Qeios

Beyond the Observable: How the Daodejing Informs Quantum Science and Modern Cosmology

This interdisciplinary research explores the remarkable convergence between ancient Chinese philosophy, specifically the *Daodejing*, and modern scientific understanding, particularly in quantum science and cosmology involving black holes and dark energy. The *Daodejing*, written over two millennia ago, offers profound insights into the nature of reality, existence, and the interplay between the seen and unseen. Through prose, it articulates concepts that uncannily correspond to modern phenomena observed in quantum mechanics and classical cosmology.

Daodejing describes the *Dao*, the ultimate source of all things, 無 (*wu*), as a dynamic and fertile state. It is not simply an absence or an empty void; instead, it is the precondition for the existence of all things. This is similar to the quantum vacuum—an invisible field of potentiality from which particles emerge. The text also reflects on the cyclical nature of transformation and the coexistence of opposites, resonating with principles such as quantum superposition and duality. Concepts such as the ineffable *Dao*, which embodies both the source and the manifestation of all things, find their counterparts in the quantum notion of superposition and the wave-particle duality, where potentiality and actuality coexist.

This paper analyzes these philosophical descriptions, drawing correspondences with key scientific principles, including the indeterminacy of quantum states, the emergence of order from chaos, and the complexity of large-scale systems with a creative ontology of interpretation. *Daodejing's* prescient understanding of the universe offers a fresh perspective on how Eastern philosophy can enrich and deepen our comprehension of scientific phenomena. Through this synthesis, the study aims to demonstrate that *Daodejing* provides a valuable conceptual framework that anticipates the complexities and mysteries of quantum mechanics and classical cosmology, offering relevant insights into contemporary scientific inquiry.

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Introduction

The increasing interest in Eastern philosophies, particularly *Dao*, as a framework for addressing human-nature relationships, has become a significant focus in contemporary discourse (Hasenkamp & Sun, 2023). The *Daodejing*, traditionally regarded as the foundational *Dao* scripture, comprises approximately 5,000 characters and has played a pivotal role in shaping *Dao* thought. Its influence is evident through the numerous translations produced in the past century and the extensive body of commentaries developed over two millennia. The text, attributed to *Laozi*, reflects a distinct philosophical inquiry from circa 722–207 BCE (Liu, 2008).

Dao, emphasizing harmony with the natural world, has increasingly attracted the attention of Western thinkers, who are often intrigued by the profound and cryptic insights found within *Daodejing*'s 81 chapters. However, efforts to interpret *Dao* principles through a Western perspective frequently result in misunderstandings, as these principles are rooted in ontological and epistemological assumptions that differ significantly from those in Western thought. A common misinterpretation is the belief that *Dao* advocates a mystical view of nature beyond human comprehension or engagement. While the *Daodejing* does explore the ineffable nature of the *Dao*, it does not suggest that nature is wholly mystical or inaccessible. Instead, *Laozi* emphasizes the concept of *ziran* (自然)—the natural order of things—as a key element of *Dao* philosophy, particularly in Chapter 25.

In this description, cosmological evolution is marked by a cyclical process—origin, expansion, dissolution, and return—that mirrors natural patterns observed in the world. The universe unfolds spontaneously through the workings of *ziran*, without purposeful action or teleological end (Chai, 2016). The *Dao*, which precedes the cosmos, is described as 'great' (*da* 大) and is responsible for both the emergence and dissolution of all things (Kamamoto, 2022). This process is continuous and eternal, indicating that the universe exists in a dynamic state of flux governed by the principles of *ziran (Liu, 2023)*. Ames and Hall (2003) emphasized that *ziran* represents a mode of being that is 'so of itself', implying an intrinsic, self-perpetuating order that does not rely on external governance or artificiality. They argue that this concept challenges Western notions of creation, which often assume a divine or external agent that initiates and directs cosmic development.

In contrast, the *Dao* cosmology, as presented in Chapter 25, posits an organic, self-organizing, and inherently harmonious universe. Ames (2023) further explored *ziran* within the broader *Dao* framework, noting that it reflects an ontological principle whereby all beings, from the most minute to the cosmic scale, are interconnected through the *Dao*. This interconnectedness is expressed through the cyclical nature of existence—growth, decay, and renewal—all of which align with the Dao's natural rhythms.

Organisms are understood as following life cycles, inherited sequences of stages through which they live, reproduce and adapt. Disrupting pest and pathogen life cycles plays key roles in agriculture, biomedicine and public health. Metabolism, development and inheritance are seen to depend on self-maintaining regulatory loops, including cell-to-cell and environmental signalling systems. Organisms are connected to each other, and to the air, soil, rocks and

water, by biogeochemical cycles. The effects of human activities on the circulation not least of carbon, nitrogen and water threaten climate crisis, pollution and habitat loss. Omni-present today, cycles are also among the oldest ways of framing human existence, and of thinking about life and death, health and disease, as well as daily and seasonal rhythms of regeneration (Hopwood et al., 2021, p.2)

Ziran embodies the idea of things being natural, following their inherent tendencies without force or artificial interference (Lai, 2007). This principle is not merely a passive state but an active expression of the *Dao's* dynamic nature, which unfolds in a circulatory pattern encompassing growth, decay, and renewal (T. Michael, 2012). The circulatory pattern inherent in *ziran* is illustrated in chapter 25 of the *Daodejing*, where *Laozi* describes the *Dao* as something that "passes on in constant flow. Passing on, it becomes remote. Having become remote, it returns" (Legge, 1891). This passage highlights the *Dao's* movement through phases of expansion and contraction, reflecting a natural cycle that governs all aspects of existence. The idea of returning, or '*fan*' (返), is particularly significant, as it underscores the *Dao's* tendency to revert to its root after reaching a point of extremity where it returns to its roots (*guigen* 歸根), a concept that is central to *Dao*. *Ziran*, as a cosmological principle, implies that the natural world and human society should align with this circulatory pattern to achieve harmony and balance. This translates to understanding that all things, including social and political structures, are subject to the same emergence, decline, and renewal cycles. Governance, therefore, should not resist these natural cycles but rather work in harmony with them, allowing for the natural flow of change and adaptation.

Chapter 16 in the *Daodejing* reinforces this theme of cyclical movement and return.

The (state of) vacancy should be brought to the utmost degree,
and that of stillness guarded with unwearying vigour. All things
alike go through their processes of activity, and (then) we see them
return (to their original state). When things (in the vegetable
world) have displayed their luxuriant growth, we see each of them
return to its root. This returning to their root is what we call the
state of stillness; and that stillness may be called a reporting that
they have fulfilled their appointed end.

The report of that fulfilment is the regular, unchanging rule. To
know that unchanging rule is to be intelligent; not to know it leads
to wild movements and evil issues. The knowledge of that unchanging
rule produces a (grand) capacity and forbearance, and that capacity
and forbearance lead to a community (of feeling with all things).
From this community of feeling comes a kingliness of character; and he
who is king-like goes on to be heaven-like. In that likeness to
heaven he possesses the ***Tao***. Possessed of the ***Tao***, he endures long;
and to the end of his bodily life, is exempt from all danger of decay (Legge, 1891).

Here, the emphasis is on the inevitability of return to the root, equated with stillness and constancy—a state of alignment with the *Dao*. This cyclical return to the source reflects the natural order of existence, much like Moleschott's (1857) assertion that "just as trade is the soul of commerce, so the eternal circling of matter is the soul of the world" (p. 41). Both perspectives highlight the perpetual cycles that govern the flow of matter and the essential nature of continuity and renewal in maintaining balance.

Regarding the universe's origination, the *Dao* cosmology, as outlined in Chapter 25, suggests that the cosmos emerges from a state of undifferentiated potential. This pre-cosmic 'One' (*yi* 一), synonymous with *Dao*, gives rise to the many or the 'ten thousand things' 萬物 *wanwu*.

Given they are the most important components of ***Daoist*** thought, it is not surprising that the relation between ***dao*** 道and the One (***yi*** 一) takes many forms. It is often presumed that ***dao*** is the higher-level concept and that One supplements, or is the manifestation of, ***dao*** (Feng, 2023, p. 805).

Thus, Dao is the ultimate, ungraspable reality, the source from which all things arise, while the *One* represents the first principle of differentiation from the undifferentiated *Dao*, acting as a manifestation of *Dao* in the form of unity (Gao, 2022). This notion of a unified origin leading to multiplicity parallels contemporary scientific models of the universe's origin, particularly the Big Bang theory, the concept of cosmic inflation, and quantum singularity.

The research proposes that the *Daodejing* can be understood as an early philosophical reflection on concepts akin to quantum indeterminacy, non-linearity, and emergence. By framing these *Dao* descriptions as engagements with ideas relevant to today's scientific paradigms, the study contributes to a broader interdisciplinary understanding of how ancient metaphysical systems can intersect with and inform modern science. The primary objective of this paper is to develop an interdisciplinary dialogue that highlights how philosophical teachings, particularly those of *Daodejing*, offer profound insights into the foundational challenges facing contemporary science, including the unpredictability and complexity of natural phenomena.

Through a careful analysis of the early *Dao* texts, this paper offers a reinterpretation of these cryptic writings concerning contemporary scientific developments, particularly within cosmology. The discussion explores the nature of reality articulated in the *Dao* philosophy, focusing on the concept of *ziran* (自然) and its relevance at the microscopic particle level and within the broader context of everyday lived experience. By drawing comparisons between the *Dao* principles and modern scientific insights, this paper highlights the intersection between ancient metaphysical concepts and contemporary understandings of the universe without suggesting that they are identical. The paper explores the correspondences between these ideas, illustrating how *Daodejing* articulates natural phenomena in a manner that parallels scientific inquiry, though with less precision and formal rigour characteristic of modern scientific methodology. This interdisciplinary research investigates the deep parallels between ancient Chinese philosophical doctrines, uncovering uncanny correspondences. The *Daodejing* provides descriptions of the *Dao* and the nature of reality that, although expressed in poetic and metaphorical language, bear striking resemblances to phenomena understood in modern science—especially cosmology.

In this light, the study aims to illuminate the holistic perspectives offered by *Daodejing*, which integrate metaphysical understanding with scientific exploration. It suggests that the non-linear and emergent properties in nature and scientific systems are not new concepts but have been engaged philosophically for millennia. Considering the *Daodejing* as a philosophical text that prefigures many of the problems that classical cosmology faces, this research opens new pathways for understanding the universe's dynamic and often elusive nature. Through this comparative analysis, the study seeks to bridge the gap between ancient

wisdom and modern scientific thought, demonstrating how these fields can enrich one another in our quest for deeper understanding.

Quantum Indeterminacy and the Indescribable *Dao*

When language is employed to convey the concept of *Dao*, whether through description or articulation, it inevitably encounters limitations. The very act of attempting to express *Dao* through words distorts its true essence, as *Dao*transcends linguistic representation. Consequently, any effort to encapsulate *Dao* in any form results in an incomplete and potentially misleading representation, as the profundity and totality of *Dao* extend beyond the capacity of human language to capture fully.

The *Dao*, as described in Chapter 1 of *Daodejing*, which cannot be fully articulated or named, reflects the challenges faced in modern scientific discourse and the uncertainty of science (Feynman, 1998) when attempting to describe quantum states or cosmic vastness. In his now-famous remark, “I think I can safely say that nobody understands quantum mechanics,” delivered during Lecture 6 of *The Messenger Lecture Series* at Cornell University in 1964, physicist Richard Feynman emphasized quantum mechanics' profound and counterintuitive nature. While seemingly simple, this statement reflects a profound commentary on quantum systems' enigmatic and perplexing behaviour, which defy classical logic and intuition. Feynman’s intent was not merely to highlight the complexity of the mathematical formulations but to underscore the fundamental challenge quantum mechanics poses to our conceptual understanding of the physical world. Feynman’s comment was an admission of the enigmatic nature of the theory itself. The intent behind his statement was to highlight the idea that, while quantum mechanics provides accurate predictions and has been validated through countless experiments, the conceptual framework it operates within is so far removed from classical notions of reality that it defies conventional logic (Feynman, 2005). This lack of intuitive clarity does not detract from the theory’s validity. Instead, it serves as a humbling reminder of the limits of human cognition when confronted with the fundamental workings of the universe.

The reality we perceive through our sensory faculties differs significantly from the underlying quantum realities, where the fundamental building blocks of all matter, such as quarks, fermions, and bosons, are uniform and unobservable to the naked eye (Louis, 2021). Our everyday experience is shaped by macroscopic phenomena—objects, colours, sounds—arising from these fundamental particles' complex interactions. However, at the quantum level, the nature of reality is markedly different. The particles that constitute matter do not adhere to the classical, deterministic laws we observe in the macroscopic world (Čapek, 1991). Instead, they follow probabilistic rules governed by quantum mechanics, where uncertainty and superposition play critical roles (Roger Penrose, 2011a). At the quantum level, the particles that make up matter, such as quarks (which combine to form protons and neutrons) and fermions (the class of particles that includes electrons), are described by quantum field theory (Pickering, 1999). In this domain, matter exists not in the fixed forms we observe daily but as probability fields (Bunge, 2013). These particles exhibit wave-particle duality, a phenomenon in which particles can exhibit both wave-like and particle-like behaviours depending on the observation conditions (Dimitrova & Weis, 2008).

Similarly, bosons, such as photons and gluons, act as force carriers, mediating interactions between particles without having mass themselves (Quigg, 1985). These particles exist in quantum states that defy the intuition developed through sensory experience, revealing a

reality that operates under principles far removed from our deterministic world (Verheyen, 2021). The difference between macroscopic and quantum realities highlights the contrast between human perception and the underlying fabric of the universe. As Squires (1994) pointed out, while the macroscopic world appears solid and continuous, the quantum world is discrete and governed by rules of probability rather than certainty. The macroscopic phenomena we experience daily, such as solidity or temperature, arise from the collective behaviour of vast numbers of quantum particles. These emergent properties, such as heat, result from the statistical behaviour of particles, as described by thermodynamics and statistical mechanics, rather than from the direct properties of individual particles (Huang, 1987). Niels Bohr stated: "Everything we call real is made of things that cannot be regarded as real. If quantum mechanics hasn't profoundly shocked you, you haven't understood it yet." Bohr's (1928) philosophical approach to quantum mechanics, particularly his views on the counterintuitive nature of quantum reality, emphasized that traditional concepts of reality are inadequate at the quantum level. Quantum entities, such as electrons and photons, exhibit behaviours that defy classical explanations, such as wave-particle duality and complementarity (Bohr, 1928). These phenomena challenge our everyday perceptions of reality, leading to Bohr's (1928) assertion that understanding quantum mechanics fundamentally alters one's view of what is real. As Heisenberg (1927) also illustrated through his uncertainty principle, the nature of quantum systems is deeply tied to observation, further complicating classical notions of reality.

Moreover, the limitations of human sensory perception underscore the gap between observable and unobservable realities. Our senses are adapted to perceive and interpret information on a specific scale spectrum. We can see light in the visible spectrum and feel matter as solid (Fox, 2010), but these experiences do not reflect the quantum processes that govern these phenomena.

Chapter 14 of *Daodejing*:

視之不見，名曰夷；聽之不聞，名曰希；搏之不得，名曰微。此三者不可致詰，故混而為一。其上不皦，其下不昧。繩繩不可名，復歸於無物。是謂無狀之狀，無物之象，是謂惚恍。迎之不見其首，隨之不見其後。執古之道，以御今之有。能知古始，是謂道紀。

Chapter 14 of the *Daodejing* reflects on the nature of the unseen and the imperceptible, a theme that resonates with the paradoxes and mysteries of quantum mechanics. This chapter describes an elusive, ungraspable reality that the senses cannot fully perceive or describe through conventional means. This paper reinterprets this chapter through the lens of quantum mechanics.

1. 視之不見，名曰夷；聽之不聞，名曰希；搏之不得，名曰微 is reinterpreted as: "*Looked at but not seen, it is called unobservable; listened to but not heard, and it is called rarefied; grasped at but not touched, it is called subtle".*

This passage underscores the ineffable and intangible qualities of the *Dao*, paralleling the nature of quantum reality, which resists direct observation. At the quantum level, particles such as electrons and photons do not conform to the observable characteristics of macroscopic objects; they exist in a realm beyond the reach of the senses (Aerts, 2014). This reflects the quantum principle of *wave-particle duality*, where particles exhibit wave-like and

particle-like behaviours depending on the observation method, thus challenging classical notions of visibility and tangibility (Marman, 2018). In quantum mechanics, electrons are not directly observed in the traditional sense but are understood through probabilistic models and their effects on other systems (West, 1975). Similarly, *Laozi*'s depiction of the *Dao* suggests that the ultimate reality cannot be seen, heard, or grasped, mirroring how quantum phenomena evade sensory detection and defy classical definitions of existence.

2. 此三者不可致詰，故混而為一 is reinterpreted as: *"These three cannot be fathomed, and so they merge into one".*

In this context, the 'three' refers to elements or states that, in classical terms, would be distinct and separate. However, at the quantum level, the boundaries between these states blur, making them indistinguishable, thus leading to their unification into a single, coherent whole (Compagno et al., 2018). In quantum mechanics, particles such as electrons exist not in a single, defined state but in a superposition of states, where multiple possibilities coexist simultaneously (Haroche, 1998). This superposition cannot be fully comprehended or observed directly because the act of measurement collapses the superposition into a single state. The notion that 'these three cannot be fathomed' reflects that individual quantum states are not fully determinable when considered in isolation (Esfeld, 2004); they are inherently uncertain and interconnected.

3. 其上不皦，其下不昧。繩繩不可名，復歸於無物is reinterpreted as: *"Above, it is not bright; below, it is not dark. The appearance of the unbroken line cannot be named, it returns to nothingness".*

This paper argues that this phrase refers to the phenomena arising from wave-particle duality in the double-slit experiment. In this quantum experiment, particles such as photons or electrons exhibit wave-like and particle-like properties, depending on whether they are observed (Falkenburg, 2010). The spectrum of light and dark bands that appear in the double-slit experiment without observation can be attributed to the probabilistic interference patterns that emerge when particles behave as waves (Van Thuan, 2021). In this scenario, the particles pass through both slits simultaneously, creating a pattern of constructive and destructive interference, which results in alternating light and dark regions. This pattern reflects the wave nature of particles, where multiple possibilities coexist, and the outcomes are determined by the probabilistic superposition of the wave functions (Couder & Fort, 2012). However, when an observer is introduced to measure which slit the particle passes through, the wave function collapses, and the particle behaves more like a classical object, with no interference pattern; in this collapsed state, the probabilistic interference ceases, and the particle follows a deterministic path and appears as discrete lines behind the slits (Couder & Fort, 2012). The light and dark spectrum, which initially emerges from the wave-like behaviour, disappears under observation, leaving behind a single, unbroken line. The 'return to nothingness' can be understood as the collapse of the wave function, where the multiple potential outcomes revert to a single, definite reality upon observation. This process embodies the foundational uncertainty of quantum mechanics, where the act of measurement determines the system's final state.

Thus, the passage can be seen as an allegory for the dual nature of quantum particles and the role of observation in shaping reality. The appearance of the unbroken line represents the deterministic behaviour post-observation. At the same time, the interplay between light and dark corresponds to the probabilistic interference that arises in the absence of measurement,

ultimately converging back into the void of potentiality when observation collapses the quantum system.

4. 是謂無狀之狀，無物之象，是謂惚恍is reinterpreted as: *"This is called the shape without shape, the form without form. This is called vague and elusive".*

Laozi described the *Dao* as a 'form without form' or a 'shape without shape' that parallels quantum entities like electrons, which do not have definite positions or shapes until observed. In quantum mechanics, wave-particle duality exists in probabilistic states rather than defined forms, only manifesting measurable properties when observed (Bunge, 2012). The *Dao*, similarly, is elusive and defies description, much like how quantum particles challenge our classical understanding of matter as having fixed properties.

5. 迎之不見其首，隨之不見其後is reinterpreted as: *"Approach it, and you do not see its beginning; follow it, and you do not see its end".*

This passage reflects the elusive nature of quantum systems, where the act of approaching or measuring a particle alters its state. The idea of not seeing the beginning or end of the system corresponds to the quantum principle that a particle's position and momentum cannot be precisely known simultaneously, as articulated in the Heisenberg Uncertainty Principle (Crease & Goldhaber, 2014). When we attempt to 'approach' or measure a particle's position (the beginning), we lose certainty about its momentum (the end), and vice versa. Thus, the beginning and end of a quantum process remain indeterminate, depending on what aspect of the system is being observed. The observer effect in quantum mechanics highlights how measurement fundamentally alters the system being observed (Baclawski, 2018). Before observation, particles exist in a probabilistic state, and their behaviour cannot be definitively tracked regarding a clear origin or endpoint. Similarly, in the reinterpreted passage, the inability to perceive a beginning or an end reflects the non-deterministic nature of quantum states before observation. Once an observer interacts with the system, the wave function collapses, and a specific outcome is realized, but until then, the trajectory or evolution of the system remains indeterminate.

In quantum terms, this passage underscores the fluidity and unpredictability of quantum systems, where measurement determines the reality we observe but leaves the unmeasured aspects of the system undefined. The 'beginning' and 'end' metaphorically represent the indeterminacy and uncertainty inherent in quantum phenomena. Without observation, the system remains in a state of potential, where its path cannot be fully traced or predicted, much like the elusive nature of the *Dao* described in the *Daodejing*.

6. 執古之道，以御今之有。能知古始，是謂道紀is reinterpreted as: *"Hold fast to the ancient Dao to manage present affairs. Knowing the ancient beginning is the essence of the Dao".*

This final section speaks to the timeless and unchanging nature of the *Dao*, which governs both past and present. In quantum mechanics, the fundamental principles that govern particles and forces are considered constant and timeless, applying equally to the early universe and the present day. The *Dao* governs current affairs; the laws of quantum mechanics, which were in effect from the moment of the Big Bang, continue to govern the universe's behaviour. Understanding these principles, much like the *Dao*, provides insight into the deepest workings of reality.

Chapter 14 of the *Daodejing* describes an imperceptible, undefinable, and elusive reality—qualities that resonate deeply with the counterintuitive nature of quantum mechanics. Just as quantum theory challenges our classical notions of existence, time, and space, *Laozi*'s depiction of the *Dao* highlights the limits of human perception and understanding in grasping the whole nature of reality. Through the lens of quantum mechanics, we can see that the *Dao* philosophy of the unseen and the ungraspable aligns with the scientific revelation that much of what constitutes reality exists beyond the reach of our senses and comprehension, accessible only through the abstract, probabilistic language of quantum theory.

This divergence between sensory experience and quantum reality has been a central theme in the philosophical and scientific exploration of reality. Quantum mechanics challenges our intuitive notions of space, time, and causality, presenting a fundamentally probabilistic and interconnected universe. As Mohrhoff (2014) emphasized, the quantum world does not lend itself to direct visualization or representation because its phenomena cannot be described in terms of classical physical concepts. Instead, quantum mechanics offers a mathematical framework to describe particles' behaviour and interactions, leaving us to reconcile this with the world we experience through our senses.

The Nature of 無 as Nonbeing and Nothingness

The *Dao*'s concept of 無 (*wu*), often interpreted as 'nothingness' or 'nonbeing', transcends conventional notions of void or absence, embodying a dynamic, generative principle within the *Dao* metaphysics (Liu & Berger, 2014). Unlike the Western philosophical tradition, where nothingness is frequently associated with emptiness or negation, the *Dao* posits that *wu* is the foundational state from which all existence (有, *you*) arises (Michael, 2020). This interpretation is illustrated in chapter 42 of *Daodejing*: "The Tao produced One; One produced Two; Two produced Three; Three produced All things. All things leave behind them the Obscurity (out of which they have come) and go forward to embrace the Brightness (into which they have emerged), while they are harmonized by the Breath of Vacancy" (Legge, 1891). Here, *Dao* is depicted as the source of all phenomena. Yet, it is crucial to understand that *you* emerges from *wu*—the primordial state of nonbeing that precedes and enables the manifestation of existence.

Wu is not a mere absence or a static void; it is a fertile and dynamic state, the precursor to all forms of being. This view challenges the binary opposition between being and nonbeing by suggesting their interdependence and mutual co-creation within the overarching framework of *Da*o (Feynman, 2013), the ultimate principle of the universe. The *Dao*understanding of *wu* as an active, creative force aligns with cosmological principles that emphasize the cyclical nature of existence, where creation emerges from states of apparent emptiness or potential (Brindley, 2013). The relationship between *wu* and *you* is not one of simple negation but of profound interconnectedness and interdependence. In Chapter 40 of the *Daodejing*:

The movement of the Tao
By contraries proceeds;
And weakness marks the course
Of Tao's mighty deeds.
All things under heaven sprang from It as existing (and named);
that existence sprang from It as non-existent (and not named) (Legge, 1891).

This statement reflects the *Dao*'s belief in the cyclical and complementary processes that govern the universe, where nonbeing '*wu*' gives rise to being '*you*', and being returns to nonbeing in an ongoing, dynamic flow. This cyclical interaction parallels certain cosmological models that propose a universe in which expansion is followed by contraction, leading to new cycles of creation—a concept reminiscent of the *Dao*'s advocacy of endless cycles of birth, transformation, and renewal (Girardot, 1988).

Chapter 11 of the *Daodejing* further emphasized '*wu*':

The thirty spokes unite in the one nave; but it is on the empty
space (for the axle), that the use of the wheel depends. Clay is
fashioned into vessels; but it is on their empty hollowness, that
their use depends. The door and windows are cut out (from the walls)
to form an apartment; but it is on the empty space (within), that its
use depends. Therefore, what has a (positive) existence serves for
profitable adaptation, and what has not that for (actual) usefulness (Legge, 1891).

This metaphor underscores the essential role of emptiness or nonbeing in the functionality and existence of things. The empty space within the hub is crucial for the wheel's operation, *wu* provides the necessary potential for the emergence of *you*. The creative power of nothingness is thus integral to the existence and utility of all forms. This perspective aligns with certain interpretations in contemporary cosmology, where the vacuum of space, far from being empty, is seen as a field of potential energy that can give rise to particles and fields (Overduin & Fahr, 2001)—an echo of the *Dao* idea that nonbeing is pregnant with the possibility of being.

The mutual dependence of *wu* and *you* also finds a parallel in the interrelationship between matter and energy in modern physics, particularly as described by Einstein's mass-energy equivalence principle (Okun, 2009). The concept of *wu*transcends simple notions of emptiness or nonbeing, embodying a dynamic and generative principle that is foundational to the emergence of existence. This view challenges binary distinctions between being and nonbeing, suggesting that they are interdependent within the broader framework of *Dao*. The *Dao* understanding of *wu* as an active source of creation aligns with modern cosmological theories that explore the vacuum's creative potential and the universe's cyclical nature. Through metaphors such as the hub and the spokes, *Dao* highlights the essential role of nonbeing in the functionality and existence of all things, offering a profound vision of the universe as a dynamic, interconnected whole.

The Cosmological Role of *Dao* as a 'Negatively Creative' 靜陰 *jingyin* Source

The *Dao* is conceived as the ultimate source of existence. Still, its creative power is described as 'negatively creative' because it operates not through direct intervention or assertive action but through *wuwei* (無為), or 'non-action'. This notion of creation aligns with the principle that the *Dao* does not impose will or intention upon the cosmos. Instead, it allows things to emerge naturally from the primordial state of *wu* (無), the foundational nothingness or nonbeing. This passive or non-assertive form of creativity is central to *Dao* thought, emphasizing that creation is not a purposeful act but a spontaneous, self-generating process that arises from the interplay of being, *you*, and nonbeing, *wu*. This interpretation rejects the nihilistic notion of nothingness as absolute absence, presenting 無 instead as a dynamic,

generative principle. Unlike the existentialist view of ontological nothingness (Chai, 2014), *Dao*'s nonbeing is understood as an essential precursor to creation. Nonbeing is integral to bringing forth the multiplicity of universe forms. According to Ames and Hall (2003), *wu* is better understood as plenitude, a state of fertile potential where all things originate and emerge. This contrasts with Western metaphysical traditions, which often equate nothingness with a lack of existence or meaning.

In quantum field theory, the vacuum is not an empty void but a state of fluctuating energy filled with virtual particles that constantly appear and disappear. This seemingly 'empty' space is, in fact, a rich source of potential, capable of generating material existence through spontaneous quantum fluctuations (Hawking, 1976). Similarly, *wu* is not an inert absence but a creative force that allows a multiplicity of forms to arise. The quantum vacuum provides the preconditions for the emergence of particles and energy, and *wu* serves as the primordial ground from which the cosmos is generated. Both the quantum vacuum and *wu* challenge traditional notions of emptiness, highlighting the hidden potential within what appears to be nothing.

Moreover, the *Dao* conception of *wu* finds resonance in modern scientific theories such as the quantum vacuum, further underscoring the generative potential within apparent emptiness. Ultimately, the *Dao* cosmology presents a non-dualistic and cyclical understanding of the universe, where being and nonbeing are inextricably linked, each giving rise to the other within the broader framework of *Dao*.

Correspondences with Modern Cosmology

The correspondences between *Dao*'s cosmology, as articulated in the *Daodejing*, and modern scientific theories such as the Big Bang, cosmological inflation, and quantum mechanics offer a rich field of exploration that bridges ancient philosophy and contemporary science. Though distinct in their ontological and epistemological underpinnings, both systems provide profound insights into the origins and nature of the universe. In cosmology, the Big Bang theory posits that the universe began from a singular point of infinite density and temperature, known as a singularity (Smith, 1988), and from this singularity, space, time, matter, and energy emerged, marking the birth of the universe (Hawking & Penrose, 1970). This concept finds a remarkable parallel in the *Dao*'s cosmology, where the *Dao* is described as the undifferentiated source of all things. The *Daodejing* suggests that before the existence of heaven and earth, there was a formless, undifferentiated entity, often identified as the *Dao*, from which all things arise (*Daodejing*, Chapter 25).

> There was something undefined and complete, coming into existence before Heaven and Earth. How still it was and formless, standing alone, and undergoing no change, reaching everywhere and in no danger (of being exhausted)! It may be regarded as the Mother of all things (Legge, 1891).

The singularity represents a unified origin from which the cosmos unfolds; the *Dao* is the source of all differentiation, the One gives rise to the multiplicity of forms in the universe (Ames & Hall, 2003).

The cosmological model of inflation describes a rapid expansion of the universe from this initial singularity, during which the universe grew exponentially in a fraction of a second

(Guth, 1981). Guth (1981) asserted that a "huge expansion factor would then result from a period of exponential growth, and the entropy of the universe would be multiplied by a huge factor when the latent heat is released. Such a scenario is completely natural in the context of grand unified models of elementary- particle interactions" (p. 347). The inflationary expansion mirrors *Dao*'s conception of the universe's emergence from a compact, undifferentiated state into a complex, structured system. Both frameworks reject the notion of creation ex nihilo, instead emphasizing an emergence from a primordial, unified potential. *Dao* gives birth to the One, giving rise to a myriad of things (*Daodejing*, Chapter 42).

The Dao produced One; One produced Two;
Two produced Three; Three produced All things.
All things leave behind them the Obscurity out of which they have come, and go forward to embrace
the Brightness into which they have emerged, while they are harmonized by the Breath of Vacancy (Legge, 1891).

This cosmological vision mirrors the concept of singularity in modern cosmology, where the universe begins from an undifferentiated point of infinite density (Kragh, 2021). The *Dao* is an undifferentiated source from which all things spontaneously emerge. In modern cosmology, the Big Bang singularity represents the moment when space, time, and matter came into existence, not through a traditional causal chain but as a spontaneous event where the known laws of physics break down (Hawking & Penrose, 1970).

Einstein's (1916) General Theory of Relativity and subsequent quantum cosmological models provide a framework for understanding the universe's origins as emerging from a vacuum fluctuation. The notion of a vacuum is reinterpreted as a field filled with potential energy rather than as an empty void (Overduin & Fahr, 2001). This field allows for the spontaneous creation of particles and forces, radically challenging traditional ideas of causality and the necessity of a specific origin event for the universe (Feynman & Brown, 2005; Hawking & Penrose, 1970). In this model, quantum fluctuations within the vacuum serve as the seeds for the universe's expansion, aligning with the *Dao* as an origin point from which all phenomena arise without a deliberate cause. *Dao* is formless and infinite, giving rise to the cosmos through a spontaneous and self-generating process known as *ziran* (自然), or 'natural spontaneity' (Ames & Hall, 2003).

The Quantum Cosmological Models propose that the universe emerged from a vacuum fluctuation, a concept rooted in quantum field theory (Calzetta & Hu, 1995). In these models, the vacuum is not an empty void but a dynamic field filled with potential energy, where fluctuations can spontaneously give rise to particles, forces, and spacetime (Aitchison, 1985). This idea fundamentally challenges traditional notions of causality, where events are expected to have specific, traceable causes (Turner & Tyson, 1999). Instead, it suggests that the universe could have arisen spontaneously from this quantum vacuum, without a preceding cause, echoing the *Dao*'s principle of *ziran* (自然), or spontaneous self-arising.

Yang's (2024) framework introduces a novel interpretation of cosmic inflation, where inflation is not merely the exponential expansion of pre-existing spacetime but the dynamic generation of space and time itself. This model suggests that inflation is triggered by the condensation of Planck-scale energy into a vacuum, leading to the emergence of spacetime as a dynamical entity. Unlike traditional inflationary models that depend on an inflaton field,

Yang's (2024) approach is background-independent, meaning it does not assume a pre-existing spacetime or rely on predefined structures or forces. This conceptualization has significant parallels with *Dao* thought, particularly as articulated in the *Daodejing*, positing that the cosmos is governed by spontaneous, self-generating processes that do not require external causes or predefined structures—an idea encapsulated in the principle of *wuwei* (無為), or non-action, where actions are natural, effortless, and in harmony with the *Dao* (*Daodejing*, Chapter 37).

The Tao in its regular course does nothing for the sake of doing it, and so there is nothing which it does not do.
If princes and kings were able to maintain it, all things would of themselves be transformed by them.
If this transformation became to me an object of desire, I would express the desire by the nameless simplicity.
Simplicity without a name
Is free from all external aim.
With no desire, at rest and still,
All things go right as of their will (Legge, 1891).

All things go right as of their will or *wuwei* (無為), and the Spontaneous Cosmological Processes

In Chapter 37, *Laozi* presents the *Dao* operating without deliberate action but facilitating the manifestation of all things. This aligns with modern cosmological models, such as those in quantum cosmology, where the universe is said to arise from spontaneous quantum fluctuations in a vacuum. In these models, space, time, and matter emerge naturally from an undifferentiated state of potential energy without an external cause or predefined structure (Barad, 2007). The cosmological implications of *wuwei* are evident in the way *Dao* describes the origin and evolution of the cosmos. According to Chapter 42 of the *Daodejing*, the Dao gives birth to the One, which in turn gives rise to the Two, and from the Two come the myriad things. This cosmological sequence reflects a spontaneous process of creation that requires no external cause. The universe unfolds naturally from the *Dao*, much as space, time, and matter emerge from the quantum vacuum in contemporary cosmological theories (Wesson, 2007). Wesson's (2007) *space-time-matter* explores how higher-dimensional theories can unify space, time, and matter, positing that the universe may be structured across more dimensions than those observable in our current understanding of relativity. In Wesson's (2007) higher-dimensional cosmology, space, time, and matter are not separate entities but are intricately connected through the fabric of the universe. This reflects the *Dao*'s role as the underlying unity from which all things emerge. In the *Daodejing*, the *Dao* is described as formless and eternal, giving rise to the structured world of form and phenomena (*Daodejing*, Chapter 25). Wesson's (2007) view of higher-dimensional spacetime implies that our observable universe manifests a more profound, multi-dimensional reality that is formless and beyond direct observation—an idea that resonates with *Dao.*

The idea that spacetime and matter are interconnected and arise from a deeper, underlying reality is also compatible with Chapter 16 of the *Daodejing*, which emphasizes the cyclical nature of existence:

"All things alike go through their processes of activity, and (then) we see them return (to their original state). When things have displayed their luxuriant growth, we see each of them return

to its root. This returning to their root is what we call the state of stillness; and that stillness may be called a reporting that they have fulfilled their appointed end" (Legge, 1891). In Wesson's (2007) higher-dimensional universe, matter and energy emerge and evolve from hidden dimensions; the *Dao*'s view sees all things returning to their source in the *Dao*, indicating a cyclical, dynamic relationship between the manifest and the unmanifest.

Dao and the Unification of Spacetime and Matter

In the quest for a unified theory that reconciles the gravitational framework of general relativity with the probabilistic nature of quantum mechanics, Wesson's (2007) work on higher-dimensional cosmology offers significant contributions. General relativity, governing the macroscopic behaviour of spacetime and gravity, and quantum mechanics, describing the subatomic world of particles and forces, have long been treated as distinct domains due to their differing laws and scales. Wesson's (2007) approach—exploring the role of additional dimensions beyond the familiar four—mirrors broader scientific efforts to develop a theory of quantum gravity that would unify these two descriptions of reality under a comprehensive framework.

Wesson (2007) envisioned the universe as embedded in multiple, imperceptible dimensions that could critically explain the forces and particles governing both the macrocosmic and microcosmic realms. String theory and M-theory also incorporate extra dimensions in their attempts to unify gravity with the other fundamental forces (Green et al., 1987). Wesson's (2007) cosmology contributes to this broader theoretical landscape, suggesting that gravity, spacetime, and quantum forces are interconnected facets of a larger, multidimensional reality. This scientific pursuit of unity in the natural world resonates with the *Dao* philosophy, which emphasizes the interconnectedness of all things and the universe as a unified whole, with all phenomena arising from the *Dao*—a formless, generative source.

The challenging notions of time discussed by Hawking and Penrose (1970) find parallels in both *Dao*'s thought and modern cosmology. In classical physics, time is viewed as a linear progression (Zeh, 1989); however, general relativity and quantum mechanics introduce more complex concepts where time can curve or even cease altogether near singularities (Bruce & Giblin, 1992). This disruption of linear time is akin to the *Dao*'s view, which perceives time not as a straight line with a clear beginning and end but as a cycle of birth and return. Chapter 16 of the *Daodejing*: "All things alike go through their processes of activity, and (then) we see them return (to their original state). When things have displayed their luxuriant growth, we see each of them return to its root" (Legge, 1891). This cyclical understanding of time corresponds with modern cosmological models, such as Penrose's (2011) theory of Conformal Cyclic Cosmology (CCC), where the universe undergoes infinite cycles of expansion and contraction, with each Big Bang marking the transition from one 'aeon' to the next.

The *Dao* philosophy and Penrose's (2011) CCC challenge the traditional view of time as a linear trajectory from past to future, proposing a more fluid, dynamic understanding of existence instead. The integration of these perspectives highlights a profound correspondence between ancient metaphysical concepts and cosmological theories, where space, time, and matter are seen not as isolated entities but as interconnected aspects of a unified, cyclical reality. Hawking and Penrose*'s* (2010) "*The Nature's of Space and Time"* provides a profound exploration of the conceptual foundations of spacetime, particularly in the context of general relativity and quantum mechanics. Their work grapples with the ultimate nature of

the universe, especially regarding whether the classical models of space and time can be reconciled with the unpredictable behaviour observed in quantum systems. Hawking and Penrose (2010) discussed the singularities that appear in Einstein's (1916) General Theory of Relativity, notably in the context of the Big Bang and black holes, and how these singularities challenge our understanding of causality, time, and the structure of reality. Singularities, such as those predicted in the Big Bang and black holes under Einstein's (1916) General Theory of Relativity, mark points where the known laws of physics break down, leading to the cessation of time as we understand it and a state where the spacetime curvature becomes infinite. These singularities provide a window into the limitations of our understanding of reality and prompt questions about the nature of existence itself. This scientific discourse on singularities has intriguing parallels with the *Dao* cosmology, particularly the notion of returning to the *Dao* and the concept of 歸根 (*guigen*)—"returning to the root," a principle that is crucial in understanding *Dao*'s view of cosmological cycles.

In Einstein's (1916), black holes represent regions of space where gravitational forces become so extreme that not even light can escape. At the core of a black hole is the singularity, a point of infinite density where spacetime collapses.

The image of huge insatiable mouths that devour everything and return nothing has become, no exaggeration, a part of human culture, from science fiction to folklore. Modern astrophysics considers black holes as quite real objects in space, emerging as a result of the gravitational collapse of massive stars, while many phenomena in the cores of galaxies and quasars are well explained by the existence of supermassive black holes of billions of solar masses (Bronnikov & Rubin, 2021, p. 11).

Hawking and Penrose (2010) discussed how this singularity acts as an event horizon for the laws of physics, challenging our understanding of the universe's fundamental structure. In the *Dao*'s cosmology, black holes can be metaphorically associated with the concept of 歸根 (*guigen*)—the return to the root, an idea that refers to the cyclical return to the *Dao*from which all things emerge and to which they ultimately return. Much like this *Dao* principle, the black hole signifies a return to the most fundamental state. At this singularity, spacetime and matter dissolve into their most basic form, beyond the comprehension of classical physics. This return to the root mirrors the *Dao*'s view of *wu* (無), or non-being, as a state of potential from which all things are born and into which they ultimately dissolve. Near a singularity, the concept of time ceases to have meaning in the conventional sense because the curvature of spacetime becomes infinite. The return to the *Dao* is an essential part of existence, a process in which all beings and phenomena inevitably partake. Singularities, therefore, can be viewed as physical manifestations of this metaphysical principle—events in which the universe's structure returns to a primordial state, where the conventional distinctions between time, space, and matter dissolve.

In Chapter 40 of the *Daodejing*, the reversal and yielding are the movements of the *Dao*.

The movement of the Tao
By contraries proceeds;
And weakness marks the course
Of Tao's mighty deeds.
All things under heaven sprang from It as existing (and named);
that existence sprang from It as non-existent (and not named) (Legge, 1891).

This cyclical perspective of reality closely parallels the cosmological phenomena associated with singularities (Turok & Steinhardt, 2005), where time itself either reverses or collapses into a point of infinite density, marking the boundaries of spacetime and the limits of classical physical laws (Machamer & Silberstein, 2002). Singularities, such as those found at the centres of black holes or posited in the Big Bang, represent moments of extreme conditions where conventional conceptions of time, space, and matter cease to function as expected (Wald, 1992). This notion of a collapse or reversal resonates with the *Dao*'s concept of cyclical transformation, where the *Dao* moves in a pattern of return, constantly folding back upon itself to restore balance and initiate new phases of existence. In cyclic cosmological models, the universe is theorized to undergo repeated expansion and contraction phases, an endless loop of creation and destruction (Steinhardt & Turok, 2002). Following a period of expansion, these models suggest that the universe may eventually reverse course, contract, and collapse back into a singularity, from which a new phase of expansion could begin (Smolin, 1992). This cosmological rhythm mirrors *Dao*'s principle of reversal as an intrinsic aspect of cosmic flow, where every movement toward growth or expansion is counterbalanced by a return or contraction, maintaining a dynamic equilibrium as described in chapter 16: "All things alike go through their processes of activity, and (then) we see them return (to their original state). When things have displayed their luxuriant growth, we see each of them return to its root" (Legge, 1891).

Moreover, *Dao*'s idea of yielding as a functional principle can be expanded upon by observing natural systems' tendency to evolve through processes of adaptation and energy efficiency rather than resistance. Yielding, in this context, can be seen in how organisms and ecosystems adapt to changing environmental conditions by conserving energy and resources, maximizing survival through flexibility. Thus, reversal, in this sense, refers to the perpetual return to a primordial state—an acknowledgement of cyclical patterns that echo across the natural and cosmic order. The return to the *Dao* is an essential part of existence, a process in which all beings and phenomena inevitably partake. Singularities, therefore, can be viewed as physical manifestations of this metaphysical principle—events in which the universe's structure returns to a primordial state, where the conventional distinctions between time, space, and matter dissolve.

Black Holes as a Metaphor for the Dao's Infinite Depth

As discussed by Hawking and Penrose (1970), black holes offer a metaphorical lens through which to understand the *Dao*'s infinite depth. In Chapter 4 of the *Daodejing*, the *Dao* is described as something that is "empty yet inexhaustible" (Lin, 2017), a description that mirrors the way black holes are viewed in contemporary physics—as regions that seem devoid of matter and energy yet contain boundless gravitational pull (Joslin, 2018). Black holes are both 'empty' and 'full' in that they contain a singularity, a point of infinite density, even though they appear to be voids in space (Grotstein, 1990).

The Daoist understanding of nothingness as the infinite ground for presence. With that understanding and within the limits of language, she proposes the metaphor of porous existent. The existent is porous in the sense that boundaries are always permeable where the unfathomable depth, or nothingness, is implicated. The nothingness penetrates existence, yet it is also the ground upon which existence is perched. The existent is porous also in the sense that there are heterogeneous dimensions and intensities, slipping in at every instant of duration (Zhao, 2020, P. 77).

This paradox of emptiness and fullness in black holes parallels *Dao*'s concept of *wu* (無), or nothingness, which is not a void in the conventional sense but a fertile potential from which all things arise. With their gravitational singularities, black holes represent a place where our understanding of space and time dissolves, transcending human comprehension and linguistic description, as expressed in Chapter 1 of the *Daodejing*: "The Dao that can be spoken is not the eternal Dao". The Chinese text in Chapter 4:

道冲，而用之或不盈。渊兮，似万物之宗；挫其锐，解其纷，和其光，同其尘，湛兮，似或存。吾不知谁之子，象帝之先。

Here, this paper re-contextualizes and re-interprets Chapter 4 through the lens of cosmology as a reflection of the inherent nature of the universe and its fundamental principles of emptiness, balance, and the primordial origin of all things.

1. 道冲，而用之或不盈 is reinterpreted as *the Dao is empty, yet its use is inexhaustible.*

When applied to black hole physics, "道冲" (*dao chong*) reflects the behaviour of spacetime and matter as they interact with the gravitational pull of a black hole (Oriti, 2014). A black hole, as described by general relativity, is a region of spacetime where gravity is so intense that the escape velocity exceeds the speed of light (Penrose, 1972). This creates an event horizon, a boundary beyond which no information or matter can escape (Punsly & Coroniti, 1989). The 冲 (*chong*) or 'rushing in' can be metaphorically linked to how matter and energy are drawn into the black hole, accelerating as they approach the event horizon. The 'rushing' aspect of the *Dao* mirrors the rapid pull of matter towards the event horizon of a black hole. As an object approaches this boundary, time dilation and gravitational forces increase exponentially, effectively 'rushing' the object towards the singularity. This behaviour aligns with the description of the *Dao* as an inexorable force pulling all things inward without filling or becoming exhausted—a perfect analogy for the event horizon, which constantly absorbs matter and light but remains unchanged in its form and function.

As objects approach the event horizon, they experience time dilation due to the intense gravitational field of the black hole (Wald, 1992). To an external observer, it appears as though the infalling object slows down, asymptotically freezing at the edge of the event horizon. In contrast, from the object's perspective, it continues to fall towards the singularity. This paradox of simultaneous rushing and stillness reflects the *Dao*'s dual nature as both dynamic and tranquil. In this sense, '道冲' not only represents the rush of matter into the black hole but also the stillness that accompanies it from the perspective of an external observer. This stillness aligns with the *Dao*'s enigmatic, paradoxical qualities.

2. '渊兮，似万物之宗' is reinterpreted as *deep like the gravitational well, with the origin of all things.*

This 'deepness' refers to the gravitational well drawing all things into the singularity (Penrose, 1969). The singularity, a point of infinite density and zero volume, represents the ultimate source of all matter, energy, and spacetime (Misner, 1969). The passage's reference to the *Dao* as 'the origin of all things' mirrors this cosmological understanding, where from the 'depth' of the singularity, the entire universe emerged in a process of rapid expansion, giving birth to galaxies, stars, and planets.

3. ‘挫其锐，解其纷’ is reinterpreted as *dulling sharpness, resolving its complexity.*

In black hole physics, ‘dulling its sharpness’ here can metaphorically be referred to as how matter and energy are smoothed out as they fall into a black hole (Rossi et al., 2010). As matter is drawn toward the event horizon, it undergoes extreme tidal forces due to the black hole’s immense gravitational gradient (Gezari, 2021). This gravitational stretching, often called spaghettification, reduces objects' structural integrity, smoothing them out into elongated streams of matter (Moored, 2017; Viththani et al., 2024). This process effectively ‘dulls’ the sharpness or distinctiveness of objects, reducing them to simpler forms as they approach the black hole. The concept of ‘dulling sharpness’ also mirrors the homogenizing effects seen within accretion disks around black holes (Balbus & Hawley, 1998). Accretion disks consist of gas, dust, and other matter spiralling inward toward the black hole (Abramowicz & Straub, 2014). The intense gravitational and frictional forces within the disk dissipate the energy of this material, causing it to lose its sharp, chaotic distinctions and instead form a relatively smooth, uniform disk of matter. Over time, this process results in a balanced, stable inflow of matter—akin to how the *Dao* ‘dulls’ the extremities of sharpness and brings about balance.

The phrase 解其纷 ‘resolving its complexity’ can be linked to the black hole’s capacity to reduce complex systems into simpler, more ordered states through entropy and energy dissipation. In thermodynamics, black holes are known to increase entropy, as matter and energy that fall into the black hole lose their detailed structure and become part of the black hole’s overall mass and energy distribution (Hayward, 2004). This loss of complexity can be viewed as the black hole ‘resolving’ the chaotic and disordered states of infalling matter, leading to a simplified state characterized by the black hole’s mass, charge, and spin, as described by the No-Hair Theorem[1] in black hole physics (Tang & Xu, 2022). Additionally, as the black hole absorbs matter, it loses its unique properties hidden behind the event horizon (Hawking, 1976). This corresponds to *Dao*’s principle of resolving complexity by breaking down distinctions and unifying disparate elements into a singular, undifferentiated whole. In black hole dynamics, once matter crosses the event horizon, it is no longer distinguishable from other matter—the overall gravitational system of the black hole subsumes its complexity (James et al., 2015). This mirrors how the *Dao* reduces complexity and confusion by harmonizing and simplifying diverse elements into a unified flow.

The tidal forces at play near a black hole, which cause spaghettification and the breakdown of matter, serve as the ‘sharpness-dulling’ aspect of the *Dao*. These forces strip matter of its original form and reduce it to fundamental components, erasing any irregularities or distinct shapes. Similarly, the increase in entropy as the matter is absorbed by the black hole reflects the ‘resolution of complexity’ inherent in the *Dao*. As matter is drawn into the black hole, its internal complexity is lost, and the system as a whole moves towards greater disorder while at the same time becoming more unified in terms of its mass-energy distribution.

In both the *Dao* and cosmological contexts, ‘挫其锐，解其纷’ represents a natural process of harmonization. The black hole, like the *Dao*, simplifies and unifies. Matter that falls into a black hole is stripped of its complexity and reduced to fundamental properties, as the *Dao* ‘dulls sharpness’ and ‘resolves confusion’ to bring about balance and order. This ongoing simplification mirrors the *Dao*'s continuous function of regulating and balancing all things, drawing them into a state of unity.

4. ‘和其光，同其尘’ is reinterpreted as *harmonizing its light with the dust.*

The phrase "和其光，同其尘," traditionally interpreted as ‘harmonizing its light with the dust’, is reinterpreted in this paper through a cosmological and relativistic lens, particularly in the context of Einstein’s (1905) equation $E=mc^2$, where energy (E) is equated to mass (m) multiplied by the speed of light squared (c^2). In this interpretation, ‘光’ (light) corresponds to energy, while ‘尘’ (dust) symbolizes mass or matter. Therefore, the idea of harmonizing light and dust resonates with the fundamental unity between energy and mass, as articulated by Einstein’s (1905) theory of relativity.

Einstein’s (1905) equation $E=mc^2$ expresses the profound equivalence of mass and energy, asserting that mass can be converted into energy and vice versa. The phrase ‘和其光，同其尘’ can, therefore, be re-interpreted as describing the process by which mass and energy interact and transform, particularly under the extreme conditions near a black hole. In black hole environments, this equivalence becomes particularly significant. As matter (dust) is drawn into the black hole, its mass-energy content is transformed—potentially releasing radiation (light) in electromagnetic emissions as the matter accelerates and heats up in the accretion disk before crossing the event horizon. This process exemplifies the harmonization of light and dust, or the transformation of mass into energy, according to the principles of $E=mc^2$. In the context of black holes, the accretion disk is a region of matter spiralling inward toward the event horizon. As the matter (dust) accelerates due to the black hole’s intense gravitational field, it undergoes friction and collisions, converting its gravitational potential energy into radiation (light) (Balbus & Hawley, 1998). This process of energy emission from the accretion disk is a direct manifestation of the equivalence of mass and energy, where the infalling matter releases photons, particularly in the form of X-rays (Abramowicz & Straub, 2014). The light emitted from the accretion disk symbolizes the ‘光’ harmonizing with the ‘尘’ of the matter as it is transformed and radiated away. This phenomenon can be described by relativistic models of energy conversion, where the intense gravitational forces near the black hole accelerate matter to relativistic speeds, allowing for a highly efficient conversion of mass into energy (Amaro-Seoane, 2018). According to astrophysical models, up to 10% of the mass of matter falling into a black hole can be converted into radiation (Adams & Laughlin, 1997), making black holes some of the brightest objects in the universe despite their reputation for being invisible (Shapiro & Teukolsky, 2008).

As light and dust approach the event horizon, they interact in complex ways. Photons (light) experience gravitational redshift, where their wavelengths stretch as they climb out of the black hole’s gravitational well, while particles (dust) may be stretched and compressed through tidal forces (James et al., 2015). This interaction can be seen as a metaphorical ‘harmonization’ of light and matter, where both entities are subject to the same gravitational effects, unifying their behaviour as they approach the singularity. The redshift of photons near the event horizon signifies the alteration of energy as it interacts with the gravitational field (Mottola, 2011), further illustrating how the black hole environment harmonizes mass and energy.

A deeper cosmological implication of ‘和其光，同其尘’ is found in black hole thermodynamics, particularly through Hawking radiation. According to Hawking’s (1976) theory, black holes can emit radiation due to quantum effects near the event horizon.

Hawking radiation arises from quantum effects near the event horizon of a black hole. According to quantum field theory, the vacuum of space is not truly empty but is filled with fleeting pairs of virtual particles that continuously form and annihilate. Near the event horizon of a black hole, one of these virtual particles can fall into the black hole while the other escapes, appearing as radiation to an outside observer (Freivogel, 2014). This process produces thermal radiation from the black hole, known as Hawking radiation, which causes the black hole to lose mass over time (Hawking, 1974). Hawking radiation implies that black holes are not entirely 'black' but emit radiation due to quantum processes. This radiation slowly depletes the black hole's mass, meaning that, over incredibly long timescales, a black hole can evaporate completely (Hawking, 1974). Hawking radiation directly embodies the equivalence of mass and energy expressed by Einstein's equation $E=mc^2$. In this process, mass from the black hole is transformed into radiation. Thus, 'harmonizing its light with the dust' can be interpreted as the black hole's intrinsic ability to convert its mass (尘) into light (光) through the mechanism of Hawking radiation. As the black hole emits this radiation, it diminishes in size and mass, demonstrating the dynamic interplay between these two fundamental properties of the universe.

In the previous discussion of '挫其锐，解其纷' (dulling its sharpness, resolving its complexity), in the context of Hawking radiation, this phrase takes on an additional layer of meaning. The quantum processes near the event horizon resolve the complexity of virtual particles and matter into simple radiation, allowing the black hole to release energy (Hawking, 1974). This conversion reflects the *Dao*'s concept of resolving and harmonizing opposing forces—as mass and energy are reconciled in the radiation process. Another example of the harmonization of light and dust is the relativistic jets[2] emitted from supermassive black holes (Blandford, 2001; Blandford & Rees, 1974). These jets are highly energetic outflows of particles and radiation emitted perpendicular to the accretion disk. Launching these jets involves the interaction between the black hole's magnetic fields and the matter (dust) in the accretion disk. As the dust spirals inward, some of its energy is channelled into these powerful beams of light and radiation extending far into space, again illustrating the harmonization of light (energy) and dust (mass).

The phrase "和其光，同其尘" in the context of black hole physics, when reinterpreted using Einstein's $E=mc^2$, speaks to the integral connection between light (energy) and dust (mass). Mass is regularly converted into energy in the extreme environments around black holes, demonstrating the principle of mass-energy equivalence. This harmonization of light and dust can be seen in the processes of accretion, relativistic jets, and Hawking radiation, where matter is transformed into radiation through the immense gravitational forces of the black hole. The *Dao*'s imagery of harmonizing light with dust resonates deeply with the relativistic and cosmological understanding of black hole behaviour, further bridging ancient philosophical insights with modern astrophysical discoveries.

5. '湛兮，似或存' is reinterpreted as *still, as if barely existing.*

In this context, the *Dao* is portrayed as tranquil and nearly imperceptible, a characterization that parallels the elusive yet fundamental nature of dark matter and dark energy. These mysterious forces, which remain invisible to direct observation, constitute most of the universe's mass-energy composition (Spergel, 2015). Much like the *Dao*, their existence is inferred indirectly through their gravitational effects on visible matter and the large-scale

structure of the cosmos (Rees, 2008). Despite being undetectable through conventional means, dark matter and dark energy exert a profound influence, shaping the universe's formation and driving its accelerated expansion (Sen, 2024). This analogy underscores the concept of an unseen but crucial element that governs the underlying mechanics of reality, highlighting the depth of their role in maintaining cosmic order while remaining beyond ordinary perception.

6. '吾不知谁之子，象帝之先' is reinterpreted as not knowing how this arises, but it seems to be the precedent process.

The *Dao* is described as timeless and beyond origin, much like the notion of a pre-Big Bang state, which eludes conventional understanding. Modern cosmology struggles with questions about what, if anything, preceded the Big Bang, as our current theories break down at the singularity. This line alludes to the mystery of the *Dao*'s origin, paralleling the cosmological challenge of understanding the universe's ultimate beginnings. The phrase 'precedent process' could signify the *Dao*'s primacy over all creation, similar to how cosmologists view the singularity or even quantum fields as predating the observable universe. The passage from the *Daodejing* weaves together philosophical ideas that align with cosmological principles. The *Dao*'s emptiness and inexhaustibility resonate with the vacuum of space, which, though empty, serves as the arena for cosmic phenomena. Its 'deepness' reflects the singularity at the heart of the Big Bang, the mysterious source of all existence. The processes of entropy, the interplay between light and matter, and the imperceptible presence of dark matter and dark energy all serve as cosmological counterparts to the *Dao*'s action, reinforcing the text's depiction of the *Dao* as the invisible, all-encompassing force behind the universe's formation and operation.

Conclusion

The research presented here bridges the ancient philosophical insights of *Dao*, as articulated in the *Daodejing*, with contemporary cosmological theories, offering a profound interdisciplinary dialogue that enhances our understanding of the universe. By exploring the correspondences between the *Dao* concepts of *wu* (nonbeing), *ziran* (natural spontaneity), and modern scientific principles such as quantum mechanics, relativity, and higher-dimensional cosmology, this study illuminates how ancient metaphysical frameworks can inform and enrich contemporary scientific inquiry.

The primary objective of this research was to establish connections between the *Dao*'s worldview, particularly the concept of *Dao* as the formless, generative source of all existence, and modern scientific challenges in understanding the nature of reality. The study sought to demonstrate how *Daodejing* anticipates key themes in quantum indeterminacy, non-linearity, and the emergence of complex systems, proposing that these ancient insights provide valuable interpretive frameworks for addressing some of the most fundamental questions in contemporary science. By comparing the *Dao* principles of cyclical existence, non-action (*wuwei*), and the interdependence of being and nonbeing with modern theories such as quantum cosmology, the Big Bang, and black hole physics, the research highlights the relevance of *Dao* thought in the context of modern scientific exploration.

This research contributes to a broader interdisciplinary understanding by showing how ancient philosophical doctrines, particularly those of the *Daodejing*, intersect with and inform

modern scientific and social theories. The comparison between *Dao* cosmology and contemporary scientific models enriches our understanding of both fields and opens new pathways for exploring the dynamic and often elusive nature of reality. By framing the *Daodejing* as an early philosophical reflection on concepts relevant to today's scientific paradigms, this study demonstrates how ancient wisdom can offer profound insights into modern challenges, particularly in cosmology, quantum physics, and social science.

In conclusion, the *Daodejing* provides a holistic perspective integrating metaphysical understanding with scientific and social exploration. This research underscores the value of interdisciplinary dialogue in uncovering the deep parallels between ancient and modern thought, ultimately bridging the gap between philosophical traditions and contemporary scientific inquiry. This study enhances our understanding of the universe by revisiting and reinterpreting the *Daodejing* in light of modern science. It offers practical guidance for addressing complex social and political issues, advocating for a more harmonious and adaptive approach to governance and human-nature relations.

Statements and Declarations

Conflict of Interest Statement

The author declares that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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Footnotes

[1] The no-hair theorem posits that all stationary black hole solutions within the Einstein-Maxwell equations of gravitation and electromagnetism in general relativity are fully described by three independent, externally observable classical parameters: mass, electric charge, and angular momentum. Other properties, such as geometry and magnetic moment, are determined by these parameters, while any additional information (referred to metaphorically as "hair") about the matter that formed or is falling into the black hole becomes inaccessible beyond the event horizon. Once the black hole stabilizes—emitting gravitational and electromagnetic waves—this extraneous information is lost to external observers. The term "black holes have no hair" was popularized by physicist John Archibald Wheeler to capture this concept.

[2] Relativistic jets are narrow, highly collimated streams of plasma that are ejected from the regions surrounding compact objects like black holes at velocities approaching the speed of light. These jets are typically observed in systems such as active galactic nuclei (AGN), quasars, and X-ray binaries. Relativistic jets are believed to be powered by the rotational energy of a black hole or by the magnetic fields associated with its accretion disk. The material in these jets is accelerated to near-light speeds, and the jets often extend for vast distances, sometimes thousands of light-years, interacting with the surrounding medium. This phenomenon is central to understanding high-energy astrophysics and the mechanisms of black hole accretion and feedback (Blandford & Rees, 1974).

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