowledge to explore such forces in full. He therefore left the question of the first cause to theology and urged humanity to focus instead on the development of material philosophy (first philosophy) and material science (second philosophy).

Today's scientific achievements owe much to him. *Aristotle is one of the greatest physicists in history—the intellectual founder of physics itself.*

The final sentence of this chapter asks:

Why is there something rather than nothing?  
And answers:" Because things do not last.

From the viewpoint of *cosmic origin thought*, anything that can be expressed in *language, text, or numbers* must necessarily possess a *structured beginning and end*. Every existence has a start and finish to its process. In form, it follows a cycle from *zero to zero*; in process, it travels from *zero to a value*, then back to *zero*. None of these concepts imply permanence or eternity.

Even as we discuss the origin and existence of the universe today, the truth remains: *let us begin at zero.*

*What may be eternal?*

Perhaps *space and the existence within space*—we do not yet know what these are.

For now, let us express them through the language of physics.

them be: God and Zero.

Let us explore them, Let physics begin—from *emptiness and nothingness*—to explore the yin–yang life process of existence.

### 2.3. The Mathematical Foundations of the Philosophical Study of Zero

Mathematics was always my weakest subject. Fortunately, cosmic origin philosophy holds that *mathematics and numbers* are merely informational tools used to study *matter* and *material existence*.

*To explore cosmic origin, one needs only study zero.*

Richard Webb's *The Birth of Zero* (Jeremy Webb, 2018, pp. 25–32) and Ian Stewart's *The Mathematical Magic of Zero* (Jeremy Webb, 2018, pp. 129–136) are both outstanding essays—valuable mathematical works for studying *zero* as the key to the universe's origin.

Mathematics and numbers are tools created by humanity for survival and existence. They are also the instruments of science, vital for understanding the material world and the nature of physical existence. Yet if humanity's philosophical thinking is flawed, *mathematics can mislead thought itself.*

The invention of four-dimensional spacetime coordinates is a magnificent achievement. However, it led to an unfortunate side effect: it nudged human thought into higher-dimensional space, and this very shift has prompted the re-evaluation of the concepts and origins of *space and time*.

The mathematician and philosopher I most admire is Professor Edward Witten. I deeply respect his mathematical genius, but I fundamentally disagree with the philosophical thought of M-theory. This theory of *multidimensional space* undermines the very foundation of *cosmic origin philosophy*.

I have not studied Professor Witten's original works in detail. However, M-theory is widely discussed in physics classrooms, and its ideas of higher and multidimensional space have gained immense popularity in China and around the world.

Some have even attempted to *incorporate higher-dimensional space theory into Buddhist and Daoist philosophy*, which is *entirely inappropriate*.

In response, I have written several books and numerous essays reflecting on this issue. The focus of my critique is not M-theory per se, but rather the *philosophical implications of four-dimensional spacetime and its origin in Aristotelian material philosophy*.

Through this reflection, I have proposed a *re-examination of the origin of space and time*.(Samo Liu, 2025c)I have also written *The Physical Principles of Natural Philosophy*(Samo Liu, 2024i), and introduced the idea of the God of Cosmic Nature through *cosmic natural philosophy*.(Samo Liu, 2024g)

The core problem of M-theory is that it *fails to clarify the logical relationship between Material philosophical concepts and first principles*.

The concepts of *point*, *string*, and *membrane* are ambiguous. In the material world, any *point string*, and *membrane*—depending on the philosophical framework and coordinate system—can represent both *infinity*无穷大 and *infinitesimality*无穷小.

If we can distinguish between *material* and *non-material*, and treat such entities as *non-material points, strings, and membranes*, they may become powerful *informational tools* for exploring *cosmic origin and creation*.

These *non-material* conceptual entities—points, strings, and membranes—may indeed hold the key to understanding cosmic origin.(Liu Hongjun & Samo Liu, 2021b)

Within the realm of materialist philosophy, humanity formulated Goldbach's Conjecture. But we must ask:

Why is  $1 + 1 = 2$ ?

From the perspective of *cosmic origin*, we can ask many similar questions:

Why does placing zero *before* any digit not change its value, but placing it *after* multiplies it by ten?  
 Why is zero plus any number still that number?  
 Why is zero minus any number negative?  
 Why is zero multiplied by any number still zero?  
 Why is zero divided by any number still zero, but any number divided by zero yields infinity?  
 And most importantly:  
 Why can the binary system—zero and one— serve as the mathematical foundation for computer numerical calculations?

*Language, writing, numbers, mathematics, coordinate systems, and science* are all informational tools created by humanity for survival and existence.



*Mathematics, numbers, and numerical systems* are tools to express knowledge and information with precision.

*This tool is extraordinary.*

Without it, not only could we not express the material universe accurately—we could not express cosmic origin at all.

The *creativity of humanity* is truly marvellous. Humanity invented mathematics and numbers to describe the universe—and this expression is extraordinarily *precise* and *seamless*. Why?

Yet, this same creativity, if not guided by sound philosophy, can also be dangerous. When used improperly, it may mislead thought itself.

No matter what, *humanity was born from the cosmos*, and went on to create language, writing, numbers, mathematics, coordinate systems, and science as tools of information.

We should be grateful to the universe for giving humanity this supreme gift: the ability to *think, research, and explore*.

But even *without humanity*, without language, writing, mathematics, coordinate systems, or science—the *universe would still exist*, matter would still exist, *all things would still exist*.

Yet, in the absence of anyone to express that existence—its representation would be: zero. And could only ever be: zero.

Dinosaurs once roamed the Earth for a very long time. They disappeared, and humanity has been studying them ever since.

Yet aside from fossilised skeletons, we have not discovered any retrievable knowledge or information from them.

Modern physics and the cosmic origin philosophies passed down by our ancestors both suggest that the universe originated from "emptiness and nothingness"—from zero.

Then came the birth of matter. *Something from nothing; something from something*. And eventually, humanity was born.

Human beings created knowledge and information, and have come to realise: this world is not empty, it is material.

What is astonishing is this: through quantum mechanics, relativity, and *thermodynamics*, we have discovered that *matter truly arises from emptiness and nothingness—zero*.

Therefore, building on the knowledge and information we now possess, we might reconsider the universe and humanity anew—*starting from zero*.

*Thus, zero is the mathematical foundation of cosmic origin philosophy.*

Let us bring this to the attention of the academic community for open discussion.

### III. CONCLUSION

This article could have been far longer.

But the core idea—that zero forms the philosophical foundation of cosmic origin—has now been expressed with clarity.

It is presented here for the academic community to critique, supplement, and refine.



Let us begin anew—using the scientific knowledge available to us—to reframe human thought, and arrive at a more comprehensive understanding of the universe and of humanity.

May more people join the discussion on the question of cosmic origin.

This question, which has evolved over 2,500 years, now stands at the crossroads of science and philosophy.

Right or wrong, *human thought has reached this critical point.*

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The author declares no competing interests.

#### *Data Availability Statement*

In accordance with publication policies and ethical standards, the data and concepts presented in this article are publicly available in support of open knowledge sharing.

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