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Between science and philosophy: Hypotheses on the existence of God and the future evolution of humanity into a deity

Edoardo J. Bruno¹

Abstract

This article examines two related questions that have received insufficient academic attention: whether contemporary science leaves conceptual space for the existence of God or gods and under what conditions human or extraterrestrial civilizations might become “god-like.” After surveying cosmological models, fine-tuning arguments, multiverse and simulation hypotheses, and scenarios such as technological singularity, the Barrow scale, and Omega Point theories, the paper argues that current physics and cosmology neither demonstrate nor rule out a deity. It also contends that future intelligent civilizations could acquire capacities that are maximal within given physical laws but still fall short of absolute omnipotence and omniscience in the classical theological sense. The central claim is that philosophy and science, together with advances in artificial intelligence, cosmological information theory, and possible contact with extraterrestrial intelligence, may significantly refine our assessment of views about God and of “god-like” futures, while supporting a stance of temporary pragmatic agnosticism.

Keywords: God; Future of Human Civilization; Technology; Universe; Philosophy of Science.²

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1. Introduction

The questions “Does God exist?” (Diller and Kasher, 2013; Spitzer, 2010; Stenger, 2007) and “Will human civilization one day become similar to God?” (Akinsanya, 2024; Estes, 2022; Prisco, 2013) remain the subject of endless scientific, philosophical, and theological debates. In recent decades, a scientific movement—primarily represented by Richard Dawkins, Lawrence Krauss, Stephen Hawking, and Leonard Mlodinow—has advocated for the non-existence of God. Dawkins (2006) asserts that evolution, governed by purely random processes, constitutes sufficient proof of the non-existence of God. Krauss (2012) argues that because our cosmos has emerged from a quantum fluctuation preceding the Big Bang, the God hypothesis is redundant. Hawking and Mlodinow (2010) employ multiverse theory to assert the non-existence of God, claiming that because our universe is merely one among infinite existing universes, a God is not needed to ignite the spark of the cosmos. Conversely, the idea that human civilization may one day acquire divine faculties is not reflected in the doctrines of established religions, such as Judaism, Christianity, and Islam. Indeed, a cornerstone of their dogmas is that humanity’s inherent limitations, tied to its corrupt and mortal nature, prevent it from becoming akin to God. Regarding the possibility of determining whether God exists, Israeli mathematician Aczel (2014, p. 249) uses Gödel’s incompleteness theorems to argue that humankind will never be able to definitively establish the existence or non-existence of God, because this question is beyond the reach of human comprehension. His reasoning applies to the idea that humanity may not acquire divine faculties because science is limited in that not all of nature can be understood by the human mind.

Against this background, the present article addresses two closely related research questions: first, to what extent do contemporary scientific theories about the origin and structure of the cosmos, emergence of life, and future of intelligence leave conceptual space for the existence of God or gods and second, under what conditions, if any, might human or extraterrestrial civilizations come to possess capacities that are meaningfully described as “god-like,” while still remaining bounded by physical laws? Unlike the theses of Dawkins, Krauss, Hawking, and Mlodinow and the doctrines of various religions, I argue that not only is the hypothesis of God possible but also that we—along with extraterrestrials—may one day attain levels of knowledge and power such that we become akin to God in a qualified, analogical sense. I do not claim that future discoveries will make recourse to a divine being logically inevitable; rather, I maintain that advances in cosmology, astrobiology, information theory, and technology may strengthen or weaken different hypotheses involving God and the denial of God without compelling any single metaphysical conclusion. Similarly, when I speak of future civilizations

becoming “like God,” I understand this as the attainment of capacities that are maximally extended within a given set of physical laws, and not as the acquisition of absolute omnipotence or omniscience in the classical theological sense. In section 2, I emphasize that studying physical laws, universal constants, the theory of everything, the solar system, life’s origin, and evolution does not preclude the existence of God. Furthermore, I argue that humans and extraterrestrials may, in principle, gain quasi-divine faculties within the constraints of their respective cosmoi. In sections 3 and 4, I highlight scientific theories proposing the existence of God and the potential for humans to become god-like, and I clarify the distinction between physically maximal power and knowledge and the absolute attributes traditionally ascribed to a deity. Additionally, the question of God’s existence may be better understood by studying infinite regression and infinite replication paradoxes. In section 5, I explore the possibility of human and extraterrestrial species determining whether God truly exists and contemplate whether humans and extraterrestrial civilizations will acquire divine-like faculties through the study of specific subjects and with the aid of particular means, including probabilistic and informational analyses.

In summary, throughout the manuscript, I emphasize the importance of philosophy, which is fundamental to a deeper understanding of various aspects related to God and to the question of our potential to become akin to Him, and of science, which is crucial in refining, and in some cases testing, these theories. The central thesis defended here is that current scientific knowledge neither demonstrates nor rules out the existence of God or gods; future progress may provide stronger empirical and conceptual grounds for preferring some positions over others, without making it epistemically unavoidable to appeal to a divine being. The idea that human or alien civilizations might become “god-like” should be interpreted as the possible realization of physically maximal but still finite capacities, rather than as the literal attainment of absolute omnipotence and omniscience. This work thus highlights the possibility—seldom explored within the academic community—that certain means could enable human civilizations both to investigate more rigorously the existence of God and to approach faculties of a quasi-divine nature, while remaining conceptually clear about the limits of such analogies.

2. Between science, philosophy and God: The finely tuned universe and the future of the cosmos

The Big Bang remains one of the few scientifically indisputable aspects of the cosmos, given that the discovery of cosmic microwave background radiation in 1964 and the COBE satellite detections in 1992 provided strong evidence that the universe

originated approximately 13.7 billion years ago. Although the Big Bang is an established scientific framework, questions concerning the physical processes that occurred at, or very near, its origin have provoked animated debates within academia. The presence of a tiny primordial energy core that imploded 13.7 billion years ago and gave rise to an ordered universe capable of harboring life remains one of cosmology's greatest mysteries. The Big Bang has compelled us to consider fundamental questions, such as those proposed by Leibniz (1898) in the eighteenth century when he asked, "Why is there something rather than nothing?" The Big Bang was followed by a series of highly specific physical processes, many of which gave rise to what we now describe as physical laws³. These laws—such as those of gravitation, relativity, and quantum mechanics—are all fundamental to preventing the universe from imploding or exploding, thus enabling planets to develop the conditions necessary for life. Philosophically, this invites both metaphysical questions about why there are such laws at all and epistemological questions about how far scientific explanation can reach before giving way to more ultimate forms of explanation. Albert Einstein emphasized the exceptional nature of physical laws in a letter to Romanian mathematician Maurice Solovine (1987, p. 118), acknowledging that logic should have led humanity to conclude that a universe dominated by chaos was more likely. Instead, our cosmos is characterized by the order of natural laws, whose presence was not logically required.

Closely related to the question of physical laws is the problem of a "theory of everything"⁴, which seeks to unify all known physical processes within a single interpretative framework. Philosophically, the search for such a theory raises issues about reductionism, the status of unifying principles in science, and whether a final theory would really count as a complete explanation or would itself call for further justification. The main challenge in creating a theory of everything is developing a framework that reconciles two different domains of physical law—relativity and quantum mechanics—within the same universe. Relativity describes gravity on large scales, while quantum mechanics examines the three non-gravitational fundamental interactions—electromagnetism, the strong nuclear force, and the weak nuclear force—on small scales. To date, several theories of everything have been proposed, including string theory (Kaku, 1999), loop quantum gravity (Bojowald, 2010), causal fermion systems (Finster, 2006), causal set theory (Surya, 2019), causal dynamical triangulation (Ambjørn et al., 2010), and ER=EPR (Maldacena and Susskind, 2013). While these theories attempt to unify

³ The study of the nature of physical laws was notably addressed by Feynman (1965).

⁴ Barrow (1991), Close (2017), and Weinberg (1993) are some of the physicists who attempted to discover a theory of everything.

relativity and quantum mechanics, they neither explain why there is a cosmos at all—whether a single universe or an ensemble of infinite parallel or serial universes suitable for life—nor do they by themselves address the deeper metaphysical question of why there is a “lawful” structure rather than no universe at all. Most laws of physics possess universal constants⁵, which remain the same throughout the observable universe. These universal constants comprise numerical values that, if even slightly different, would not have permitted the emergence of life or would have resulted in the demise of our cosmos billions of years ago.

Rees (1999) claims that our universe depends on six fundamental dimensionless constants: the ratio of electrical forces to gravity, strength of atomic bonds, amount of dark matter, magnitude of cosmic antigravity, “fabric” of the universe, and number of spatial dimensions. Life could not have emerged if these constants had differed slightly. The most crucial constant in his account is the atomic bond strength, set at 0.007; variations to 0.006 or 0.008 would have prevented life on Earth. This alleged “fine-tuning” extends beyond the constants Rees mentioned, including the strong nuclear force, fine-structure constant, cosmological constant, weak nuclear force, electromagnetic force, and gravity. Our existence would not be possible if any of these were even slightly different (Carroll, 2006; Hogan, 2000; Tegmark et al., 2006; Weinberg, 1987). Technically, these discussions engage with deep puzzles in high-energy and gravitational physics, such as the small but non-zero value of the cosmological constant and the apparent narrow life-permitting ranges of key dimensionless parameters, themes also discussed in Schellekens’s (2013) analysis of life at the interface of particle physics and string theory. The fine-tuned universe, represented by the laws of nature, universal constants, and the search for a theory of everything, suggests that the hypothesis of the existence of God is one way of interpreting why the cosmos is life-permitting. However, as the philosophical literature has emphasized, the inferential step from fine-tuning to theism is controversial. Proponents of fine-tuning arguments for theism (Barnes, 2012; Collins, 2009; McGrew et al., 2001; Swinburne, 2004) argue that, given an appropriate probability framework, fine-tuning supports theism over chance or over non-theistic hypotheses. By contrast, critics (Colyvan et al., 2005; Dawid, 2013; Ikeda and Jefferys, 2006) contest whether the relevant probabilities are even well defined, or whether the data genuinely favor a theistic explanation. Thus, fine-tuning provides a powerful starting point for the dialogue between cosmology and the philosophy of religion but does not, by itself, settle that dialogue.

⁵ The issue of universal constants has also been the subject of much scientific debate, as evidenced by Barrow (2002) and Eddington (1956).

To address the problem of the finely tuned universe—namely that of physical laws and universal constants—physicists have proposed various theories⁶, such as multiverse scenarios, cyclic universes, “universe from nothing” models, and holographic-universe proposals. These aim to explain the universe’s origins and its suitability for life. Multiverse theories include eternal inflation (Garriga and Vilenkin, 2001; Guth, 2007), black-hole cosmology (Good, 1972), cosmological natural selection (Smolin, 1997), and the many-worlds interpretation (Everett, 1957). Cyclic universe models include the Big Bounce (Ashtekar et al., 2006), the ekpyrotic universe (Steinhardt and Turok, 2007), conformal cyclic cosmology (Penrose, 2010), the quasi-steady-state universe theory (Hoyle et al., 1993), and the Baum–Frampton model (Baum and Frampton, 2008). Theories suggesting that the universe emerged “from nothing” include the Big Bang from quantum fluctuation (Tryon, 1973), the Hartle–Hawking state (Hartle and Hawking, 1983), emergent-universe scenarios (Ellis and Maartens, 2003), and quantum potential cosmology (Farag Ali and Das, 2015). The holographic-universe model has recently been defended by Hertog (2023). Philosophically, these proposals differ not only in physical mechanism but also in the kind of explanation they offer. Multiverse scenarios (Carr, 2007; Linde, 1990; Susskind, 2005) seem to “naturalize” fine-tuning by embedding our universe in a larger ensemble, so that it is not surprising that at least one domain is life-permitting. However, critics (Ellis, 2007; Ellis and Silk, 2014; Steinhardt, 2011) argue that such multiverse frameworks rely on entities (other universes) that may be permanently unobservable, face the so-called measure problem (how to assign probabilities over an infinite or vast ensemble), and risk merely shifting rather than resolving the question of why the totality is such as to generate life-permitting regions at all. Recent technical discussions of prediction and explanation in multiverse settings (Garriga and Vilenkin, 2008) emphasize that anthropic selection effects and measure choices are central but contested ingredients in attempts to account for fine-tuning in terms of an inflationary multiverse and a “landscape” of possible low-energy constants. Cyclic-universe models confront a partly different cluster of objections. Although they might appear to dilute fine-tuning by positing an eternally recurring cosmos or repeated cycles of contraction and expansion, critics note serious tensions with current observational cosmology, which favors a late-time accelerated expansion driven by dark energy rather than a future re-collapse. Moreover, cyclic scenarios must address challenges concerning entropy accumulation, the stability and robustness of successive

⁶ Vaas (2011) pointed out that there are many scientifically plausible hypotheses about what might have preceded the Big Bang.

cycles, and the physical plausibility of the mechanisms proposed to reset initial conditions in a way compatible with life-permitting universes (Ellis, 2007; Steinhardt, 2011).

While multiverse and cyclic models face these epistemic and methodological challenges, universe-from-nothing and holographic proposals raise a somewhat different family of issues. Universe-from-nothing models, often inspired by quantum cosmology, have been subjected to substantial philosophical criticism. Earman (1995), Grünbaum (1991), and Oppy (2013), for instance, dispute whether such models genuinely describe creation *ex nihilo* rather than a reformulation of prior boundary conditions. On this view, quantum cosmological accounts tend to transform an initial classical singularity into a different kind of boundary condition, rather than eliminating the need for an initial state altogether (Craig and Sinclair, 2009; Grünbaum, 1991; Oppy, 2013). Holographic-universe theories, by contrast, typically posit a single universe whose bulk properties are encoded on a lower-dimensional boundary or emerge from a more fundamental informational or energetic substrate. Although rooted in developments in quantum gravity and black-hole thermodynamics, strongly holographic or otherwise highly speculative cosmological frameworks raise concerns about their empirical testability and explanatory status: it remains unclear to what extent they provide genuine answers to fine-tuning questions, as opposed to re-describing them in new formal terms (Ellis, 2007; Ellis and Silk, 2014; Rovelli, 2018; Smolin, 2015).

The issue with all these theories is that they do not render our universe obviously less special, even if they are proven empirically or theoretically adequate. Even if infinite parallel or serial universes existed⁷, if the Big Bang had arisen from a quantum fluctuation, or if the laws of nature had evolved, the mystery would remain of why our cosmos possesses all the physical processes necessary for the development of life. A natural scientific perspective suggests that a randomly selected universe from a multiverse, cyclic-universe, or holographic ensemble would likely be empty or incapable of supporting life, governed by chaotic or sterile laws. This tension lies at the heart of the controversy about whether multiverse explanations genuinely reduce the need for any further explanation of fine-tuning, or whether they too require some deeper principle to account for the existence of life-permitting regions. Within this context, philosophers and theologians (Barnes, 2012; Craig, 2003; Leftow, 2012; Swinburne, 2004) argue that there remains conceptual space for a Creator who grounds the existence and structure of either a single universe or a multiverse, while other authors (Dawid, 2013; Ellis and Silk, 2014; Ikeda and Jefferys, 2006) contend that the appeal to a divine cause introduces explanatory

⁷ Regarding the questions related to infinity, see Barrow (2005), Heller and Woodin (2011), and Rucker (1984).

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elements that are difficult to integrate with the methodological standards of physics. Thus, when one connects fine-tuning, multiverse scenarios, and theism, it is important to distinguish clearly between empirical questions about which cosmological model best fits the data and philosophical questions about which kinds of ultimate explanation are acceptable or necessary.

To understand who or what “God” might be in such discussions, we must consider a wide range of possibilities often explored in the philosophy of religion and speculative cosmology. God could be conceived as the origin of the universe, the multiverse, a cyclic universe, or a universe born “from nothing,” or even—under more unorthodox hypotheses—as a being that emerged through some evolutionary process in another universe. Simultaneously, if a primordial energy core were the primary cause of the cosmos and there were nothing “before” the Big Bang in physical terms, a Creator’s possible “emergence” immediately after the implosion, that is, during the Planck era, has sometimes been entertained in philosophical speculation. However, such scenarios go beyond standard empirical science and should be understood as conceptual possibilities rather than as consequences drawn directly from current physical theories. Another crucial consideration is whether a possible God could also intervene during the evolution of the cosmos. During the earliest phases of cosmic history, a series of extraordinary processes occurred. Within the first three minutes, the “superforce” separated into gravity, electromagnetism, and the weak and strong nuclear forces. The universe underwent dramatic expansion, likely through an inflationary phase. Elementary particles such as quarks, protons, electrons, and atoms were formed, and primordial nucleosynthesis enabled the formation of hydrogen and helium (Weinberg, 1977). Subsequently, over millions of years, thanks primarily to gravitational forces, the elements formed in the first three minutes came together to form the first galaxies and stars. At the end of their life cycle, many of these stars perished or exploded as supernovae, releasing chemical elements vital for the formation of new generations of galaxies and stars. In the first three minutes and over millions of years thereafter, these processes unfolded systematically, laying the groundwork for life on planets. Consequently, studying the Big Bang phases raises questions regarding the fine-tuned universe and the apparent “remarkableness” of a sequence that leads from an early hot plasma to a universe rich in complex chemistry (Davies, 2007; Hogan, 2000). Philosophically, this invites debate on whether such apparent directedness toward complexity is adequately captured by purely statistical and dynamical accounts, or whether it suggests deeper teleological or design-like features.

The uniqueness of Earth and our solar system must also be considered. Earth orbits within the so-called habitable zone: not too hot and not too cold, ideally suited for

sustaining liquid water, the fundamental ingredient of life as we know it. Moreover, its nearly circular orbit ensures it remains within this habitable zone. Other crucial factors for life on Earth include Jupiter, which intercepts many asteroids, and the Moon, which stabilizes Earth's axial rotation (Lewis and Barnes, 2016). These conditions are often cited in discussions of the "rare Earth" hypothesis, which maintains that complex life may be extremely uncommon in the cosmos (Gribbin and Rees, 1989; Ward and Brownlee, 2000). Critics (Bostrom, 2002; Lineweaver, 2001; Scharf, 2009), however, caution against strong conclusions, noting observational selection effects and the still limited sample of known planetary systems. When discussing the origin and evolution of life, fine-tuned processes at smaller scales must also be recognized. Hoyle (1959) noted that the laws of nuclear physics seemed "designed" with consequences for stars in mind. Life on Earth emerged through regulated chemical processes that resulted in the birth of the primordial cell. Currently, two principal families of theories aim to explain the origin of life on Earth. The first suggests that life arose through chemical processes on Earth around four billion years ago (Bernal, 1951; Haldane, 1929; Oparin, 1924). Contemporary origins-of-life research details complex scenarios involving self-assembling lipids, autocatalytic reaction networks, and RNA or RNA-like polymers as possible early informational molecules, as well as the central role of bioenergetics in driving prebiotic chemistry (Deamer and Weber, 2010; Ruiz-Mirazo et al., 2014; Szostak, 2012). The second family of theories, panspermia (Wickramasinghe, 2011), holds that life, or its basic building blocks, originated in space and arrived via cometary or meteoritic impacts, bringing fundamental elements for the primordial cell. In both approaches, the origin of life is understood as the result of precise, highly constrained chemical and physical processes, although there is considerable scientific controversy about where, how, and how often life can arise, and whether biochemical fine-tuning supports broader teleological readings (Cleland, 2019; Davies, 2007; Fry, 2000).

A similar logic applies to life's evolution. Over the past 500 million years, billions of species formed through Darwinian evolution (Darwin, 1859), where natural selection tends to preserve those organisms best adapted to their environment, while those that do not adapt perish. Dawkins (2006) emphasizes that the sponge *Euplectella aspergillum*, the plant *Aristolochia trilobata*, the giant sequoia *Sequoiadendron giganteum*, and chlorophyll-based photosynthesis evolved through processes that are highly calibrated by local environmental conditions and genetic constraints. Philosophically, evolution introduces additional questions: whether evolutionary processes are purely contingent and blind, or whether there are convergent trends (e.g., toward complexity, intelligence, or consciousness) that might be interpreted as "directional," and how such trends—if real—should be reconciled with either a theistic or a purely naturalistic worldview (Ayala,

2007; Morris, 2003; Ruse, 2010). Another important issue related to evolution concerns consciousness⁸—the difficulty in understanding why humans possess an awareness that allows them to think, feel, and interpret the reality around them. This consciousness might also belong to many other beings who have lived, are living, and will live on Earth. The debate involves, among others, Chalmers (1995), who formulates the “hard problem” of consciousness, Dennett (1991), who defends a broadly physicalist and functionalist account, and Nagel (1974, 2012), who argues that subjective experience poses challenges to reductive physicalism. The hard problem of consciousness has been taken by some authors (Chalmers, 1996; Nagel, 2012) to suggest limitations in our current physical theories, while others (Churchland, 1986; Dennett, 1991) argue that it can eventually be accommodated within physicalism. This debate intersects with fine-tuning and cosmology when authors propose that minds, or information-bearing structures more generally, play a fundamental role in the universe (Davies, 2007; Wheeler, 1990). It is important to remember that the stages of the Big Bang, the formation of the solar system and Earth, the origin and evolution of life, and the emergence of consciousness developed because of a series of precise laws—such as gravity—that were not logically destined to originate from the Big Bang itself. These laws were fundamental for the realization of each of these processes. Thus, any philosophical interpretation—whether theistic, deistic, or naturalistic—must grapple with both the apparently contingent character of these laws and the fact that we only ever directly observe one realized cosmos.

One possible approach that addresses the enigma of life on Earth is the anthropic principle (Barrow and Tipler, 1986; Carter, 1974). This philosophical and methodological concept asserts that the universe must have the characteristics it possesses in order for conscious life capable of observing these features to exist. In other words, if we humans exist and can observe the universe, it is because the conditions of the universe were such as to permit our existence. In its weak form, the anthropic principle is often taken as a selection effect: among all regions or universes (if there are many), we can only find ourselves in one compatible with our existence. In its stronger forms, it has been interpreted as suggesting that the universe is in some sense compelled or oriented toward producing observers (Barrow and Tipler, 1986; Leslie, 1989). The anthropic principle, by itself, does not preclude the presence of a divine being. A Creator could be hypothesized to have set the initial conditions, the laws, or both, so as to make a life-permitting universe highly probable or even inevitable (Craig and Sinclair, 2009; Swinburne, 2004). At the same time, a number of philosophers and cosmologists (Bostrom, 2002; Ellis, 2007; Ikeda

⁸ For topics related to consciousness, see Chalmers (1996), Dennett (1991), Hameroff and Penrose (2014), Penrose (1989, 1994), Schneider and Velmans (2017), Searle (1997), and Seth (2021).

and Jefferys, 2006; McGrew et al., 2001) argue that anthropic reasoning, together with multiverse hypotheses, can offer non-theistic accounts of why we should not be surprised to find ourselves in a fine-tuned universe, and that such accounts weaken or neutralize traditional design arguments. The limitation of the anthropic principle, however, is that it does not provide a causal explanation for why the universe possesses these specific characteristics. In its weak form, it risks being merely a restatement of the fact that we can only observe conditions compatible with our existence. It does not address the deeper question of why the global structure of physical reality—whether a single universe or a multiverse—is such that life-permitting domains exist at all. Consequently, many authors (Bostrom, 2002; Ellis, 2007; Rees, 1999) consider it more as a methodological constraint on our reasoning than as a significant contribution to ultimate explanation in cosmology and philosophy. This limitation raises questions about how and why the conditions of the universe came to be this way, and leaves open, among other possibilities: purely physical explanations yet to be discovered, multiverse-based accounts combined with selection effects and non-trivial measure-theoretic assumptions (Garriga and Vilenkin, 2008), and the hypothesis that the universe is in some sense intended or designed for life. Philosophically, the status of the anthropic principle therefore remains contested: several authors defend its role as an indispensable heuristic in cosmology and as a constraint on theory construction (Bostrom, 2002; Rees, 1999), while others argue that it is explanatorily thin unless embedded in a richer theoretical framework, such as specific multiverse models or accounts of fundamental physics (Hogan, 2000; Smeenk, 2013).

Finally, I consider the ultimate fate of the universe⁹. Multiple theories address this issue, including the Big Freeze (Thomson, 1882), which suggests that, in trillions of years, the cosmos will become a dark and cold place where life will ultimately perish. By contrast, the Big Crunch (Friedman, 1922) proposes that at some point the universe's expansion will cease and the cosmos will contract again, ultimately returning to a gravitational singularity reminiscent of the Big Bang. Other theories—such as the Big Rip (Caldwell et al., 2003), Big Decay (Leslie, 1996), Big Brunch (Kiefer and Zeh, 1995), and Big Hit (Starobinsky, 2000)—posit that, in billions of years, spacetime itself could rupture or undergo radical transformation. The Mars–Senovilla–Vera model (Mars et al., 2007) even suggests that time could eventually entirely cease. These scenarios illustrate not only the limits of our current empirical knowledge but also deeper philosophical questions about whether time, entropy, and cosmic “beginning” and “end” are features of reality itself or dependent on the particular theoretical framework adopted. Science suggests that human civilization may eventually face extinction. However, a potential escape has been

⁹ Works by Davies (1994) and Mack (2020) highlight most of the hypotheses about the end of the universe.

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envisaged in speculative discussions: the progressive enhancement of our capacities through technology, perhaps to the point where our influence on cosmic processes becomes non-negligible. If humanity survives over the next billion years (which current physics does not inherently forbid), it could dramatically extend its control over matter, energy, and information, thereby reshaping aspects of its cosmic environment. The likelihood of this occurring depends primarily on technological development, which is destined—barring catastrophe—to become ever more significant in our lives. In the future, technological advancements may be applicable to the universe itself, at least locally or within certain causal domains. Human civilization, billions of years from now, might acquire technological resources sufficient to radically improve its prospects for long-term survival and to mitigate some threats associated with specific cosmic end scenarios.

Philosophically, these possibilities invite comparison with attributes traditionally ascribed to God in classical theism, such as omnipotence and omniscience. It is important, however, to distinguish carefully between maximal capacities realizable by finite agents within given physical laws and constraints, and the absolute, unlimited attributes usually associated with a divine being. Even a civilization that could manipulate vast regions of spacetime would remain, in principle, constrained by the underlying laws of physics, by its location in the causal structure of the universe, and by its own contingent origin. Thus, while future humans (or their descendants) might acquire powers that are “god-like” relative to our current condition, these would still differ conceptually from the traditional notion of an omnipotent, omniscient, and necessary deity. Consequently, the universe might become increasingly subject to human (or post-human) agency, and humanity, through its technological discoveries, could acquire faculties reminiscent of those attributed to God in some religious traditions—for example, the ability to engineer environments, perhaps even to initiate new cosmic domains, or to indefinitely preserve conscious life. Yet such scenarios should be understood as speculative extrapolations grounded in current discussions about technological trajectories and the physical limits of computation, rather than as predictions mandated by existing science. They also raise ethical and metaphysical questions: whether possessing great power entails corresponding moral responsibilities and whether finite beings could ever fully transcend the contingency and vulnerability that characterize creaturely existence.

In principle, the ideas explored in this section are not necessarily exclusive to the human species. If other intelligent species exist (Webb, 2015), they will likely contemplate analogous questions. Extraterrestrial civilizations, like humans, may debate the existence of God or gods based on their universe’s physical laws and unique features.

Elements such as universal constants, the Big Bang (or its analogues in their cosmological models), and the origins of life can prompt intelligent species to ask whether their existence has a divine, naturalistic, or hybrid explanation. Even in universes or cosmic regions with different laws, such beings might ponder whether some higher-level agency influenced their existence, as their creation processes would remain, from their perspective, remarkable and in need of interpretation. Regardless of their universe, such beings might also imagine becoming divine themselves in a derivative sense. Through advanced technology or as-yet-unknown processes, they could explore ways to avoid their universe's end, to preserve or replicate consciousness, and to exercise extensive control over matter and information, thereby perceiving themselves as "deities" of their own cosmic domains. Whether one interprets these developments as approximations to the divine, as natural outgrowths of intelligent life, or as ethically and metaphysically problematic forms of self-deification remains a central philosophical question at the boundary between cosmology, technology studies, and the philosophy of religion. A further conceptual possibility is the existence of a plurality of gods or god-like agents. No current scientific theory logically rules out the hypothesis that the physical laws, universal constants, or life itself were established by a collective of powerful agents who jointly configured them so as to generate life in the cosmos or on Earth. At the same time, from a philosophical standpoint, such hypotheses confront many of the same issues as single-deity models: questions about the ultimate origin of these beings, the explanatory gain achieved by positing them, and the criteria by which such explanations are to be assessed in relation to purely naturalistic accounts.

In summary, this section has examined the intersection between contemporary cosmology and philosophical–theological reflection by considering the universe's origin, the origin and evolution of life, the emergence of consciousness, and the possible end of the cosmos. Throughout, the focus has been on the status of physical laws and constants, the fine-tuning problem, and the various explanatory strategies—naturalistic, theistic, and hybrid—that have been proposed. While scientific theories about the Big Bang, multiverses, cyclic models, and ultimate cosmic fates continue to evolve, they inevitably give rise to further questions about contingency, necessity, and purpose—questions that, at least for now, keep open a conceptual space for ongoing dialogue between science, philosophy, and theology.

3. Scientific and philosophical hypotheses regarding the existence of God: An investigation from different perspectives

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Several scientific theories propose multiple gods or a God. The laboratory-created universe hypothesis suggests that our cosmos emerged from an experiment by an extraterrestrial civilization aiming to create a livable universe. Harrison (1995) supports this thesis. Origin-of-life research also explores whether a Creator established life. Crick and Orgel (1973) proposed directed panspermia, which suggests that life originated on Earth owing to alien intervention, either directly or via spacecraft, to create the necessary chemical processes for the primordial cell. Directed panspermia remains debated but has not been ruled out as an explanation for life's origin. Other hypotheses about a God relate to the nature of our reality, which unknown beings may govern. Significant theories include the simulated universe, brain-in-a-vat, and Boltzmann brain scenarios. The simulated universe concept (Bostrom, 2003) posits that advanced past civilizations could create computer simulations of universes. Thus, our cosmos might be a simulation running on the computer of an alien civilization. This idea has substantial implications about the nature and limits of reality. Different types of simulation may exist, such as creating an entirely simulated universe or simulations confined to specific objects, such as computers, mobile phones, or televisions. A similar hypothesis—referred to as brain-in-a-vat—was conceptualized by Putnam (1981), who proposed that a mad scientist could have extracted a person's brain, placed it in a vat of nutrient-rich fluid, and connected it to a supercomputer. The entity in the vat would live a life believing it to be real, when in fact it would be nothing more than a fictional reality created by the scientist. This hypothesis raises the possibility that each individual in human civilization may be nothing more than a brain in a vat created by a mad scientist or an unknown entity from another universe. A related concept is Austrian physicist Ludwig Boltzmann's brain hypothesis. The Boltzmann brain is a hypothetical sentient entity that emerges from quantum fluctuations in chaos. This entity would then create a reality similar to the one we experience in order to avoid existing in an empty space dominated by nothingness (Dyson et al., 2002). This process could occur multiple times, giving rise to numerous Boltzmann brains. Thus, each individual in human civilization may be nothing more than a brain that has created our reality to experience a richer and less monotonous existence.

Thus far, I have described the possibility that a scientific God or gods may have created the universe, engendered life, or altered reality. However, multiverse theory introduces the possibility of all types of gods existing, whether scientific, religious, or philosophical. Tegmark (2014) and Greene (2011) theorize the possibility of different types of multiverses. Tegmark proposes four levels of multiverse, while Greene identifies nine. The most relevant categories of multiverses for our discussion include Tegmark's four-level multiverse, in which universes with different physical laws exist, and Greene's extreme multiverse, in which all possible types of universes exist. In Greene's extreme

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multiverse, any universe with a non-zero probability of existing will manifest. This suggests the possibility that all types of gods, whether those of religious traditions or philosophical constructs, will inevitably develop somewhere within the multiverse if they have a non-zero chance of being created. Such a multiverse could include universes dominated by the Christian, Islamic, or Jewish God or deities from Eastern religions, as well as a deistic, pantheistic, pandeistic¹⁰, or maltheistic¹¹ God, Hoyle's (1983) superintelligence, Descartes' (1641) malevolent demon, or Plato's demiurge (Brumbaugh and Wells, 1968). Simultaneously, universes created by gods worshipped by the Greeks, Romans, Egyptians, Germanic peoples, polydeists¹², or neopagans could exist. Furthermore, both monotheism and polytheism might exist in Greene's multiverse through natural processes or intervention. Universes could emerge from precise physical processes or be created by an alien civilization, mad scientist, or Boltzmann brain. Despite a lack of scientific support for the gods of religions and philosophies in this multiverse, they could still exist. Tegmark's four-level multiverse theorizes universes with varied physical laws, potentially enabling the emergence of these gods. Furthermore, unimaginable scientific gods could arise in both multiverses. Some universes might feature a scientific God from the Planck era or a God ruling purely with evil or irrationality. Such multiverse theories suggest an infinite variety of gods with unique traits.

In these contexts, talk of "gods" or "scientific deities" is often best understood in a metaphorical or analogical sense. Hypothetical agents who create universes in laboratories or run vast simulations may possess capacities that are maximal relative to their own technological and physical context, yet they would still be finite beings acting within some overarching framework of laws and constraints. Philosophically, this contrasts with the traditional attributes of a classical theistic God, usually characterized as absolutely omnipotent and omniscient—able to do anything that is logically possible and knowing all truths, including counterfactuals and timeless propositions. By comparison, even the most advanced universe-creating civilization would at most display "maximal power" and "maximal knowledge" within a given set of laws. Hence, invoking future or extraterrestrial civilizations as "god-like" should be read as an analogy that

¹⁰ Pandeism is the hypothesis that God created the universe but subsequently became one with the cosmos.

¹¹ Maltheism, on the contrary, asserts that God is not an infinitely good being but rather an evil, cruel, and arrogant Creator whose aim is to make people suffer.

¹² Polydeism shares common grounds with deism, which posits that God created the universe but ceased to intervene immediately after its formation. The distinction between the two concepts is that, while deism proposes that a single God generated the cosmos, polydeism suggests that a group of gods formed the universe without intervening in its processes after it was created.

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highlights extreme but still limited capacities, not as an identification with the absolute attributes central to many religious traditions. This possibility raises questions about utilizing past concepts of God to solve universal mysteries, particularly because our universe originated from precise physical processes leading to structured laws and constants of life. The same reasoning can be applied to the origin of life and evolution of species, where the processes that resulted in the emergence of the primordial cell, numerous living species, and human consciousness were highly ordered. Responses to these mysteries may involve scientific, philosophical, or religious theories about God. However, limitations must be acknowledged; for example, laboratory-created universes and directed panspermia are restricted to explaining the universe's origins and life. By contrast, concepts like simulated universes, the brain-in-a-vat, and Boltzmann brains address the entire universe, from inception to end. We cannot dismiss the possibility that we live in a universe created by a deistic God or the Christian God, especially if we exist within a universe shaped by such a deity owing to multiverse randomness.

Similar reasoning applies to extraterrestrial civilizations that could inhabit other universes with comparable physical laws. Strictly from a scientific perspective, theories like laboratory-created universes and simulated realities would also interest extraterrestrials. They might not study only those gods specific to human religions. Conversely, instead of focusing on our religious gods, extraterrestrials might consider their own historic beliefs as valid within the multiverse. If they exist under different physical laws, they might possess religions beyond our understanding. Yet, they would not overlook the idea of scientific deities beyond our imagination that enabled their existence. Finally, the philosophical concept of infinity warrants discussion. If concepts like laboratory-created universes and simulated realities are valid, questioning the origin of the civilization or scientist behind our universe becomes crucial. This leads to the paradox of infinite regression, where each universe is spawned by another civilization or scientist from a different cosmos, continuing the past indefinitely. The same reasoning may be applied to the present and future. In this case, the resulting paradox would be that of infinite replication. At this very moment, an infinite number of civilizations or scientists would exist, creating simulated or laboratory universes. Furthermore, this process would continue infinitely. The above conclusions also apply, albeit with slight variations, to the possible existence of the God of religions, philosophers, or Boltzmann brains. If these models of God are considered the primary cause of the universe they created, then an infinite number of prior gods would exist, formed in the infinite past, present, and future of the multiverse. The paradox of infinite regression and replication does not exclude the possible existence of all types of God or gods described, as no physical or mathematical law prohibits the possibility of infinite regression or infinite

current and future replication associated with the presence of one or more Creators within the multiverse.

4. Becoming gods: Future scenarios for humanity and extraterrestrial civilizations

Another significant issue concerns the possibility that humankind or an alien species may someday attain a god-like status. Shermer (2002, p. 33) asserts that “any sufficiently advanced extraterrestrial intelligence is indistinguishable from God.” This statement does not exclude the possibility that our species or extraterrestrials may one day acquire seemingly divine attributes through technological advancement. From this perspective, several scientific theories explore the prospect of humankind one day attaining divine abilities. Among the most renowned of these theories is that of technological singularity. Kurzweil (2005) argues that technological progress surpasses human predictive capabilities. He describes six epochs in human evolution, with the sixth being particularly intriguing: in this stage, the universe “awakens” as human intelligence expands across the cosmos. This sixth epoch introduces unprecedented scenarios, as humanity will have acquired technologies so advanced that they will appear to confer powers and knowledge far beyond current human limitations. Loosely, such a civilization might be described as “omnipotent” or “omniscient.” However, conceptually, it is important to distinguish between capacities that are maximized within a fixed set of physical laws—such as the ability to manipulate matter and energy on cosmological scales or to access and process enormous amounts of information—and the absolute attributes traditionally associated with the divine in many religious traditions. Classical omnipotence is usually understood as the ability to realize any logically possible state of affairs, unconstrained by antecedent physical laws, while classical omniscience is taken to involve infallible knowledge of all truths, including timeless, counterfactual, and future contingents. Even in the most optimistic technological scenarios, a future civilization would remain bound by whatever laws of nature obtain; its power and knowledge would therefore be maximal only relative to those laws, not unlimited in the strong, metaphysical sense implied by classical theism. A similar argument can be made regarding the Kardashev Scale, a method for classifying civilizations based on their level of technological advancement, developed by Russian astronomer Nikolai Kardashev (1964). Barrow (1998) suggests that up to seven types of civilizations can be identified and asserts that in the seventh type, a future human civilization may be able to modify spacetime structures. Upon reaching this stage, humanity would become a “deity-like” agent, as it could alter the fabric of the universe according to its will within the constraints of the governing physical principles.

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Another type of divinity is associated with the concept of the Omega Point, a concept theorized as early as the 19th century. Hegel (1807) emphasized that humanity will one day witness the rise of a spirit ascending toward a final point where absolute knowledge will be attained. Similarly, Peirce (1931–1958) argues that the universe evolves from an initial state of pure chaos to a final point in which a singular consciousness will permeate the entire cosmos. The Omega Point concept was further developed in the 20th century, mainly by Teilhard de Chardin (1955) and Tipler (1994, 2007). The French Jesuit Teilhard de Chardin published various writings claiming that human evolution is progressing toward an ultimate destiny called the Omega Point, where a transcendent God will emerge. Tipler echoes this thesis, asserting that our civilization will acquire divine faculties through the Omega Point shortly before the occurrence of the Big Crunch. Teilhard de Chardin and Tipler's hypotheses differ in the physical process through which the Omega Point will be accomplished. According to the Jesuit hypothesis, the Omega Point will occur naturally, whereas Tipler hypothesizes that it will be achieved through simulation. All aforementioned ideas are based on the assumption that we will become akin to God. Yet, again, there is an important conceptual distinction: in Teilhard de Chardin and Tipler's models, "divinization" may involve an ultimate unification or maximalization of consciousness and informational capacity, but this does not straightforwardly imply the possession of unqualified omnipotence or omniscience in the strong, classical sense. Rather, the envisaged "god-like" state is tied to particular cosmological dynamics (such as a final singularity or an asymptotic evolutionary limit) and remains conceptually dependent on the structure of the cosmos itself. At this stage, recall that the assumptions from section 2, suggesting that extraterrestrial civilizations created the universe or life, may apply to humanity. Through advancing technology and consciousness, humans could influence life creation or new universes, developing divine faculties. Future humans may create universes in a lab, generate new life forms, or initiate primordial cell formation on other planets through directed panspermia. Additionally, future humanity might develop simulated universes in computers or devices, impacting inhabitants' lives. In the distant future, a mad scientist could also submerge multiple brains in a vat, allowing individuals to experience a false reality.

The end of the universe is another crucial consideration. As discussed in section 1, theories on the universe's end predict the extinction of life and intelligent species. However, technology and evolving consciousness may offer a different outcome. Technological singularity, the Barrow scale, various Omega Points, and creating simulated or lab-born universes could help humanity escape this dark fate. These theories offer varied approaches to the cosmos' end. A technological singularity could permit the construction of time machines to prevent natural processes from leading to the universe's

demise. Accessing the seventh level of the Barrow scale might enable humanity to modify spacetime structure and create new physical laws to prevent cosmological destruction. The Omega Points theorized by Hegel, Peirce, Teilhard de Chardin, and Tipler could be pivotal mechanisms for avoiding the universe's end. The highest consciousness complexity level could allow civilization to survive beyond the cosmos' demise. According to Teilhard de Chardin, this occurs through transcendence, while Tipler suggests that the ultimate gravitational singularity of the Big Crunch could play a vital role. Furthermore, creating simulated and laboratory universes would offer an alternative pathway for continued existence. Through a wormhole¹³, a future human species might migrate to a newly laboratory-created universe or simulated universe and thus continue to exist. All these processes are highly significant, as they could render our species akin to a God endowed with extraordinarily extensive abilities. Nonetheless, even in such scenarios, humanity's power and knowledge would remain conditioned by some overarching framework of physical or informational constraints. For this reason, it is more precise to speak of "god-like" or "quasi-divine" capacities—indicating extreme but still finite powers—rather than to equate a future civilization straightforwardly with a being that is absolutely omnipotent and omniscient in the sense central to many classical doctrines of God.

The same reasoning applied to the possibility of extraterrestrials believing in God can be extended to whether their species might one day attain divine status. As the theories concerning deification are scientific, it is plausible that extraterrestrial beings would consider acquiring god-like abilities through technological singularity, the Barrow scale, or the Omega Point, whether in this universe or in others governed by similar physical laws. Similarly, with abilities developed over millions or billions of years, they might become capable of creating laboratory or simulated cosmoi, placing extracted brains in vats, or even exporting life to other planets through directed panspermia, thereby acquiring divine faculties in the weaker, physically maximal sense just described. The reasoning mentioned in section 3 about God as the creator of the universe or life applies here as well. It raises the question of whether extraterrestrial beings, formed under different physical laws, could one day attain god-like status. In universes governed by physical principles distinct from our own, possible alien species might develop unknown processes that enable them to achieve divinity—processes beyond human comprehension yet scientifically feasible within their respective physical laws. When considering the hypothesis of becoming god-like through technological singularity—for example, the Barrow scale, the Omega Point, and the creation of laboratory or simulated universes—

¹³ Einstein and Rosen (1935) were the first physicists to study the possible existence of wormholes.

these concepts can be connected to the philosophical notion of eternity. Indeed, if extraterrestrials or the human species in the distant future were to master time travel through the construction of time machines¹⁴, they could theoretically repeat this process ad infinitum, thereby perpetually avoiding the universe's ultimate fate. By contrast, the eternity associated with the Omega Point differs fundamentally, as it would be attained in a transcendent or immanent realm beyond the cosmos, eliminating the need for cyclically using a time machine to evade the death of the universe. A more complex concept of eternity emerges in the Barrow scale and in laboratory-created or simulated universes. In these scenarios, much would depend on whether it is possible to modify physical laws or create universes free from cosmic termination. If human or alien civilizations can inhabit a universe where such extinction processes do not occur, a simple adjustment to the laws of nature or the creation of a stable cosmos would be enough for eternal existence. On the contrary, if every universe is destined to end, these species would be forced to continually revise physical laws or build successive laboratory or simulated universes to maintain their eternal existence.

5. Means and methods for investigating the existence of God or gods

At this point, it is important to ask whether the theories previously proposed regarding the possible existence of God could one day be confirmed or refuted. One approach to assessing the existence or non-existence of God involves the concept of probability, encompassing both formal accounts of chance and inductive inference and more qualitative judgments about plausibility (Hacking, 2001; Jaynes, 2003; Kolmogorov, 1950; Swinburne, 2004). Throughout what follows, "probability" and "improbability" are thus to be understood in this broad sense unless otherwise specified. In some contexts, "improbable" will be used qualitatively, to indicate processes that appear highly unexpected or finely constrained against an appropriate background of possibilities; in others, probabilistic language suggests that, in principle, one could assign quantitative measures within a more explicit probabilistic framework, even if current science does not yet allow for robust numerical estimates. Regarding the universe's origin, the phases of the Big Bang, life, and the evolution of species, Aczel (2014) maintains that the improbability of certain processes occurring is truly striking. If the physical laws, universal constants, or phases of the Big Bang had been even slightly different, the universe would have imploded or exploded billions of years ago. A similar line of

¹⁴ According to Davies (2002), the feasibility of time travel, whether into the past or future, is scientifically supported.

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reasoning applies to the origin of the Earth, the emergence of life, and the evolution of species. If the processes that led to the birth of the primordial cell and of consciousness had been even marginally different, humanity would never have existed. In these discussions, “improbability” should not be understood as a precise numerical claim based on a well-defined probability distribution over all possible universes but rather as an expression of how delicately constrained these processes appear in light of current physical and biological theories. If, in the future, it was shown—on the basis of a well-specified probabilistic framework and appropriate cosmological models—that, in a multiverse or cyclic-universe scenario, a large fraction of universes is suitable for life, this would significantly strengthen the case for a theistic explanation, on the assumption that it would be difficult to understand how life-friendly conditions arise so frequently without a deeper explanation.

The same kind of reasoning could be applied to the case of a single universe. The existence of just one cosmos, originating from a primordial energetic nucleus with physical laws and universal constants favorable to life, could be interpreted as evidence of God’s existence. Moreover, if the processes that occurred on Earth—currently regarded as highly “improbable” in a qualitative sense—were common in the cosmos, this too could be read as further support for the hypothesis of a Creator. In all cases, such claims would be warranted if, within an appropriate probabilistic model, such a configuration were judged to have a very low prior probability. As for identifying which God or gods might exist, some insights may be derived from the information available in the cosmos and on our planet. Our universe, like other universes, is governed by information (Lloyd, 2006; Seife, 2007; Wheeler, 1990). Physical laws, universal constants, equations, and initial parameters all comprise a code that has enabled the occurrence of all physical processes throughout the history of our universe. The same principle applies to life: the primordial cell and human genome contain information essential for governing physical processes associated with life and consciousness. Through the study of information within the universe and life itself, it may be possible to determine whether our universe is a simulation, whether it was created in a laboratory, whether we are brains in a vat or representatives of Boltzmann brains, or whether life on Earth was created by an alien civilization. Furthermore, mathematics may assist us in understanding whether the spacetime of the cosmos and the information contained within it follow a precise code, which could be construed as a certain type of God or as evidence of a more general informational structure underlying reality. Simultaneously, it cannot be excluded that information relating to the universe and the Earth could confirm or refute the existence of any form of God, in the sense that future discoveries might either point

toward patterns suggestive of intentional design or instead support a picture in which all observed regularities admit fully naturalistic explanations.

Regarding the hypothesis of God's existence, studying the mathematics of the cosmos' spacetime will be essential. Hsu and Zee (2006) suggest that the cosmic microwave background offers a remarkable opportunity for an eventual Creator of the universe to send messages to its inhabitants, using Lagrangian mathematics. Furthermore, Broadbent (2023) proposes an equation similar to the well-known Drake Equation, composed of 15 factors, which represents the probability that intelligent life in a prior universe initiated our cosmos. This equation can serve as a structured thought experiment to help identify key factors related to the origin of our universe and facilitate the examination of each, with the aim of exploring whether our universe was intentionally created by God or an advanced civilization. Once again, the relevant probabilities here are best understood as model-dependent tools for organizing uncertainty and comparing hypotheses, rather than as precise and final measures of how likely divine creation is in an absolute sense. Thus, mathematics may play a decisive role in assessing whether the cosmos displays signatures that are more naturally interpreted as the product of design, simulation, or laboratory creation, or as the outcome of impersonal physical processes.

Additional means of investigating the existence or non-existence of God may arise from technological advancements, human evolution, and contact with alien civilizations. The development of technology will be crucial in enhancing our intellectual capabilities, unveiling the secrets of the cosmos, and refining our assessments of competing hypotheses about a deity. For example, by constructing highly advanced computers and robots, artificial intelligence (Luger and Stubblefield, 2004; Rich et al., 2010; Russell and Norvig, 2021) could become a valuable ally in addressing questions regarding the existence of God. Another possibility could involve implanting microchips in the human brain or transforming humans into super-intelligent cyborgs (Clark, 2004; Gray, 1995; Mann and Niedzwiecki, 2001) who, with their immense cognitive capacities, might be better equipped to evaluate large bodies of data, complex models, and subtle philosophical arguments related to the deity hypothesis. The final avenue for exploring the question of God's existence may arise from contact with extraterrestrial civilizations. Vinge (1993) argues that extraterrestrial civilizations could reach technological singularity, while Smart (2012) emphasizes that, in the future, aliens might transcend the spacetime of the cosmos. These approaches lead to the conclusion that any potential alien civilizations in the universe would likely possess advanced intellectual and technological capabilities, enabling them to understand the structure of the cosmos and our place within it.

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Should we establish communication with alien civilizations in the future, they could be highly advanced and may have already developed sophisticated views on fundamental questions regarding God. They might, for example, have articulated and tested theories about whether we are part of a simulation, the product of a laboratory experiment, brains in a vat, or representatives of Boltzmann's brain or whether life on Earth emerged through directed panspermia. Moreover, extraterrestrials could offer insights into whether our species has the potential to become "like God" by achieving something analogous to an Omega Point or the seventh level of the Barrow scale. Importantly, such scenarios should be understood, conceptually, in terms of approaching maximal power and knowledge permitted by the physical laws of a given cosmos. Even if aliens were to share technologies that vastly enhance our capacities, they would not thereby confer absolute omnipotence or omniscience in the classical theological sense. Rather, they might help us realize extremely advanced but still law-bound forms of agency and understanding. The search for extraterrestrial intelligence program can also be connected to the thesis presented in this section. It continues to play a crucial role in the search for intelligent life in the universe (Montebugnoli et al., 2022). If the hypotheses of a vacuum universe or a holographic universe—which propose the existence of a single universe—are valid, then an immanent God could be present within our cosmos. Consequently, a research project similar to the search for extraterrestrial intelligence program, but aimed at discovering a Creator in the universe through the construction of highly advanced radio telescopes or analogous instruments, might be conceived as a way to search for signatures of such a being at a specific point in spacetime or encoded in large-scale structures. From such an analysis, we could also gain insights into the physical or biological processes that might, under these speculative models, constitute God.

To conclude, agnosticism must be applied to the hypothesis of a deity and the possibility of humanity one day becoming like God. Dawkins (2006) distinguishes between two types of agnosticism. The first, termed temporary pragmatic agnosticism, pertains to the suspension of judgment concerning a natural mystery that has a valid answer yet remains undiscovered by humankind. The second, termed permanent theoretical agnosticism, applies to enigmas that will never be resolved owing to the lack of evidence confirming or refuting them. Temporary pragmatic agnosticism should be applied to the issues discussed in this chapter. We do not presently know whether scientific theories regarding the possible existence of God or a future "god-like" humanity are true or false. The study of mathematics, probability, and cosmic information, combined with technological advancements and potential contact with extraterrestrials, could help us refine our assessment of these hypotheses.

6. Conclusions

The question of God's possible existence or non-existence remains unresolved. Unlike Hawking and Mlodinow (2010), Dawkins (2006), and Krauss (2012), who deny the possible existence of a Creator, the study of the universe's origin, the theory of everything, the solar system, the origin of life, and the evolution of species does not exclude the possibility of a specific type of deity's existence. At the same time, the available scientific evidence does not compel such a conclusion, but rather leaves open a range of interpretations involving God, the denial of God, and agnosticism. Furthermore, unlike the doctrines of established religions that reject the idea that humans can become like God, human civilization, supported by technological advancements, may in principle develop faculties that appear "god-like" relative to our current condition. Such faculties, however, would be better understood as approaching the maximal powers and knowledge permitted by the laws of nature, rather than as conferring absolute omnipotence or omniscience in the classical theological sense. Theories concerning what preceded the Big Bang and the ultimate fate of the universe do not negate these previous observations about the potential existence of a deity or the possibility of humanity acquiring quasi-divine faculties. For example, the idea of a multiverse or cyclic universe does not diminish the significance of our universe, particularly when considering the unique physical laws that govern it. This perspective suggests that our universe could be part of a broader cosmic context that still holds its importance. Conversely, theories about the eventual end of the cosmos, even those predicting the cessation of life, do not necessarily preclude the possibility that advanced technology could enable humanity or other intelligent species to mitigate, postpone, or partially reshape their cosmic fate. Notably, no physical law explicitly excludes the possibility of not only one God but also a plurality of gods, and it is conceivable that discussions regarding the potential existence or non-existence of a deity may likewise be ongoing among alien species.

In this essay, I have highlighted scientific theories that hypothesize the existence of a God or gods or that predict the potential for human or alien species to become god-like. The hypotheses of a laboratory-created universe, directed panspermia, simulated universe, brain-in-a-vat, and Boltzmann brain indeed include the possibility of intervention by powerful agents—whether described as "gods" or advanced civilizations—at specific points in the history of our universe. The God conceived by established religions or philosophers cannot be dismissed either, as universes in which such a deity emerged or acts may exist within a multiverse. I have also highlighted the philosophical and scientific aspects of the question of a deity's existence. This consideration leads to the argument that, in the past, another deity could have created

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every deity, while in the future, we might engender new types of “deities” through processes that could in principle repeat without bound, such as infinite regression and replication. These speculative scenarios do not demonstrate that such chains of creators actually exist but illustrate how certain cosmological and multiverse models can accommodate them without evident contradiction. Thus, science and philosophy may be combined to explore the question of God further. Science does not preclude the possibility that humanity or an alien species could become god-like one day. Technological singularity, the Barrow scale, and various theories concerning the potential existence of the Omega Point pave the way for the hypothesis that one day we may acquire extraordinarily extensive capacities for control and understanding. Yet, conceptually, these would still constitute powers and knowledge bounded by the operative physical laws and conditions of whatever cosmos such beings inhabit. They would therefore fall short of the absolute omnipotence and omniscience traditionally attributed to the divine, and should be described more cautiously as “quasi-divine” or “maximal within a given nomological framework.” The same theories that hypothesize the existence of a God, as discussed in section 2, may also be applied to humanity, as we may one day create laboratory or simulated universes, place people’s extracted brains in a vat, or generate primordial cells on other planets. In each case, the analogy with divinity is suggestive but not identity-conferring: such creators would be powerful finite agents, not unconditioned, metaphysically ultimate beings.

Currently, the limitations of this study are related to the lack of technological tools and our incomplete understanding of many aspects of the cosmos, which leave hypotheses about the existence of God and the possibility of human civilization developing divine faculties unresolved. However, in this article, unlike Aczel (2014), who denies the possibility of discovering God’s existence and, indirectly, whether humans can become like God, I highlight that there are tools and methods that could, in principle, allow human civilization to address these fundamental questions more effectively. Such methods include not only empirical investigation and theoretical modeling but also refined conceptual analysis that clarifies how terms like “probability,” “creation,” “omnipotence,” and “omniscience” are being used. The study of mathematics, technological advancements, and contact with extraterrestrial civilizations could prove crucial in evaluating theories about God’s existence or non-existence. Moreover, future research could explore how interdisciplinary approaches—combining progress in physics, cosmology, technology, and philosophy—may offer new insights into questions related to God and to the possible future status of intelligent life. Therefore, a temporary pragmatic agnosticism should be adopted regarding the deity hypothesis, as scientific and conceptual progress may one day enable a more informed assessment, and perhaps even

strong confirmation or refutation, of some specific theories involving God or denying His existence. In conclusion, this study outlines a framework for a future in which the great mysteries regarding the existence of God and the possibility that human civilization may develop god-like faculties could be investigated through the use of artificial intelligence, contact with extraterrestrial civilizations, and a thorough exploration of mathematical and cosmic information. It also encourages researchers to pursue the unknown with boldness and creativity, while remaining cautious about inferring inevitability or logical compulsion from future discoveries. As Einstein (1938, p. 83) stated: “To pose new questions, new possibilities, and to view old problems from a new angle requires creative imagination and marks real progress in science.”

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A Critical Realist Perspective on Beauty in Physics

Matthew D'Antuono¹

Abstract

The statements of physicists about the beauty of physics have inspired philosophers to investigate the nature of such claims from a philosophical perspective. When philosophers look at what physicists say, however, they find a variety of theories and aspects of physics that are identified as beautiful as well as some disagreement. Just using the physicists' statements, it is difficult to determine where exactly the beauty of physics lies. This paper proposes to use the critical realist philosophy of aesthetics as a foundation for examining what scientists say about the beauty of their subject, and the main contention is that critical realist aesthetics best accounts for their assertions.

Keywords: physics, science, beauty, aesthetics, realism.²

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1. Introduction

It is not uncommon to find physicists expounding on the beauty of physics and even, sometimes, claiming that beauty is or has been a guide to finding what is true. Such statements, of course, raise a series of philosophical questions, the most important being whether or not those statements are true. Other questions which arise involve the nature of beauty, the nature of physics, what it might mean for physics to be beautiful, and how the natures of beauty and physics might intersect.

Philosophers have devoted time and energy to such questions (e.g. de Regt, 2002; Ivanovna, 2021; McAllister, 1996; Root-Bernstein, 2002). Many of these studies begin with the data of the statements of the physicists themselves and then begin to piece together what it is they might mean by reference to the beauty of physics and whether or not they line up with each other. In general, they look for a pattern in the writings of the scientists for agreement about particular theories or aspects of theories that might be beautiful. When patterns do not emerge or physicists disagree about particular aspects they find beautiful, it is sometimes concluded that the scientists are, therefore, wrong in identifying beauty (e.g. de Regt, 2002).

Besides the disagreement that can be found among physicists is the fundamental and universal objection to statements about beauty in general, and that is the simple fact that people disagree about what is beautiful, and this disagreement is alarmingly common if there is to be any hope of finding objectivity in claims about what is beautiful (cf. Kovach, 1976, p. 62).

This paper proposes a different way of approaching the situation and attempts to demonstrate the utility of the critical realist perspective on philosophical aesthetics in the attribution of beauty in physics. Essentially, the traditional viewpoint on beauty, as developed by Plato, Aristotle and Aquinas, and synthesized in the work of Francis Kovach gives the best account for the beauty that physicists find in their science as well as a sufficient response to the objection that people disagree about what is beautiful.

The other questions as to the nature of science and, ultimately, whether or not there is beauty in physics, are beyond the scope of this paper, worthy though they are of attention.

2. What the physicists say

It is important to begin with what might be called the “raw data,” the statements of the physicists themselves, so we will take some time now to look at a sampling of some of the things physicists have said about beauty in physics and take note of some patterns. What I would like to look at in particular are the characteristics of beautiful things that

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are identified, rather than what theories or equations are said to be beautiful, although there are a couple of theories which are almost universally regarded as such: Einstein's theory of relativity (Schrödinger, 1996, p. 25; Engler, 2002; Stewart, 2007, pp. vii - viii) and Maxwell's equations (Engler, 2002; Stewart, 2007, p. 180; Lederman and Hill, 2008, p. 68). It is, instead, the aspects of what is found aesthetically pleasing which will be most helpful here.

It would take up too much time here to present a large number of quotes, so the passages cited here are those where physicists describe *why* they find physics beautiful. The most helpful statements are the ones where physicists attempt to describe what it is about a theory that they find beautiful so that a pattern can be discovered. There are a few physicists who have attempted to go into detail, and their comments are very valuable for philosophical analysis.

To begin with, David Bohm identifies *oneness*, *totality*, *wholeness*, and *harmony* (2010, p. 3). Of the four words he uses, the first three appear to be synonymous with each other, while the last, *harmony*, has to do with how something is unified in the way the parts relate to each other and to the whole. Another characteristic identified by Bohm is what is *fitting* (Ibid., p. 127), which seems analogous to *harmony*, the way in which things fit together to form a whole.

Werner Heisenberg's description of beauty fits well with Bohm's, and he calls beauty the "right concordance of parts" (1970). This can be called *harmony* or *fittingness* which is part of what makes a thing whole and entire, a unity. Chandrasekhar agrees with Heisenberg (1987, p. 52).

An idea that is similar to the idea of *harmony* and *fittingness*, is that of *order*, as mentioned by Pierre Duhem (1991, p. 24) and *order* is also identified by Bohm as a fundamental component of beauty (2010, pp. 8, 39, 42, 117). Heisenberg's description of beauty could very well substitute the word *order* for *concordance* (1970).

The physicist John Taylor finds beauty in the reduction of number of principles and laws so that physics becomes *simpler* and more *unified* (2001, p. xi). Physicist Paul Davies (1992, pp. 21, 211) and mathematician Ian Stewart (2007) explain how *symmetry* is an expression of the *simplicity* and *unity* of the universe which scientists find particularly beautiful. The title of Stewart's book sets his assertion about the beauty of symmetry center stage: *Why Beauty is Truth: A History of Symmetry*.

This is only a small sampling of the available data, but it follows the general trend of the comments found in the work of physicists. More direct quotes can be found in my previous work (2021; 2026). The quotations selected here are representative of the handful of qualities which constantly recur: *simplicity*, *harmony*, *order*, and *fittingness*. Even when those exact words are not used, they refer to the same kinds of qualities.

Either the physicists are imagining things, or they are talking about a real aspect of their work and of the world. Either beauty is real and has these qualities, or it is only in the minds of the physicists. What becomes necessary to examine here, then, is the philosophy of beauty. The physicists are not philosophers, and a fuller account of the nature of beauty must be found in the domain of philosophy.

3. The nature of beauty

The primary challenge that faces the aesthetics of science is the simple fact that scientists do not always agree on what they find beautiful or why they find it beautiful (cf. de Regt, 2002). As the passages cited above demonstrate, physicists use a variety of language, even if there are observable patterns. So, basing a philosophy of aesthetics on the statements of scientists may not be the best approach. An already established philosophy should be able to do justice to what physicists say. Kovach presents such a philosophy (1976). While Kovach does not discuss *scientific* aesthetics, his philosophy forms a foundation that can sustain what scientists have said about beauty in science.

Two key features of Kovach are his realist approach and his definition of beauty. Kovach argues that beauty is a feature of reality itself, and he defines beauty as “*order, that is, integral unity, or integral unity with or without proportional parts*” (Ibid., p. 215). As such, Kovach is an aesthetic realist according to current terminology (Bender, 2009, pp. 96-97), which differs from the terminology Kovach uses (1976, pp. 51, 156). According to both sets of word usage, Kovach is a realist since he argues that beauty is a real feature of reality, not simply that statements about beauty have truth value regardless of whether or not beauty is actually a part of things (Bender, 2009, pp. 96-97). According to current usage, an objectivist would hold that true statements can be made about beauty or that characteristics can be called beautiful even if beauty is not actually outside of the human person and in the exterior world and the objects being identified as beautiful (Ibid.).

Kovach, in his realist perspective, identifies beauty as order and integral unity (1976, p. 215). This definition is derived from a survey of philosophers of aesthetics who discuss the various reasons why people identify things as beautiful. He synthesizes those various characteristics into a succinct definition that does justice to the various reasons people find things as beautiful, just as I am trying here to synthesize the things physicists have identified as beautiful.

Another key aspect of Kovach’s aesthetics is that there is a metaphysical basis for his definition. *Order* is not just another characteristic like the coordination of colors or balance of sensory input; *order* has to do with how something exists. In other words, it has to do with the being of the thing in question. Remove all order and unity from an

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object, and it ceases to be a thing at all. The order determines the relation of the parts to the whole and the whole to the parts. Far from being something that results from a property or a collection of properties (supervenience), what is at issue here is the manner of existence of a thing according to the kind of thing that it is.

That fact that the nature of a thing is what determines *order* for it highlights the role of the intellect in this aesthetics. Beauty is not merely or even primarily known through the senses; the work of the intellect is necessary (Ibid., pp. 55-64). The importance of the role of the intellect is also attested to in neuroaesthetic research. Leder, Belke, Oeberst and Augustin, as a result of fMRI scans, have developed a 5-stage model of aesthetic appreciation when it comes to modern art that highlights the role that the intellect plays in recognizing, analyzing and identifying modern art (2004). Kovach operates generally within the framework of Thomas Aquinas who also identified the importance of the intellect in recognizing the natures of things and, therefore, their beauty as well (Summa Theologiae, I, q. 5, a. 4, ad 1). Things are beautiful insofar as they are intelligible, and things are intelligible insofar as they exist to the fullness of their nature. If, regarding order and unity, Roger Scruton asks “unity and order according to what” (2011, p. 162), the answer would be: according to the kind of thing that it is.

This role of the intellect in the recognition and experience of beauty is the reason I am calling this a *critical* realist perspective. Beauty is mediated to us through the intellect and the human ways of knowing, like science, and we recognize and analyze aesthetic delight by reflecting on such encounters. The union of a human’s experience and the real world is the cause of our appreciation of beauty. Thus the necessity that we have the right disposition, education, and attention to see beauty, otherwise we will not be receptive to the order and unity that is truly present in things.

Among the first of those who would deny aesthetic realism is Baruch de Spinoza who claims that the minds and tastes of men vary considerably, and people make judgements about beauty according to those various dispositions (1998, Appendix). What one person thinks is orderly another finds confused, and what one finds delightful, another finds odious, he argues (Ibid.). In other words, beauty is not an objective reality, but only an expression of what an individual finds pleasing and harmonious and there is no criterion of beauty outside of the individual observer. In making such an argument, Kovach would classify Spinoza as an aesthetic subjectivist (1976, p. 82). Spinoza, of course, is not the only aesthetic subjectivist (e.g. Stolnitz, 1960, p. 392), and in each case the primary argument for aesthetic subjectivism is the simple fact that people disagree about what is beautiful.

As the reader can observe, much of the discussion of the philosophy of aesthetics takes place within the context of art, but even when it comes to the beauty identified by

physicists, there is not complete agreement about which theories are beautiful and why (cf. de Regt, 2002); however, there does seem to be general agreement about some theories such as Maxwell's equations (Engler, 2002; Stewart, 2007, p. 180; Lederman and Hill, 2008, p. 68) and Einstein's theory of relativity (Schrödinger, 1996, p. 25; Engler, 2002; Stewart, 2007, pp. vii - viii). Chandrasekhar himself says that beauty is subject to the temperaments of the individuals (1987, p. 153), similar to Spinoza (1976, p. 82), and yet at the same time he approves of Heisenberg's definition of beauty as a harmonious order of parts (1987, p. 52; cf. Heisenberg, 1970).

Disagreement over what is beautiful need not disprove aesthetic realism, though, especially as it is defined and defended by Kovach who discusses 36 reasons why there might be disagreement among people when it comes to differences of opinion about what is beautiful (1976, pp. 101-136). As for a few examples, the disagreement is sometimes only apparent because the people are not operating from a common understanding of the term *beautiful*; some people may simply mean that they find something pleasing while others may have a more formal and objective definition in mind (Ibid., pp. 105-107). Another reason, he argues, why people may disagree is that one observer may be overfamiliar with a beautiful object and over time have been dulled to the beauty which strikes someone who experiences it for the first time or who sees it from a new perspective (Ibid., pp. 107-108). In some cases, it takes time and education to be able to see the beauty in something, as is definitely the case in physics; someone without significant training in physics simply will not be able to see the beauty in the theories, and that would lead to disagreements about what is beautiful (Ibid., p. 111). Two more examples: the conditions of a person's senses as well as a person's emotional or physical state may get in the way of someone's ability to perceive a particular beauty (Ibid., pp. 114-134). In summary, there are many reasons why people may disagree about *what* is beautiful.

However, when we look at *why* people say that something is beautiful, if they have the ability to articulate it, there is a striking pattern. Take the quotes from the physicists in section 2. The ideas of order, harmony, proportion, integrity, and unity. Essentially, when people find something beautiful, the *reasons* they find it beautiful are in alignment with one another; i.e., there is agreement about why the things that are beautiful are beautiful. Even when Spinoza argues for the subjectivity of beauty, he says that it is because people differ in what they find delightful and orderly (1998, Appendix). Even in his evaluation, it is implied that *order* is what people find beautiful. Kovach would argue that people disagree, then, because of their different capacities, whatever the reasons, for recognizing order and delighting in it.

Since the standard for beauty in the realist perspective has to do with *why* things are beautiful instead of agreement on *what* things are beautiful, disagreements over which

theories are beautiful or whether or not the beauty of physics lies in the equations, the theories, or some other aspect of science do not disprove the objective nature of beauty. To view it from the other side, consider cases where people praise the beauty of something *because* of its disorder, dissonance, and lack of unity. Even in cases where the disorderly and grotesque (e.g. Eco, 2007; Fine, 2023) are praised as beautiful, what is praised is not necessarily the disorder and grotesque in itself, but because those traits are somehow given meaning or are well-ordered to the work as a whole, the nature of art itself, the historical context of the art, the current trends in art, or the state of society and culture of its time. A painting that depicts something ugly is still a painting; if it lacked all order, it would not be a painting (or anything!) at all.

4. Beauty in physics

The same can be said for the universe itself. The discoveries of physics have revealed a real and fundamental order about the universe. Beauty has an objective reality, but it is known by humans through the methods and mathematical language of physics. It adds another layer of complexity which takes into account *how* humans know things and know beauty. The physics we have is the product of many methods, developments, and paradigm shifts over the years. Beauty is known through the union of the human mind with the aspects of the physical universe described by physics, a human endeavor shaped by centuries of human development and discovery. It is through these modes that we discover and come to appreciate order and integral unity in the quantifiable characteristics of the physical universe. Whatever is described as beautiful by physicists, whether they agree in particulars or not, can be accounted for by this critical realist perspective on beauty.

When physicists discuss the beauty of physics, it is always some sort of order that they praise. For the most part, their comments imply that physics in fact reveals something about the universe itself. Some physicists are explicit in claiming that the beauty science reveals is the beauty not just of equations or products of the human mind but the universe itself (Davies, 1992, p. 152; cf. Penrose, 1999, p. 430). This is best accounted for by a critical realist perspective on beauty. We are dealing here not even with particular characteristics or properties, but the nature of the being of the universe; the symmetries and intelligibility of the fundamental existence of the universe itself come to the surface through physics. Any other philosophy of aesthetics would undermine what physicists say; the goal of philosophy here is to explain what they say, not explain it away. Comments like those of Davies and Penrose require more than mere aesthetic objectivism in order to be true.

So, the definition of the beauty of physics I propose here, as I have elsewhere (D'Antuono, 2026) is this: *the order and unity of the physical universe as observed and understood by human minds*. This definition is based on a rigorous metaphysical and aesthetic philosophy, and it does justice to what the physicists have said about the beauty of physics.

There are some physicists who claim that their science does not necessarily give information about the universe itself; theory is only a way of organizing experimental results (e.g. Duhem, 1991, p. 54). It is beyond the scope of this paper to investigate the philosophy of physics as well, but it can be noted that the philosophy of science and the philosophy of aesthetics are necessarily intertwined when it comes to these things that physicists say. Duhem's perspective, however, does not undermine the realist *aesthetic* philosophy proposed here. The definition of the beauty of physics as the order and unity of the universe as understood by human minds explains the beauty argued for by both Penrose *and* Duhem.

This definition also does justice to the claim made by some physicists about the relationship between the beauty of a theory and its truth. A true theory is one that describes the intelligibility of the universe, and the universe's intelligibility is encountered as beauty *and* truth in the mind of the physicist. Sometimes, it takes time for physicists to appreciate the beauty of a theory, but this process is united with the times it takes to see the truth of a theory, as McAllister has outlined (1996, pp. 33, 65, 78). As the mind meets with oneness of reality as it truly is, the intellect recognizes and delights in its intelligibility.

In summary, the fact that people disagree about beauty does not disprove the realist theory of beauty, and that is part of what makes Kovach's definition of beauty useful in making sense of the beauty of physics where there is some disagreement. Also, his definition fits well with the aspects of theories identified as beautiful: order, harmony, simplicity, fittingness, etc. Over the years, as paradigms and tastes have shifted and as some theories have come to be appreciated over time, account can be taken by considering the *critical* aspect of critical realism which considers the way in which science is known through human modes of knowing, describing, and discovering.

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From Noise to Information: A Thermodynamic Epistemology of Brandolini's Asymmetry

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Abstract

Brandolini's Law states that refuting nonsense requires far more effort than producing it, yet it has remained largely metaphorical. This paper develops a thermodynamic-informational framework for this asymmetry by modeling misinformation as noise, refutation as entropy reduction, and parsimony as free energy minimization. The resulting generalized Brandolini principle links the work of refutation to the reduction of the hypothesis space, scaled by informational temperature. The paper further extends the model to networks of interacting claims, showing how circular reinforcement among false statements increases systemic epistemic cost, especially in low-mobility environments such as echo chambers and niche pseudoscientific communities. The framework suggests that Brandolini's Law and Occam's Razor are not independent heuristics but complementary expressions of informational dynamics: parsimony defines low free energy epistemic states, whereas Brandolini's asymmetry describes the cost of restoring them after noise has expanded the hypothesis space.

Keywords: Brandolini's Law; misinformation; entropy; free energy; parsimony; epistemology.[†]

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1. Introduction

The contemporary epistemic landscape is marked by a striking asymmetry between the ease of producing misinformation and the difficulty of refuting it. This imbalance has been popularized as Brandolini’s Law, or the “Bullshit Asymmetry Principle,” which states that the amount of energy required to refute nonsense is an order of magnitude greater than that needed to produce it. While the observation is intuitively compelling and resonates with everyday experience—from social media debates to public controversies in science—its conceptual underpinnings remain largely metaphorical. The law is typically invoked as a rhetorical principle rather than a theoretical framework. Yet, if this asymmetry is pervasive, it should admit formalization in terms of the fundamental laws of information and knowledge production.

Parallel to this, the principle of parsimony, often expressed through Occam’s Razor, has long served as a guiding heuristic in science and philosophy: among competing hypotheses, the simplest explanation consistent with the evidence should be preferred. Parsimony is not merely an aesthetic preference but a pragmatic rule that reflects the cognitive and social economy of inquiry. Scientific practice advances most efficiently when it avoids unnecessary complexity and restricts itself to models that minimize redundancy (Frigg & Nguyen, 2020). In this sense, Brandolini’s asymmetry and Occam’s Razor describe two sides of the same epistemic coin: one highlights the penalty of abandoning parsimony by generating informational noise, while the other highlights the benefits of minimizing explanatory overhead.

Recent developments in the philosophy of information and cognitive science provide tools for bridging these ideas. Floridi (2011) has argued that information should be treated as a fundamental building block of reality, and that epistemology itself can be reinterpreted in informational terms. In parallel, thermodynamics of computation, pioneered by Landauer (1961), has shown that processing and erasing information carries an irreducible physical cost, measurable as a minimum dissipation of energy. These insights suggest that epistemic processes—whether generating, filtering, or validating information—can be fruitfully described within a thermodynamic framework.

From this perspective, misinformation can be described as informational noise: it inflates the number of possible states or hypotheses (Ω_{noise}) without necessarily constraining them toward truth. In contrast, refutation corresponds to the production of information: it reduces the multiplicity of possible states to a smaller, more ordered set ($\Omega_{\text{info}} \ll \Omega_{\text{noise}}$). The entropy difference between these two states implies a cost in free energy:

$$\Delta F = kT \ln \left(\frac{\Omega_{\text{noise}}}{\Omega_{\text{info}}} \right)$$

This expression, formally analogous to Landauer’s principle, quantifies Brandolini’s asymmetry: to recover information from noise requires work proportional to the reduction in accessible states. The generalized Brandolini principle thus emerges as a consequence of thermodynamic constraints on informational systems.

The problem, however, is not merely one of individual cognition. As numerous studies of the “post-truth” era emphasize (Lewandowsky, Ecker, & Cook, 2017; Wardle & Derakhshan, 2017), misinformation is often amplified by the architecture of digital platforms and by the dynamics of collective attention. High-mobility environments, such as global social networks, correspond to high “informational temperatures” (T): in these contexts, false claims may spread rapidly, but so can their corrections, leading to relatively efficient fact-checking. By contrast, in low-mobility environments—niche communities, pseudoscientific subcultures, or insulated epistemic bubbles—the effective informational temperature is low. Here, corrections struggle to propagate, and misinformation persists disproportionately longer, exacerbating Brandolini’s asymmetry. These dynamics resonate with empirical studies of online echo chambers (Bessi & Ferrara, 2016) and with philosophical accounts of epistemic injustice and hermetic knowledge structures.

The present paper develops this perspective by offering a formal model that unifies Brandolini’s asymmetry with the principle of parsimony under the umbrella of free energy minimization. We first introduce the theoretical framework that connects noise, information, entropy, and informational temperature. We then propose a model of interacting news items, analogous to interacting particles in statistical mechanics, in which falsehoods can form clusters that reinforce one another. In this model, two false claims that cite each other do not reduce the system’s energy but instead raise it, reflecting the epistemic penalty of circular support. Finally, we show how the principle of parsimony emerges naturally as the minimization of free energy, and how Brandolini’s asymmetry can be understood as the energetic cost of restoring parsimony after it has been disrupted by noise.

By grounding Brandolini’s law in thermodynamic and informational principles, this paper aims to transform a rhetorical observation into a general epistemic framework. Such a framework not only clarifies why misinformation is harder to refute than to generate but also provides tools for understanding why certain types of misinformation—particularly those in low-mobility epistemic niches—are more resilient than others. The implications extend beyond abstract epistemology: they inform practical debates on fact-checking, the governance of digital platforms, and the role of parsimony in the production and validation of knowledge.

2. Background and Related Work

2.1 Brandolini’s Law and epistemic asymmetry

Brandolini’s Law, also known as the “Bullshit Asymmetry Principle,” has gained visibility in public discourse as a heuristic observation: the energy needed to refute nonsense is an order of magnitude greater than that required to produce it. While frequently cited in discussions of misinformation, political rhetoric, and public debates, the principle remains largely informal. It has rarely been subjected to systematic philosophical or mathematical analysis. Its appeal lies in articulating an asymmetry that resonates with daily experience: unsubstantiated claims can be produced cheaply, but countering them requires evidence, verification, and time. The absence of

a rigorous theoretical framework, however, has limited its integration into broader epistemological debates.

2.2 Parsimony and the principle of economy

The principle of parsimony—often attributed to William of Ockham’s famous injunction not to multiply entities without necessity—has long guided scientific reasoning. Parsimony functions as a normative criterion: when confronted with multiple explanations, the simpler one, consistent with the data, is to be preferred. Beyond heuristic appeal, parsimony can be interpreted as a strategy for minimizing cognitive, social, and informational costs. By restricting the hypothesis space, parsimony reduces entropy, focusing resources on models that maximize explanatory power while minimizing redundancy (Frigg & Nguyen, 2020). In this sense, parsimony is not opposed to Brandolini’s law but complements it: while Occam’s Razor prescribes efficiency in knowledge production, Brandolini’s law highlights the costs of inefficiency once the epistemic economy is disrupted.

2.3 Philosophy of information and the ontology of data

Luciano Floridi’s philosophy of information has provided a conceptual foundation for treating information as a primary ontological category (Floridi, 2011). On this view, epistemology and metaphysics can be reframed in informational terms: knowledge production is the structured manipulation of data, and truth corresponds to the alignment of information with reality. This informational turn offers fertile ground for analyzing misinformation and epistemic asymmetry. Rather than treating falsehoods merely as cognitive errors or rhetorical devices, they can be modeled as informational states—specifically, as high-entropy states that enlarge the set of possible descriptions without converging toward truth.

2.4 Thermodynamics of computation and Landauer’s principle

In parallel, research in the thermodynamics of computation has revealed that information processing entails irreducible physical costs. Landauer (1961) famously showed that erasing one bit of information dissipates at least $kT\ln(2)$ of heat. This principle anchors information theory in thermodynamic law: information is not abstract but physically embodied. Later developments in statistical mechanics and quantum information have extended this insight, demonstrating that every informational transformation has energetic implications. For epistemology, the implication is clear: processes such as learning, verifying, and refuting are not cost-free but bound by physical constraints. The analogy between refutation and information erasure is particularly striking: both involve reducing entropy by eliminating possibilities.

2.5 Misinformation, disinformation, and the post-truth condition

The rise of digital platforms has transformed the ecology of information. Scholars have documented how misinformation spreads faster and deeper than corrections (Lewandowsky,

Ecker, & Cook, 2017). Wardle and Derakhshan (2017) distinguish between misinformation (false information spread without intent), disinformation (false information spread deliberately), and malinformation (true information spread maliciously). These distinctions emphasize that epistemic asymmetry is not merely cognitive but socio-technical: platform architectures, attention dynamics, and algorithmic amplification all shape the circulation of truth and falsehood. Empirical work confirms that falsehoods often exploit high-mobility environments, propagating quickly across networks, while corrections lag behind (Bessi & Ferrara, 2016). This asymmetry resonates with Brandolini's observation but situates it within a broader context of structural vulnerabilities in the information ecosystem.

2.6 Complexity, rare events, and epistemic resilience

The literature on complexity and uncertainty further contextualizes epistemic asymmetry. Taleb (2007), in his work on Black Swan events, underscores how improbable yet impactful events can dominate epistemic landscapes. The difficulty of refutation parallels the difficulty of anticipating rare but disruptive occurrences: both reveal the fragility of epistemic systems. Moreover, models from network science suggest that local reinforcement—when claims cite and recirculate one another within closed communities—creates self-sustaining clusters of belief. These “epistemic bubbles” or “echo chambers” exhibit resilience not because their claims are strong but because their structure insulates them from correction. In thermodynamic terms, these are low-temperature environments: informational mobility is low, so once noise becomes entrenched, restoring order demands disproportionate energy.

2.7 Toward a unified framework

Despite these converging literatures, no unified model currently integrates Brandolini's asymmetry, parsimony, and the thermodynamics of information. The philosophy of information provides the ontological tools, Landauer's principle provides the physical grounding, and studies of misinformation highlight the empirical stakes. Yet these strands remain disconnected. This paper aims to bridge them by treating misinformation as noise (high entropy), refutation as information (low entropy), and parsimony as the minimization of free energy. In this view, Brandolini's law is not merely a social observation but a manifestation of fundamental informational asymmetries. By articulating this framework, we aim to contribute to both the philosophy of science and the interdisciplinary study of information in the post-truth era.

3. Theoretical Framework

The thermodynamic vocabulary used in this framework—entropy, free energy, and informational temperature—is intended as a *formal analogy* that maps structural properties of epistemic systems onto well-understood thermodynamic relations. These terms do not refer to physical heat dissipation or literal thermodynamic processes in belief revision. Rather, they capture how hypothesis spaces expand or contract, how information circulates, and how epistemic constraints behave in ways that parallel thermodynamic principles.

This analogy has clear boundaries. Real epistemic processes involve cognitive biases, social structures, platform dynamics, and strategic communication, none of which follow idealized thermodynamic behavior. Entropy and temperature here represent constraints on information flow and hypothesis multiplicity, not physical quantities. The framework therefore offers a conceptual model—useful for understanding epistemic asymmetries—but not a literal physical description of human reasoning.

3.1 Noise, information, and entropy

In informational terms, we can distinguish between two kinds of epistemic states:

- **Noise:** claims or signals that enlarge the set of possible descriptions without constraining them toward truth. Noise increases entropy because it multiplies the number of states compatible with a given situation. Let the multiplicity of states under noise be denoted by Ω_{noise} .
- **Information:** claims or signals that restrict the set of possibilities, reducing entropy and converging toward truth. Information corresponds to a smaller set of compatible states, $\Omega_{\text{info}} \ll \Omega_{\text{noise}}$.

Formally, entropy is given by the Boltzmann relation:

$$S = k \ln(\Omega),$$

where k is Boltzmann's constant (or its informational analogue).

The transition from noise to information thus involves an entropy change:

$$\Delta S = S_{\text{info}} - S_{\text{noise}} = k \ln \left(\frac{\Omega_{\text{info}}}{\Omega_{\text{noise}}} \right) < 0$$

3.2 Free energy and the cost of refutation

At constant temperature, the Helmholtz free energy is defined as:

$$F = U - TS,$$

where U is internal energy and T is temperature.

Moving from noise to information corresponds to reducing entropy, and therefore raising the free energy of the system:

$$\Delta F = -T\Delta S = kT \ln \left(\frac{\Omega_{\text{info}}}{\Omega_{\text{noise}}} \right).$$

By the second law of thermodynamics, the minimum work (W_{min}) required to perform this transformation is:

$$W_{\text{min}} \geq \Delta F.$$

This inequality expresses the energetic asymmetry between generating noise and producing information: the former may require negligible cost, while the latter demands work proportional to the reduction in entropy.

3.3 Informational temperature

The parameter T can be reinterpreted in epistemic terms as **informational temperature**. Analogous to physical temperature, which measures the ease with which energy produces entropy, informational temperature measures the ease with which information circulates within a system.

- **High T :** information flows rapidly. Corrections spread widely, reducing the asymmetry between noise and information.
- **Low T :** information is trapped in niches or echo chambers. Corrections diffuse poorly, amplifying the asymmetry.

This interpretation aligns with studies of social media and epistemic bubbles: high-mobility environments facilitate fact-checking, while low-mobility niches preserve misinformation.

3.4 Generalized Brandolini Principle

The transition from noise to information involves reducing the multiplicity of admissible states from Ω_{noise} to Ω_{info} . The entropy change associated with this transition is

$$\Delta S = k \ln(\Omega_{\text{noise}}) - k \ln(\Omega_{\text{info}}).$$

The minimum work required to perform this entropy-reducing transformation at informational temperature T_{info} is

$$W_{\min} \geq k T_{\text{info}} \ln \left(\frac{\Omega_{\text{info}}}{\Omega_{\text{noise}}} \right).$$

Definitions:

- Ω_{noise} : multiplicity of states compatible with the noisy claim.
- Ω_{info} : multiplicity of states compatible with the informative claim.
- T_{info} : informational temperature, i.e., the degree of epistemic mobility or ease of information flow.
- k : Boltzmann constant or its informational analogue.
- $W_{\min}$: minimum work required to convert noise into information.

Generalized Brandolini Principle: The minimum work required to transform noise into information is proportional to the logarithm of the ratio of noise states to information states, scaled by the informational temperature of the system.

This principle formalizes Brandolini's law: the asymmetry between producing noise and refuting it is not accidental but follows from fundamental constraints on entropy and free energy.

3.5 Connection to Landauer's bound

The expression above is directly analogous to Landauer's principle in computation, which states that erasing one bit of information requires at least $kT \ln(2)$ of energy. Refutation, like erasure,

eliminates possibilities by compressing the hypothesis space. Each bit of evidence corresponds to a unit of entropy reduction, with an associated energetic cost.

Thus, Brandolini’s law can be interpreted as a social-scale manifestation of Landauer’s bound: while producing falsehoods may be entropically cheap, refuting them incurs the universal cost of informational erasure.

4. Model of Interacting News

4.1 From isolated claims to interacting systems

The generalized Brandolini principle, as formulated above, addresses the energetic cost of transforming a single noisy claim into ordered information. Yet in real epistemic environments, claims rarely exist in isolation. News items, scientific hypotheses, and social assertions interact with one another, forming networks of mutual support or contradiction. To capture this, we require a framework that treats misinformation not as isolated noise, but as part of a dynamic system of interacting informational states.

4.2 Network representation

Let us represent the information environment as a graph $G = (V, E)$, where each node $i \in V$ corresponds to a news item or claim, and each edge $(i, j) \in E$ represents a relation of citation, endorsement, or propagation between claims. Each node can be assigned a state variable s_i , with $s_i = +1$ indicating veridical (information-bearing) content and $s_i = -1$ indicating noisy or false content. This binary representation can be generalized to continuous or categorical states, but it suffices for illustrating the basic dynamics.

4.3 Interaction energy

Analogous to interacting spins in statistical mechanics, we define an energy function for the system:

$$E(s) = \sum_i h_i s_i + \sum_{(i,j) \in E} J_{ij} \Phi(s_i, s_j).$$

- The term h_i represents the external evidential field acting on claim i . A strong empirical basis corresponds to $h_i > 0$, pushing the claim toward truth.
- The couplings J_{ij} represent the strength of relation between claims i and j .
- The interaction potential $\Phi(s_i, s_j)$ captures epistemic coherence. Truthful claims that cite one another lower the system’s energy, while false claims that cite each other without external support increase it.

This asymmetry prevents the system from rewarding mere mutual reinforcement among falsehoods, reflecting the epistemic intuition that “two wrongs do not make a right.”

4.4 Clusters of misinformation

When multiple false claims cite one another, they may form clusters that appear coherent within their subgraph, despite lacking external evidential support. These correspond to “epistemic bubbles” or “echo chambers.” In our framework, such clusters do not stabilize the system; instead, they raise its energy due to penalization terms for closed loops of mutual reinforcement.

Formally, cycles composed entirely of false nodes contribute an additional cost:

$$\mathcal{R}_{loops} = \lambda \sum_{\mathcal{C}} 1\{s_k = -1 \forall k \in \mathcal{C}\},$$

where the sum runs over cycles $\mathcal{C}$ in the graph and $\lambda > 0$ scales the penalty. This ensures that misinformation cannot reduce free energy merely by accumulating circular endorsements.

Worked Example (Three-Node Network)

Consider a simple network with three nodes: A, B, and C. Nodes A and B are false claims that cite each other, forming a closed loop, while node C is a true claim supported by strong external evidence. The A–B loop increases the system’s energy because it constitutes circular reinforcement without empirical grounding. When C connects to either A or B, the external evidential field $h_C \gg 0$ lowers the overall free energy, illustrating how anchoring misinformation to strongly supported evidence dissolves high-energy misinformation clusters.

4.5 Informational temperature and diffusion

The dynamics of the system can be described probabilistically using a Boltzmann distribution:

$$P(s) \propto \exp\left(\frac{-E(s)}{kT}\right).$$

Here, the informational temperature T again controls mobility:

- At high T , states fluctuate easily, allowing corrections to spread and preventing false clusters from persisting.
- At low T , dynamics are sluggish: once a false cluster forms, it tends to remain, requiring disproportionate external work to dissolve.

This formalism captures the empirical observation that misinformation is particularly resilient in closed, low-mobility epistemic environments, such as niche pseudoscientific communities.

In empirical contexts, informational temperature can be approximated using observable quantities such as exposure diversity, cross-community mobility, platform mixing rates, or the frequency of links between otherwise disconnected subgroups. These metrics provide operational proxies for estimating how easily corrective information can circulate within a given epistemic environment.

4.6 Implications of the model

The model highlights three key points:

1. **Asymmetry is systemic.** The difficulty of refuting misinformation is not just a property of individual claims but of their interactions in a network.
2. **Clusters amplify asymmetry.** When false claims reinforce one another, the energetic penalty of restoring parsimony increases superlinearly, as entire clusters must be dismantled.
3. **Temperature determines resilience.** High informational temperature facilitates refutation, while low temperature exacerbates Brandolini's asymmetry, explaining why niche pseudosciences are disproportionately difficult to dislodge.

5. Connection with Parsimony

5.1 Parsimony as an epistemic principle

Occam's Razor, or the principle of parsimony, is one of the oldest and most influential heuristics in scientific reasoning. It prescribes that, among competing explanations, the one with fewer assumptions should be preferred. Philosophers of science have debated whether parsimony is a merely pragmatic guideline or whether it has deeper ontological significance (Frigg & Nguyen, 2020). From an informational perspective, parsimony can be understood as the minimization of redundancy in the hypothesis space: simpler models are those that restrict the number of admissible states while retaining explanatory adequacy.

5.2 Parsimony as free energy minimization

The framework developed here allows us to reinterpret parsimony in terms of free energy. Recall that:

$$F = U - TS,$$

where U is internal energy (or evidential cost), S is entropy (or hypothesis multiplicity), and T is informational temperature. Minimizing F corresponds to choosing models that balance explanatory adequacy (U) with economy of assumptions (S). Parsimonious explanations are those that achieve the lowest free energy: they explain the data without inflating the hypothesis space unnecessarily.

5.3 Noise as the violation of parsimony

Misinformation and epistemic noise can now be seen as violations of the parsimony principle. False or unsubstantiated claims expand the set of possible states (Ω_{noise}), thereby raising entropy and lowering free energy artificially. They appear cheap because they bypass evidential costs, but in doing so they break the economy of inquiry. This explains the intuitive appeal of falsehoods: they offer low free energy states in the short term, but only by bloating entropy at the expense of parsimony.

5.4 Refutation as the restoration of parsimony

To refute a false claim is to compress the inflated hypothesis space back to a parsimonious subset. This requires reducing entropy, thereby increasing free energy:

$$\Delta F = kT \ln \left(\frac{\Omega_{\text{noise}}}{\Omega_{\text{info}}} \right) > 0$$

The cost of refutation is thus precisely the cost of restoring parsimony after it has been violated. Brandolini's asymmetry follows as a corollary: once the economy of inquiry has been disrupted by noise, the system must pay a disproportionate energetic penalty to recover it.

5.5 Epistemological implications

This reinterpretation carries several implications:

1. **Parsimony is not merely aesthetic.** It corresponds to a real reduction of free energy, grounding Occam's Razor in thermodynamic terms.
2. **Brandolini's asymmetry is the cost of non-parsimony.** The greater the departure from parsimonious modeling, the greater the energetic penalty required to restore it.
3. **Science as free energy economy.** Scientific practice can be viewed as a process of continually minimizing free energy by balancing evidence with simplicity, while resisting the entropy-inflating effects of misinformation.

In this light, the principle of parsimony and the generalized Brandolini principle are not independent heuristics but manifestations of the same informational dynamics. Parsimony prescribes the path of minimal free energy, while Brandolini's law describes the cost of returning to that path once it has been abandoned.

6. Discussion

6.1 From abstract principle to epistemic practice

The generalized Brandolini principle formalizes the asymmetry between producing misinformation and refuting it. Yet its significance lies not only in the mathematical expression $\Delta F = kT \ln(\Omega_{\text{noise}}/\Omega_{\text{info}})$, but in its capacity to illuminate practical challenges of epistemology in the digital age. By situating Brandolini's law within the framework of free energy, we can reinterpret familiar phenomena—pseudoscience, conspiracy theories, echo chambers—as predictable outcomes of informational thermodynamics.

6.2 Viral falsehoods versus niche pseudoscience

A striking implication of the model concerns the relative resilience of different kinds of falsehoods. Viral misinformation spreads rapidly across high-mobility environments, where informational temperature T is high. In such contexts, false claims may initially diffuse widely,

but they can also be corrected more efficiently, as fact-checks and counter-evidence circulate with comparable speed.

By contrast, niche pseudosciences and insulated epistemic bubbles operate at low informational temperature. Here, the mobility of information is limited: once noise infiltrates the system, it persists, because corrections cannot propagate effectively. According to the generalized Brandolini principle, the cost of refutation diverges as $T \rightarrow 0$. Thus, the most persistent and dangerous forms of misinformation are not necessarily the most viral, but those embedded in low-mobility niches where entropy can accumulate unchecked.

6.3 Clusters, loops, and epistemic bubbles

The network model of interacting news reinforces this insight. False claims that cite one another form clusters that, within their subgraph, appear coherent. To external observers, however, these clusters increase systemic energy: circular reinforcement without external validation constitutes epistemic redundancy rather than epistemic strength. Penalization of loops in the model mirrors the intuition that self-referential citation does not provide genuine evidence. This resonates with studies of echo chambers in online networks (Bessi & Ferrara, 2016) and with philosophical accounts of epistemic injustice: closed communities can sustain internally coherent but externally false worldviews.

6.4 Parsimony as epistemic economy

The connection with parsimony underscores the normative stakes. Parsimonious models minimize free energy by compressing the hypothesis space without sacrificing explanatory adequacy. Misinformation violates this economy by inflating entropy cheaply, creating the illusion of explanatory simplicity while actually destabilizing the epistemic system. Refutation, then, is the costly work of restoring parsimony. This reframing positions Occam's Razor not as an aesthetic preference but as an energetic necessity: scientific communities that consistently violate parsimony pay higher costs in correcting themselves.

6.5 Implications for fact-checking and governance

The framework also sheds light on contemporary debates about fact-checking and platform governance. Fact-checking can be understood as the systematic expenditure of free energy to compress inflated hypothesis spaces. Its effectiveness depends on the informational temperature of the environment: in high- T contexts, corrections can spread efficiently, while in low- T contexts, fact-checking struggles to overcome the inertia of insulated communities. This suggests that interventions should not only produce corrections but also raise informational temperature—by increasing exposure, diversifying sources, and lowering barriers to information flow.

6.6 Broader epistemological lessons

At a broader level, the analysis suggests that epistemology itself can be reframed in informational thermodynamic terms. Knowledge production is a continual negotiation between entropy and evidence, between noise and parsimony. Misinformation reveals the fragility of this negotiation: small injections of noise can disproportionately increase the energetic cost of inquiry.

Brandolini's law, when formalized, is not an idiosyncratic social observation but a manifestation of the fundamental asymmetry between disorder and order, entropy and information, that governs both physical and epistemic systems.

While Landauer's principle has long established the energetic cost of information erasure in computation, and while parsimony has been linked to notions of complexity minimization in Bayesian and cognitive models (Friston, 2010), no existing work has explicitly connected these principles to Brandolini's asymmetry. Likewise, studies of misinformation diffusion have applied network models inspired by epidemiology or statistical mechanics, but they lack an explicit term penalizing circular reinforcement among false claims. The present framework thus integrates previously disparate literatures—thermodynamics of information, epistemology of parsimony, and network models of misinformation—into a single account. By doing so, it establishes a novel theoretical bridge between physical principles and epistemic dynamics.

6.7 Limitations and future directions

It is important to emphasize that the framework presented here is not intended as a closed or fully predictive model but as a theoretical program. The analogies with thermodynamics and statistical mechanics are meant to formalize epistemic asymmetries at a conceptual level, rather than to provide empirical quantification in their current form. In this sense, the generalized Brandolini principle and the notion of informational temperature should be understood as tools for guiding further inquiry. Future research may test these ideas by applying them to empirical datasets of misinformation diffusion, simulating epistemic networks with varying informational mobility, or integrating them with cognitive models of belief revision. The contribution of this paper lies in opening a new perspective—what may be called a *thermodynamic epistemology*—that connects long-standing principles such as parsimony and Brandolini's asymmetry with the physics of information.

7. Conclusion

This paper has developed a unified framework that formalizes Brandolini's law—the asymmetry between the ease of producing misinformation and the difficulty of refuting it—using concepts from the thermodynamics of information. By modeling misinformation as noise (high entropy), refutation as information (low entropy), and parsimony as the minimization of free energy, we have transformed what was once a rhetorical observation into a theoretically grounded principle. The generalized Brandolini principle, expressed as

$$W_{\min} \geq kT \ln \left(\frac{\Omega_{\text{noise}}}{\Omega_{\text{info}}} \right),$$

demonstrates that the energetic cost of transforming noise into information is proportional to the reduction in hypothesis space, scaled by the informational temperature of the system. This relation parallels Landauer's principle in computation, where erasing information incurs an irreducible energetic cost. The analogy underscores that epistemic processes—such as verifying, correcting, and refuting—are not free, but bound by fundamental informational constraints.

The network model of interacting news extended this framework to social contexts, showing how clusters of false claims can reinforce one another within epistemic bubbles. These clusters raise systemic energy rather than lower it, reflecting the epistemic penalty of circular support. The concept of informational temperature clarified why viral misinformation, though disruptive, may be easier to correct in high-mobility environments, whereas niche pseudosciences and insulated communities are disproportionately resilient. In low-temperature epistemic environments, Brandolini's asymmetry is amplified: refutation requires disproportionately more work, often approaching practical impossibility.

The connection to the principle of parsimony highlights the normative dimension of this analysis. Parsimony is not merely an aesthetic guideline but the epistemic strategy of minimizing free energy. Noise violates parsimony by inflating entropy, while refutation is the costly work of restoring it. Scientific practice can therefore be interpreted as a continual struggle to maintain parsimonious, low-entropy representations against the constant influx of noise.

By formalizing Brandolini's law in this way, we contribute to both the philosophy of science and the interdisciplinary study of information in the digital age. The framework provides not only a conceptual bridge between thermodynamics, information theory, and epistemology but also practical insights into fact-checking, governance of digital platforms, and the resilience of scientific inquiry.

Future work could extend this approach by applying the model to empirical datasets of misinformation diffusion, simulating epistemic networks under varying informational temperatures, and testing interventions designed to increase informational mobility. Such extensions would deepen the bridge between abstract principles and concrete epistemic practice. In conclusion, the generalized Brandolini principle reveals that the asymmetry between noise and information is not accidental but rooted in the fundamental dynamics of entropy and free energy. Parsimony emerges as the path of minimal free energy, while Brandolini's law describes the energetic penalty for departing from it. Together, they articulate a thermodynamic epistemology: an account of knowledge in which the economy of inquiry is inseparable from the physics of information.

Beyond its immediate implications, the framework proposed here may inaugurate a new line of inquiry that could be termed *thermodynamic epistemology*: the study of knowledge processes through the lens of informational entropy, free energy, and energetic costs. Such an approach suggests that epistemology is not only normative and descriptive, but also subject to constraints rooted in the physics of information. Future research in this emerging field may extend the present model to empirical data on misinformation diffusion, test interventions aimed at altering informational temperature, and explore the broader consequences of treating epistemic practices as free energy economies. In this sense, the generalized Brandolini principle is not the end of an argument but the beginning of a research program.

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The 3S+3T Model: Temporal and Spatial Skew in a Quasi-Flat Spacetime

Günter Muchow¹

Abstract

This essay expands the previously developed three-directional time model by introducing a spatial skew of comparable magnitude to the formerly introduced temporal skew, proposing that both time and space possess subtly tilted planes. The superposition of temporal and spatial skew redefines flatness: the minute tilt of the τ -axis in Time relative to θ induces temporal anisotropy, just as the mirrored skew of z relative to x adds, in Space, a similar directional bias. Though nearly imperceptible locally, their cumulative effect across cosmological distances not only redefines how events are realised, thus propagating Time, but also how entropy evolves, and how information propagates. Observable consequences may include polarisation rotation in the Cosmic Microwave Background (CMB), anisotropic redshift behaviour, entropy gradients, and alignment patterns in large-scale universal structures. Rather than abandoning flatness, this model retains local orthogonality as it introduces global anisotropy – not through curvature, but through geometric skew. Time and Space are treated not as orthogonal absolutes, but as emergent, directionally biased, interdependent structures – tilted just enough to leave fingerprints in the universe.

Keywords: 3S+3T, spacetime anisotropy, non-metric geometry, causal emergence, cosmic microwave background, Planck-scale physics, astrophysics²

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1. Introduction

The conventional perception of geometry, as applied in physics, tends to over-simplify our view of nature and the universe. Although this 3S+3T model departs from Einstein's strict orthogonality in spacetime and his limitation to a four-dimensional continuum, it still remains consistent with his broader preference for a flat universe. The superposition of the Time and Space dimensions, and the skewed geometry introduced preserves local flatness and zero intrinsic curvature, aligning with Einsteinian principles over large parts – yet offering a refined structure capable of explaining observed anisotropies across different realms of physics.

In this essay, an analogy will be drawn between the presented three-directional time model and Space. The proposed model employs Planck-Time Units (PTUs) to structure its temporal geometry: the linear time axis t is measured in PTUs, defining the resolution of event progression. The θ - τ plane references the Planck length as the spatial threshold governing event locality, tunnelling, and trace effects. For space, similar conditions are applied when measuring distances along the axes in Planck-Length Units (PLUs). Although this introduces mixed units within the combined 3S+3T model, each operates within a distinct functional domain: temporal versus spatial bounds. It should be recalled that Planck length l_P and Planck time PTU are related by $l_P = c \cdot \text{PTU}$, where c is the speed of light. Thus, the formalism remains consistent – mirroring standard practice in early-universe cosmology and quantum gravity. Further, terms such as *event realisation*, *memory*, and *trace* are used in an operational and geometric sense, referring to persistence and weighting of realised events within the model's causal structure. No psychological, epistemic, or metaphysical interpretation is implied.

Similar approaches by other researchers have sought to generalise time beyond a single axis. However, they typically rely on higher-dimensional field equations and compactification schemes to conceal additional temporal directions, which can generate causality conflicts or instabilities.

As outlined in a previous paper, the present model retains three temporal axes explicitly (Muchow 2020 [1]). It defines their geometry through a Planck-scale apex separation of future and past cones, and a minute skew angle that preserves near-orthogonality. This explicit inclusion of three temporal axes is introduced to maintain causal consistency within the model. It also avoids arbitrary compactification and places the emphasis on cone structure and asymptotic alignment, thereby offering an alternative route to reconcile multiple temporal directions with empirical constraints.

Earlier attempts to accommodate more than one temporal dimension include a two-time physics framework, where physical laws are reformulated to remain consistent despite the presence of an additional temporal axis (Bars 1997a [2a]; Bars 2001b [2b]). Subsequent investigations considered spacetimes with extended metric signatures, examining how familiar dynamical limits arise when more than one temporal direction is permitted (Álvarez 2000 [3]). Another line of work emphasised the role of signature change, interpreting multi-time

frameworks through topological and geometric features of spacetime (Pavšič 2001 [4a]; Pavšič 2005 [4b]).

Recent studies have proposed frameworks with more than one temporal dimension, incorporating two compactified time-like dimensions alongside the conventional three spatial and one temporal dimensions, aiming to address the quantum non-locality dilemma, commonly known as the EPR paradox, by suggesting that quantum systems utilize all six dimensions, while classical systems are confined to four. This interpretation is model-based, acknowledging that apparent non-locality emerges from projecting six-dimensional events into four-dimensional spacetime. Consequently, events that are time-like separated in the six-dimensional spacetime may appear space-like separated and non-local when projected into four-dimensional spacetime (Furquan et al. 2025 [5]). In this context, a further contribution was made earlier this year, also advancing a 3T framework with three temporal dimensions, which correspond to quantum-particle-interaction, and cosmological scales (Kletetschka 2025 [6]). In a follow-up, electric charge is interpreted as a topological property of three-dimensional time, with quantisation arising from a temporal winding number (Kletetschka 2025 [7]).

However, these approaches stress scale separation and topological invariants, whereas the presented model derives the existence of skew in the τ -axis in Time from geometric necessity: the geometrically assigned ± 1 PTU apex separation of the time-cones enforces a small but finite tilt of τ relative to t and θ , preserving a near-to-orthogonal framework. Given the intertwinement of time and space – as commonly accepted since Einstein – the structure of the 3S+3T model itself implies a key question: are the space axes truly orthogonal? This question is explored in the light of the skewed τ -axis in Time, and considering the potential consequences of a similar shift of the z -axis in Space. The potential observational consequences in cosmology and quantum mechanics, resulting from these proposed alterations will be examined in subsequent sections.

2 Skewed τ and z

Minkowski's light cones do not allow any causal interaction between future and past cones; they simply define a geometry consistent with Einstein's special relativity (Minkowski 1908 [8]). In contrast, the introduced 3S+3T framework presented in previous publications relies on interactions between these cones, postulating that no arrow of time exists beyond the steady sequence of events that generate the flow of time. Recently, it has been argued that time is not a primitive parameter but emerges from relations among discrete events (Conti 2025a; Conti 2025b [9]). Resonating with this perspective, the present model assigns temporal skew to the dynamic ordering of events, while spatial skew remains a fixed geometric bias. Long-range anisotropies in both cosmological and quantum domains arise through the ordering and comparison of realised events. The superposed Time and Space dimensions create a framework in which these domains evolve not as isolated grids but as interwoven fabrics subtly tilted in tandem. Realising and non-realising events are influenced by the introduced asymmetry

(Muchow Mar. 2025 [10]). The τ -axis defines the asymptotic structure of the time cones, so any skew introduces a directional bias to trace density, which is amplified when applying an identical tilt to the spatial z -axis. In the early universe, fluctuations were extremely sensitive to underlying geometric structures: the proposed τ -skew could have seeded preferential directions of evolution. These introduced components challenge the principle of statistical isotropy assumed in conventional cosmology and suggest that directional memory embedded in time's geometry may shape the visible universe. As a result, large-scale features such as the alignment of galaxy spins, elongated cluster orientations, and filamentary structures may not be stochastic anomalies, but rather fossil evidence of the τ - and z -skews in this model (Hutsemékers 2014 [11a]; Tiwari 2015 [11b]).

Earlier essays established a three-directional, probabilistic time model, originally built on orthogonality between the axes t , θ , and τ (Muchow Feb. 2025 [12]). However, introducing a minute skew of the z -axis in Space, in alignment with the τ -tilt in Time – both defined by the angle $\kappa = 0.0054^\circ$ – consequently leads to an enhanced anisotropy in the model. Just as Minkowski's independent light cones define causal structure independent of experimental measurement, the proposed tilts define the causal geometry in this 3S+3T framework. The resulting $z\tau$ -skewed light-cone structure is illustrated schematically in figure 1.

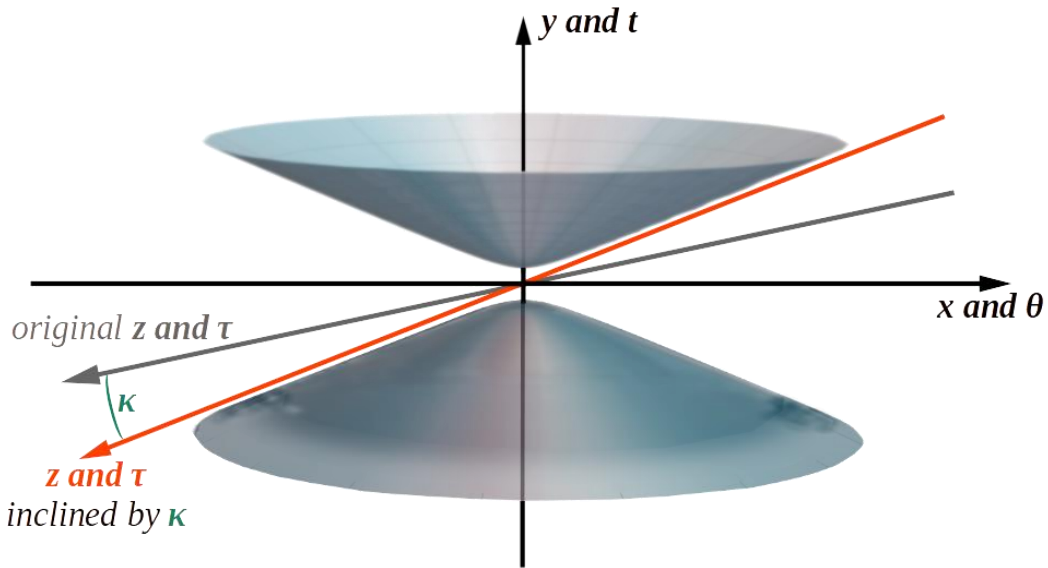


Figure 1: The combined $z\tau$ -skew in the quasi-flat 3S+3T model.

The orthogonal axes y and t , and x and θ (in black) are orthogonal to one another; the originally orthogonal axes z and τ (in gray) are shown to illustrate the shared deviation of the z - and τ -axes (in orange) in the model, caused by the tilt-angle κ – far exaggerated above the true value of 0.0054° . The cone apexes are ± 1 PTU above and below the origin of both the Time and the Space dimension.

2.1 Precisions on the Gap Region

Earlier work introduced a connection between future and past cones – contrary to Minkowski’s unconnected light cones: a transitional window, allowing realising events to pass from the future into the past cone. This process reinforces the perspective on an Event Arrow of Time, which will be discussed in a future essay. The gap is located at the origin of the 3S+3T model with $x=y=z=t=\theta=\tau=0$, and it extends into the θ - τ plane. As realising events pass through this gap dynamically, their transition through the gap along the perceptive time axis t defines the perceived temporal passage. The resulting gap region at t_0 is shown schematically in figure 2.

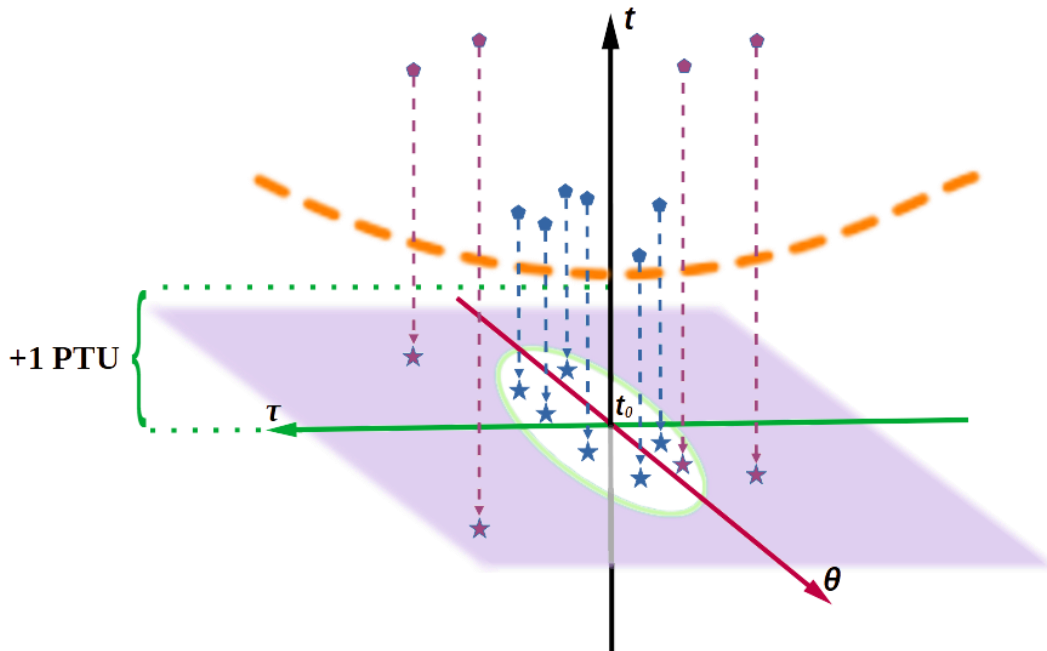


Figure 2: Gap region ($\Delta t = 1$ PTU) at t_0 within the skewed θ - τ plane.

In the above figure, the arc designed in a dashed orange line symbolises the future cone’s apex at +1 PTU, from where events pass the gap – for clarity, the past cone’s apex situated at – 1 PTU is not shown. The lower ends of the vertical arrows, marked with stars, indicate the instant at which events intersect the θ - τ plane. All events pass into the past cone eventually: whereas realising – true, countable – events incur lasting traces in the past cone (blue dashed arrows), non-events (arrows in magenta) with a few of them also passing the gap leave only very short-lasting traces. For clarity only a few non-events are shown, although they outnumber events largely.

Based on the proposed probability profile of event realisation, the following specifications are introduced:

$$t = 1-1.5 \text{ PTU: } P_{\text{real}} \gg 99\%, \text{ essentially all events realise}$$

$t = 1.5\text{--}2.5$ PTU: $P_{\text{real}} > 95\%$, defining the main transition region $\Delta t_{\text{gap}} = 1$ PTU along t
 $t = 2.5\text{--}3$ PTU: P_{real} drops below 95%, marking a gray zone where the event probability still may increase or decrease.

For the main gap region 1.5–2.5 PTU, the expected number of realised events per PTU is $N \approx 2 \cdot 10^{25}$, based on model-based reasoning using fluctuation estimates, which yield approximately 10^{35} per cubic metre, when counting vacuum modes up to the Planck scale. The previously used figure of $\approx 10^{25}$ events per PTU referred to a configuration with a smaller effective cross-section. In the present treatment, the same temporal gap is considered with a larger cross-section, naturally implying a higher total number of realised events while keeping the flux per PTU consistent.

In order to evaluate the event-density, a 4-volume (V4) of the gap must be defined:

$$V4 = A \cdot \Delta t_{\text{gap}} \quad (\text{equ. 1})$$

where $\Delta t_{\text{gap}} = 2$ PTU is the temporal thickness along t , i.e. real distance of the apexes of future and past cones from one another. A is the cross-section area in the θ - τ plane. Solving for A :

$$A = N / (\rho \cdot \Delta t_{\text{gap}}) \approx 10^{25} / (3 \cdot 10^{22} \cdot 2) \approx 167 \text{ PTU}^2 \quad (\text{equ. 2})$$

with $\rho \approx 3 \cdot 10^{22}$ events/PTU⁴.

Notes:

- The τ - and z -axes' tilt is fixed at $\kappa = 0.0054^\circ$ for all calculations. Inclusion of the high-realisation region $t = 1 \rightarrow 1.5$ PTU, or the gray zone $t > 2.5$ PTU does not significantly alter N or D .
- Non-events and tunnelling: Non-events generally do not traverse the gap. Certain non-events tunnel from the region just above the gap from the future cone apex, but their realisation probability is very low, and they do not contribute to the count of realised events. Thus, the gap size and 4-volume calculations consider only events that actually realise.
- Given the probabilistic and quantum nature of events, and Heisenberg uncertainty limitations, the above values are approximate rather than exact.

Using the observed polarisation birefringence from Planck 2018 ($\alpha = 0.35^\circ \pm 0.05^\circ$), the corresponding model parameter calculates to $\kappa = \alpha \cdot \pi / 180 \approx 0.0061$ rad. Likewise, the CMB temperature anisotropy $\Delta T/T \approx 1.0 \times 10^{-5}$ (Planck 2018, cosmological parameters) translates via the model calibration $\kappa \approx 10^{-3}$, corresponding to $\Delta T/T \approx 10^{-5}$, into $\kappa \approx 0.001$ rad ($\approx 0.057^\circ$). The observations are fully consistent with the proposed range for κ values – see Tables 1 and 2 in the following section.

2.2 The κ value

To promote the passing of events from the future to the past cone, the apexes of their cones are postulated to be separated along the t -axis by ± 1 PTU each from the $x=y=z=t=\theta=\tau=0$ point – the origin in both space and time axes. This distance represents the smallest possible

The 3S+3T Model: Temporal and Spatial Skew in a Quasi-Flat Spacetime

separation between the apexes in temporal coordinates. Given that realising events pass through a finite area around $t = \theta = \tau = 0$ in the θ - τ plane, a geometrical evaluation of the τ tilt becomes feasible (Muchow, Apr 2025). To preserve a near-to-orthogonal framework, this tilt must remain small.

The parameter κ is introduced as a dimensionless skew quantity; when interpreted geometrically, it corresponds to a small rotation angle, so that κ may be expressed numerically in radians or degrees. Using a reference length L_0 of approximately 21,000 PTU along the τ -axis, and a 2 PTU separation between future and past cones, the illustrative skew satisfies the small-angle relation

$$\tan \kappa \approx \kappa \quad \text{for } \kappa \ll 1, \text{ in radians (equ. 3)}$$

to give

$$\kappa \approx 9.524 \times 10^{-5} \text{ rad} \approx 0.0054^\circ \text{ (equ. 4)}$$

Further considerations support a conservative range of κ , within which orthogonality is locally preserved:

$$\kappa \in [0.005^\circ, 0.03^\circ].$$

Thus, the specific value presented here – applied similarly to the z -axis of Space for consistency – serves as a provisional fit parameter. The chosen κ -range reflects a minimal but non-negligible deviation from orthogonality, preserving the quasi-Euclidean character of the 3S+3T framework. Whereas the lower limit ensures that the combined z - and τ -skew effects remain physically meaningful rather than purely mathematical, the upper bound is set by observational constraints. For κ -values larger than about 10^{-3} rad, the predicted asymmetry from the combined z - and τ -skews would imply directional variations exceeding what current observations report. In other words, the Planck satellite and comparable CMB studies have established that the anisotropy of the cosmic microwave background is at the level of $\Delta T/T \approx 10^{-5}$, which sets the order of magnitude for directional variations consistent with observation. A $\kappa > \sim 10^{-3}$ (corresponding to a rotational angle of about 0.057°) would be expected to generate structural anisotropies that, when projected over cosmological distances, surpass this empirical tolerance. Within the chosen range, near-orthogonality is maintained, yet the skew remains sufficient to allow cumulative structural effects across cosmological scales. For $\kappa \ll 1$, as is the case here, cross-terms in the metric appear linearly, and higher-order effects are negligible; no non-tensorial transformation is implied, ensuring consistency with standard tensor calculus. The proposed skew of 0.0054° corresponds to $\kappa \approx 10^{-4}$ rad, which actually lies below current experimental bounds on Lorentz invariance violation (Kostelecký 2011 [13a]).

However, considerations concerning the chosen reference length and calculations with selected values from the range of κ indicate that the effects on polarisation of the cosmic background radiation may entirely be observable today (Planck Collaboration 2018 [14a]; Minami et al 2020 [14b]). The following table illustrates this:

L_o (PTU)	κ (°)	Observational status
10,000	0.0027	Local orthogonality preserved
21,000	0.0054	Reference case; small cumulative effect
30,000	0.0077	Noticeable skew; directional effects
50,000	0.0128	Upper reference limit

Table 1: Illustrative τ -skew angles for selected reference lengths

Thus, for minimal κ , local orthogonality is effectively preserved and directional effects are negligible. At the reference scale $L_o \approx 21,000$ PTU, orthogonality is only weakly perturbed and cumulative effects remain small. Larger reference lengths correspond to increasingly noticeable skew, providing an upper illustrative range in which anisotropic effects may approach current observational sensitivity.

Additional observed anisotropies, namely redshift and entropy, follow the trends summarised below:

Effect	Estimate / Trend	Relevant Dataset
Redshift anisotropy	$\Delta z/z \propto \kappa$	Planck, Euclid
Entropy anisotropy	qualitative trend	Planck, Simons Observatory

Table 2: Redshift and entropy anisotropies in light of recent data.

The redshift constraints summarised in Table 2 draw on CMB and large-scale structure observations (Planck Collaboration 2018; Euclid Collaboration 2022 [15a]). Entropy-related considerations follow standard cosmological treatments (Liddle & Lyth 2000; Penrose 2010 [15b]). As can be deduced from table 2, the framework is falsifiable in principle: tightening isotropy and birefringence limits below $\kappa \approx 10^{-4}$ rad would directly exclude the proposed range. The introduced skew angle κ must not be seen as an adjustable post hoc parameter, but as a structural parameter constrained jointly by causal consistency and observational upper bounds. Thus, κ enters as a global geometric relation between subspaces which cannot be reduced to a coordinate-dependent metric artefact.

Recent analyses used effective quantum-gravity energy-scale measurements to constrain anisotropic Lorentz invariance violation, indicating that κ within the value range as above remain below current empirical limits (Guerrero 2025 [16]). Observations of high-energy gamma-ray bursts provided further stringent bounds on Lorentz violation, reinforcing these limits (Cao 2024 [17]). Additional research using GRB time-of-flight measurements and atomic spectroscopy further tighten SME coefficient constraints, reinforcing that the possible κ values remain below actual empirical limits (Dreissen et al. 2022 [18]). In a complementary low-energy test, high-precision Ramsey spectroscopy on trapped ions was employed, and likewise reported no detectable Lorentz-violating effects within their sensitivity (Franco 2006 [19]).

Alternative formulations of Lorentz transformations, such as the vectorial treatment proposed, demonstrate that consistent extensions remain mathematically viable without violating the established tensor framework (Minami & Koyatsu 2018 [20a]; Gluscevic & Kamionkowski 2010 [20b]).

2.3 Skew induced polarisation

One major consequence of temporal skew is a possible reorientation of electromagnetic wave polarisation vectors across cosmological distances, as illustrated schematically in figure 3 for the τ -skew only.

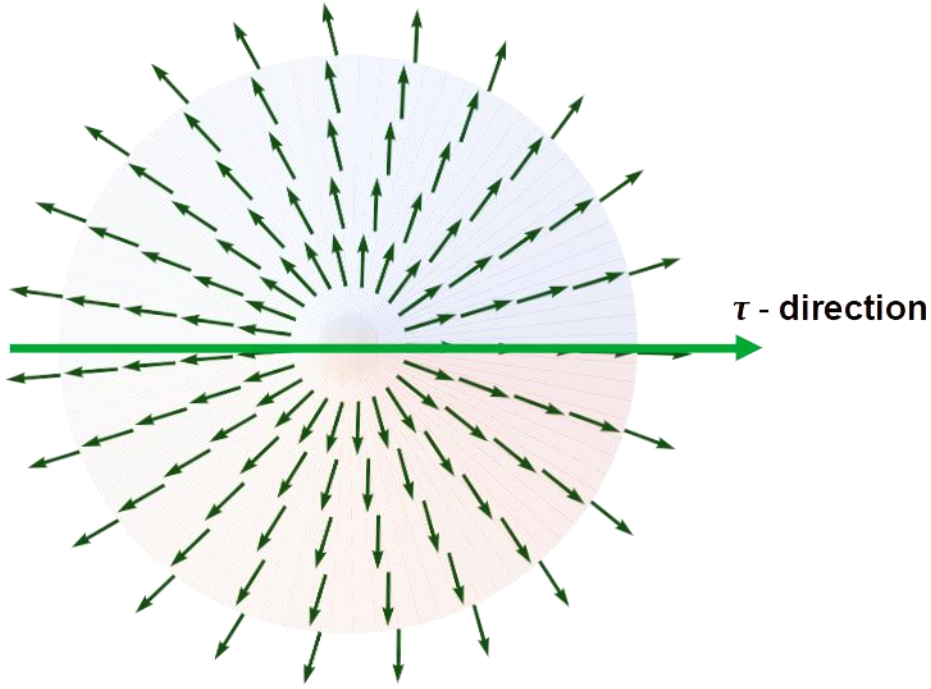


Figure 3: Schematic representation of polarisation reorientation; arrows denote polarisation vectors. For clarity, the effect is shown with κ exaggerated by a factor of 5.

The spiral pattern in figure 3 reflects how a small temporal skew alone may induce a systematic rotation of polarisation across the sky. When both spatial and temporal skews are considered, their combined effect is expected to amplify this reorientation across cosmological distances. Thus, a deviation from isotropy in the z - and τ -directions would manifest as cosmic birefringence, subtly rotating the polarisation of electromagnetic waves emitted during the last scattering epoch. Since the CMB retains signatures from this era, the combined minute z - and τ - skews could imprint a systematic rotation in the observed E-mode and B-mode polarisation patterns. These shifts, while small, are cumulative and may already be detectable in high-resolution CMB datasets (Planck Collaboration 2018).

Although the per-detector angle repeatability in some modern instruments is better than 0.02° , map-level systematics, such as beam effects, T→P leakage, foreground angle uncertainty and pipeline self-calibration, dominate global-rotation inference. This is why the proposed 0.078° rotation remains below robust detection thresholds for published map products without dedicated re-analysis. A focused end-to-end injection and cross-experiment reanalysis – avoiding blind EB self-calibration and including foreground-angle marginalisation – would be necessary to evaluate whether the predicted rotation could be recovered with current technology.

Therefore, κ is considered a theoretically well-motivated value that currently lies below reliable map-level detectability without dedicated re-analysis and improved calibration. However, if confirmed, such directional polarisation anomalies would strongly suggest the presence of a temporal asymmetry embedded in the large-scale structure of spacetime.

The expected long range polarisation impact, and other effects discussed in the following paragraphs, can be connected to the combined z - and τ -tilts, which contribute with a static and a dynamic component, respectively. Whereas the static z -tilt defines the geometric background orientation of the temporal manifold, the dynamic τ -tilt describes minute, time-varying deviations. These are caused by local event distributions and/or energy concentrations, reinforcing the asymmetry between the future and past cones. However, these transient fluctuations do not significantly alter the overall geometry but they modulate the passage rate of realising events through the gap, introducing short-term variations in persistence and trace density.

2.4 Entropy

The θ - τ asymmetry along with the tilted z -axis in this skewed model also introduces a subtle but persistent directional bias in entropy evolution. Entropy may accumulate or dissipate along specific temporal and spatial orientations, leading to directional thermodynamic gradients across the universe (Padmanabhan 2005 [21]). This, in turn, can affect the timing and distribution of structure formation, the anisotropic decay of information in large-scale systems, and even the thermal history of cosmic voids and galaxy clusters.

Each skewed plane introduces anisotropy within its respective domain: in Space, z deviates from x , which remains orthogonal to y , creating anisotropic structure formation, infers on light propagation, and redshift accumulation (Zeh 2007 [22]). In Time, τ is a direction that deviates from θ , which in turn remains orthogonal to t , creating biased memory traces and entropy flow (Rovelli 2014 [23]).

Such effects – while at present presumed, but unconfirmed – may result in non-uniform entropy densities over cosmological scales, thereby modifying how energy distribution unfolds, how radiative cooling operates within asymmetric geometries, and how information degrades or persists. These distortions would not only shape local thermodynamic processes but could also affect how thermal disequilibria propagate, how entropy clusters in certain regions, and how information-theoretic boundaries evolve over time. Instead of flowing isotropically

outward from initial conditions, entropy exhibits a preferred directional component, governed by the θ - τ skew. Since the trace structure of past events is uneven, entropy itself becomes a geometric imprint – not merely a scalar field, but a tensor-like memory of the universe’s asymmetric temporal fabric.

In standard models, entropy gradients would be radial, smooth, symmetric. This changes significantly when we consider entropy in the proposed superposition of Space and Time, illustrated schematically in figure 4:

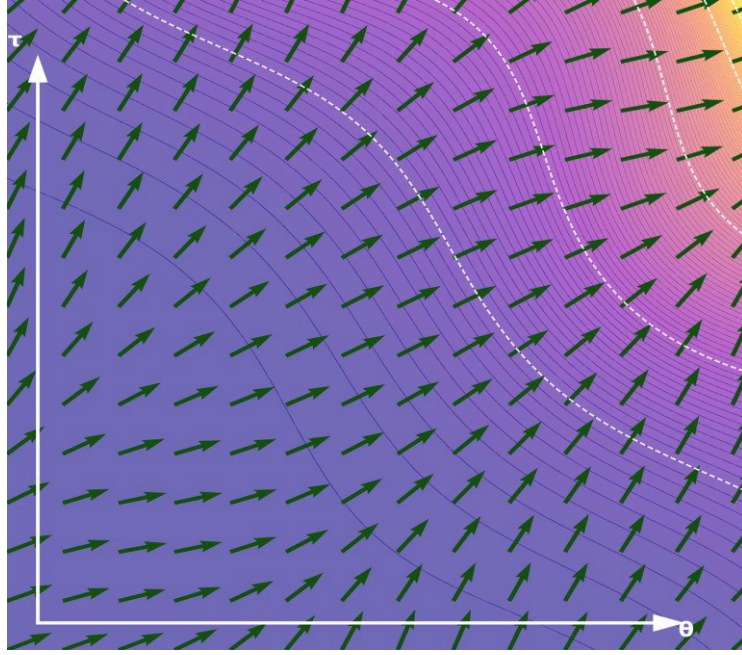


Figure 4: Impact of skewed Time-Space geometry on entropy.

The entropy flow vectors (green) bend along the curvature of the underlying manifold, here extended five times, and not perpendicular to the equipotentials any longer. The curved dashed lines in the figure are entropy “contours”, where entropy remains constant. Their bend shows that symmetry is broken: because of the temporal skew of τ and the spatial skew of z , entropy is oriented along a direction neither purely in τ nor in z , but along a combination of the two (Bousso 2002 [24]).

2.5 Anisotropic redshift

Another observational consequence of the z - and τ - skews concerns the anisotropic accumulation of redshift. According to standard cosmology, redshift arises from cosmic expansion and local motion, assumed to occur within a statistically isotropic background. In this model, the subtle skew of the z - and τ -axes introduces a directional asymmetry in temporal evolution. Light propagating through a temporally skewed geometry will accumulate redshift differently, depending on its orientation relative to z and τ as illustrated in figure 5:

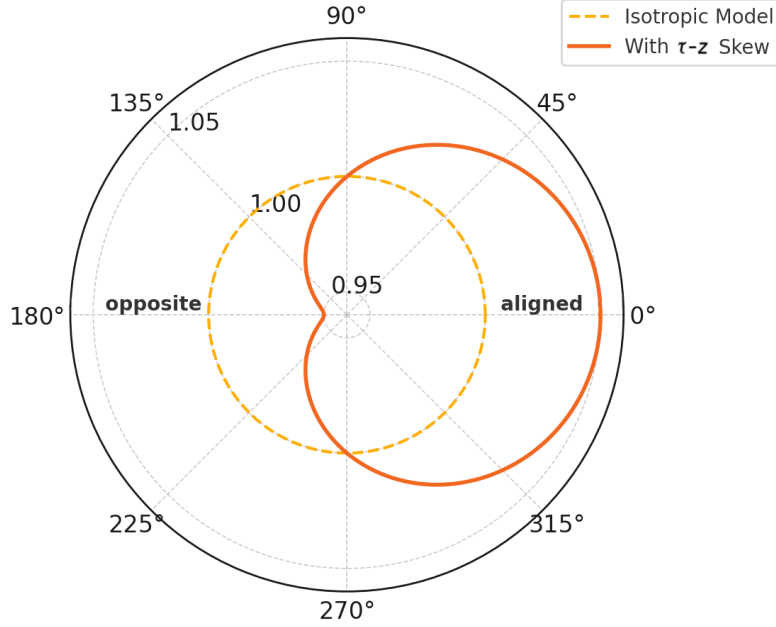


Figure 5: Schematic representation of anisotropic redshift accumulation under combined z - and τ -skews. The dashed circle denotes isotropic redshift accumulation in the standard model, the solid curve illustrates directional variation for exaggerated skew; schematic, not to scale.

The difference arises because light propagating through a temporally and spatially skewed geometry experiences uneven time evolution, affecting how much redshift it accumulates. Even though the skew is minute, its cumulative effect over cosmic distances may lead to measurable redshift anisotropies. These could appear as direction-dependent deviations in the Hubble flow, or as subtle anisotropies in redshift-distance relations – such as angular clustering distortions in redshift surveys, or variations in luminosity distance measurements of standard candles (Lusso et al. 2025 [25a]; Bogomazov & Tutukov 2011 [25b]).

2.6 General remarks about the intertwinement of Space and Time

The two temporal and spatial planes are not independent layers but structurally parallel distortions of the orthogonal manifold. They do not intersect or interact directly; rather, they redefine the orientation of time and space around their respective anchoring points. It is understood that the temporal origin t_0 constantly advances onward in discrete PTUs, remaining anchored in $x=y=z=0$. The entire θ - τ plane is re-instantiated at each PTU step to t_0 , maintaining its orientation. In fact, this skewed temporal plane is the projection surface for events in the future cone, where the weighted projections contribute to their likelihood of

realisation (Hossenfelder 2013 [26]). This dynamic reapplication preserves its role in the filtering process, even as time progresses.

The spatial skew, by contrast, remains static. It does not evolve dynamically but sets a directional preference in the spatial structure of the universe. Its effects accumulate over cosmological distances, acting as a fixed geometric bias rather than a re-instantiated projection filter (Landauer 1991 [27]).

Over cosmic scales, this anisotropic entropy flow could influence not only local thermodynamic systems but the entire thermal evolution of the cosmos. In conventional models entropy increases uniformly in all directions, evolving toward equilibrium over a statistically isotropic backdrop. The presented model challenges that view by introducing a temporal anisotropy that steers the universe's thermodynamic development along privileged directions.

Additionally, the proposed skew may contribute to systematic discrepancies across sky sectors, potentially offering an alternative explanation for redshift-based anomalies such as the Hubble tension, without invoking spatial curvature or exotic energy components (Di Valentino et al. 2021 [28]).

Finally, the skew in τ could produce non-isotropic expansion histories, allowing for slight directional variations in the presumed cosmic expansion, without invoking curvature. Such a feature may align with data hinting at large-scale anisotropies in the cosmic background (Schwarz et al. 2016 [29]).

3 Spatial Orthogonality Reviewed

The orthogonality of time was reconsidered through the introduction of a temporal skew (Muchow April 2025), rendering τ non-orthogonal to θ and t , and creating a tilted temporal plane: therefore, the τ -axis is no longer orthogonal to θ , but forms an angle with it and consequently with the t -axis, creating a tilted temporal plane, at the same time being the asymptote to the time cones. Consequently, if the time dimension itself does not remain orthogonal, then the spatial axes, traditionally presumed to be at right angles, also had to be re-examined. This calls into question a long-standing assumption in physics: the orthogonality of spatial dimensions. The principle of Euclidean orthogonality has historically underpinned classical and relativistic physics, offering mathematical simplicity and calculational efficiency. However, it has to be considered an idealised construct, not a physical law: nature is not beholden to Euclid and Pythagoras.

Modern physics leans heavily on the convenience of this orthogonal assumption, especially in metric definitions, coordinate systems, and symmetry operations. Yet symmetry, when confronted with cosmological and quantum evidence, often proves to be a mere approximation rather than a governing principle (Muchow Dec 2025 [30]). In light of the skewed three-directional time dimension, it becomes relevant to examine whether one of the space axes also exhibits a minute but non-zero skew. The fact that two axis may be tilted remains a topic for

discussion in a future paper. Here, a corresponding deviation in the spatial manifold is proposed, specifically along the z -axis, to mirror the asymmetry already attributed to the temporal domain.

The spatial skew – introduced at the same magnitude to that of the temporal skew – would have negligible impact at human or laboratory scales. However, over cosmological distances and in the quantum realm, even a minute deviation from orthogonality could lead to observable anisotropies, especially given the cumulative impact of skewed time and space acting together.

Observations such as the alignment of cosmic filaments, the coherent orientation of quasar polarisation vectors, and the large-scale dipole anomalies in the CMB hint at underlying directional structures that challenge the assumption of perfect isotropy (Jaffe et al. 2005 [31a]; Saadeh et al. 2016 [31b]). Generally, Bianchi models are invoked to account for such features (Pontzen & Challinor 2007 [32]). The framework presented here offers an alternative grounded in geometric skew rather than curvature or topological anisotropy.

On the microscopic side of physics, quantum theory also shows signs of directional preference: the well-documented parity violation in weak interactions breaks the expected symmetry in left-right processes (Wu et al. 1957 [33a]; Nanos et al. 2014 [33b]; Gorgannejad 2015 [33c]). Although this is usually interpreted as a feature of internal particle symmetries, it evokes the possibility that even at quantum scales, certain spatial directions are not treated equally. A subtle geometric skew in space – as proposed here – might offer a broader framework for interpreting such asymmetries.

A philosophical argument may also support this view: just as we have no sensory organ capable to directly perceive time, our perception of space is mediated through emergent constructs like vision and movement. Eyes do not measure geometry, they assemble lines to create something meaningful; they interpret light gradients shaped by matter to estimate distances – but these are reconstructions performed by the brain, not a comprehension of what space *is*. Thus, space should be regarded as no less emergent than time, both arising from deeper causal and/or probabilistic structures. A similar standpoint has been advanced, suggesting that space and time are conceptually inseparable and equally emergent (Guy 2008 [34]). If skewed time has observable consequences, it is reasonable to explore whether skewed space plays a similar role in shaping the universe we observe.

Consequently, the orthogonality of spatial axes, long considered a cornerstone of physical reasoning, should better be viewed as a *locally valid* approximation. The introduction of a spatial skew aligned with τ -induced anisotropies and asymmetries opens the door to a revised understanding of the universe's structure – not as a perfectly gridded manifold, but as an intricately twisted fabric where time and space evolve together, guided by a shared asymmetry subtly steering the evolution of both temporal and spatial structures, including the directional orientation of cosmic filaments (Kraljic et al. 2019 [35]).

4 Effects of Combined Temporal and Spatial Skew

Previous sections explored the independent effects of a skewed time axis τ and the proposed spatial deviation along the z -axis. It must be noted that both the τ -skew and the proposed spatial z -skew are extremely small – each introduced at near-imperceptible angles. However, when both asymmetries are considered acting together, they redefine the geometry of event realisation and perception across spacetime considerably. The resulting structure introduces a compounded anisotropy, one that affects how information propagates, how entropy evolves, and how cosmological measurements are interpreted.

Physical observations are confined to the (t, x, y, z) submanifold. The additional temporal directions τ and θ are not observable coordinates but biasing directions that shape event realisation, propagation, and accumulation probabilistically. When six-dimensional events are projected onto four-dimensional spacetime, the skews manifest as anisotropic corrections to otherwise standard observables, and not as additional degrees of freedom. Thus, the model simply proposes direction-dependent deviations within established cosmological and quantum observables, as illustrated in figure 6:

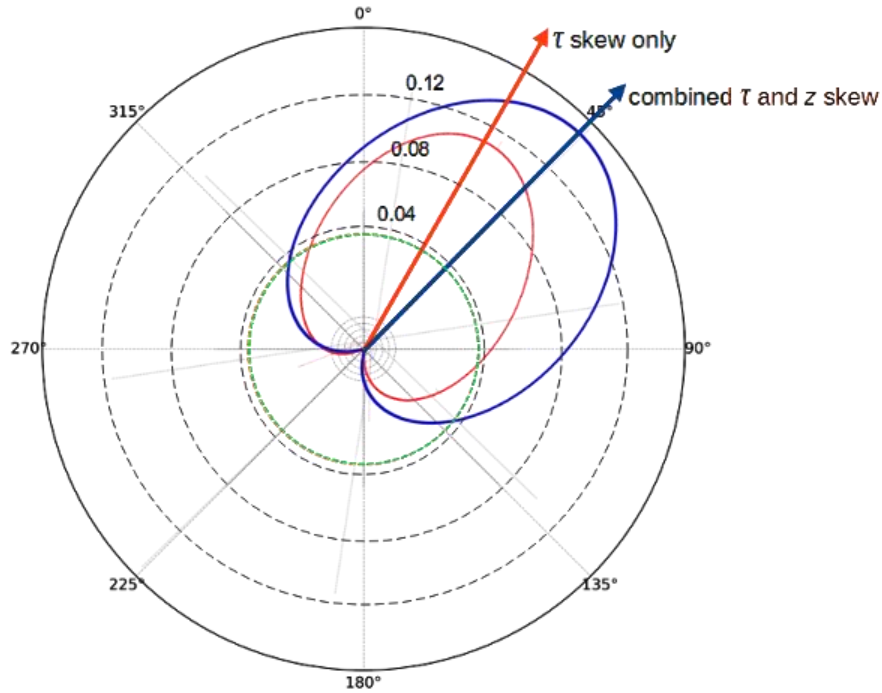


Figure 6: Idealised schematic of directional distribution under combined τ - and z -skews. The dashed circle denotes an isotropic, unskewed baseline; the inner curve shows τ -skew alone, while the outer curve illustrates the amplified directional distribution when τ - and z -skews act together.

When temporal and spatial skews are superposed, their directional alignment produces a characteristic imprint on the distribution of realised events. Both skew vectors align in the same general direction, leading to amplified event density in that orientation – and diminished density in the opposite. This idealised geometry reflects how compounded skew reconfigures event distribution, subtly privileging certain Time-Space directions over others.

Additionally, such directional bias in the structure of realised events may influence not only entropy flow and redshift accumulation (Kraljic et al. 2022 [36a]; Secrest et al. 2021 [36b]). Other potential consequences include deviations in standard candle behaviour, distortion of Baryon Acoustic Oscillation patterns, and the emergence of Anisotropic Structural Alignment, including preferred orientations of filaments and quasar polarisation vectors (Rubart & Schwarz 2013 [37a]; Hutsemékers et al. [37b]; Perivolaropoulos & Skara 2021 [37c]).

The following metric-like representation is introduced as a geometric bookkeeping device; it is not intended as a replacement for the dynamical spacetime metric of general relativity. To formalise the coupling between temporal and spatial skew, the quasi-flat structure of spacetime can be represented by the following metric tensor $\mathbf{g}$. For clarity, the representation below shows only the τ - z sector of the full 6×6 metric; the remaining components remain orthogonal in this formulation:

$$\mathbf{g} = \begin{pmatrix} -1 & \xi & 0 & 0 \\ \xi & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \text{ (equ. 5)}$$

where $\xi = \tan \kappa \approx 9.4 \times 10^{-5}$ for $\kappa = 0.0054^\circ$. The off-diagonal terms represent the τ - z coupling, expressing a constant-coefficient, quasi-flat geometry. Since all components of $\mathbf{g}$ are constant, the corresponding Christoffel symbols vanish, and the flat Riemann tensor satisfies $R_{\mu\nu\rho\sigma} = 0$, confirming that the geometry remains flat despite the τ - z skews, which encode global orientation rather than curvature. However, this does not imply that the introduced skews can be eliminated without violating the imposed causal and topological constraints of the model.

The introduced off-diagonal terms in the above metric represent the global geometric skew. Although a local linear coordinate transformation can diagonalise the metric in a neighbourhood, no single global transformation exists that simultaneously preserves: first, the fixed ± 1 PTU separation of future and past cone apexes; second, the monotonic ordering of τ as the master temporal parameter; and third, the finite gap geometry through which events realise. The skew is therefore invariant under admissible global transformations, compatible with the causal structure of the model. Local flatness is preserved, although orthogonality is globally relaxed under physically imposed boundary conditions.

As stated before, these effects may be negligible locally, their cumulative imprint is expected to become evident across cosmological distances. Isotropy, in this context, becomes a testable assumption – one this model challenges through a geometrically minimal, yet directionally significant skew.

5 Conceptual and Mathematical Refinements

5.1 Superposition of Tilted Planes in Time and Space, Consequences and Effects

In this section, a minimal mathematical formalism will be introduced to reflect how such skew alters spacetime structure at the level of event evolution, entropy flow, and information trace formation. So far, this model has been developed from conceptual grounds, outlining how a slight temporal skew (τ relative to θ), together with a spatial skew of the same order of magnitude along z , could produce observable anisotropies across the cosmos and in the quantum realm. The dimensions of space and time are thought to be in superposition (Misner et al. 1973 [38]).

Both the temporal and spatial manifolds feature a tiny skew of 0.0054° . In the Time dimension the skew is on τ relative to θ , and in Space between z and x – forming tilted planes within 3T-time and 3S-space, anchored respectively in t_0 and $x=y=z=0$.

5.2 Mathematical Refinements

5.2.1 Anisotropy in Light Propagation

In standard cosmology, light is assumed to travel along null geodesics through a statistically isotropic and orthogonal spacetime. These geodesics are defined by the Minkowski metric:

$$ds^2 = 0 = dt^2 - dx^2 - dy^2 - dz^2 \quad (\text{equ. 6})$$

This equation reflects the path of light as a straight trajectory in flat spacetime. However, in the present model, the temporal and spatial manifolds are slightly skewed. The θ - τ plane and the x - z plane are tilted by the same angle κ relative to the primary temporal axis, to the primary spatial axis, respectively. These tilts introduce directional biases into the spacetime metric – not as curvature, but as off-axis anisotropies (Kostelecký & Mewes 2002 [39]).

In order to capture these biases, first-order perturbative corrections to the flat Minkowski metric are introduced. For small angles ($\kappa \ll 1$), the skewed metric can be expressed as:

$$ds^2 \approx dt^2 - dx^2 - dy^2 - dz^2 - 2 \cdot \kappa \cdot d\theta \cdot d\tau - 2 \cdot \kappa \cdot dx \cdot dz \quad (\text{equ. 7})$$

Here, the term $2 \cdot \kappa \cdot d\theta \cdot d\tau$ represents the projection of τ into θ , forming the tilted temporal plane, whereas $2 \cdot \kappa \cdot dx \cdot dz$ captures the projection of z into x , forming the tilted spatial plane. It is to note that the standard orthogonal metric is recovered when $\kappa = 0$. Overall, the geometry remains flat, the Riemann curvature tensor $R^i_{jkl} = 0$ untouched, and the skewed terms do not imply gravitational curvature – they reflect orientation changes within the manifold (Skrotskii 1957 [40a]; Hehl & Obukhov 2003 [40b]).

Under this modified geometry, the null geodesic condition $ds^2 = 0$ becomes:

$$dt^2 = dx^2 + dy^2 + dz^2 + 2 \cdot \kappa \cdot d\theta \cdot d\tau + 2 \cdot \kappa \cdot dx \cdot dz \quad (\text{equ. 8})$$

This expression shows that the effective light path length includes directional corrections from both the temporal and spatial skew.

This means that, in the 3S+3T framework, a light wave becomes orientation-dependent (Carroll 1990 [41]). Light propagating along the direction of the skews, e.g. diagonally through the θ - τ or x - z planes, experiences a cumulative deviation that could manifest as direction-dependent redshift accumulation, featuring polarisation rotation anomalies known as cosmic birefringence (Itin 2004 [42]). Also, subtle differences in electromagnetic wave travel time across orientations may be observed. This orientation-dependence parallels how light propagation varies across media of different refractive indices: the constant c defines the vacuum limit, yet in matter the effective propagation speed decreases with the medium's optical density.

The above noted deviations preserve local Lorentz invariance, but embed anisotropic structure into the global metric background. Photons, under this interpretation, act as sensitive tracers of the spacetime geometry itself, without invoking gravitational curvature. They are merely revealing curvature, but exposing skewed orientations otherwise hidden in the assumptions of perfect isotropy.

5.5.2 Event Trajectories in Skewed Time

In this model, events evolve within a skewed temporal manifold – or Time-Space, as the 3S+3T model distinguishes itself significantly from Einstein's unified spacetime – whereas the spatial dimension remains static and does not contribute to this consideration. Event evolution does not proceed along a simple orthogonal grid, but instead unfolds within a skewed temporal geometry. The θ - τ plane, tilted by the angle κ , introduces directional anisotropy into the event flow. While the main temporal axis t remains vertical and unskewed relative to θ , the τ -direction deviates slightly from both, producing a tilted manifold that subtly affects how events emerge and propagate through time (Gell-Mann & Hartle 1990 [43]).

To describe event trajectories, the evolution of an event in time space is represented by the vector:

$$\frac{dT}{d\lambda} = \left(\frac{dt}{d\lambda}, \frac{d\theta}{d\lambda}, \frac{d\tau}{d\lambda} \right) \quad (\text{equ. 9})$$

Here, λ is a general evolution parameter, analogous to proper time, and the vector components define the event's progress along t , θ , and τ .

In flat time space, one might expect the components to evolve independently or symmetrically. However, due to the skew, their evolution becomes coupled. The components evolve as follows:

$\frac{dt}{d\lambda} = 1$, meaning that the flow of time along the t -axis is treated as uniform and steady, setting the basic clocking rate.

$\frac{d\theta}{d\lambda} = \alpha \cdot P(\lambda) + \eta(\lambda)$, indicating that the θ -component evolves in proportion to the local event probability $P(\lambda)$, scaled by a coupling constant α , and is modulated by a noise term

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$\eta(\lambda)$ that captures the inherent uncertainty in event branching (Breuer & Petruccione 2002 [44]).

$\frac{d\tau}{d\lambda} = \beta \cdot \frac{\partial P}{\partial \theta} + \kappa \cdot \frac{d\theta}{d\lambda}$ with τ evolving from directional gradients and skew, linking asymptotic structure to local dynamics.

The τ -component is influenced both by the gradient of the event probability in the θ -direction ($\partial P / \partial \theta$), scaled by a second constant β , and by a skew correction term $\kappa \cdot d\theta / d\lambda$. This second term reflects how the skewed geometry causes any evolution along θ to “leak” into τ .

This coupling implies that an event’s trajectory is not just governed by probabilistic factors, but also by the geometric tilt embedded in the structure of time itself (Tegmark 2000 [45]). In flat space, $d\tau / d\lambda$ would be independent of $d\theta / d\lambda$. In this model, they are intrinsically linked.

The full evolution of an event is thus not merely random or deterministic, but geometrically conditioned: trajectories in the future cone – as well as when passing through the gap or when tunnelling – deviate in probability space due to the skewed manifold (Muchow Feb 2025 [46]). The more strongly an event evolves along θ , the more it is deflected into the τ - and z -directions – a drift introduced not by any force, but by geometry.

Such effects may remain invisible at small scales but become relevant when summing over ensembles of events, as in trace accumulation or large-scale memory formation. Over time, the skew leads to a directional preference in realised event paths, subtly distorting the structure of the realised history in the τ -direction.

Not only the trajectories of individual events are affected, but also the accumulation of memory traces – which in this model encode past events’ persistence and influence.

Each event leaves a memory trace $M(t)$, which decays over time. The strength of this trace is governed by:

$$M(t) = \sum [w_i \cdot P_i(t) \cdot \exp^{-\gamma \cdot (t - t_i)}] \quad (\text{equ. 10})$$

Here:

- $P_i(t)$ is the realisation probability of the i -th event,
- w_i is its assigned weight (e.g. based on how many timelines converge at that event),
- γ is the trace decay constant, and
- t_i is the moment of event realisation.

This formula defines memory not as a fixed mark, but as a decaying signal dependent on both event relevance and how long ago the event occurred. The longer an event lies in the past, the weaker its trace. But, as outlined before: realised events with accumulated timelines leave long-lasting traces, whereas non-events leave rapidly fading traces.

Now geometry comes into play: due to the skew in τ , the projected location of an event in the θ - τ plane determines its trace footprint. The skewed projection shifts the effective contribution of a past event depending on its orientation. If an event is at coordinates (θ, τ) , its radial distance from the τ -axis is:

$$r^2 = \theta^2 + (\tau - \theta \cdot \tan \kappa)^2 \quad (\text{equ. 11})$$

The distance r determines how much an event “misses” the τ -axis. The closer r is to zero, the stronger its projected contribution to the filtered memory. Hence, even if two events occurred at the same t , their trace impact differs depending on where they sit in the tilted θ - τ manifold.

This leads to directional memory weighting: events aligned with τ contribute more stably to memory, while lateral ones decay faster and/or leave weaker traces. Over time, this results in anisotropic memory density, skewed in favour of the τ -direction.

Thus, in this model, memory is not only a probabilistic decay, but a geometric imprint: shaped by the event’s position within a skewed temporal fabric, reinforcing the directional evolution of history.

5.2.3 Entropy Dynamics in Skewed Time-Space

Entropy, in this model, is no longer a passive scalar expanding isotropically from initial conditions. It becomes a directionally shaped field, evolving within a skewed spacetime that subtly favours certain orientations due to the τ - θ tilt in the temporal manifold and the z - x tilt in the spatial domain (Jaynes 1957 [47a]; Garcia-Colin & Sandoval-Villalazo 2009 [47b]).

In standard formulations, entropy increases uniformly over time:

$$\frac{\partial S}{\partial t} \geq 0 \quad (\text{equ. 12})$$

In the presented geometry, however, entropy flow is no longer uniform in all directions. The skew in τ relative to θ introduces a preferred direction along which entropy traces persist longer or propagate more efficiently. However, Bell’s inequalities and their quantum mechanical violation are preserved, since the three-directional geometry does not alter local quantum statistics (Bell 1964 [48a]; Aspect 1981 [48b]). For $\kappa \ll 1$, the standard predictions of quantum mechanics, including non-classical correlations, remain unchanged.

Thus, the entropy flux vector $\mathbf{J}$, incorporating both temporal and spatial skew effects must be redefined:

$$\mathbf{J} = -\mathbf{D} \cdot \nabla_s \mathbf{S}, \quad (\text{equ. 13})$$

where $\mathbf{D}$ is a direction-dependent diffusivity tensor, and $\nabla_s \mathbf{S}$ is the skewed entropy gradient. In conventional isotropic space, $\mathbf{D}$ reduces to a scalar and $\nabla \mathbf{S}$ follows standard spatial derivatives. In this model, $\mathbf{D}$ contains off-diagonal components induced by skew:

$$\mathbf{D}_{time} = \begin{pmatrix} D_t & \kappa & 0 \\ \kappa & D_\theta & 0 \\ 0 & 0 & D_\tau \end{pmatrix} \quad (\text{equ. 14})$$

with similar structure in space for the z - x skew:

$$\mathbf{D}_{space} = \begin{pmatrix} D_x & \kappa & 0 \\ \kappa & D_y & 0 \\ 0 & 0 & D_z \end{pmatrix} \quad (\text{equ. 15})$$

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The off-diagonal terms of κ couple entropy flow between directions. Here, $\mathbf{D}_{time}$ and $\mathbf{D}_{space}$ represent the temporal and spatial 3×3 diffusion tensors, respectively; together they form the full 6×6 structure coupling all directions. Thus, the entropy gradient in θ or x also generates flux in τ or z , respectively. This generates a directional entropy leakage – where entropy appears to drift preferentially along the skewed directions.

The entropy flow divergence is defined as:

$$\nabla \cdot \mathbf{J} = -\frac{\partial S}{\partial t} \quad (\text{equ. 16})$$

Substituting $\mathbf{J}$, one gets the anisotropic entropy equation for temporal contributions:

$$\partial S / \partial t = \mathbf{D}_t \cdot \partial^2 S / \partial t^2 + \mathbf{D}_\theta \cdot \partial^2 S / \partial \theta^2 + \mathbf{D}_\tau \cdot \partial^2 S / \partial \tau^2 + 2 \cdot \kappa \cdot \partial^2 S / \partial \theta \partial \tau \quad (\text{equ. 17})$$

and analogously for spatial contributions:

$$\partial S / \partial x = \mathbf{D}_x \cdot \partial^2 S / \partial x^2 + \mathbf{D}_y \cdot \partial^2 S / \partial y^2 + \mathbf{D}_z \cdot \partial^2 S / \partial z^2 + 2 \cdot \kappa \cdot \partial^2 S / \partial x \partial z \quad (\text{equ. 18})$$

The last terms in each expression, the mixed partial derivatives, explicitly encode skew-driven entropy anisotropy (Kestin 1979 [49]). These are not curvature effects; they emerge purely from the geometry of directional distortion introduced by τ and z tilts.

This means that entropy spreads physically faster along τ and z than in orthogonal directions. Over time, this leads to anisotropic thermodynamic gradients. In the universe, cosmic voids and high-entropy regions may display directional cooling, and thermal histories of galaxy clusters could subtly diverge across orientations. Additionally, the second law becomes geometry-sensitive: entropy increases, yes – but not equally in all directions.

Over cosmic scales, this entropy deformation can accumulate into a global thermodynamic asymmetry, potentially visible in CMB temperature anisotropies, large-scale structure entropy density, or alignment of cooling flows in the intra-cluster medium.

Entropy, in this framework, is not just a scalar arrow of time, but a vectorial field, subtly steered by the skewed geometry of time and space.

6 Conclusion

This essay has extended the three-directional time model, presented in previous papers, by proposing a corresponding spatial skew, resulting in a framework where time and space evolve on subtly tilted planes. The skew in τ relative to θ introduces temporal anisotropies, while a mirrored skew in z relative to x introduces directional preference in the spatial manifold. Though both skews are minute in magnitude, their cumulative effects stretch across cosmological and quantum domains.

The superposition of the tilted planes in Space and Time alters particularly the geometry of event realisation, information propagation, and entropy flow. Possible observable consequences, as outlined above, include directional biases in redshift accumulation, polarisation rotation in the CMB, anisotropic entropy gradients, and structural alignments on galactic and quantum scales. These phenomena, often treated as statistical noise or unresolved anomalies, may instead be signatures of a deeper geometric asymmetry.

The present model provides a potential geometric basis for such features. The skewed τ - and z -axes introduce intrinsic directionality at the Time-Space level, and if the associated skew parameter range κ can be verified since the early universe, this will result in observable directional correlations. Rather than requiring exotic fields or fine-tuning, the observed anisotropies in the CMB might thus be viewed as a direct imprint of the underlying non-orthogonality of the cosmos.

This model does not abandon the flatness of spacetime, it refines it. Orthogonality is retained locally, but globally, the introduced skews emerge as a quiet force – steering the evolution of the universe not through curvature, but through subtle directionality. The familiar grid is not broken, merely slanted. This slant, if proved real, requires a thorough rethinking of time and space – not as fixed orthogonal arenas, but as emergent structures, shaped by the very processes they contain.

Finally, the present model retains the essential structure of general relativity and quantum field theory in the limit $\kappa \rightarrow 0$, where the temporal and spatial axes recover orthogonality. The skews introduced here can be represented as a small rotation in a higher-directional 3S+3T manifold, preserving tensor transformation properties to first order in κ . Causality is maintained by the monotonicity of τ , which serves as the master parameter for chronological ordering, precluding the formation of closed time-like curves. Since the future and past cones are separated by two Planck lengths, the resulting skew renders them practically flat, shifting the asymptotes to the proposed, calculated angle. Thus, causal direction is encoded without permitting closed time-like curves.

It is clear that this model is far from perfect – so, new approaches have to be envisaged, especially concerning gravity (which is work in progress) and other seemingly conflicting concepts like “spacetime”, the various existing arrows of time, causality, and more. The main issue seems to be the rigidity of established conventions, for example the idealisation of symmetry – whereas the universe exists only through asymmetry. Future observations connecting the 3S+3S model to actually detected anisotropy and polarisation may allow testing it with future high-precision instruments within the conservative κ -range $[0.0054^\circ, 0.03^\circ]$ and beyond.

Annex

Constants and PTU Conversions

Symbol	Value	Notes
κ	0.0054° or 9.524×10^{-5} rad	Angular deviation of z - and τ -axis from orthogonality
PTU (Planck Time Unit)	$\sim 5.39 \times 10^{-44}$ s	Fundamental time resolution
Realised events per PTU	$\sim 10^{24}$	Structurally realised events per PTU
Non-realised events per PTU	$\sim 10^{29}$	Events bypassing realisation, tunnelling to past cone
Temporal radial distance r^2	$\theta^2 + (\tau - \theta \cdot \tan(\kappa))^2$	Governs memory/trace decay

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Scienza e immaginazione. Charles Dickens tra Charles Babbage e Ada Lovelace

(Science and Imagination: Charles Dickens Between Charles Babbage and Ada Lovelace)

Carla Petrocelli*

Sunto

Charles Dickens, amico, lettore e corrispondente sia di Charles Babbage che di Ada Lovelace, ha con loro un rapporto di stretta amicizia, dimostrato dai numerosi manoscritti di cui disponiamo. Sebbene sia opinione comune che nell'immenso corpus letterario dello scrittore inglese non vi siano riferimenti a temi legati alla scienza, tramite questo contributo si evidenzia tuttavia che Dickens ha subito l'influenza dei due pionieri del calcolo programmabile, dimostrandosi nei suoi scritti attento osservatore di quelle procedure simboliche che, in prospettiva contemporanea, possiamo leggere come affini a processi di codifica, dalla rappresentazione dell'informazione mediante codici, alla schematizzazione di un problema attraverso algoritmi.

Parole chiave: Dickens; Babbage; Lovelace; scienza; letteratura.[†]

Abstract

Charles Dickens was a friend, reader, and correspondent of both Charles Babbage and Ada Lovelace. The numerous surviving manuscripts testify to the close relationship he maintained with them. Contrary to popular belief, Dickens's extensive body of work does contain references to scientific themes, as this article demonstrates. Dickens was influenced by the two pioneers of programmable computation, and his writings demonstrate that he was a keen observer of symbolic procedures that can be interpreted as coding processes from a contemporary perspective. These include the representation

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of information through codes and the schematisation of problems via algorithms.

Keywords: Dickens; Babbage; Lovelace; science; literature.

1. Introduzione

Nel presente contributo si vuole analizzare un nuovo modo di pensare Dickens (1812-1870), amico, lettore e corrispondente sia di Charles Babbage (1791-1871) che di Ada Lovelace (1815-1852), precursori vittoriani della tecnologia informatica. Dickens si muove negli stessi circoli sociali di Babbage, inventore di un calcolatore programmabile, e di Lovelace, prima programmatrice di queste macchine meccaniche, e con loro ha un rapporto di stretta amicizia, dimostrato dalle numerose lettere di cui disponiamo. Sebbene sia opinione comune che nell'immenso corpus letterario dello scrittore inglese non si colgano interessi e commenti su argomenti scientifici, proprio grazie agli scambi epistolari intercorsi con i due scienziati inglesi, viene fuori una realtà diversa, nella quale emerge l'attenzione dello scrittore verso questi temi, oltre a una profonda conoscenza degli scritti di Babbage e di Lovelace. Subendo evidentemente l'influenza dei due pionieri del calcolo programmabile, nei romanzi di Dickens registriamo una sottilissima distinzione tra animato e inanimato in cui anche il confine tra macchina e uomo si assottiglia talmente tanto da arrivare a dissolversi: egli divulga la scienza intrecciandola nelle trame dei suoi romanzi, che solo apparentemente appaiono 'non scientifici' e che rispecchiano ciò che affermerà nell'ultimo decennio della sua vita, ovvero che vi sono ampi effetti benèfici sulla nazione e sulla qualità della vita, dovuti proprio alla scienza e alla tecnologia¹. In questo contesto, Dickens appare attento a quelle che saranno le basi della moderna informatica.

2. *A Tale of Two Cities*

[...] se la mia signora si è assunta di tenere il registro soltanto in mente, non ne perderà una sola parola, nemmeno una sillaba. Intrecciato nelle sue maglie, con i suoi simboli, il registro le sarà sempre chiaro come il sole. Dà retta a me, abbi fiducia in madama Defarge. Sarebbe più facile, per la creatura più codarda di questo mondo, togliersi la vita che cancellare una lettera del suo nome e de' suoi delitti dal registro a maglia di madama [11, 197; 169]².

¹ Le riflessioni di Dickens sugli effetti benèfici della scienza e della tecnologia per la nazione e la quotidianità sono confermate dal suo biografo Peter Ackroyd che riferisce che lo scrittore inglese «alla fine della sua vita elogiava le principali scoperte e invenzioni del suo periodo. In questo senso Dickens era molto moderno, molto legato al suo periodo e molto scettico sui 'bei tempi andati'» [1, 632].

² In questo articolo si farà riferimento all'edizione dell'opera del 1868 con i commenti di Andrew Lang e alla traduzione italiana curata da M. Fabietti del 1938. Pertanto, per ogni riferimento all'opera si riporteranno rispettivamente i numeri di pagina dell'edizione inglese e della traduzione italiana.

Sono queste le parole del ‘bettoliere’ Defarge, un oste robusto, tra i quaranta e i cinquanta anni, persona assai risoluta e di carattere fermo, uno dei personaggi di *A Tale of Two Cities* di Charles Dickens, pubblicato nel 1859 [11, 308; 259]. Un ‘melodramma storico’, come lo definisce Andrew Lang nell’introduzione all’edizione del 1868, ambientato nel periodo che precede e segue la Rivoluzione francese, dal 1775 al 1793, i cui personaggi si muovono fra Parigi e Londra, le due città del titolo.

Nelle sue parole, Ernest Defarge si riferisce a sua moglie, una ‘rivoluzionaria’ descritta da Dickens come una donna dura e volitiva, la cui vita dietro al bancone della loro osteria le permette non solo di essere ben informata sugli eventi politici, ma anche di far circolare velocemente tutte le notizie che vuole. Madame Defarge si assumerà la responsabilità di tenere ‘memoria’ delle persone da giustiziare una volta avviata la Rivoluzione.

Pubblicato sia in forma di libro che in trentuno puntate sulla rivista *All the Year Round* a partire da sabato 30 aprile e fino al 26 novembre del 1859, *Le due città* analizza il conflitto tra principi democratici e aristocratici durante la Rivoluzione francese.³ È un romanzo ambientato alla fine del Diciottesimo secolo a Parigi e Londra in cui, negli anni precedenti la Rivoluzione, lo scrittore affronta temi sociali quali la sottomissione del proletariato francese all’oppressione dell’aristocrazia, seguita dalla brutalità degli stessi rivoluzionari nei primi anni della sollevazione. Dickens considera «l’orrenda rivoluzione, che si era scatenata con tanto terribile furore» [11, 281; 236], come una malattia, una febbre contagiosa che si espande a una velocità sempre più evidente e crescente. Tuttavia, il narratore, che non viene mai identificato, ha accesso ai pensieri e ai sentimenti di tutti i personaggi e dunque la Rivoluzione diventa uno sfondo romantico e la turbolenza dei tempi è usata come pretesto per rivelare qualità umane e morali. I protagonisti vivono le loro vite attraverso questi eventi, anche se l’autore inglese preferisce dare priorità agli aspetti puramente etici, indebolendo il legame tra i problemi della vita dei personaggi e gli eventi della Rivoluzione francese [33].

Epico nella sua portata storica, diventa dunque un libro intimo, che mostra come si mescolino i sentimenti personali con il credo politico e che mette in evidenza le cause e gli effetti della violenza, compresa la lotta per mantenere un equilibrio mentale sottoposto a violenti abusi. Il turbine di violenza che segue la caduta della monarchia francese travolge i personaggi del romanzo, i cui destini si amalgamano con gli avvenimenti storici: coloro che rischiano la ghigliottina non sperano di ottenere la ‘pietà del popolo’, ma è una misura della bravura di Dickens la simpatia che proviamo nei loro confronti. Nel romanzo, l’autore è solidale al rovesciamento dell’aristocrazia francese, ma rimane comunque sempre molto critico nei confronti del regno del terrore che ne seguirà.

Nella prefazione al libro, Charles Dickens sostiene che l’idea di questo romanzo lo aveva «completamente posseduto». Lo stato di ossessione immaginativa in cui fu scritto può essere percepito in due aspetti piuttosto diversi dell’opera: nel modo in cui incalza senza sosta verso il suo violento finale e nel modo in cui particolari scene assumono

³ C. Dickens. *A Tale of Two Cities*. *All the Year Round*, I, 1. 30 April 1859. disponibile su Dickens Journal Online <https://www.djo.org.uk/all-the-year-round/volume-i.html>

un'intensità visionaria, cariche di emozioni oscure e potenti, non pienamente controllate, né comprese. Le scene di frenetica violenza collettiva sono gli esempi più eclatanti di questo tipo di scrittura, ma ci sono altri momenti, meno legati alla traccia principale della storia, in cui le immagini e le idee irrompono nel testo con un'energia spontanea che arresta, piuttosto che favorire, lo slancio della narrazione [45, 576-577].

Tra le molteplici vicende umane che si intrecciano in queste pagine spicca quella di Madame Defarge, incarnazione di una femminilità sfigurata, personificazione della Rivoluzione stessa e della sua perversione.

3. Madame Defarge

Gli eventi di quel tempo avevano snaturato profondamente parecchie donne; ma nessuna era più da temere di quella creatura dall'animo spietato [11, 421; 352].

È questa la descrizione di Dickens della cattiva implacabile del romanzo, Thérèse Defarge.

La sua malvagità non è senza ragione e, in un certo senso, rappresenta metaforicamente lo spirito rivoluzionario che attraversa la Francia nel Diciottesimo secolo che, prima chiede uguali diritti per tutti i cittadini e poi li toglie a molti innocenti. Senza figli e senza pietà, Madame Defarge è l'antitesi di Lucie Manette. Entrambe le donne possiedono la capacità di ispirare gli altri, ma mentre Lucie crea e alimenta la vita, Madame Defarge la distrugge. La sua intera famiglia era stata sterminata quando era solo una bambina e dunque Thérèse, «piena sin dall'infanzia di un amaro senso delle ingiustizie sofferte», vuole vendicarsi non solo di chi ha causato le sue sofferenze, ma dell'intera classe sociale da cui proviene. Cercando di perseguire questi obbiettivi, acquisisce la stessa spietatezza degli uomini che hanno massacrato i suoi familiari, tanto da far sembrare che la Rivoluzione sia stata causata principalmente «per servire i suoi scopi privati» [11, x; 38]. Ciò che la rende così minacciosa, feroce, implacabile, è un'ostinata pazienza, quel saper attendere il momento migliore per colpire, cogliere l'occasione giusta.

Fin dalla sua prima apparizione, molto prima dell'inizio della Rivoluzione, leggiamo di una Thérèse Defarge che lavora a maglia instancabilmente, con una frenesia quasi inquietante: ha sempre il suo lavoro tra le mani, sia che si trovi dietro il bancone della 'bettola', sia che stia camminando, sia che si trovi in una carrozza pubblica oppure in mezzo alla folla.⁴ Con il progredire del romanzo, questo personaggio disegnato da

⁴ Rispettivamente in [11, x; 39], «Poi girò gli occhi come per caso nella bettola, riprese il suo lavoro a maglia, apparentemente con grande calma e tranquillità di spirito, e parve tutta assorta in quella occupazione.», *Le due città*, p. 39); in [11, 212; 181], «[...] madama Defarge, col suo lavoro in mano, passava di luogo in luogo, di gruppo in gruppo, come una missionaria [...]»; in [11, 198; 170], «Era poi tutt'altro che piacevole veder la signora lavorare a maglia, senza interruzione, in un pubblico ritrovo; ed era proprio sconcertante vederla continuare imperterrita il suo lavoro in mezzo alla folla, quando, durante il pomeriggio, tutti aspettavano di veder passare il cocchio del re e della regina».

Dickens, che all'inizio appare abbastanza passivo nel suo sferruzzare nell'enoteca che gestisce col marito, si sposta verso quello più dinamico di testimone attivo della vita politica. Tuttavia, si dovranno attendere i capitoli XV, *Facendo la calza*, e XVI, *Sempre al lavoro*, per scoprire il segreto di questo suo continuo sferruzzare: Thérèse non lo fa per passare il tempo o, come le donne del quartiere in cui vive, per cercare di dimenticare la fame.⁵ Il suo lavoro ha un significato politico molto preciso, è il «registro fatale» [11, 350; 323], sul quale tiene memoria dei nomi e dei crimini dei grandi uomini e delle spie dell'*Ancient Regime*. È proprio questo subdolo ricamo che lascia i brividi: Madame Defarge sta 'scrivendo' a maglia i nomi di tutti coloro che saranno ghigliottinati o giudicati nella prossima Rivoluzione [31, 33]. A chi le chiede che cosa fa, risponde serafica: «lenzuoli funebri» [11, 199; 170].

Come afferma con forza Hilary Schor, Madame Defarge ha lavorato a maglia niente meno che l'intera Rivoluzione francese, incarnando il movimento delle *sansculotte* che assistono all'esecuzione di migliaia di persone. Se alla fine Thérèse è motivata dalla vendetta per lo stupro della sorella, allora la logica che guida la sua storia è che il crimine segreto della violenza sessuale contro le donne alimenta la Rivoluzione stessa [47, 70-98]: è lei la capofila delle *tricoteuses*, di quelle donne del popolo che, lavorando a maglia, siedono in tribuna a sostegno dei politici di sinistra alla Convenzione nazionale, partecipano alle riunioni del club giacobino, alle udienze del Tribunale rivoluzionario, e si godono lo spettacolo «di quella scaltra femmina, nata da poco e chiamata 'ghigliottina'» [11, 292; 247],⁶ sempre continuando a lavorare a maglia. Vi è dunque un'associazione diretta di queste 'consorelle' alla ghigliottina, al sangue, alla morte che sottintende quanto di più orribile la Rivoluzione possa produrre.

Una donna gentile diventa poi feroce, si trasforma in un mostro sanguinario che viene identificato con una Rivoluzione che è essa stessa mostruosa.⁷

⁵ «Tutte le donne lavoravano a calza. Facevano indumenti inutili; ma quel lavoro meccanico sostituiva l'altro pure meccanico del bere e del mangiare; le mani si movevano in luogo delle mascelle e dell'apparato digerente; se le dita ossute si fossero fermate, lo stomaco avrebbe sentito maggiormente gli stimoli della fame.» [11, 212; 181].

⁶ La presenza di donne che lavorano seguendo i dibattiti nelle gallerie delle assemblee rivoluzionarie e l'esistenza di un pubblico femminile che assiste alle esecuzioni ha dato all'espressione *tricoteuses* una connotazione offensiva. Questi personaggi femminili rappresentano la cosa più orribile che la Rivoluzione potesse produrre: donne gentili, diventate feroci. Così, in una certa tradizione controrivoluzionaria, la *tricoteuse* è un mostro sanguinario che viene identificato con una Rivoluzione che è essa stessa qualcosa di mostruoso. Cfr. [21].

⁷ La storica della Rivoluzione francese Dominique Godineau, attraverso lo studio della vita quotidiana rivoluzionaria delle 'donne del popolo', rende molto ben visibili lavandaie, venditrici ambulanti e signore del mercato che riempiono la città con le loro voci e che la sera partecipano ai dibattiti politici. Sono donne i cui rapporti coniugali sono spesso segnati dalla violenza che caratterizza tutte le relazioni sociali dell'epoca ma che acquisiscono una vera cultura politica occupando le gallerie dove non si può comunque votare o deliberare, ma che consente loro, tra schiamazzi e chiacchiere, di dimostrare il sostegno o il rifiuto di una proposta. Cfr. [22].



Figura 1 - Madame Defarge intenta a lavorare a maglia. Illustrazione di Hablot Browne, The wine shop, in *A Tale of Two Cities*, Libro secondo, Capitolo XVI (figura inserita tra pagina 210 e pagina 211)

A questa Rivoluzione, i coniugi Defarge parteciperanno attivamente. Nel successivo periodo del Terrore, Thérèse consulterà più volte «le proprie annotazioni a maglia per denunciare gente, che la ghigliottina andava mietendo via via» [11, 350; 294]. Sarà lei a guidare le malvage donne intente a lavorare a maglia [11, 255; 215]. Dickens mostra queste sferruzzatrici davanti alla ghigliottina, sedute su file ordinate di sedie, non pervase dal terrore, bensì come fossero in un giardino pubblico, rilassate, a godersi un momento di riposo [11, 433; 363].

Nel corso del romanzo, Dickens farà perdere piano piano a Defarge le sue qualità femminili; le esperienze della giovane Thérèse ne deformeranno e distorceranno la ragione, che sarà solo alimentata dalla vendetta. Thérèse è come la folla dei rivoluzionari che non si fermano a pensare che le loro stesse azioni possono essere ingiuste: con le mani fredde e pesanti, che non smetteranno mai di lavorare a maglia, sarà guidata non solo dalla vendetta, ma dalla convinzione di portare giustizia a quelle madri e quelle mogli che hanno sofferto la miseria, la fame e l'oppressione.

La malvagia Thérèse verrà sconfitta dall'unica cosa che non le appartiene: l'amore per gli altri.

Questo momento del romanzo sottolinea uno dei punti principali di Dickens, ovvero che l'amore, la compassione e la vera giustizia possono essere la rivale migliore; egli

non resta indifferente ai mali che subiscono personaggi come Madame Defarge e la sua famiglia, ma fa pagare loro un prezzo straordinariamente alto che li porta a spogliarsi finanche della loro umanità [36].

4. I cifrari e gli algoritmi: i contatti di Dickens con Charles Babbage

Thérèse Defarge lavora a maglia e, nel suo operare, codifica segretamente i nomi di coloro che dovranno essere giustiziati; appare continuamente in affanno nel portare a termine il lavoro avviato, sempre intenta a sferruzzare, così da non destare alcun sospetto, e aggiungere i nomi al suo ‘registro di memoria’ anche di fronte a coloro che la guardano senza sapere cosa sta facendo. Dotata di ottima memoria,⁸ Thérèse avrebbe potuto semplicemente cercare di ricordare tali nomi. Tuttavia, i rivoluzionari le chiedono un ‘registro fisico’ da consultare e riguardare nel corso del tempo e lei, per tenerlo segreto, pensa di utilizzare il suo lavoro a maglia. Naturalmente, Madame Defarge non si limita a incidere sulla maglia i caratteri corrispondenti ai nomi di cui tener traccia: non sarebbero stati segreti se chiunque, guardando il lavoro risultante, avesse potuto leggerli.

Dickens, purtroppo, non descrive la soluzione che fa adottare a Madame Defarge per registrare le informazioni. Questa sua scelta indubbiamente ci fa capire che fosse a conoscenza di strutture simboliche che oggi potremmo interpretare in chiave proto-informatica: a seconda delle tecniche usate per lavorare a maglia, rende possibile una memorizzazione e una codifica dei dati che vuole conservare. Più che un sistema cifrato in senso tecnico, sembra funzionare come dispositivo narrativo e metaforico: un archivio silenzioso della vendetta rivoluzionaria, che trasforma un gesto domestico e tradizionalmente femminile in strumento di memoria e di condanna [36]. Studi come quello di Linda Lewis hanno sottolineato il carattere allegorico di questa figura, descritta come una sorta di ‘storica’ che conserva un testo delle vittime della Rivoluzione [31, 31]. In questa prospettiva, l’idea di una codifica, pur non dimostrabile in senso tecnico, può essere intesa come radicalizzazione di una tendenza già individuata dalla critica: quella di attribuire alla maglia un valore semiotico, come archivio occulto della violenza rivoluzionaria [28, 147-149] [53, 209-214].

Charles Dickens sa perfettamente che la lettura di tale messaggio implica la padronanza delle regole che consentono di convertire i simboli di un alfabeto di partenza in caratteri corrispondenti, ma diversi. Solo chi fosse stato a conoscenza della ‘chiave’ segreta adottata, sarebbe riuscito a decodificare il messaggio poiché i nomi sono, come scrive l’autore inglese, intrecciati «nelle sue maglie, con i suoi simboli» [11, 186; 169].

Intorno alla metà dell’Ottocento, crittografare i messaggi era pratica consueta. Codici e cifrature erano stati usati per decenni da re, regine e generali, nel tentativo di mantenere segrete le loro comunicazioni. Persino alcuni uomini di scienza ne avevano fatto uso per

⁸ «[...] se la mia signora si è assunta di tenere il registro soltanto in mente, non ne perderà una sola parola» [11, 197; 169].

nascondere le loro scoperte, assicurandosi al contempo un modo per attestarne la paternità in tempi successivi.⁹ Anche il matematico inglese Charles Babbage si era profondamente appassionato a questi temi; aveva manifestato il suo interesse per i codici e i cifrari già durante gli anni scolastici: «I ragazzi più grandi preparavano cifrari, ma se riuscivo a disporre di poche parole, di solito, scoprivo la chiave.» Il giovane inglese aveva anche maturato la convinzione che «decifrare è, secondo la mia opinione, una delle più affascinanti arti» [2, 198]. L'atto di decodifica per lui era simile a quello della scoperta scientifica: il crittoanalista, esattamente come lo scienziato, confrontandosi con quello che all'inizio gli appariva come un muro impenetrabile, doveva pian piano aprirsi un varco fino a rivelare i segreti nascosti dietro quel muro. Intorno agli anni Trenta dell'Ottocento, Babbage era tornato a concentrarsi sullo studio dei cifrari, approfondendo quegli interessi che già aveva manifestato in giovane età; egli era pienamente coinvolto nelle attività della *Statistical Society* di Londra, fondata da poco, e nella sezione statistica della *British Association*. Fu qui che cominciò ad applicare questa scienza ai problemi di cifratura, quasi un secolo prima di William Friedman, a cui invece va il primato di questi studi [20, 211- 213].

Nel luglio del 1854, al St Clement's Inn, era stata istituita una Commissione per la Demenza allo scopo di valutare lo stato mentale del capitano Jonathan Childe della *Royal Horse Guards*, i cui sentimenti deliranti nei confronti della regina Vittoria lo rendevano pericoloso: già dal 1841 aveva manifestato la convinzione che la Regina fosse innamorata di lui e negli anni successivi le aveva inviato numerose lettere, in gran parte cifrate, disgustosamente oscene. Childe era finito sotto osservazione delle autorità britanniche e successivamente rinchiuso nel manicomio di Hayes Park, vicino Londra, dal momento che aveva cominciato a seguire la regina nei suoi spostamenti, a sedersi nel palco dell'opera di fronte a lei, a pederla nelle sue passeggiate nei parchi. L'istituzione della Commissione per la Demenza era stata voluta dalla *Alleged Lunatic's Friend Society*, un'associazione di avvocati che speravano di dimostrare che il capitano Childe fosse stato ingiustamente «confined» [23, 264]. Il loro caso però era stato ostacolato dalle prove esibite durante il processo che mostravano che, anche dal manicomio, l'uomo aveva dedicato la maggior parte del tempo a scrivere lettere alla Regina. Era stato proprio l'avvocato Kinglake, legale del padre di Childe speranzoso che la giuria confermasse l'infermità mentale del figlio, a chiedere a Babbage di decifrare quelle missive per usarle come prove processuali. Il caso era divenuto talmente noto da farne parlare persino Charles Dickens in uno dei suoi articoli pubblicati sulla rivista *Household Narrative*. Anche Dickens aveva ammesso che Childe aveva «impiegato gran parte del suo tempo a scrivere lettere in codice, che sono state accertate essere evidenti dichiarazioni del suo

⁹ Nel 1610 Galileo aveva spedito l'anagramma «smaismailmepoetalemibunenugttauras» a Keplero che in quel periodo stava studiando i movimenti di Marte e si convinse che Galileo aveva osservato due lune di quel pianeta, poiché lo decifrò nel messaggio in latino «salve umbistineum geminatum Martia proles» («salve, compagni gemelli, figli di Marte»). In realtà, il messaggio si riferiva alle osservazioni che Galileo aveva fatto degli anelli di Saturno, anelli che peraltro non riconobbe come tali, interpretandoli piuttosto come due rigonfiamenti ai lati del pianeta perché scrisse: «Altissimum planetum tergeminum observavi» («ho osservato che il pianeta più distante ha una forma tripla») [54, 103-104].

mai cessato amore per la Regina» [9, 158]. Il padre del capitano Childe aveva ringraziato Babbage per essere riuscito a decifrare le lettere e, dunque, per aver fornito le giuste prove necessarie per confermare la malattia del figlio. Come spiegato anche dall'avvocato della famiglia Childe, il loro caso aveva avuto quella conclusione grazie alla presenza di un nome illustre come quello di Babbage e alla «chiara ed erudita spiegazione che avete dato dei principi attraverso i quali siete giunto alla certezza della scoperta della chiave di cifratura».¹⁰ Alla fine, Childe venne rinchiuso nel manicomio di Ticehurst, dove rimase fino alla morte, avvenuta nell'aprile del 1862.

Charles Babbage era figura di spicco della società londinese. Dickens lo invitava spesso a cena e, a sua volta, lo scrittore era uno degli ospiti sempre presenti alle riunioni serali del matematico inglese, incontri che rappresentavano uno dei momenti culminanti della stagione mondana londinese [50, 68], «frequentati in modo molto brillante da signore alla moda, così come da gentiluomini letterati e scienziati, e dove si incontrano persone di alto livello in tutte le professioni e illustri stranieri», come descrive il naturalista Charles Lyell [34, 466]. Sebbene a Babbage piacesse parlare di diversi argomenti, era particolarmente desideroso di discutere di scienza e di spiegare le sue invenzioni a chiunque volesse ascoltarlo. Mostrava sempre con orgoglio ai suoi ospiti il funzionamento della sua *Difference Engine*, una macchina automatica progettata per calcolare le complesse tabelle aritmetiche utilizzate, ad esempio, nella navigazione. A una di queste dimostrazioni avrà sicuramente assistito anche Charles Dickens. Ne abbiamo prova da una lettera scritta nell'agosto del 1846, nella quale Dickens critica la classe politica inglese e utilizza la *Difference Engine* per fare un paragone con l'inefficienza di tali uomini:¹¹

*«[...] faranno sempre naufragare i loro amici, come li hanno fatti naufragare durante l'elaborazione della legge sulla povertà. Neanche tutte le cifre che la macchina calcolatrice di Babbage potrebbe produrre in venti generazioni, reggerebbero alla lunga contro il cuore del paese».*¹²

Nella prima metà dell'Ottocento, sia gli scrittori che gli inventori cercavano di trascendere le loro origini di classe e di costituirsi come professionisti, chiedendo un riconoscimento allo Stato nel garantire loro protezione sia sul diritto d'autore che per il deposito dei brevetti. Scrittori e inventori, tra cui Dickens e Babbage, cooperarono abitualmente in queste campagne di riforma [434, 185]. Proprio sulla base di tali comuni coinvolgimenti, alcuni studiosi di Dickens sostengono che Daniel Doyce, personaggio de

¹⁰ Si vedano William Childe a Babbage, 24 luglio 1854, BL Add. ms. 37,205, ff. 127-28; John S. Gregory a Babbage, 26 luglio 1854, BL Add. ms. 37,205, ff. 129-30.

¹¹ Dickens paragona la macchina di Babbage alla macchina burocratica di un governo insensibile: «Not all the figures that Babbage's calculating machine could turn up in twenty generations, would stand in the long run against the general heart.» [19, 235].

¹² [50] rispettivamente (Letters 2:307), (Letters 2:251), (Letters 3:477). Dickens e Babbage si occuparono di cause quali la *Corn Law*, la tassazione e la *Society of Authors*.

La piccola Dorrit, sarebbe proprio ispirato alla personalità unica e vibrante di Babbage.¹³ Anthony Hyman evidenzia, ad esempio, che gli infruttuosi sforzi di Babbage per ottenere i finanziamenti governativi per la sua *Difference Engine* generarono al matematico problemi molto simili a quelli che Doyce riscontra nel perfezionare la sua invenzione: ideatore di alcuni dispositivi meccanici che avevano ricevuto numerosi consensi sia a Parigi che a San Pietroburgo, Doyce torna in Inghilterra con la vana speranza di ottenerne un brevetto [24, 193-194]. Le lotte di Doyce sono incentrate sulle difficoltà incontrate per contrastare una feroce burocrazia governativa, espressione della frustrazione di Dickens, influenzato senza dubbio dai noti contrasti del suo amico Babbage con la classe politica, nei confronti delle lungaggini burocratiche che logoravano il governo britannico [8]. Proprio come Babbage, che era arrivato a intendere la professione del matematico come separabile negli aspetti interessanti e gratificanti da quelli ripetitivi, noiosi e quindi meccanici dell'inventore, e che sperava di delegare a terze persone la costruzione del Motore differenziale, nel suo romanzo Dickens delega agli impiegati tutto ciò che poteva essere meccanizzato [27, 261].

5. «I shall, in due time, be a Poet»¹⁴: le idee di Lovelace sulla matematica come linguaggio poetico

Ospite abituale delle riunioni mondane organizzate da Babbage era anche la giovane Augusta Ada Byron, futura contessa di Lovelace, che con lo scienziato inglese condividerà un'amicizia profonda nata dall'interesse per le sue macchine e testimoniata da una corrispondenza di lunga data.¹⁵

La ragazza era rimata affascinata dallo scienziato inglese sin dal loro primo incontro, avvenuto il 5 giugno del 1833, ma ancora di più aveva apprezzato la sua macchina calcolatrice, la *Difference Engine*, nonché le sue riflessioni sull'*Analytical Engine*, ambizioso progetto finalizzato all'automazione del calcolo meccanico. In pochi furono capaci di cogliere le potenzialità di questa macchina: Babbage aveva ottenuto scarsa

¹³ Cfr. [27, 247-274]. Dickens scrive l'opera tra il 1855 e il 1857 e la pubblica in fascicoli mensili a partire dal 1 dicembre 1855 [12]. Riferendosi a Doyce, Dickens scrive: «Non ha una grande azienda, ma la sua ingegnosità è ben nota. Una dozzina d'anni fa, mediante un curioso procedimento segreto, è riuscito a perfezionare e a mettere a punto un'invenzione di grande importanza per il paese e per l'umanità in genere. Non saprei dirvi quanto denaro vi abbia profuso né quanti anni della sua vita abbia passato lavorandovi attorno: fatto sta che una dozzina d'anni oro sono riusciti a portarla a termine» [trd. it, 12, 153-154].

¹⁴ A. A. Lovelace, *Letter to Lady Byron*, 11 gennaio 1841, in [52, 138].

¹⁵ Anthony Hyman sostiene che «Ada era una giovane donna molto dotata che mostrava grandi capacità [...] che all'età di quindici anni aveva già dato prova di precocità matematica». Ada ebbe, tra gli altri, mentori del calibro dell'algebrista Augustus De Morgan, primo professore di matematica all'University College (così come allora era chiamata l'Università di Londra), ma anche Mary Somerville (traduttrice della *Mecanique Celeste* di Laplace). Dal primo incontro con Babbage, avvenuto nel 1833, fino alla sua morte nel 1852, Ada si è interessata con acume alle macchine progettate dal matematico inglese. Nel 1835 sposò il barone King, che divenne conte di Lovelace nel 1838, da cui ebbe tre figli tra il 1836 e il 1839 [24, 177-178].

attenzione sia dai politici inglesi che dalle riviste scientifiche, ma la giovane Byron ne fu subito entusiasta. A solo un anno di distanza dal loro incontro, Ada scriverà a Mary Somerville di essere grata a Babbage per averle inviato alcune tavole che riportavano le specifiche della 'macchina a vapore' tramite la quale il matematico aveva l'intento automatizzare il calcolo.¹⁶ I progetti dell'*Analytical Engine* furono difatti compresi da Ada senza alcuna difficoltà, come riferisce lo stesso Babbage: «l'Incantatrice, ha gettato il suo incantesimo magico attorno alla più astratta delle scienze e l'ha afferrata con una forza che pochi intelletti maschili avrebbero avuto».¹⁷

Sia prima che durante il matrimonio con William, Lord King (diventato successivamente conte di Lovelace) Ada aveva trascorso del tempo a visitare le fabbriche del nord dell'Inghilterra industriale, rimanendo particolarmente colpita dal modo in cui, con il telaio automatico inventato dal francese Joseph-Marie Jacquard, si utilizzassero le schede perforate per produrre broccati di rara bellezza [16, 121].¹⁸ Questa tecnica di codifica e rappresentazione dell'informazione da comunicare al telaio, che aveva ispirato anche Babbage per la progettazione della Macchina Analitica, era stata immediatamente compresa da Lovelace e riconosciuta nei progetti del matematico inglese.

Con queste conoscenze e con il suo bagaglio di esperienze, la contessa di Lovelace diventa testimone delle nuove idee del vulcanico Charles Babbage; le sue intuizioni sulle potenzialità della macchina, le acute osservazioni, i suggerimenti sugli sviluppi e le applicazioni possibili, sono il tema principale dei numerosi scambi epistolari con il matematico londinese il quale, partecipando al Secondo Congresso degli Scienziati italiani a Torino nel 1840, spiega i suoi progetti e le sue idee anche a un pubblico scientificamente competente. Il giovane ingegnere italiano Luigi Federico Menabrea, che assiste al Congresso e che rimane colpito dalle potenzialità della macchina, pubblica una prima descrizione dettagliata in francese dell'*Analytical Engine*, nell'ottobre del 1842 [38].¹⁹

Nonostante i suoi doveri sociali e familiari, che la portano a frequentare esclusivamente gli ambienti di corte, la contessa di Lovelace continua a confrontarsi con Babbage e cerca di infittire i suoi legami con la comunità scientifica londinese. Sarà proprio Charles Wheatstone, figura di spicco della scienza inglese e amico di famiglia dei Lovelace a «interessarsi con molta simpatia ai progetti di Ada, diventando una sorta di consigliere per la sua carriera» [48, 88]. Consapevole della loro amicizia e dell'interesse che Lovelace nutriva per il lavoro di Babbage, Wheatstone le suggerisce di tradurre in

¹⁶ La lettera è datata novembre 1834. Mary Somerville era stata tutrice di Ada, ma con lei aveva poi stretto un legame di amicizia [52, 61].

¹⁷ Il 9 settembre del 1843, Babbage scrive al suo amico Michael Faraday: «Dimenticate questo mondo e tutti i suoi guai e, se possibile, i suoi numerosi ciarlatani - dimenticate ogni cosa ma non l'*Enchantress of Numbers*» [52, 19].

¹⁸ Per una spiegazione approfondita del telaio Jacquard si veda [15].

¹⁹ Luigi Federico Menabrea (1809-1896), uomo di scienza (si laurea dapprima in ingegneria e poi in architettura), militare di carriera, diplomatico, esponente della destra italiana, venne nominato due volte Primo Ministro. Fu membro di numerose società scientifiche, fra cui della Pontificia Accademia delle Scienze (Nuovi Lincei) e dell'Accademia delle Scienze di Torino.

inglese l'articolo di Menabrea: la sua conoscenza del francese si rivela un'abilità inestimabile, ma la contessa arricchisce la traduzione aggiungendo una serie di *Note* di approfondimento che ci fanno comprendere quanto bene conoscesse la meccanica dell'invenzione di Babbage. Quello che Lovelace scrive è molto più di una semplice traduzione, usa un linguaggio molto accurato, strutturando un testo che si rivelerà fondamentale per l'informatica moderna. Nelle *Note*, difatti, la contessa inglese passa da spiegazioni dettagliate del funzionamento dell'*Analytical Engine* (come la spiegazione degli ingranaggi che memorizzano i numeri - «ogni disco può ruotare orizzontalmente in modo da poter vedere qualsiasi cifra richiesta tra quelle inscritte sul suo margine»), a idee più sofisticate che, pur avendo senso oggi, potrebbero non essere state di così facile comprensione all'epoca.²⁰

La poesia e la scienza saranno sempre intrecciate nella mente e nelle visioni di Lovelace, tanto da essere assolutamente convinta che con il passare del tempo sarebbe stata celebrata come 'poetessa'.

Purtroppo, la sua vita fu tragicamente breve. Morì il 27 novembre del 1852, all'età di 36 anni. Sul letto di morte, Lovelace non chiese del suo eterno amico Babbage, preferì incontrare Charles Dickens: le era stato riferito che era fuori città, tuttavia, il 19 agosto del 1852, Dickens la raggiunse, rimanendo con lei per circa un'ora. Lo scrittore inglese era un uomo di quarant'anni dalla personalità irresistibilmente magnetica, i cui modi e discorsi esercitarono su di lei quell'attrazione immediata che sapeva essere dono fatale di suo padre [43, 13-30]: gli parlò del «conforto che aveva tratto dalle loro idee concordanti sul futuro» e gli chiese di leggerle la scena della morte del bambino di sei anni, Paul Dombey, dal suo romanzo del 1848 *Dombey and Son*.²¹ In particolare, espresse il desiderio di ascoltare il capitolo intitolato *What the Waves were Always Saying*, che descrive la vita del piccolo Dombey che scorre via come l'acqua di un fiume verso il mare.²² Dickens era rimasto colpito e assai commosso dal coraggio e dall'audacia della contessa, tanto da sentire di esternare la grande emozione provata in una lettera inviata alla baronessa di Highgate e Brookfield, Angela Burdett-Coutts, il 25 agosto:

La sera prima di lasciare la città (sabato scorso) ricevetti un biglietto da Lord Lovelace che mi diceva che Lady Lovelace stava morendo e che la morte del piccolo Dombey era stata così presente nei suoi pensieri e l'aveva rasserenata a tal punto che desiderava vedermi ancora una volta, se mi fosse stato possibile. Andai e rimasi seduto con lei da solo per qualche tempo. È stato molto solenne e triste, ma la sua forza d'animo

²⁰ Nella *Nota B*, ad esempio, allude all'idea di «come chiaramente [il Motore] separa le cose che sono in realtà distinte e indipendenti e unisce quelle che sono reciprocamente dipendenti», suggerendo la modularità che è insita nella progettazione del software e che è alla base della moderna gestione di sistemi di dati efficienti ed efficaci [32, rispettivamente 701 e 706].

²¹ BL Add. ms. 54089, Sabato, 21 August 1852, anche in [48, 241].

²² Lord Lovelace aveva annotato nel suo Diario che la moglie aveva espresso un forte desiderio di vedere Dickens e che il passaggio tratto da *Dombey and Son* che riguardava la morte del ragazzo sulle rive dell'oceano, l'aveva colpita particolarmente, tanto da scrivergli consigliando di affrettarsi se avesse voluto vederla viva [39, 321].

*è stata sorprendente [...] Desiderava vivere fino a sabato prossimo, per vedere uno dei suoi ragazzi che è assente.*²³

Non si hanno purtroppo fonti che ci dicono quale fosse stata la conversazione, durata circa un'ora, sul letto di morte di Lovelace con il suo confidente Dickens. La giornalista americana Kate Field, che con lo scrittore inglese ebbe amicizia profonda e che da lui aveva saputo dell'incontro con la contessa, riferisce di un dialogo dal quale si evinceva la consapevolezza di essere alla fine dei suoi giorni.²⁴

Come sostiene Doris Langley Moore, Lovelace era una grande ammiratrice di Dickens, lo aveva incontrato diverse volte e si erano scambiati lettere deliziose, in una delle quali lo aveva invitato a cena mentre si trovavano entrambi a Brighton [39, 321n].²⁵ La contessa aveva sempre sospettato che Dickens l'avesse avvicinata semplicemente perché era la figlia di George Gordon Byron; evidentemente riuscì a persuaderla del contrario, visto che in seguito furono legati da profonda amicizia [56, 363-364].

L'interesse di Lovelace per la letteratura doveva essere piuttosto profondo. Dal 1840, nella giovane matematica figlia del poeta romantico Byron, era emersa l'istintiva esigenza di ampliare la sua formazione con lo studio della filosofia, di dare spazio alla dimensione poetica, di usare l'immaginazione come strumento per scrutare il mondo sotto una prospettiva diversa: «Mi accorderai la filosofia poetica, la scienza poetica?» [56, 319],²⁶ aveva scritto alla madre intransigente la cui rigida educazione, che aveva come principale obbiettivo quello di far sì che sua figlia non subisse le influenze di un padre 'pericoloso', l'aveva tenuta lontana dalla nefasta letteratura, fulcro di immoralità e disordine.²⁷

Tracce rilevanti di tali riflessioni emergono anche dalla fitta corrispondenza con Charles Babbage: Lovelace si sofferma sul senso della scoperta scientifica, arrivando alla conclusione che scienza e immaginazione coesistono, anzi, si alimentano a vicenda; solo con l'immaginazione si possono scrutare quei mondi sconosciuti e inosservati che non

²³ *Letter from Charles Dickens, Derby, to Angela Burdett-Coutts, 1852 August 25*, Ms Morgan Library, MA 1352.282; anche in [50, 745-746]. Ralph, il figlio minore di 13 anni, si trovava allora in Svizzera; dopo un viaggio di 48 ore, riuscì ad arrivare per tempo, verso la mezzanotte del 26 agosto. Gli altri due figli, Byron, visconte Ockham, all'epoca guardiamarina della Royal Navy, di 16 anni, e Anne, di 15 anni, si trovavano nella casa, al numero 6 di Great Cumberland Place, con lei.

²⁴ «“Pregghi mai?”, chiesero le labbra malinconiche e morenti. ‘Sempre; ogni sera e ogni mattina’, aveva risposto Dickens, con riverenza; e chi dubita che le sue preghiere abbiano contribuito ad accelerare l'anima di lei che si allontanava?» [46, 78] Kate Field (1838-1896), fu una giornalista, docente e attrice di origini americane; formatasi nel New England e poi in Inghilterra, effettuò un prolungato soggiorno in Europa come corrispondente di vari giornali e riviste americane.

²⁵ Appuntamento che Dickens non riuscì a rispettare a causa di un improvviso problema domestico: «[...] and few had a greater warmth of admiration for Dickens than Lord Byron's “Ada,” on whom Paul Dombey's death laid a strange fascination» [19], in *Victorian Literary Studies Archive*, <http://victorian-studies.net/CD-Forster-6.html>

²⁶ Cfr. [18, 143-144].

²⁷ Così ebbe a definirlo Lady Caroline Lamb nel 1812, con cui il poeta ebbe una turbolenta storia d'amore, terminata la quale prese a dargli una caccia ossessiva. Questa celebre frase è stata riportata dalla sua amica Lady Morgan (nelle sue memorie), anche se Paul Douglass osserva che non vi è alcuna prova per dimostrare che Lady Caroline la pronunciò. Cfr. [13, 200]; [14, 104;164].

esistono neanche per i nostri sensi. Secondo la contessa inglese, tutti gli scienziati avrebbero dovuto avere profonda conoscenza di questi mondi e utilizzare la scienza matematica, il suo linguaggio rigoroso, per mostrare la loro essenza:

*L'immaginazione è, o dovrebbe essere, coltivata in particolare dagli scienziati, da tutti coloro che vogliono entrare nei mondi intorno a noi!*²⁸

Le è chiaro, dunque, come la matematica sia un linguaggio che ben descrive l'armonia dell'Universo e che può essere anche poetico. In questo Ada rimane figlia di suo padre, sensibile a tal punto da vedere un'equazione come una rappresentazione della splendida natura, «il più efficace strumento attraverso il quale la fragile mente umana può decifrare le opere del proprio Creatore» [38, 696].

Anche in relazione all'*Analytical Engine*, Lovelace sostiene che la macchina può essere utilizzata per operare su cose 'oltre al numero': lo spettro della poesia composta dalla macchina rianimerebbe le ansie romantiche riguardanti i processi della mente poetica e la natura della 'originalità' di uno scritto.²⁹

Il suo legame con Dickens non è dunque di tipo storico diretto, ma concettuale: entrambi partecipano a un medesimo orizzonte culturale in cui la meccanicità non è vista come opposta alla creatività, bensì come una sua possibile condizione. In forma analogica, ciò che Lovelace teorizza sul piano matematico e computazionale trova un corrispettivo nelle strategie narrative di Dickens, in particolare negli usi romanzeschi della mimesi tecnologica. Per diventare creative, le macchine non devono necessariamente somigliare agli esseri umani; piuttosto, sono gli esseri umani a poter riconoscere le capacità creative insite nella meccanicità [18, 143-168].

I personaggi di Dickens, più che affidarsi all'imprevedibilità, si inscrivono in un più ampio immaginario culturale che esplora come i processi meccanici possano amplificare la novità invece di soffocarla [55, 144-164]. In questo quadro, la visione di Lovelace - secondo cui il potere della macchina di «distribuire e combinare le verità e le formule dell'analisi» può diventare fonte di creatività - trova un parallelo nella narrativa dickensiana, dove la combinazione e riorganizzazione di elementi dati viene utilizzata per gettare vecchie idee in 'nuove luci' [32, 722]. Se combinata con l'intuizione umana, la computazione diventa dunque un motore creativo.

In modo analogico, le riflessioni di Dickens e Lovelace possono dunque essere accostate come due declinazioni - narrativa e matematica - di una medesima immaginazione scientifica.

²⁸ Note segnate da Ada un martedì prima di un incontro con Babbage [52, 94].

²⁹ «For, in so distributing and combining the truths and the formulae of analysis, that they may become most easily and rapidly amenable to the mechanical combinations of the engine, the relations and the nature of many subjects in that science are necessarily thrown into new lights, and more profoundly investigated» [32, 694].

5.1 Dickens e Lovelace tra mesmerismo e scienze della mente

Dickens e Lovelace si muovono anche all'interno di un medesimo orizzonte culturale che intreccia scienza, immaginazione e teorie della mente.

Negli anni Trenta e Quaranta dell'Ottocento, in Inghilterra si era diffusa la pratica del mesmerismo, secondo cui si potevano ottenere cure mediche miracolose manipolando i flussi invisibili di 'magnetismo animale' che passavano attraverso e tra i corpi: si faceva cadere in trance il soggetto, permettendo il passaggio dell'energia nel corpo del paziente, come se si andassero a ricaricare le sue energie. Questo fenomeno, teorizzato per la prima volta da Franz Anton Mesmer nella Parigi pre-rivoluzionaria, era diventato un trattamento medico popolare poiché, durante la fase di trance, il paziente acquisiva spettacolari poteri soprannaturali, quali visioni del futuro o sensi acuti [35]. Nel gennaio del 1838, Dickens si era trovato ad assistere a una dimostrazione dei potenti poteri curativi del magnetismo animale condotta da John Elliotson, con cui era rimasto in contatto anche dopo il suo allontanamento dall'università nella quale aveva esercitato la professione di medico.³⁰ Lo scrittore inglese aveva anche iniziato a praticare il mesmerismo con evidente entusiasmo, soprattutto nel lungo periodo in cui aveva visitato l'Italia, ovvero tra il 1844 e il 1845, come si desume dalle lettere e dalle memorie di questi anni³¹. Secondo Fred Kaplan, il mesmerismo esercitò su di lui un'influenza tale da fornirgli non solo un fondamento logico per il funzionamento della personalità e della mente dei suoi personaggi, ma anche un linguaggio e un immaginario da usare nella creazione narrativa [26, 112-113]. Come sostiene anche Adelene Buckland, il mesmerismo diventò una potente pratica scientifica vittoriana, che divenne centrale nel pensiero di Dickens e della sua posizione retorica [4, 445-446].

Proprio in questi anni, anche Ada Lovelace si era ritrovata ad approfondire una materia scientifica, la frenologia, che sosteneva che il cervello era composto da diversi organi, ognuno dei quali controllava differenti aspetti del carattere umano, e riteneva che la sua struttura influenzasse il comportamento. La frenologia fu presa molto sul serio dalla comunità scientifica all'inizio dell'Ottocento, anche se da allora la scienza ha dimostrato che non aveva alcun fondamento di verità. L'esplorazione dettagliata dei meccanismi dell'*Analytical Engine* potrebbe aver ispirato anche il desiderio della contessa di risolvere il mistero delle connessioni corpo-cervello: il mesmerismo, del quale si interessò approfonditamente, insieme alla frenologia, si sarebbe rivelato un tema che ben sposava queste sue curiosità, quindi maturo per ulteriori approfondimenti.³² La sua vita diventò essa stessa un esperimento: cominciò a dilettersi con queste pratiche esoteriche e suggerì un modo per collegare il potere delle emozioni con il flusso delle forze elettromagnetiche

³⁰ John Elliotson fu il fondatore dello *University College Hospital* e professore di medicina pratica. Fermo sostenitore del mesmerismo per il trattamento medico (sebbene fosse un celebre medico che, tra le altre cose, aveva promosso in Gran Bretagna l'uso dello stetoscopio), la sua fama fu per sempre oscurata dalle sue pratiche, per le quali venne licenziato dall'università e relegato ai margini della comunità scientifica [6, 1].

³¹ Si veda particolarmente in [50, 247-255].

³² Il primo riferimento a questa pratica appare in una lettera di Ada al marito, Lord Lovelace [52, 102-103].

[56, 276-277]. E anche qui, utilizzando queste conoscenze, sfruttando il suo lavoro sulla programmazione del Macchina, volle imbattersi in un modello teorico che univa la matematica con i sentimenti per «lasciare alle generazioni future un Calcolo del Sistema Nervoso».³³

Nelle loro similitudini concettuali, Dickens e Lovelace rielaborano anche, in forme diverse, il linguaggio del mesmerismo e delle scienze della mente per pensare il rapporto tra corpo, emozioni e intelletto: pur operando in ambiti diversi, sono entrambi influenzati dal linguaggio e dalle metafore delle scienze del loro tempo arrivando a formalizzare modelli affini della mente e della personalità.

6. Conclusioni

Anche i lettori più attenti farebbero fatica a trovare nell'immenso corpus letterario di Dickens qualche commento sulla scienza. Probabilmente, si è spesso tratti in inganno dal primo celebre articolo del 1872 di George Henry Lewes, *Dickens in Relation to Criticism*, in cui Dickens appare «completamente estraneo alla filosofia, alla scienza e alla letteratura superiore, un uomo troppo indifferente per fingere di provare interesse per esse» [30, 151-152]. Questa affermazione ha senza dubbio ostacolato l'indagine sui rapporti di Dickens con la scienza, inducendo a concludere che avesse poco o nessun interesse per l'argomento. Tuttavia, nella puntuale disamina che ci propone Jude Nixon, viene fuori una realtà diversa nella quale emerge l'attenzione dello scrittore inglese verso questi temi, soprattutto nelle riviste da lui curate, *Household Words* e *All the Year Round*, che affrontano regolarmente argomenti come la botanica, la chimica, la fisica della luce, l'etere, la fotografia, l'esplorazione [42]. Pur essendo generalmente entusiasta del cambiamento, celebrativo della tecnologia emergente e curioso degli sviluppi scientifici, Dickens rimane comunque cauto, mostrandosi attento a quelle che considera conseguenze sociali e ambientali delle rivoluzioni scientifiche e industriali del Diciannovesimo secolo.³⁴

Le sue idee sul modo in cui emergono i nuovi campi della scienza le esprime principalmente in *History of a young ology*, pubblicato nel 1861, nel quale usa il termine *ology* riferendosi al suffisso da aggiunge ad alcuni lemmi per indicare la disciplina scientifica corrispondente. La sua osservazione è che nei primi anni di vita di una 'ologia' ci può essere un'ampia moltitudine di risultati che potrebbero rivelarsi invece non eccessivamente accurati e neppure interessanti.³⁵ Tuttavia, se se ne spiegassero e

³³ Lovelace chiese invano la collaborazione di parecchi scienziati, tra cui il grande pioniere dell'elettromagnetismo Michael Faraday che rifiutò a causa della sua malattia. Nel 1844, rafforzò queste sue convinzioni scrivendo una recensione di un articolo del Barone Karl von Reichenbach, *Research on Magnetism*, che non venne neppure pubblicata [48, 142; 315-317].

³⁴ Si fa riferimento, ad esempio, alla protesta condotta contro l'inquinamento atmosferico e alla cattiva salute dei fiumi inglesi. Nella rivista *Household Words*, Dickens promosse addirittura una campagna sulle condizioni igieniche di Londra con l'articolo *Un modo per pulire i fiumi* del 1858 [41].

³⁵ «Deve essere sempre difficile decidere in quale punto preciso del progresso della conoscenza un particolare ramo della scienza diventa sufficientemente importante e indipendente da richiedere di essere

divulgassero gli aspetti utilitaristici al pubblico e agli altri scienziati, progredirebbe più velocemente anche a livello tecnico. L'obiettivo più profondo e ambizioso dello scrittore inglese diventa pertanto quello di informare il pubblico utilizzando metodi che si rivelino i più efficaci possibile, in modo da consentire a coloro che si interessano di scienza di esplorare in autonomia le implicazioni di alcune idee scientifiche.³⁶ Dickens propone dunque queste idee e divulga la scienza intrecciandola con le più recenti osservazioni e teorie nelle trame dei suoi romanzi (lo abbiamo descritto ampiamente per *A Tale of Two Cities*) che solo apparentemente appaiono 'non scientifici'.³⁷

«La nostra riluttanza a pensare a Dickens in relazione alle straordinarie attività della scienza che si svolgevano durante la sua vita è sbagliata», ricorda George Levine, perché Dickens in realtà mantenne un rapporto caloroso sia con la scienza che gli scienziati [29, 253; 256]. Del resto, dato il modo in cui il pensiero scientifico pervade l'Ottocento e vista la sua ampia cerchia sociale e intellettuale, Dickens non avrebbe potuto evitare l'argomento. La sua biblioteca personale comprendeva un'ampia selezione di libri scientifici, tra cui le opere del paleontologo Louis Agassiz, con cui ebbe un'amicizia personale, diversi libri sulle esplorazioni artiche, il *Bridgewater Treatise* di William Whewell del 1852, l'*Origine delle specie* di Charles Darwin del 1859 e *Antiquity of Man* di Charles Lyell del 1863, solo per citarne alcuni [49, 26]. Come ha osservato Fielding, solamente guardando al patrimonio librario di Dickens ci si rende conto della sua curiosità scientifica: possedeva tutti i sedici volumi della *Natural History* di Georges Louis Buffon, l'*Animal Kingdom* di Georges Cuvier, l'*Outlines of Astronomy* di John Herschel, era insomma «un lettore attivo, la cui mente era influenzata dalla scrittura scientifica» [17, 204-206].

Nella biblioteca della sua casa di campagna di Gad's Hill Place nel Kent, è stata ritrovata una copia dell'articolo *Sketch of the Analytical Engine invented by Charles Babbage... with notes by the translator*, rilegata, probabilmente per custodirla accuratamente, in un volume con altri diciotto opuscoli inerenti questioni di suo interesse, dalla riforma penale al benessere dei bambini. Si tratta di una rara ristampa della traduzione di Ada Lovelace dell'articolo di Luigi Federico Menabrea sulla *Analytical Engine* di Charles Babbage. Quando fu pubblicato in *Scientific Memoirs* nel 1843, l'editore ne aveva consegnato a Lovelace una manciata di copie (in forma di pamphlet), una delle quali venne data in dono a Dickens.³⁸

In questo suo scritto, Lovelace aveva sostenuto che la debolezza della *Analytical Engine* consisteva proprio nell'impossibilità di «*originate anything*», di non avere originalità e creatività [32, 772 (corsivo nella fonte citata)]. L'uso del termine *originate* fa parte di una più ampia discussione culturale vittoriana sull'originalità, di cui si è

considerato come una nuova scienza, sotto un nuovo nome, e da meritare il riconoscimento come centro indipendente di indagine umana. attorno al quale raggruppare i fatti e da cui trarre le conclusioni» [10].

³⁶ Come sostiene Adelene Buckland, che fa una disamina accurata degli assertori e degli antagonisti di 'Dickens scienziato', lo scrittore inglese possedeva una pronta comprensione dei modi in cui la scienza poteva creare nuovi miti e rispondeva intuitivamente ai grandi sviluppi del suo tempo [4].

³⁷ Per una approfondita analisi dei temi scientifici trattati nei romanzi di Dickens, si vedano [25], [40, 161].

³⁸ Questo volume è stato recentemente messo in vendita in un'asta organizzata da Christie's.

precedentemente accennato, che all'indomani della Rivoluzione industriale, assume nuovi significati.

Si è dunque in questo scritto dimostrato come Lovelace elabori una concezione della macchina che esclude una creatività autonoma, ma ne valorizza il potenziale quando essa viene combinata con l'intelligenza umana, dando luogo a una forma distinta di originalità. Questa posizione si inserisce in un più ampio contesto vittoriano, in cui il rapporto tra meccanicità, calcolo e immaginazione è al centro di un dibattito diffuso, che coinvolge non solo la riflessione scientifica ma anche quella letteraria.³⁹ Emerge pertanto con chiarezza come la macchina costituisca un termine di confronto cruciale anche per il realismo, spesso utilizzato per interrogare i limiti e le possibilità della creatività umana.

In questa prospettiva, le riflessioni di Lovelace sulla creatività, lo abbiamo dimostrato, possono essere lette in parallelo con le strategie narrative di Dickens, che sembrano esplorare, sul piano letterario, la stessa possibilità che la meccanicità non soffochi l'originalità, ma anzi la amplifichi [3, 469]. Più che un'influenza, si è riconosciuta una convergenza: la narrativa dickensiana può essere interpretata come una sorta di traduzione immaginativa di un modello di creatività fondato sulla combinazione, la riorganizzazione e l'interazione tra elementi dati e intervento umano.

In *A Tale of Two Cities*, ad esempio, il banchiere Jarvis Lorry dichiara di separare i suoi sentimenti affettuosi per i Manette dalla sua funzione lavorativa quando dice a Lucie Manette di considerarlo «né più né meno che una macchina parlante» [11, 20-21]. Anche la rappresentazione di Toodle, l'impiegato delle ferrovie in *Dombey and Son*, tanto caro a Lovelace, illustra bene il collegamento che Dickens definisce tra la psiche umana e la meccanica. L'affermazione di Toodle: «What a Junction a man's thoughts is» [7, 198], si rifà proprio alla metafora della ferrovia per la rappresentazione dei percorsi mentali. Tuttavia, come sostiene Jill Matus, l'immaginazione tecnologica di Dickens per questo riferimento della mente di Toodle non è solo un'analogia ai macchinari della sua epoca, ma potrebbe essere un riferimento ai dispositivi progettati da Babbage, che Dickens conosceva bene [37, 422]. Il cervello di Toodle appare come una ferrovia con i pensieri che si muovono lungo una serie di percorsi; la sua mente si trasforma in una macchina di Babbage e, come le ruote dentate degli assi della *Difference Engine* trasportano numeri da una serie di assi all'altra, Toodle osserva: «Arrivo a un ramo: assumo ciò che trovo lì; e un intero treno di idee gli si aggancia».⁴⁰

Anche quando è diventato autore celebre e prolifico, editore energico e attivista politico e sociale, Charles Dickens è rimasto sempre consapevole dell'importanza della scienza e della tecnologia, anzi, ne ha tratto ispirazione, impegnandosi persino a promuoverle e spiegarle. La possibilità di scriverne sulle sue riviste ha rappresentato per lo scrittore inglese un mezzo per poter manifestare il suo profondo orgoglio per le cosiddette 'scienze dure'.

³⁹ Per quel che riguarda la figura di Lovelace legata alla letteratura vittoriana, si veda [5, 105-123].

⁴⁰ «I comes to a branch; I takes on what I finds there, and a whole train of ideas gets coupled on to him [...]» [37, 198].

Dal 1854, l'immaginazione di Dickens aveva assorbito a tal punto 'la meccanizzazione dell'Inghilterra' da permettergli di scrivere opere interamente ambientate in un mondo industrializzato. Il paesaggio meccanizzato non è più un'escrescenza sulla superficie dell'Inghilterra; diventa lo scenario della vita quotidiana e il mondo pastorale un luogo di rifugio temporaneo. Possiamo dunque concordare con Herbert Sussman e affermare che i resoconti di Dickens sulla tecnologia nei suoi scritti occasionali sono pezzi pieni di orgoglio e meraviglia perché, nella sua consapevolezza di giornalista, Dickens considerava la macchina come oggetto in sé, con le sue grandi potenzialità, non solo come parte del suo ambiente sociale e morale [51, 46-48].

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From Rota to the Logic of Partitions and the Notion of Logical Entropy

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Abstract

This paper traces an intellectual journey that starts with some unfinished work of Gian-Carlo Rota on making a logic of equivalence relations or partitions. Rota understood the category-theoretic duality between subsets and partitions which implied there should be a logic of partitions dual to the usual Boolean logic of subsets. Rota also conjectured that subsets are to probability as partitions are to information. And just as probability starts quantitatively with the size of a subset, so he saw that information should start with some notion of size of a partition. In the duality between subsets and partitions, the elements of a subset are dual to the distinctions (or dits) of a partition, i.e., the ordered pairs of elements in different blocks of the partition. Since logical probability starts with the normalized number of elements in a subset, the corresponding logical notion of information is the normalized number of distinctions in a partition so that is the definition of *logical entropy*. Finally, logical entropy is contrasted with the usual Shannon notion of entropy.

Keywords: Gian-Carlo Rota, logic of subsets, dual logic of partitions, logical probability, dual notion of logical entropy.¹

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1 Introduction

This paper is a result of my collaboration with Gian-Carlo Rota in the mid-80s. Rota died suddenly at the young age of 66 in 1999. Those who had worked with him picked up unfinished threads of his work to see if we could develop them further. My choice, which turned out to be more fruitful than I could imagine, was his joint paper with two young colleagues on the logic of a certain type of equivalence relations Finberg et al. [1996]. An *equivalence relation* on a universe set $U = \{u_1, \dots, u_n\}$ is a reflexive, symmetric, and transitive binary relation on the set. Each point in the set has an equivalence class of other points equivalent to it and the equivalence classes form a partition on the set, i.e., a set of non-empty subsets (“blocks”) of U that are disjoint and cover all of U . Thus the notions of a partition and an equivalence relation are essentially the same mathematical concept (Rota would say “cryptomorphic”) viewed from different viewpoints. The viewpoint taken here will focus on the notion of partitions. In spite of the label “logic”, that paper used only the lattice operations of join and meet and didn’t have an operation of implication on partitions. The lattices of partitions are so varied that the only formulas true in all partition lattices are general lattice identities Whitman [1946] which is why the Rota paper focused on a specific type (“commuting”) of equivalence relation.

Hence the first step of extending Rota’s work on this thread had two challenges: to develop the operation of implication for partitions and to develop the general logic of arbitrary partitions on a universe set. This step led to developing Rota’s conjecture that subsets are to probability as partitions are to information. Since probability starts with the quantitative version of subsets, the quantitative version of partitions would define a logical notion of information, logical entropy—which can then be compared and contrasted with the usual Shannon notion of entropy.

2 The logic of partitions

2.1 The subset-partition duality

“Logic” is usually taken to be the Boolean logic of subsets, usually presented only in the special case of propositional logic, and its sublogics and extensions. Rota knew that it was important to focus on general subsets, rather than just subsets of 1 (1 and $\emptyset$ representing truth and falsehood of propositions) since subsets and partitions are dual concepts in category theory. Given a set function $f : X \rightarrow Y$, its *image* $f(X)$ is a subset of Y and its dual *coimage* (inverse image) is a partition $f^{-1} = \{f^{-1}(y)\}_{y \in f(X)}$ on X . By paying attention to this

duality, the logic of partitions can be developed in parallel to the usual Boolean logic of subsets.

2.2 The Boolean lattice and algebra of subsets

The powerset $\wp(U)$ is a Boolean lattice with the join as set union, the meet as set intersection, and the partial order as set inclusion. The lattice has a top (maximal element) U and a bottom (minimal element) $\emptyset$. The Boolean lattice become a Boolean algebra by the addition of the implication or conditional operation: for $S, T \in \wp(U)$, $S \supset T := S^c \cup T$ (where $S^c = U - S$ is the complement of S). The key relationship of the set implication is that when it equals the top, then the partial order of inclusion holds:

$$S \supset T = U \text{ iff (if and only if) } S \subseteq T.$$

2.3 The lattice and algebra of partitions

A *partition* π on a set $U = \{u_1, \dots, u_n\}$ is a set $\pi = \{B_1, \dots, B_m\}$ of non-empty subsets of U called *blocks* that are disjoint and their union is all of U (for our expository purposes, we stick to finite universe sets). A *distinction* or *dit* of π is an ordered pair of elements of U that are in different blocks of π , and the set of all distinctions of π is the ditset $\text{dit}(\pi) \subseteq U \times U$. An *indistinction* or *indit* is an ordered pair of elements of U in the same block of π , and the set of all indistinctions of π is the indit set $\text{indit}(\pi) \subseteq U \times U$. The ditset and indit set are complementary subsets of $U \times U$, i.e., $\text{dit}(\pi)^c = \text{indit}(\pi)$. The indit set $\text{indit}(\pi)$ is the equivalence relation version of the partition π . The binary relations that are the ditsets of a partition might be called *partition relations* but they are also known as *apartness relations*.

Given another partition $\sigma = \{C_1, \dots, C_{m'}\}$, the partition *join* $\pi \vee \sigma$ is the partition whose blocks are all the non-empty intersections $B_j \cap C_{j'}$. The ditset of the join is just the union of the ditsets, $\text{dit}(\pi \vee \sigma) = \text{dit}(\pi) \cup \text{dit}(\sigma)$. By DeMorgan's law, the indit set of the join is the intersection of their equivalence relations, $\text{indit}(\pi \vee \sigma) = \text{indit}(\pi) \cap \text{indit}(\sigma)$ which tells us that the intersection of two equivalence relations is always an equivalence relation. Hence given any subset of $U \times U$, there is always a smallest equivalence relation containing that subset. Taking the subset to be $\text{indit}(\pi) \cup \text{indit}(\sigma)$, the smallest equivalence relation containing it is defined as: $\text{indit}(\pi \wedge \sigma)$, the indit set of the partition *meet* $\pi \wedge \sigma$. The partial order (PO) that turns the set of partitions $\Pi(U)$ on U into a lattice is *refinement*: $\sigma \preceq \pi$ (read π refines σ or σ is refined by π) if for every $B_j \in \pi$, there is a block $C_{j'}$ such that $B_j \subseteq C_{j'}$. Intuitively, π refines σ means that π could be obtained from σ by chopping up some blocks of σ . The refinement

PO is the parallel to the inclusion partial order of the Boolean lattice, and, in fact, refinement is equivalent to the inclusion of ditsets:

$$\sigma \preceq \pi \text{ iff } \text{dit}(\sigma) \subseteq \text{dit}(\pi)$$

This plants the hint that distinctions of a partition are parallel or dual to the elements of a subset.

The top of the lattice of partitions $\Pi(U)$ on U is the *discrete partition* $\mathbf{1}_U = \{\{u_i\}\}_{u_i \in U}$ where all the blocks are singletons, and the bottom is the indiscrete partition $\mathbf{0}_U = \{U\}$ whose only block is all of U . For $U = \{a, b, c\}$, the two dual lattices, the Boolean lattice of subset and the lattice of partitions, are illustrated in Figure 1.

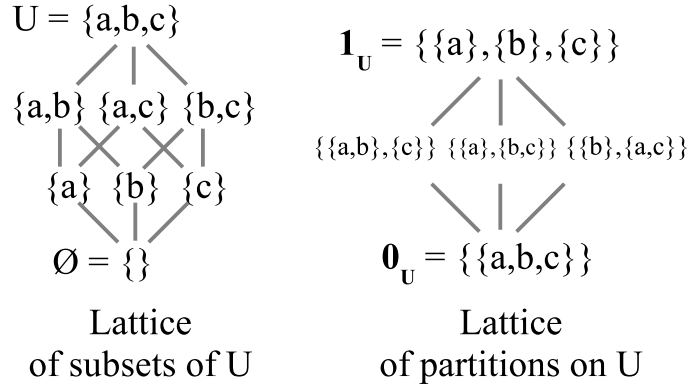


Figure 1: The two dual lattices on $U = \{a, b, c\}$

The lattice of partitions $\Pi(U)$ was known in the 19th century (e.g., Richard Dedekind and Ernst Schröder). But no new operations on partitions, e.g., the implication operation, were defined in the 20th century. In a 2001 paper commemorating Gian-Carlo Rota, the three authors first note the fundamentality of partitions and then acknowledge the sole operations of join and meet.

Equivalence relations are so ubiquitous in everyday life that we often forget about their proactive existence. Much is still unknown about equivalence relations. Were this situation remedied, the theory of equivalence relations could initiate a chain reaction generating new insights and discoveries in many fields dependent upon it.

This paper springs from a simple acknowledgment: the only operations on the family of equivalence relations fully studied, understood and deployed are the binary join $\vee$ and meet $\wedge$ operations.[Britz et al., 2001, p, 445]

The implication $\sigma \Rightarrow \pi$ operation on partitions can be motivated by requiring that it satisfy the corresponding requirement as in the Boolean algebra, i.e., the implication equals the top iff the partial order holds, i.e., $\sigma \Rightarrow \pi = 1_U$ iff $\sigma \lesssim \pi$. The refinement $\sigma \lesssim \pi$ means that for every block $B_j \in \pi$, there is a block of σ which contains it. This property of π -blocks can be characterized by a characteristic function. That is, the implication $\sigma \Rightarrow \pi$ can be defined simply like a characteristic or indicator function for that inclusion-property of the π -blocks. Thus if B_j is contained in some $C_{j'} \in \sigma$, then B_j is replaced by blocks of its discrete version, i.e., 1_{B_j} , the discrete partition on B_j , and if not, then B_j remains whole as B_j , the block of its indiscrete version 0_{B_j} , the indiscrete partition on B_j . Thus $\sigma \Rightarrow \pi$ is motivated by seeing it as the characteristic function taking 1, 0 values according to whether a block $B_j \in \pi$ is or is not contained in a block of σ . This is how the *partition implication* $\sigma \Rightarrow \pi$ is defined and it automatically satisfies the parallel to $S \supset T = U$ iff $S \subseteq T$:

$$\sigma \Rightarrow \pi = 1_U \text{ iff } \sigma \lesssim \pi.$$

The addition of the partition implication operation turns the partition lattice into the *partition algebra* $\Pi(U)$ on U . In this manner, the logic of partitions can be developed that is parallel or dual to the Boolean logic of subsets (Ellerman [2010], Ellerman [2014], Ellerman [2023]).

3 Quantitative versions of subset logic and partition logic

The next step in developing Rota's program is to define the quantitative version of the two logics. Rota was well-aware of the category-theoretic duality between subsets and partitions and he used it to make the key analogy: "The lattice of partitions plays for information the role that the Boolean algebra of subsets plays for size or probability." [Kung et al., 2009, p. 30] Rota also attributed the idea to Alfred Rényi [Rota, 2001, p. 65]. This could be symbolized as:

$$\frac{\text{Subsets}}{\text{Probability}} \approx \frac{\text{Partitions}}{\text{Information}}.$$

Probability 'starts' with the probability of a subset S of the set of outcomes U as the (normalized) size of the subset $\Pr(S) = \frac{|S|}{|U|}$. Rota reasoned that since "Probability is a measure on the Boolean algebra of events" that gives quantitatively the "intuitive idea of the size of a set," we may ask by "analogy" for some measure "which will capture some property that will turn out to be for [partitions] what size is to a set." [Rota, 2001, p. 67] Since the size of a subset is the number of

elements, we already have a hint that the dual notion to an element of a subset is a distinction of a partition. Table 1 shows that elements and distinctions are indeed parallel or dual notions.

Lattice of subsets $\wp(U)$	Lattice of partitions $\Pi(U)$
Its = Elements of subsets	Dits = Distinctions of partitions
PO Inclusion of subsets $S \subseteq T$	PO $\sigma \preceq \pi$ iff $\text{dit}(\sigma) \subseteq \text{dit}(\pi)$
Join: $S \vee T = S \cup T$	Join: $\text{dit}(\sigma \vee \pi) = \text{dit}(\sigma) \cup \text{dit}(\pi)$
Top: U all elements	Top: $\text{dit}(\mathbf{1}_U)$ with all possible dits
Bottom: $\emptyset$ no elements	Bottom: $\text{dit}(\mathbf{0}_U) = \emptyset$ with no dits

Table 1: Duality of “subset elements” and “partition distinctions”:

$$\frac{\text{Elements}}{\text{Subsets}} \approx \frac{\text{Distinctions}}{\text{Partitions}}$$

Since no element in U can be distinct from itself, i.e., cannot be in two different blocks of a partition, the only indits of $\mathbf{1}_U$ are the self-pairs (u_i, u_i) , i.e., $\text{indit}(\mathbf{1}_U) = \Delta = \{(u_i, u_i) \mid u_i \in U\}$, i.e., the diagonal, so $\text{dit}(\mathbf{1}_U) = U \times U - \Delta$ is all possible dits. And since all the elements of U are in the one block of $\mathbf{0}_U$, it has no distinctions.

Rota’s suggestion to measure information by the “size” of a partition was correct, but he tried to shoehorn the Shannon entropy into that role [Rota, 2001, p. 68] rather than see the duality between elements of a subset and distinctions of a partition illustrated in Table 1. Hence Rota’s suggestion can be implemented by taking the measure of information in a partition as the (normalized) number of distinctions in the partition so that is the beginning (equiprobable points in U) definition of *logical entropy*:

$$h(\pi) = \frac{|\text{dit}(\pi)|}{|U \times U|} = \frac{|U \times U| - |\text{indit}(\pi)|}{|U \times U|} = 1 - \frac{|\cup_j B_j \times B_j|}{|U \times U|} = 1 - \sum_j \left(\frac{|B_j|}{|U|} \right)^2.$$

With the points of U having probabilities $p = (p_1, \dots, p_n)$, then $\Pr(B_j) = \sum_{u_i \in B_j} p_i$, and:

$$h(\pi) = 1 - \sum_{j=1}^m \Pr(B_j)^2 = \sum_{j \neq k} \Pr(B_j) \Pr(B_k)$$

where the last equation holds since: $1 = \left(\sum_{j=1}^m \Pr(B_j) \right)^2$. Since the probability distribution p defines the product probability measure $p \times p$ on $U \times U$, we also have:

$$h(\pi) = p \times p(\text{dit}(\pi)).$$

This shows the interpretation of the logical entropy $h(\pi)$ is the probability that in two independent draws from U that one gets a distinction of π .

Since the logical entropy is the value of a (probability) measure, the compound notions of logical entropy are defined by the usual Venn diagram:

- *Joint logical entropy*: $h(\pi \vee \sigma) = p \times p(\text{dit}(\pi) \cup \text{dit}(\sigma))$,
- *Difference logical entropy*: $h(\pi|\sigma) = p \times p(\text{dit}(\pi) - \text{dit}(\sigma))$, and
- *Mutual logical entropy*: $m(\pi, \sigma) = p \times p(\text{dit}(\pi) \cap \text{dit}(\sigma))$,

as illustrated in Figure 2.

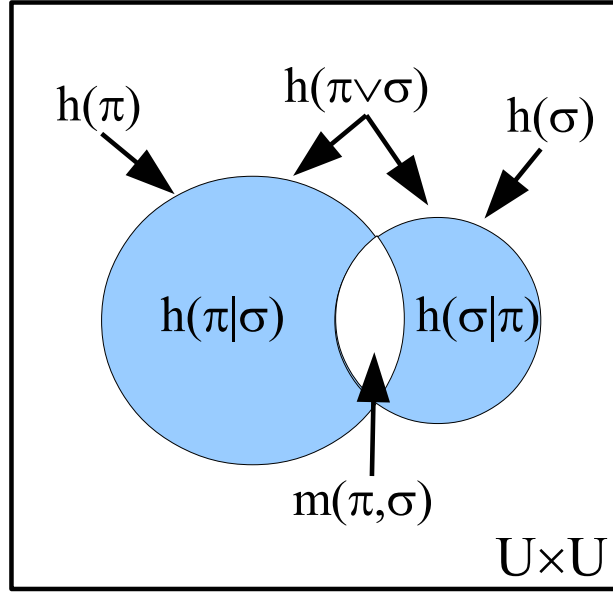


Figure 2: Compound logical entropies as values of subsets of a probability measure on $U \times U$

The logical entropy $h(\mathbf{1}_u)$ could also be taken as just the logical entropy of the probability distribution p :

$$h(p) = 1 - \sum_{i=1}^n p_i^2 = \sum_{j \neq k} p_j p_k$$

where the last equation holds since $1 = (\sum_{i=1}^n p_i)^2 = \sum_{i=1}^n p_i^2 + \sum_{j \neq k} p_j p_k$.

The logical entropy of a probability distribution can be illustrated in Figure 3 with a box diagram.

For this distribution, the logical entropy is: $h(p) = 1 - \sum p_i^2 = 1 - (\frac{1}{4} + \frac{1}{16} + \frac{1}{16}) = 1 - \frac{6}{16} = \frac{5}{8}$ with $\frac{5}{16}$ area on each side of the diagonal squares. The derivation of the logical entropy formula as the quantitative version of partitions is new, but the formula goes back to Corrado Gini's index of mutability suggested in 1912 Gini [1912]. Given a probability distribution p on the points of U and a distance function d_{jk} between points u_j and u_k that is non-negative and has

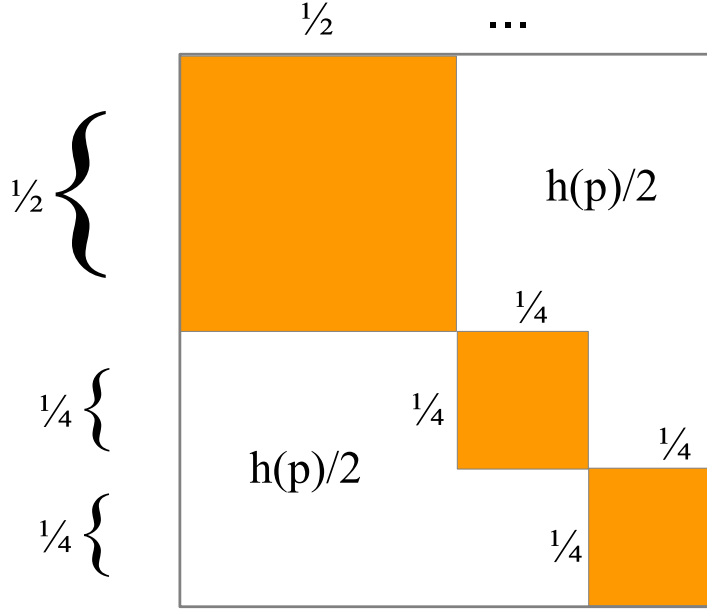


Figure 3: Logical entropy box diagram for $p = (\frac{1}{2}, \frac{1}{4}, \frac{1}{4})$

$d_{ii} = 0$, C. R. Rao defined the *quadratic entropy* as $\sum_{j,k} p_j p_k d_{jk}$ Rao [2010]. There is a *logical distance function*, $1 - \delta_{jk}$, the 1-complement of the Kronecker delta function, which just represent identity (distance 0) and difference (distance 1). The quadratic entropy of the logical distance function is the logical entropy: $h(p) = \sum_{j,k=1}^n p_j p_k (1 - \delta_{jk})$.

To summarize, the duality between subsets and partitions in their quantitative versions gives a duality between probability theory and information theory illustrated in Table 2.

	Logical Probability Theory	Logical Information Theory
Outcomes	Elements of S	Distinctions of π
Events	Subsets $S \subseteq U$	Ditsets $\text{dit}(\pi) \subseteq U \times U$
$p_i = \frac{1}{n}$	$\Pr(S) = \frac{ S }{ U }$	$h(\pi) = \frac{ \text{dit}(\pi) }{ U \times U }$
Probs. p	$\Pr(S) = \sum_{u_i \in S} p_i$	$h(\pi) = \sum_{(u_i, u_k) \in \text{dit}(\pi)} p_i p_k$
Interpretation	1-draw probability of a S -element	2-draw probability of a π -distinction

Table 2: Duality of quantitative subsets and partitions

4 Logical Entropy compared to Shannon Entropy

4.1 Comparison using ‘surprise’ factors

Intuitively, if $p_i = 1$, then there is no information in the occurrence of u_i , so information is measured by the 1-complement, the ‘surprise’ factor. But there are two 1-complements, the additive 1-complement of $1 - p_i$ and the multiplicative 1-complement of $1/p_i$.

The additive average of the additive 1-complements is the logical entropy:

$$h(p) = \sum_i p_i(1 - p_i).$$

The multiplicative average of the multiplicative 1-complements is the anti-log of the Shannon entropy:

$$\prod_i \left(\frac{1}{p_i}\right)^{p_i} = \log^{-1}(H(p))$$

so the Shannon entropy is:

$$H(p) = \log\left(\prod_i \left(\frac{1}{p_i}\right)^{p_i}\right) = \sum_i p_i \log\left(\frac{1}{p_i}\right).$$

Then the log is chosen appropriate to the subject matter, e.g., log to the base 2 for coding theory or natural logs for statistical mechanics.

4.2 Negative Shannon Mutual Information

It is long been held that there is no such thing as “negative information” (at least up to the Trump Era). There is the basic Shannon definition of “entropy” and then there are the compound notions of joint entropy, conditional entropy, and mutual information where the compound notions are all carefully defined so they stand in the usual Venn diagram relationships [Cover and Thomas, 2006, p. 22].

Shannon then showed that if the probability distributions for the random variables X and Y were independent, then the mutual information $I(X; Y)$ was zero. That made a lot of sense, no information in common between independent random variables, and that was a significant “selling point” for that notion of entropy.

For a joint probability distribution $\Pr(X, Y)$, the random variables X and Y are independent if the joint probability is equal to the product of the marginals, i.e., $\Pr(X, Y) = \Pr(X) \Pr(Y)$.

In the case of logical entropy (represented by the lower-case h), there are natural Venn diagrams since it is a probability measure.

In that case, when X and Y are independent, then the logical entropy just mimics the definition using probabilities, $m(X, Y) = h(X)h(Y)$.

All the compound notions of Shannon entropy with one or two random variables are non-negative. But when the Shannon definitions were extended to three or more random variables, then the Shannon mutual information for three variables can be negative. This occurs in the standard examples in most any probability theory texts which notes the independence for three or more random variable is not the same as pairwise independence.

Consider flipping two fair coins with the random variables are $X = 1$ for heads and 0 for tails for the first coin and similarly for Y and the second coin. Then take $Z = 0$ if $X + Y$ is odd and 1 if even. Those three random variables are pairwise independent but mutually dependent, i.e., the values of any two of the variables determines the value of the third variable. In the Venn diagram, the pairwise overlaps have to be zero but the three-way overlap $I(X; Y; Z)$ has to be non-zero, i.e., negative, as in the following Venn diagram.

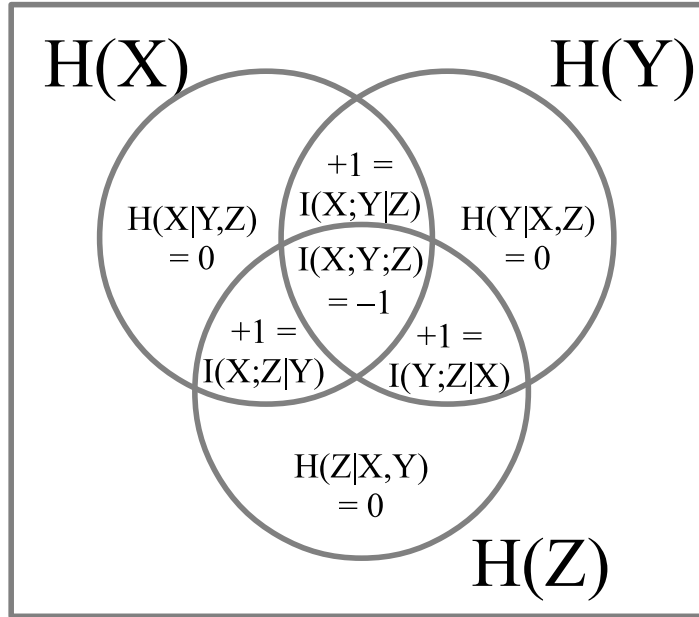


Figure 4: Example of negative Shannon mutual information

The response of Shannon information theorists to this rather anomalous result is interesting to illustrate how Shannon's reputation seems to bias independent judgment of the theory. Shannon himself just avoided the problem by never defining mutual information for more than two random variables. In the most authoritative book on Shannon information theory Cover and Thomas [2006], the other compound Shannon notions are extended to n -variables, but the anomaly for mutual information is only mentioned in a problem (2.25) without any follow-up as if it was not a Problem.

2.25 There isn't really a notion of mutual information common to three random variables. Here is one attempt at a definition: Using Venn diagrams, we can see that the mutual information common to three random variables X , Y , and Z can be defined by

$$I(X; Y; Z) = I(X; Y) - I(X; Y|Z).$$

... Unfortunately, $I(X; Y; Z)$ is not necessarily nonnegative. [Cover and Thomas, 2006, p. 49]

In contrast, all the n -variable compound notions of logical entropy are non-negative. In fact, logical is a measure, indeed a probability measure.

It might also be noted that for certain countable probability distributions, the Shannon entropy is undefined in the sense of going to infinity [Cover and Thomas, 2006, Problem 2.19, p. 48], while the logical entropy for all countable probability distributions is always well-defined, i.e., finite.

4.3 Venn diagrams and Measures

Venn diagrams are creatures of measures in the sense of measure theory (e.g., Halmos [1974]). Shannon carefully defining his compound notions of (two variable) entropy to satisfy the usual Venn diagram relationships. Indeed, "Shannon carefully contrived for this 'accident' to occur" [Rozeboom, 1968, p. 153]. But in spite of Shannon entropy being routinely taken as "the measure" of information, it is actually not a measure in the sense of measure theory. Hence the Venn diagram relations are described as only a "mnemonic" for the relationship between the compound notions. e.g., Campbell [1965], which points out the desirable properties if it was a measure.

In contrast, logical entropy is a measure, even a probability measure, i.e., the logical entropy of a random variable is the probability in two independent samplings of getting different values.

If not a measure, how to account for the Shannon "Venn diagram" mnemonic? There is a nonlinear monotonic transformation, the "dit-bit transform," between the compound two variable logical entropies and the compound Shannon entropies, and that transformation preserves the simple Venn diagram relationships. Ellerman [2021].

4.4 MaxEntropy

Among all finite probability distributions, both Shannon and logical entropy have maximum values on the Laplacian equal distribution. But suppose there are

constraints on the allowed probability distributions so that the equiprobable distribution is not allowed. What then is the distribution closest to the equiprobable one? The maximization of Shannon entropy and logical entropy over the allowed distributions will in general give different results. Which is best?

That depends on how one defines the “closest distance to the equiprobable distribution.” If one uses the Kullback-Leibler distance, then the Shannon entropy maximum is the closest distribution by that notion of distance.

There is a whole ‘MaxEntropy school’ of information theorists, founded by Edwin Jaynes (1922-1998), with many books and annual conferences all using this notion of maximum (Shannon) entropy.

But one might pause at some point and ask if the K-L distance is really a good notion of distance. The K-L distance at least has the distance between a probability distribution and itself is zero, but otherwise it is not even symmetric. That is, the K-L distance from a distribution p to a distribution q is not necessarily as the distance from q to p ! And it is not even close to satisfying the triangle inequality.

There is the usual notion of Euclidean distance between probability distributions that is symmetric and satisfies the triangle inequality. Hence one might naturally ask: Is there is a notion of entropy so that maximizing that entropy also minimizes that notion of distance, e.g., the Euclidean distance of a probability distribution to the equiprobable distribution. Yes, it is the logical entropy.

4.5 Entropy in statistical mechanics

Consider a container whose space is divided up into m equally sized cells and the container contains n particles of gas. How can one describe the distribution of the particles between the cells that would characterize “equilibrium” within certain constraints. Ludwig Boltzmann (1844-1906) proposed a notion of entropy, Boltzmann entropy, whose maximum value, he hypothesized, would describe equilibrium. The formula for Boltzmann was a constant times the natural log of the multinomial coefficient. Thus, the formula involved the natural log of n -factorials, i.e., $\ln(n!)$, which is quite intractable for calculations. Hence one should work with numerical approximations, but which ones. There is an infinite series, the Stirling series, for $\ln(n!)$ so an approximation is obtained by taking only a finite number of terms. If one takes the two-term approximation, $\ln(n!) \approx n \ln(n) - n$, from the Stirling series, then the resulting formula obtained by Boltzmann and Josiah Willard Gibbs (1839–1903) is the formula now known as the Shannon entropy which is quite mathematically tractable. Of course, a better approximation would be obtained by considering more terms in the Stirling series but the resulting formulas are too intractable. And there are better approximations (unrelated to the Stirling series) than the two-term one, but the resulting

formulas are also not analytically tractable. It is that sequence of approximation and tractability choices that connects the Boltzmann entropy in statistical mechanics and the Shannon entropy, even though one often finds references to the “Boltzmann-Shannon entropy” as if they were the same notions.

The treatment of statistical mechanics based on logical entropy has not, to my knowledge, been developed. However, the equalizing nature of increasing logical entropy is immediate and trivial—without the sequence of approximation and tractability choices.

Consider a partition where the number of cells or blocks is fixed at m like the cells in a container. The logical entropy is the normalized number of distinctions in the partition where a distinction is an ordered pair of elements in different blocks or cells. Suppose one block has n_1 elements and another block has n_2 elements. Then the number of pairs of different-block elements contributed by those two blocks is just $n_1 n_2$ and the number of ordered pairs is twice that. Suppose the numbers are different with $n_1 < n_2$. If $n_2 = n_1 + 2$, then there are $(n_1 + 2) n_1 = n_1^2 + 2n_1$ pairs of elements in different blocks. Now suppose we make the equalizing move of one element from the larger block to the smaller block. Then there are $(n_1 + 1) (n_1 + 1) = n_1^2 + 2n_1 + 1$ pairs in different blocks so that increases logical entropy. That simple argument generalizes so that any movement of elements from the larger blocks to the smaller blocks (consistent with constraints if there are any) increases logical entropy. Hence the equilibrium configuration is the one that maximizes logical entropy (subject to any constraints).

4.6 Kolmogorov’s criticism

Given a partition on a universe set U , the ditset of the partition is subset of $U \times U$ consisting of all the ordered pairs of elements in different blocks called “distinctions.” The notion of a partition on U is equivalent to the notion of an equivalence relation on U where the blocks of the partition are the equivalence classes of the equivalence relation. The equivalence relation as the subset of $U \times U$ is just the set of ordered pairs of elements in the same blocks, i.e., the complement of the ditset. The beginning definition of logical entropy of a partition is just the size of its ditset normalized by the size of $U \times U$. No probabilities are involved. If there is a probability distribution p on U , then there is the product distribution $p \times p$ on $U \times U$, and then the logical entropy of the partition is just that product probability of the ditset, i.e., the probability of getting a distinction in two independent draws (i.e., with replacement) from U .

A measure in the sense of measure theory is a certain type of assignment of numbers to subsets of a universe set U , e.g., a counting measure giving the size of the subsets for a finite U . The Shannon entropy is not a measure in the sense

of assigning numbers to certain subsets of U . Instead, the Shannon entropy is defined directly in terms of the probabilities and that was the basis for criticism by Andrei Kolmogorov (1903–1987).

Information theory must precede probability theory, and not be based on it. By the very essence of this discipline, the foundations of information theory have a finite combinatorial character. [Kolmogorov, 1983, p. 39]

Kolmogorov had his own designs, but in the case of logical entropy, the object of “a finite combinatorial character” is the ditset of a partition.

4.7 Shannon entropy as a “measure of uncertainty”

Shannon entropy is often described as a “measure of uncertainty” in, say, a real-valued random variable $X = \{x_1, \dots, x_n\}$ where $\Pr(x_i) = p_i$ for $i = 1, \dots, n$. But there is already a well-established measure of uncertainty, namely the variance: $\text{Var}(X) = E(X^2) - E(X)^2$.

That well-known and well-developed notion of uncertainty can be developed as a special case of logical entropy. Given a probability distribution $p = \{p_1, \dots, p_n\}$, the *logical distance* between the indices is: $1 - \delta_{ij}$, i.e., one minus the Kronecker delta. Then in two independent draws from the set of indices $\{1, 2, \dots, n\}$, the average logical distance (squared) between them is the logical entropy:

$$h(p) = \sum_{i \neq j} p_i p_j (1 - \delta_{ij})^2.$$

For a real-valued random variable, a better distance is Euclidean distance (squared). The logical entropy formula applied to that distance function squared is twice the variance.

$$\sum_{i \neq j} p_i p_j (x_i - x_j)^2 = 2\text{Var}(X).$$

If we only consider pairs of distinct indices rather than ordered pairs:

$$\sum_{i < j} p_i p_j (x_i - x_j)^2 = \text{Var}(X).$$

Thus the approach through logical entropy yields the usual “measure of uncertainty.” The duality between logical probability and logical information theory implies there is a type of duality between the statistical mean and variance Ellerman [2025b].

5 Discussion

The Shannon entropy has its natural applications in coding theory and what Shannon called a “Mathematical Theory of Communications.” Shannon [1948] Shannon noted that his theory didn’t supply a definition of information: “no concept of information itself was defined.” [Shannon, 1993, p. 458] But Shannon considered his entropy to be a quantification of information, and that is correct. There is a non-linear monotonic transformation, the Dit-Bit transform, from logical entropy to Shannon entropy. That transform can be read off of both formulas when expressed as additive probability averages:

$$h(p) = \sum_i p_i(1 - p_i) \text{ and } H(p) = \sum_i p_i \log\left(\frac{1}{p_i}\right).$$

Thus the Dit-Bit transform takes the term $1 - p_i$ in the logical entropy formula to the term $\log\left(\frac{1}{p_i}\right)$ in the Shannon formula. The transform is monotonic so the Shannon entropy is indeed a quantification of information-as-distinction—intuitively, it is the minimum average number of *binary* distinctions it takes to distinguish the messages. Moreover, the Dit-Bit transform preserves the Venn diagrams from logical entropy as a measure to Shannon entropy as a mnemonic Campbell [1965]—so it provides an account of how the compound Shannon entropy formulas can satisfy the usual Venn diagrams in spite of not being a measure in the sense of measure theory.

The more controversial question is whether or not Shannon entropy is a satisfactory basis for information theory—as opposed to the theory of communications and coding. We have argued that logical entropy provides that (logical) foundation, and that Shannon entropy is the appropriate transform for the applications in communications and coding theory Ellerman [2021].

For further contrast between the logical entropy and the Shannon entropy, see the special issue of the journal 4Open on logical entropy Manfredi [2022] which includes Ellerman [2022].

The extension of Shannon entropy used in quantum mechanics is the von Neumann entropy, and the extension for logical entropy is the quantum logical entropy Ellerman [2025a].

6 Conclusions

The purpose of this paper is to give the results obtained by following out Gian-Carlo Rota’s guidance starting with his initial logic of commuting equivalence relations Finberg et al. [1996]. The first result was the general logic of partitions (or equivalence relations) which is dual to the usual Boolean logic of

subsets. Then following Rota's suggestion that subsets are to probability as partitions are to information, we developed the quantitative version of partitions, i.e., logical entropy, dual to the quantitative version of subsets, i.e., logical probability. Then we argued that for the purposes of information theory, i.e., the measure of information-as-distinctions, as opposed to coding and communications theory, the notion of logical entropy was superior to the Shannon entropy.

There is more to the story that runs beyond the scope of this paper. There is a fundamental duality schema that begins with the above mentioned dualities and then connects to and explains category-theoretic duality and then extends to physics itself Ellerman [2024].

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Returns to the Greeks: Conceptual Crisis, Interpretive Strategies, and the Role of the Ancient Greeks in Modern Physics

Alberto Bardi*

Abstract

This paper explores how modern physicists—Schrödinger, Heisenberg, and Rovelli—draw on Greek philosophy in different ways. For Schrödinger and Heisenberg, Greek ideas offer conceptual tools to address quantum theory's challenges, with Schrödinger favoring pre-Socratic realism and continuity, while Heisenberg emphasizes Platonic and Aristotelian notions of potentiality and epistemic limits. Rovelli uses Aristotle to support scientific cumulativeness, arguing older theories remain relevant within new frameworks. However, this conflates the recoverability of previous theories with historical continuity. The shift from Aristotelian to Newtonian physics represents a fundamental change in what counts as explanation, so references to the Greeks do not inherently guarantee cumulative knowledge; their impact depends on how Greek concepts are interpreted.

Keywords: Science cumulativeness; Ancient Greek philosophy; Quantum Physics; Erwin Schrödinger; Werner Heisenberg; Carlo Rovelli.[†]

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1. Introduction

In moments when the conceptual resources of physics appear strained—when established categories no longer yield an intelligible picture of what the formalism is about—physicists have repeatedly staged a return to Greek philosophy. These returns are rarely antiquarian. They function as attempts to recover, reconfigure, or legitimize the most basic commitments of physical inquiry: what counts as an explanation, what sort of reality a theory can be said to describe, and what the aims of scientific knowledge ought to be (Palacios 2024). The appeal to “the Greeks,” in other words, often signals that the crisis is not merely technical but foundational.

This paper examines three such returns across the twentieth and twenty-first centuries—those of Erwin Schrödinger, Werner Heisenberg, and Carlo Rovelli—and argues that their invocations of Greek thought exemplify distinct epistemic uses of antiquity. Schrödinger and Heisenberg turn to Greek philosophy as a living conceptual resource under the pressure of quantum theory, a theory whose empirical success outpaced the interpretive capacities of classical concepts. By contrast, Rovelli’s recent appeal to Aristotle is mobilized primarily to support a broad historiographical thesis: that physics is “largely cumulative,” and that scientific development is best understood as continuity across centuries rather than rupture (Rovelli 2024). The central claim advanced here is that these uses of “the Greeks” must be sharply distinguished. Schrödinger and Heisenberg appeal to Greek philosophy to reopen framework questions—questions about continuity and discreteness, realism and representation, being and becoming—when modern physics renders inherited answers unstable. Rovelli, on the other hand, appeals to Greek physics to underwrite a continuity narrative about scientific progress, one that relies on a methodological slide from regime-based recoverability (the fact that later theories can reproduce certain older descriptions under certain conditions) to historical continuity of explanation (the claim that physics develops cumulatively in its conceptual and explanatory aims). I argue that this slide is not justified. It conflates extensional overlap in descriptive output with intentional continuity in explanatory norms, ontological commitments, and the very sense of what physics is trying to do.

A recent and particularly relevant contribution is Fernández Mouján (2024), who reconstructs the “return to the Greeks” in Heisenberg, Pauli, and Schrödinger as a response to the conceptual crisis induced by quantum mechanics, emphasizing themes such as the revision of atomism, the reconfiguration of “understanding,” and critiques of disciplinary and metaphysical “separations.” While valuable as a synthetic account of shared motivations, Fernández Mouján’s treatment is not organized around a systematic contrast between Schrödinger’s and Heisenberg’s different Greek genealogies and the

distinct philosophical functions those genealogies serve in their competing interpretations of quantum theory. The present article builds on this literature by foregrounding that contrast (Ionian/continuity-oriented realism versus Platonic–Aristotelian form and potentiality), and by extending the analysis to a contemporary “return” in Rovelli, where Greek genealogy is mobilized not primarily to navigate a foundational crisis but to stabilize a continuity narrative about scientific development—precisely where the distinction between recoverability and framework continuity becomes methodologically decisive.

Verelst and Coecke (2006) offer a philosophically ambitious attempt to recover early Greek paradoxes (Being/non-Being, motion, One/Many) as resources for an explicitly ontological approach to interpretive problems in quantum mechanics, arguing that modern scientific categories—especially the assumption of a separable, stable “system”—inherit deep metaphysical commitments shaped by Platonic–Aristotelian strategies for securing stability and non-contradiction. Their paper is valuable for our purposes as a contemporary exemplar of “Greek return” literature that treats antiquity as a repertoire for diagnosing conceptual constraints internal to modern physics rather than as mere historical background. However, their project is largely programmatic and reconstructive, not a historically fine-grained analysis of how particular twentieth-century physicists selectively constructed different Greek genealogies for distinct interpretive ends. The present article therefore uses Verelst and Coecke as a conceptual foil: we keep the insight that Greek resources re-enter physics at moments of foundational strain, while shifting the focus to Schrödinger’s and Heisenberg’s contrasting, historically situated appropriations of “the Greeks,” and to Rovelli’s contemporary deployment of Aristotle in support of a continuity narrative about scientific development.

The phrase “return to the Greeks” can mislead if taken as a single gesture. Greek philosophy does not speak with one voice; its canonical tensions—Parmenides and Heraclitus, atomists and continuum theorists, Platonists and Aristotelians—offer not a unitary legacy but a repertoire. That plurality is precisely what makes Greek thought attractive to modern physicists seeking conceptual orientation. A return to the Greeks is typically a selective construction: a retrieval of a particular lineage that can serve as an intellectual anchor when contemporary categories become contested.

Schrödinger’s case is paradigmatic. In *Nature and the Greeks*, he presents early Greek natural philosophy as inaugurating a distinctive ambition: a rational, unified, intelligible order of nature, articulated not as myth but as coherent world-understanding (Schrödinger 1954). His admiration is closely linked to his dissatisfaction with features of the Copenhagen settlement—especially discontinuity, abrupt “jumps,” and the prominence of measurement in the articulation of quantum phenomena. Schrödinger’s

preferred “Greek” lineage is pre-Platonic and monistic: a model of intelligibility and continuity that supplies a normative image of what physics ought to aspire to say about reality.

Heisenberg’s return differs in both its sources and its philosophical function. In *Physics and Philosophy*, he frames quantum mechanics as a transformation in the conditions of description and knowledge, emphasizing the limits of classical concepts and the irreducibility of the measurement context (Heisenberg 1958). Greek philosophy matters to Heisenberg because it provides a language for articulating a mode of being that is neither the straightforward actuality of classical realism nor mere subjective appearance. His appeal to Aristotelian potentiality—*dynamis*—is not decorative: it supplies a conceptual schema for treating the quantum state as real yet not classically actual prior to measurement. Greek philosophy thus functions as a legitimizing precedent for epistemic modesty and conceptual mediation, not as a warrant for continuity with classical pictures of nature.

Both Schrödinger and Heisenberg therefore use “the Greeks” to renegotiate what physics can claim about reality under quantum pressure. In doing so, they implicitly acknowledge a key point: foundational crises in physics are simultaneously crises of conceptual authority—crises about which philosophical commitments can still be responsibly carried by physical theory.

Rovelli’s continuity thesis begins from a plausible observation: older theories are not simply discarded, but remain effective within restricted domains; in ordinary circumstances, Newtonian mechanics remains reliable even if later frameworks offer deeper or more general accounts (Rovelli 2024). From this starting point, Rovelli proposes a general historiographical moral: physics should be understood—“contrary to what is often stated”—as a cumulative body of knowledge (Rovelli 2024). A pivotal move in the paper is his rehabilitation of Aristotelian physics via everyday falling in a resisting medium: once drag is included, motion rapidly approaches constant velocity, and this is presented as aligning with an Aristotelian description of natural motion as approximately constant-speed under “everyday conditions” (Rovelli 2024). On this basis, Rovelli suggests that Aristotelian claims are not simply superseded but are, in an important sense, “right” in their domain—and that the historical narrative of physics as a sequence of ruptures is misleading (Rovelli 2024).

The present paper does not dispute the mathematical point that Newtonian dynamics with drag predicts terminal velocity, nor the pedagogical value of showing how different regimes yield different effective descriptions. The critique is methodological and philosophical: Rovelli’s argument moves too quickly from a formal or phenomenological observation (later theory can reproduce some older descriptive regularities) to a

historiographical and epistemological moral (physics is broadly cumulative; conceptual continuity predominates). That inference—recoverability $\Rightarrow$ continuity—is precisely what must be defended rather than assumed.

To put the point sharply: regime-based recoverability is a relation between descriptions; historical continuity is a relation between explanatory frameworks. A modern theory can often generate behavior that an earlier vocabulary can capture approximately, but this does not entail that the earlier theory's explanatory aims, ontological structure, or norms of adequacy are preserved. Treating such recoverability as evidence of continuity risks a kind of presentist harmonization: the past is redescribed in the idiom of the present, and the ease of translation is then mistaken for a fact about historical development.

This methodological worry becomes vivid in the Aristotelian–Galilean transition. Even if one grants that some everyday appearances can be cast in Aristotelian-sounding terms, the passage from Aristotle to Galileo is not well captured by a continuity narrative, because it is not primarily a matter of correcting quantitative predictions. It is a reconstitution of what counts as a physical explanation.

On the Aristotelian framework, motion in the sublunary realm is embedded in a teleological explanatory economy: “nature” is not merely a set of regularities but a principle of directedness, and the intelligibility of motion is tied to a cosmos whose structure is not uniform. Whatever one's preferred formulation of Aristotle's mature position, it is inseparable from a differentiated world-picture and from explanatory forms in which final causes are not optional ornaments but integral resources. In the Galilean program, by contrast, the aspiration of physics becomes inseparable from mathematization and idealization; crucially, physical explanation of motion proceeds by excluding final causes from the explanatory machinery of mechanics (Dear 1995). The cosmos is treated as unified in relevant respects for the study of motion, and the explanandum shifts from “why this natural tendency?” to “what lawlike, mathematically expressible relations govern change of motion under specified conditions?” The very job description of physics changes.

This rupture matters not merely for historical classification but for understanding why Newtonian mechanics becomes possible. Newton's laws presuppose an explanatory stance in which motions are not fundamentally oriented toward natural ends and in which a unified dynamical framework is intelligible across terrestrial and celestial phenomena. The historical continuity that is philosophically salient here runs through a transformation

in explanatory norms—precisely what is at risk of being obscured when Aristotelian descriptions are treated as domain-true in a way that blurs the conceptual break.

Methodologically, this paper distinguishes three levels at which appeals to Greek philosophy operate in modern physics: (1) Historical influence: which texts are read, cited, and taught; how a physicist’s education and intellectual milieu shape their exposure to “Greek thought;” (2) Philosophical alignment: which conceptual motifs are extracted as congenial to a given interpretation (continuity vs. discreteness; realism vs. epistemic constraint; being vs. becoming); (3) Rhetorical authority: how “the Greeks” are used to confer legitimacy—presenting an interpretive stance as a return to deep rational origins rather than a local, contingent response to crisis.

This distinction allows a middle path between two unsatisfactory extremes: treating physicists as reliable historians of antiquity on the one hand, or dismissing their classical references as mere ornament on the other. Schrödinger and Heisenberg are best read as offering philosophical self-interpretations, selective but serious, in which Greek thought provides a vocabulary for framing what quantum mechanics permits one to say about reality (Schrödinger 1954; Heisenberg 1958). Rovelli, by contrast, uses Greek physics chiefly to authorize a claim about the overall structure of scientific development, and it is here that the difference between recoverability and conceptual continuity becomes decisive (Rovelli 2024).

The paper proceeds as follows. Section 2 clarifies the distinction between recoverability, conceptual continuity, and historiographical narrative, and identifies the inferential step at stake in contemporary continuity claims. Section 3 analyzes Schrödinger’s “Greeks,” focusing on how the ideal of unity and continuity functions as a normative constraint on interpretation of quantum theory (Schrödinger 1954). Section 4 turns to Heisenberg, reconstructing his appeal to Plato and Aristotle, especially potentiality, as a conceptual strategy for articulating contextual actuality and epistemic limitation in quantum mechanics (Heisenberg 1958). Section 5 then examines Rovelli’s appeal to Aristotle in service of a cumulativeness thesis, showing how the argument depends on conflating regime-based descriptive adequacy with continuity of explanatory aims (Rovelli 2024). Section 6 offers the Aristotelian–Galilean rupture as a decisive counterexample to the continuity inference: the break is not captured by limit-style reconstructions because it concerns the transformation of explanation itself. The conclusion draws a general moral: “returns to the Greeks” can illuminate how physics rethinks its foundations, but they cannot be used indiscriminately to support a continuity narrative about scientific progress.

In short, the recurring invocation of Greek philosophy in modern physics is not evidence for a single story about continuity, cumulativeness, or “the origins” of scientific

reason. It is evidence that, when physics confronts foundational instability, it reaches back to a repertoire of ancient possibilities in order to renegotiate what science is allowed to claim. Understanding how these negotiations differ in Schrödinger, Heisenberg, and Rovelli clarifies not only the philosophical stakes of quantum interpretation, but also the methodological limits of continuity narratives that mistake present-day reconstructions for historical development.

2. Recoverability Is Not Continuity: A Methodological Clarification

Continuity narratives in the history and philosophy of physics often trade on an ambiguity in what “continuity” is supposed to mean. On one reading, continuity is a claim about performance: later theories preserve the predictive and practical successes of earlier ones within certain ranges of conditions. On another reading, continuity is a claim about framework: later theories preserve the explanatory aims, ontological commitments, and conceptual roles that structured earlier approaches. The two senses can come apart, and conflating them can distort how scientific change should be described (Palacios 2024).

Rovelli’s recent defense of cumulativity is a useful contemporary site at which this ambiguity becomes visible. His argument moves from the unobjectionable point that earlier frameworks can remain effective in restricted regimes to the stronger moral that the history of physics is “largely cumulative,” and that major transitions—Aristotle to Newton, Newton to Einstein—exhibit deep continuity once interpreted properly (Rovelli 2024). This section isolates the methodological step that makes that move tempting and explains why, especially for the Aristotelian–Galilean case, it does not by itself deliver what a continuity narrative requires.

2.1 Three theses that are often run together

It helps to distinguish three theses that are frequently treated as interchangeable (Palacios 2024).

(T1) Regime validity (domain-limited adequacy). A theory can be reliable within a restricted domain even if it is not fundamental. Newtonian mechanics remains indispensable for many terrestrial and engineering purposes despite its limitations

relative to relativity and quantum theory. Rovelli explicitly endorses this idea and uses it as a premise in his historiographical argument (Rovelli 2024).

(T2) Recoverability (limit, correspondence, approximation). A later framework can often recover aspects of an earlier one as a limiting case, approximation, or special regime. Rovelli leans on this reasoning, for instance, when he suggests that adding drag to Newtonian dynamics yields behavior that approaches constant-speed motion, which he associates with an Aristotelian description of ordinary falling (Rovelli 2024).

(T3) Historical continuity (continuity of explanatory framework). A transition is historically continuous when the conceptual roles, explanatory aims, and ontological architecture of the earlier framework are substantially retained, so that later work can plausibly be read as extension or systematic improvement rather than reconstitution of the enterprise.

The central point is that (T1) and (T2) do not entail (T3). Regime validity and recoverability are relations between successful descriptions; historical continuity is a relation between frameworks of explanation (Crowther 2020; Palacios 2024). Even if an Aristotelian-sounding sentence can be made approximately true inside a Newtonian-with-drag reconstruction, it does not follow that Aristotelian physics stands in a cumulative relation to Galilean dynamics in the sense relevant to historiography or philosophy of science (Norton 2012).

2.2 Why recoverability is attractive—and why it is insufficient

Recoverability arguments are attractive because they resonate with a powerful internal virtue of physics: unification by subsumption. Later theories can explain why earlier ones worked as well as they did in certain regimes, revealing structure in both the world and our theorizing. This is a genuine epistemic achievement.

But this virtue also encourages a familiar historiographical temptation: reading the past through the lens of present theory, treating the ease of translation into modern equations as evidence that the past was already “on the way” to the present (Norton 2012). The danger is not that the mathematics is wrong; it is that the historical inference is too quick. Rovelli’s strategy makes the issue vivid because it uses a modern reconstruction (Newtonian dynamics with drag) to generate a qualitative behavior (approach to terminal velocity) and then reads that as vindicating Aristotle “in everyday conditions” (Rovelli 2024). Even if the modeling is defensible as pedagogy, the

historical conclusion requires an additional premise about what counts as continuity across frameworks.

2.3 Extensional overlap and intensional continuity

A helpful way to state the gap is to distinguish extensional overlap from intensional continuity (Palacios 2024). Extensional overlap concerns whether two theories agree (approximately) on observable regularities in a shared domain. Intensional continuity concerns whether the meaning and explanatory function of key terms and distinctions are preserved—whether the theories explain in the same way, with the same resources, for the same kind of explanatory purpose.

Continuity narratives based on recoverability often rely on extensional overlap to suggest intensional continuity. The drag example is emblematic: it shows how a modern model yields a regime in which motion is approximately constant-speed and then treats this as significant continuity with an Aristotelian characterization of ordinary falling (Rovelli 2024). But in Aristotle the meaning of “natural motion” belongs to a broader explanatory economy in which why a body moves is inseparable from its nature, its place in a structured cosmos, and forms of explanation not reducible to a differential equation plus a resistance term. Extensional agreement on a kinematic pattern does not suffice to establish continuity of explanatory framework (Norton 2012).

2.4 Continuity as a claim about explanatory aims

A more reliable way to avoid flattening is to treat continuity, in the historiographically relevant sense, as a claim about explanatory aims and norms, not only about approximate descriptive success (Crowther 2020). A mature scientific framework is a structured practice that implicitly answers questions such as: What counts as an acceptable explanation? What kinds of causes are admissible? What role should mathematics play in representation and explanation? What counts as the proper object of theory? What standards of adequacy govern appraisal?

When these norms shift, continuity cannot be read directly off shared outcomes. Often the explanandum itself is redescribed: the “same” phenomenon becomes intelligible under different explanatory questions. This is exactly what is at stake in the transition from a teleological physics of natural tendencies to a mechanics of

mathematically expressible relations (Dear 1995). Continuity narratives that rest primarily on recoverability risk missing this deeper transformation.

2.5 The inferential step at stake in Rovelli's cumulativeness thesis

With these distinctions in place, we can state the inferential step that underwrites Rovelli's cumulativeness claim. Rovelli begins from (T1) and (T2): theories are domain-limited, and later theories can recover earlier descriptive successes in the appropriate regime (Rovelli 2024). From this he draws a broader moral: science is "largely cumulative," older theories are not "discarded," and the standard story of discontinuous revolutions is misleading (Rovelli 2024).

The move looks plausible because (T1) and (T2) are forms of retention. But what is retained need not be what matters for the historical identity of a framework. Recoverability shows that later theory can explain why earlier description worked in a restricted range; it does not show that the earlier framework's explanatory aim was continuous with the later one, nor that its central concepts retain their roles across the transition.

To defend a continuity narrative, one needs an additional premise—call it the continuity premise: if a later theory can recover an earlier theory's successful descriptions in an appropriate regime, then the earlier theory's framework is retained in a cumulative lineage. This premise is controversial in precisely the Aristotelian–Galilean case (Crowther 2020).

2.6 A diagnostic: when recoverability misleads

A practical diagnostic helps clarify when recoverability is likely to mislead as evidence for continuity. Recoverability is a good guide to continuity when the earlier framework's core explanatory ideals remain in place and the later framework extends the same representational strategy into new domains. Recoverability is a poor guide when there is a change in what counts as explanation, what counts as basic ontology, or what role mathematics plays in representation. In such cases, later theories may reproduce earlier empirical successes while redescribing the phenomenon within a different explanatory enterprise.

The Aristotelian–Galilean transition belongs to this second category. It is not merely a matter of improved numbers. The Aristotelian explanatory economy—teleology and a stratified cosmos, among other commitments—ceases to be an admissible basis for mechanics, and the aim of physics is reconstructed. If this is right, then "Aristotle was right in everyday conditions" may function as a pedagogically

useful gloss, but it cannot carry the historiographical weight placed upon it by a cumulativeness thesis.

This methodological clarification also explains why the comparison with Schrödinger and Heisenberg is not ornamental. Their returns to Greek philosophy respond to conceptual instability in quantum foundations: Greek plurality is used as a repertoire of options for renegotiating realism, representation, and intelligibility. Rovelli's return, by contrast, aims to stabilize a historiographical narrative by redescribing historical transitions in regime terms (Rovelli 2024). That is why recoverability versus continuity matters here. If extensional overlap is misread as intensional continuity, "returning to the Greeks" becomes a way of smoothing over discontinuities that are historically and philosophically central—especially the discontinuity that conditions the emergence of Newtonian mechanics.

3. Schrödinger's Greeks: Unity, Continuity, and the Normative Image of Science

Schrödinger's "return to the Greeks" is best read neither as cultural ornament nor as a neutral historical survey, but as a philosophical intervention into what quantum mechanics had made newly uncertain: what a physical theory ought to be *about*, and what counts as an intelligible account of nature. In *Science and Humanism* and *Nature and the Greeks*, Schrödinger constructs an origin-story of scientific thought that is explicitly normative. Greek natural philosophy, especially the earliest Ionian and pre-Platonic strands, is presented as the first decisive break with myth and anthropomorphic explanation and as the inauguration of a unified, impersonal, intelligible order of nature (Schrödinger 1951, 1954). This origin-story does not merely locate a beginning; it provides a standard by which Schrödinger judges modern physics—above all, the Copenhagen settlement that he regarded as epistemically successful but conceptually unsatisfying (Fernández Mouján 2024).

3.1 The Greeks as an origin of "world-understanding," not technique

Schrödinger insists that Greek science matters because it is the earliest sustained attempt to articulate what one might call world-understanding: a commitment to the intelligibility of nature, to explanation that does not depend on local narrative or divine caprice, and to a unity that makes the world describable as a coherent whole (Fernández Mouján 2024). What he admires is not primarily a specific doctrine (e. g., atomism or a

particular cosmology), but a stance: the conviction that nature is governed by general principles accessible to rational inquiry. (Schrödinger 1954).

This emphasis matters because it already signals the kind of continuity Schrödinger is after. For him, continuity is not chiefly a claim about the historical succession of theories. It is a metaphysical and methodological expectation: if physics is genuine understanding, it should deliver a picture of nature that is unified, stable, and in some sense objective. Greek thought becomes exemplary precisely because it appears to him as an early crystallization of this expectation before later philosophical developments introduced what he regarded as distortions—especially forms of subjectivism that make the observer constitutive of the physical account.

Two features of his invocation of the Greeks are especially important for the present argument. First, Schrödinger treats Greek philosophy as a moment in which physics, metaphysics, and epistemology are not yet separated into distinct professional discourses (Palacios 2024). That unity is not, for him, a deficiency. It allows foundational questions to be asked without being prematurely constrained by technical formalisms or disciplinary boundaries (Schrödinger 1954). Second, he treats those “framework questions”—what reality is, what objectivity means, what kinds of explanation are admissible—as the proper concern of a reflective physics. In other words, his appeal to the Greeks is intended to legitimate precisely the kind of philosophical reflection on physics that the postwar “shut up and calculate” mood could sometimes marginalize.

3.2 Continuity as a metaphysical constraint on quantum interpretation

Schrödinger’s use of Greek thought cannot be disentangled from his dissatisfaction with the dominant interpretive posture associated with Bohr and Heisenberg. His complaints about quantum mechanics are well known: unease with discontinuous “jumps,” with the apparent centrality of measurement, and with the retreat from picturable ontology. These were not merely aesthetic preferences. They expressed a deeper thesis: that physics should aim at an observer-independent account of nature and that discontinuity at the level of being is not easily reconciled with intelligibility.

In this context, the Greeks function as a historical and philosophical resource because they represent for Schrödinger a model of intelligibility grounded in unity. He reads early Greek natural philosophy as pursuing the thought that the many can be explained through the one: diverse phenomena are manifestations of an underlying order, and the task of inquiry is to articulate that order conceptually. This “Greek” ideal dovetails with Schrödinger’s own preference for field-like continuity and his hope (never fully realized) that quantum theory might be redescribed in an ontologically continuous manner (Fernández Mouján 2024). That hope is visible not only in the development of wave

mechanics but also in Schrödinger's later reflections on the foundations of quantum theory, where he consistently resists the idea that physical reality should depend on an act of observation in any strong sense (Schrödinger 1951; 1954).

For present purposes, the key point is methodological: Schrödinger's return to the Greeks is a way of constraining what counts as an acceptable interpretation of quantum mechanics (Palacios 2024). It is not an attempt to stabilize a narrative of continuity in the history of physics. Rather, it uses Greek philosophy to protect a particular epistemic ideal—coherent world-picture, observer-independent intelligibility—against what he perceived as the conceptual fragmentation implied by Copenhagen-style emphases on measurement and probability. Greek thought thus functions for Schrödinger as a normative image of science: science should not merely predict; it should render nature intelligible in a unified way (Verelst and Coecke 2006).

This is why Schrödinger's appeal to antiquity differs in kind from Rovelli's later use of Aristotle. Rovelli's argument relies on recoverability and domain-limited adequacy to support a thesis about cumulative continuity across centuries (Rovelli 2024). Schrödinger, by contrast, invokes the Greeks primarily to make a claim about the aim of physics in the present: physics should aspire to a unified representation of reality, and interpretive strategies that make reality dependent on observational context threaten that aspiration (Schrödinger 1954).

3.3 Selectivity: Schrödinger's "Greeks" are pre-Platonic and anti-teleological

A second crucial feature is Schrödinger's selectivity. "The Greeks" are not for him a homogeneous authority. His admiration is strongest where Greek thought appears to him most consonant with unity and continuity: pre-Socratic naturalism and the early ambition to explain the cosmos without appeal to anthropomorphic ends. Even when he expresses respect for Plato, his ideal "Greek" is not a Platonic metaphysics of two worlds, and it is certainly not Aristotelian teleology. Schrödinger's ideal is closer to a monistic picture in which nature is one coherent order that can be understood by principles that do not depend on final causes (Schrödinger 1954).

This selectivity matters because it reveals what a "return to the Greeks" accomplishes in practice: it is a construction of lineage (Fernández Mouján 2024). Schrödinger does not merely discover an origin; he fashions a genealogy that helps him make sense of what he takes to be at stake in modern physics. The value of Greek philosophy, for him, lies not in a detailed correspondence between ancient doctrines and quantum mechanics, but

in the availability of a conceptual posture—unity, intelligibility, continuity—that can be mobilized against a perceived retreat into epistemic modesty or instrumentalism.

Schrödinger’s anti-teleological emphasis is also relevant to the larger arc of this paper because it places him at an interesting angle relative to the Aristotelian–Galilean rupture discussed later. Schrödinger is not, in any straightforward sense, advocating a return to Aristotle’s physics; rather, he is using Greek naturalism as a counterweight to interpretive moves that, in his view, would make physics too dependent on conditions of observation. This difference becomes important when we contrast him with Heisenberg, who does invoke Aristotle positively—especially the concept of potentiality—to articulate a different, more context-sensitive metaphysics of quantum states (Heisenberg 1958). Schrödinger’s “Greeks” thus already foreshadow the paper’s central comparative claim: Greek philosophy functions as a repertoire that can be recruited to legitimate incompatible philosophical stances within modern physics.

3.4 The epistemic function of Schrödinger’s return

At this point we can state more precisely the epistemic function of Schrödinger’s return to the Greeks. It performs at least three tasks.

First, it provides a model of scientific rationality that is not reducible to prediction (Fernández Mouján 2024). Schrödinger repeatedly treats “understanding” as a central scientific value—an intelligible world-picture, not merely an algorithm for generating experimental frequencies (Schrödinger 1951, 1954). Second, it authorizes foundational questioning by locating it at the origin of science: the Greeks are invoked to show that asking what reality is, and what science can say about it, is not an extraneous philosophical pastime but part of the scientific enterprise at its birth. Third, it supplies a normative criterion for judging modern interpretations: discontinuity and observer-dependence appear not merely as technical novelties, but as threats to the Greek aspiration to coherent unity (Verelst and Coecke 2006).

These points also indicate how Schrödinger’s appeal to antiquity should be evaluated. One could object that Schrödinger’s account of Greek science is historically stylized or philosophically tendentious. That objection may be correct in detail. But for the purposes of philosophy of science, the more important question is not whether Schrödinger is a reliable classicist; it is what he is doing with antiquity. He is using “the Greeks” to frame a debate about realism, representation, and intelligibility in quantum theory. Greek philosophy becomes a source of philosophical leverage at a moment when modern physics forces a renegotiation of what counts as a satisfactory physical account.

Schrödinger’s appeal to the Greeks therefore functions primarily as a normative image of what physics should be: a unified, intelligible account of nature that does not

make reality depend on acts of observation. In this sense, his “return” is not a claim about the historical continuity of physics across centuries, but a way of stabilizing standards of explanation and realism at a moment when quantum theory made those standards contestable. The upshot for the paper’s comparative argument is straightforward: Greek philosophy enters twentieth-century physics here as a resource for conceptual orientation under foundational pressure, not as evidence for cumulativeness or historical smoothing.

4. Heisenberg’s Greeks: Form, Potentiality, and the Limits of Classical Description

A strikingly different construction of Greek lineage, Heisenberg’s return to Greek philosophy is neither a nostalgic appeal to origins nor an attempt to restore a classical image of nature. It is, rather, a strategy for making sense of a situation in which the classical conceptual scheme—trajectories, determinate properties, separable objects evolving continuously in time—no longer seems adequate to the phenomena. If Schrödinger invokes early Greek naturalism to defend an ideal of unified, observer-independent intelligibility, Heisenberg invokes Plato and Aristotle to justify a different conclusion: the proper lesson of quantum mechanics is that the conditions of description are not transparent windows onto an observer-independent inventory of properties. Physical theory describes nature through conceptual and experimental arrangements that partly constitute what can meaningfully be said (Palacios 2024). Greek philosophy matters to Heisenberg because it provides him with a vocabulary for articulating this conceptual mediation without collapsing into a crude instrumentalism.

4.1 Greek philosophy as precedent for conceptual mediation

In *Physics and Philosophy*, Heisenberg portrays modern physics as confronting not merely new empirical facts but a transformation in the relation between concepts and reality. Quantum mechanics, as he understands it, exposes the dependence of physical description on the experimental context and on the conceptual apparatus used to state measurement results (Heisenberg 1958). Rather than treat this dependence as a temporary imperfection to be eliminated, Heisenberg takes it to reflect something deep about the epistemic situation of physics: what can be said about nature is constrained by the kinds of questions that experimental arrangements and theoretical concepts make possible (Verelst and Coecke 2006).

This epistemic posture is one reason Greek philosophy becomes relevant. Heisenberg reads Plato and Aristotle as already grappling with the idea that knowledge is not a passive mirroring of things but is mediated by conceptual forms and by the structuring activity of

thought. In this sense, his turn to Greek philosophy is meant to inoculate the quantum revolution against two temptations: on one side, a naïve realism that insists the world must be describable in the classical way; on the other, a positivist minimalism that treats theory as nothing more than a calculus of prediction (Crowther 2020). Greek philosophy becomes a historical and conceptual resource for a middle position: the world is real, but the form in which it can be described is not independent of the conditions of description.

4.2 Plato: mathematical form and the priority of structure

Heisenberg's Platonism is not a simple metaphysical doctrine; it is closely tied to the abstraction of modern theoretical physics. He emphasizes that advanced physics increasingly abandons picturable models and replaces them with mathematical structures that cannot be reduced to classical visualization. Quantum mechanics intensifies this trend. The formalism does not yield a straightforward picture of "what is happening" in the classical sense; instead, it yields a rule-governed structure that connects preparation and measurement outcomes. For Heisenberg, the fact that the formalism works with extraordinary precision suggests that physics has access to reality through structure rather than through classical images (Heisenberg 1958).

Plato provides Heisenberg with a way of treating mathematical form as more than a convenient language. It legitimizes the idea that the deepest access physics has to reality may be mediated by abstract form, not by sensory imagination or mechanical pictures. This is not to say that Heisenberg simply maps quantum theory onto Plato's theory of Forms. It is to say that Plato supplies a culturally authoritative precedent for taking mathematical structure seriously as an epistemic and perhaps ontological guide. Where Schrödinger wants to preserve a continuous, "picturable" underlying reality, Heisenberg is prepared to say that the price of fidelity to nature is to accept forms of description that cannot be assimilated to classical images.

4.3 Aristotle: potentiality as a category for quantum states

Heisenberg's most distinctive Greek appropriation, however, is Aristotelian rather than Platonic: the appeal to potentiality (*dynamis*) and actuality (*energeia*) as a way of interpreting the quantum state. Heisenberg introduces Aristotle's language to articulate a situation in which the quantum system cannot be said to possess determinate classical properties prior to measurement, yet it is not thereby unreal or merely subjective (Fernández Mouján 2024). The quantum state represents a structured set of possibilities—

possibilities that are not merely epistemic ignorance but objective constraints on what can become actual in a given measurement context (Heisenberg 1958).

The point of this move is conceptual: it supplies a vocabulary for a mode of being that lies between classical actuality and pure fiction. Classical physics presupposes that the basic properties of objects are actual at all times—positions, momenta, trajectories—even if unknown to us. Quantum mechanics, as Heisenberg reads it, forces a different account. Certain classical descriptions become meaningful only in relation to the measurement arrangement, and the formalism yields probabilities rather than deterministic predictions. Aristotle's potentiality, in Heisenberg's hands, becomes a way of saying: the system is real, but its properties are not actual in the classical sense prior to the measurement interaction; they exist as structured potentialities that can be actualized under determinate conditions.

This is not a minor rhetorical flourish. It performs philosophical work at exactly the point where quantum theory threatens to produce interpretive bifurcation. If one insists on classical actuality, one is driven toward hidden-variable pictures or toward treating the wavefunction as incomplete. If one gives up reality altogether, one risks collapsing into an instrumentalism that deprives physics of any claim to describe nature. Heisenberg's appeal to Aristotle is designed to resist both extremes by legitimizing a non-classical ontology of potential being that is nonetheless objective enough to underwrite the scientific enterprise.

4.4 Measurement, intervention, and the transition to actuality

Heisenberg's Aristotle is also connected to a distinctive conception of measurement. Measurement is not passive observation of preexisting values; it is an intervention that helps constitute the conditions under which certain quantities can be meaningfully ascribed. The transition from quantum potentiality to classical actuality is not merely a change in our knowledge; it is a physical process in which the system becomes entangled with the macroscopic measurement arrangement and yields a definite record. Heisenberg does not need to deny an external reality to insist that description is contextual. The point is rather that quantum theory forces a rethinking of the classical separation between observer and observed, and Aristotle's potentiality/actuality provides a conceptual idiom in which that rethinking can be made intelligible (Heisenberg 1958).

Here again Heisenberg's use of Greek philosophy differs from Rovelli's. Rovelli's continuity narrative treats Greek physics as a precursor whose descriptive statements can be reinterpreted as approximately true in certain regimes, thereby supporting a cumulative account of physics (Rovelli 2024). Heisenberg's appeal to Aristotle does not aim to rehabilitate Aristotle as "right" within a domain in a way that supports historical

cumulativity. It aims to solve a modern interpretive problem: how to speak about quantum states without forcing them into classical categories of actuality. In this sense, Heisenberg's return is fundamentally conceptual rather than historiographical.

4.5 Plural “Greeks”: Heisenberg’s lineage as a deliberate construction

As with Schrödinger, the crucial point is selectivity. Heisenberg's “Greeks” are not the Ionians of naturalistic unity but the Plato and Aristotle of form, mediation, and modal being. He constructs a lineage that makes his philosophical stance in quantum mechanics appear not as an ad hoc invention but as a continuation of deep intellectual possibilities already articulated in classical philosophy. This construction is epistemically significant because it shows that appeals to antiquity can function as legitimizing devices: not merely arguments, but strategies for placing an interpretation within a broader history of reason.

This legitimizing function does not undermine the seriousness of Heisenberg's position. But it does clarify how the Greeks operate as a repertoire: their authority can be recruited to justify very different metaphysical and epistemological postures. Schrödinger's Greeks authorize an aspiration to unified, continuous, observer-independent reality; Heisenberg's Greeks authorize the acceptance of conceptual mediation, the non-actuality of properties prior to measurement, and the primacy of mathematical structure. The disagreement over quantum theory thus becomes, at least in part, a disagreement over which “Greek” legacy is to be treated as philosophically authoritative.

4.6 From quantum foundations to historiographical morals

The comparison between Schrödinger and Heisenberg already yields a general lesson: “the Greeks” operate as a plural repertoire that can legitimate incompatible philosophical stances within physics. Schrödinger's lineage secures an ideal of unified, observer-independent intelligibility; Heisenberg's lineage secures a framework of conceptual mediation, potentiality, and the primacy of mathematical structure. These are not historiographical claims about continuity of science so much as epistemic strategies for negotiating what quantum theory licenses us to say about reality.

5. Rovelli’s Aristotle: Continuity by Reconstruction and the Problem of Presentist Genealogies

Rovelli's recent “return to the Greeks” differs in kind from those of Schrödinger and Heisenberg. In their cases, Greek philosophy functions primarily as a conceptual repertoire for navigating foundational uncertainty in contemporary physics (Fernández

Mouján 2024). Rovelli, by contrast, mobilizes Aristotle chiefly to support a historiographical moral about the structure of scientific development: physics, he argues, is “largely cumulative,” and the standard image of progress as a sequence of ruptures misrepresents how scientific knowledge actually advances (Rovelli 2024). This section reconstructs the core of Rovelli’s continuity argument and locates its methodological vulnerability: the argument moves from regime-based reconstruction to claims about historical and conceptual continuity, thereby risking a presentist genealogy that smooths over precisely the discontinuities that matter most for understanding the transformation of physics from Aristotle to Galileo and Newton (Norton 2012; Palacios 2024).

5.1 The structure of Rovelli’s continuity argument

Rovelli’s paper advances a thesis that is, in one sense, immediately plausible: older theories are not simply discarded. They remain reliable and fruitful within restricted domains; later theories often preserve their successes while extending, refining, or reframing them (Rovelli 2024). This point is uncontroversial. It captures the everyday fact that Newtonian mechanics remains indispensable in many practical contexts, and that scientific practice often proceeds by layered modeling rather than abrupt abandonment.

The distinctiveness of Rovelli’s argument emerges when this domain-validity point is converted into a broader historiographical conclusion: since earlier frameworks remain “true” or “right” in their domain, science should be regarded as cumulative in a deep sense, and narratives that emphasize conceptual rupture are misleading (Rovelli 2024). The paper then seeks to give this conclusion force by using Aristotle as a test case. If even Aristotelian physics can be rehabilitated as “right” in ordinary conditions—where falling occurs in air rather than in vacuum—then the continuity thesis appears especially robust.

The argument therefore depends on a strong rhetorical and philosophical pivot: Aristotle is not merely “understandable” in context, nor merely “not stupid,” but “simply right” in a certain everyday regime (Rovelli 2024). The subsequent continuity narrative is designed to follow: if Aristotle is right in his domain, then the Aristotle–Galileo–Newton sequence becomes less a rupture than a progressive refinement, and modern physics can be redescribed as a chain of conceptual inheritances rather than a break with teleological natural philosophy.

5.2 The key maneuver: rehabilitation by modern regime modeling

Rovelli’s central maneuver is reconstructive. He models falling under Newtonian dynamics with resistance and emphasizes that, in such a model, velocity approaches a terminal value: after a transient, motion is approximately constant-speed, which he aligns

with an Aristotelian description of natural motion as constant speed in everyday experience (Rovelli 2024). This supports two associated claims: (1) The standard textbook contrast—Aristotle says constant speed; Galileo/Newton say constant acceleration—is misleading for “everyday” conditions in which drag is present; (2) Aristotle’s claims should therefore be treated as approximately correct within their proper domain, and the historical narrative of physics as a sequence of radical breaks is distorted (Rovelli 2024).

As physics pedagogy, this has real value: it reminds readers that constant acceleration is an idealization tied to neglect of drag and that actual falling frequently deviates from that idealization (Norton 2012). However, as a basis for a thesis about historical continuity, the move is fragile, because it depends on treating a modern regime reconstruction as a proxy for the conceptual content of an earlier framework. In effect, Aristotle’s descriptive claims are mapped into the language of Newtonian dynamics plus drag, and the resulting overlap in behavior is treated as vindication of Aristotle “in his domain.” The methodological worry is that this procedure establishes at most an extensional overlap, while the conclusion requires intensional continuity of explanatory framework (Palacios 2024).

5.3 Why the move does not license historical continuity

The crucial point is not that Rovelli’s model is “wrong,” but that its epistemic reach is limited. A modern model can generate patterns of motion that resemble what an older vocabulary reports, but that does not establish that the older framework and the later one share explanatory aims or conceptual structure.

To see the gap, consider what is being compared. Rovelli compares (i) a modern dynamical account (forces, equations of motion, and resistance terms) and (ii) an Aristotelian characterization, i.e. natural motion as a kind of motion whose intelligibility is tied to nature, place, and the structure of the cosmos.

Even if the Aristotelian statement “falling tends toward a roughly constant speed in ordinary media” tracks certain appearances, the Aristotelian explanation is not a proto-version of Newton plus drag. Aristotle is not offering a dynamical law with a corrective term; he is offering a different kind of account, one in which final causes and a stratified cosmos are not optional ornaments but core resources (Koyré 1968). When Rovelli treats a behavior reproduced by a Newtonian-with-drag model as a vindication of Aristotle, he effectively treats the Aristotelian claim as if it were merely a coarse-grained statement about kinematics. But the historical question is not whether Aristotle had an

approximately correct phenomenological generalization; it is whether the Aristotelian framework belongs to the same explanatory lineage as Galilean–Newtonian mechanics.

That lineage is precisely where discontinuity becomes salient. Galileo’s transformation of mechanics does not consist in finding a better value for a parameter in an Aristotelian model. It consists in rejecting teleological explanation as a basis for mechanics, elevating mathematical idealization to a constitutive role, and moving toward a unified account of terrestrial and celestial motion (Dear 1995; Wallace 1992). Newtonian dynamics then consolidates this transformation into laws that presuppose a non-teleological account of motion. The point is not that Aristotle made no contact with experience. The point is that the aim and form of explanation that makes Newtonian mechanics possible are not continuous with Aristotelian natural philosophy in the way Rovelli’s narrative suggests.

5.4 The continuity premise and its rhetorical force

Rovelli’s argument relies on a continuity premise that is rarely made explicit but does substantial work: If a later theory can reproduce the successful descriptive claims of an earlier framework in a restricted regime, then the earlier framework is retained as part of a cumulative development.

The premise is plausible when the earlier framework’s explanatory ideals remain in place and the later theory is an extension of the same representational strategy. It becomes questionable when the transition involves a change in (i) admissible forms of explanation, (ii) the ontology of what is basic, and (iii) the status of mathematics and idealization. The Aristotelian–Galilean transition is an instance of such a change; it is therefore a poor candidate for continuity by recoverability.

The rhetorical force of the premise is easy to understand: it allows one to convert a pedagogically useful point about regimes into a sweeping moral about scientific development. Yet precisely because of its rhetorical effectiveness, it demands methodological scrutiny. Without that scrutiny, a continuity narrative risks functioning as a kind of retrospective harmonization: the past becomes a set of partial descriptions waiting to be retranslated into present terms, and genuine differences in explanatory form are treated as superficial.

5.5 Presentist genealogy and the danger of Aristotle as limit case

We can now state the deeper problem: Rovelli’s continuity narrative encourages a presentist genealogy in which Aristotle becomes a kind of “limit case” of modern mechanics—valid when drag dominates and acceleration is not salient (Palacios 2024). That genealogy is attractive because it compresses historical distance: Aristotle is no

longer a fundamentally different kind of thinker; he becomes an early stage in a single unfolding project of describing motion. But this compression comes at a cost: it makes the decisive conceptual shifts that constitute early modern mechanics harder to see.

In other words, the problem is not that Aristotle cannot be redescribed using modern models; he can. The problem is that redescribing Aristotle in modern terms is not the same as understanding what changed when Aristotelian natural philosophy was displaced by Galilean–Newtonian mechanics (Bertoloni Meli 2006). A presentist genealogy reads the past as an anticipation of the present. An HPS-sensitive genealogy asks how the aims, norms, and explanatory resources of physics were transformed such that certain kinds of questions ceased to count as physical questions and certain kinds of explanations ceased to be admissible within mechanics (Dear 1995; Bertoloni Meli 2006).

Schrödinger and Heisenberg, notably, do not require such genealogical smoothing. Their “returns” exploit Greek plurality to clarify a conceptual crisis: they use Greek thought to articulate alternative stances toward realism, representation, and intelligibility. Rovelli’s return, however, uses Aristotle to underwrite a narrative of cumulative continuity. That difference in function explains why Rovelli’s use of the Greeks is particularly exposed to the objection developed in Section 2: recoverability is not continuity.

5.6 Setting up the decisive counterexample: Aristotle to Galileo

This is why the Aristotelian–Galilean transition must be brought back into the foreground. If there is a rupture in explanatory aims—teleological natural philosophy within a stratified cosmos giving way to non-teleological, mathematized dynamics within a unified order of nature—then the continuity moral cannot be read off from regime-based overlap alone (Koyré 1968; Dear 1995). The question is not whether Aristotle had a domain in which some of his generalizations track appearances. The question is whether treating those overlaps as evidence of cumulativity obscures the transformation that enabled the emergence of Newtonian law-governed mechanics.

6. Aristotle to Galileo: Rupture in Cosmology, Causation, and the Aims of Physics

If Rovelli’s continuity narrative is vulnerable, it is because the case he uses to dramatize cumulativity—Aristotle—belongs to a framework whose core explanatory aims are not continuous with those of Galilean–Newtonian mechanics. The decisive point is not that Aristotle made empirical mistakes, nor that some Aristotelian-sounding claims cannot coincide with ordinary appearances. The decisive point is that the transition from

Aristotle to Galileo is a rupture in what counts as a physical explanation and in the ontological and methodological presuppositions that structure the explanandum (Dear 1995; Palacios 2024). In this section I articulate the rupture in three dimensions: (i) cosmology (stratified cosmos versus unified order), (ii) causation (teleology and natural tendencies versus non-teleological dynamics), and (iii) aims and norms of physics (explanation as natural-philosophical account of why versus explanation as mathematically expressible lawlike relation).

6.1 Cosmology: from a stratified cosmos to a unified order of nature

A first and fundamental discontinuity concerns the structure of the world that physics is taken to describe. Aristotelian physics is not merely a set of claims about motion; it is embedded in a cosmological architecture in which the heavens and the sublunary realm are governed by different principles and exhibit different kinds of regularity (Koyré 1968; Machamer 1998). The sublunary world is the domain of change, generation and corruption, and heterogeneous motions; the celestial realm is ordered differently, displaying a distinct kind of regularity and a distinct ontological status. This stratification matters because it determines what counts as an explanatory question and what explanatory resources are admissible. The physics of a stratified cosmos is not, by default, a single unified theory of motion.

Galileo's intellectual project, by contrast, is inseparable from an aspiration to treat nature as unified in the respects relevant to mechanics. Even where Galileo's metaphysical and theological commitments remain complex, the methodological direction of his mechanics is toward uniformity of law: the same kinds of principles and mathematical relations should govern motions that earlier cosmologies treated as fundamentally different in kind. This is one sense in which early modern mechanics is oriented toward a "unified universe": not necessarily a fully modern cosmology in every respect, but a reorientation in which the explanatory division between sublunary and celestial loses its constitutive role for the study of motion (Koyré 1968; Machamer 1998).

This shift is not a minor background change. It reorganizes the very identity of physics. Under an Aristotelian framework, it is not obvious that one and the same mathematical-dynamical account should apply across the whole cosmos. Under a Galilean framework, it becomes a guiding ideal that such a unified account is precisely what physics should seek.

6.2 Causation: the exclusion of final causes from mechanics

The second discontinuity concerns causation and, more specifically, the status of final causation. In Aristotelian natural philosophy, teleological explanation is not an optional

retorical layer; it belongs to the explanatory economy by which natural change is made intelligible (Dear 1995). Motions are connected to the natures of things, and explanation is not exhausted by a description of how motions proceed. It addresses why a body tends in a certain way—why it moves toward its natural place, why certain tendencies count as natural rather than forced, and how such tendencies express the internal principles of natural beings. Physics here is not merely kinematics; it is an account of nature as purposive order.

Galilean mechanics marks a decisive departure by reconstructing the explanatory task of physics so that final causes cease to be admissible within mechanical explanation (Dear 1995; Machamer 1998). The explanation of motion is sought not in the ends toward which bodies strive, but in lawlike relations that connect quantities under specified conditions, articulated through mathematization and idealization. This does not require Galileo to deny that nature is ordered, or to deny theological interpretations of that order. It requires a methodological restriction: whatever ultimate metaphysical or theological ground one might ascribe to the order of nature, mechanics does not appeal to purposes as explanatory resources. The very intelligibility of motion is relocated from teleological ends to mathematically expressible relations.

This methodological exclusion of teleology is not merely a philosophical preference. It is a condition of the later conceptual possibility of Newtonian mechanics. Newton's laws do not explain motion by reference to final causes; they express general dynamical constraints relating forces, masses, and accelerations (or, in more modern terms, changes of momentum) in a way that is indifferent to purposes. If one treats Aristotelian teleology as continuous with this later project, one risks confusing two different senses of "natural motion": Aristotle's natural motion as directed fulfillment of nature, and the Galilean–Newtonian notion of unforced or inertial motion as motion that requires no teleological grounding.

6.3 Aims and norms: from *why* in nature to lawlike mathematical explanation

The third discontinuity concerns not cosmology or causation in isolation, but the aims and norms of physics as an epistemic enterprise. Aristotle's physics is part of natural philosophy: it aims to articulate the principles of nature and to make intelligible the patterns of change characteristic of natural bodies. Explanation is therefore deeply connected to ontology—what kinds of things exist, what their natures are, and how those natures ground their characteristic motions. The explanatory ideal is not primarily the

derivation of quantitative relations from universal mathematical laws; it is the articulation of natural principles and causes in a way appropriate to the domain of change.

Galileo's mechanics, by contrast, treats mathematization and idealization not merely as convenient instruments but as constitutive of explanation (Dear 1995; Norton 2012). To explain is increasingly to show how a phenomenon follows from a mathematically expressible relation under idealized conditions that isolate relevant factors. This is a transformation in what counts as a satisfactory answer (Wallace 1992). The shift can be described as a change in the explanatory question: from "Why does this body move as its nature dictates within a structured cosmos?" to "What general relation governs the change of motion under specified conditions, and how can it be expressed mathematically?" Once this shift occurs, the epistemic identity of mechanics changes. It becomes possible to treat explanation as lawlike structure rather than as disclosure of purpose-laden nature.

This is the sense in which the Aristotelian–Galilean transition is not well captured by regime-based recoverability. Recoverability shows that certain descriptive statements can overlap in some range of cases. It does not show that the epistemic norms governing what counts as explanation are preserved. And it is the transformation of those norms that constitutes rupture.

6.4 Why the rupture is invisible to continuity-by-reconstruction

We can now see why a continuity narrative based on modern reconstruction is likely to miss what matters. If one begins with contemporary dynamics and adds a term (drag), one can produce behavior that resembles an Aristotelian description: motion toward constant speed in a medium. But that resemblance is extensional. It concerns a kinematic pattern, abstracted from the explanatory economy in which it originally had meaning (Palacios 2024; Norton 2012).

From an Aristotelian standpoint, the interest of the pattern would be inseparable from questions about natural motion, the natures of bodies, the role of the medium, and the place of teleological explanation within physics. From a Galilean–Newtonian standpoint, the pattern is a consequence of forces, resistance, and dynamical relations expressible in mathematical form. The same observable regularity can thus be embedded in two different explanatory projects. To treat the regularity as evidence of continuity is therefore to mistake a shared output for a shared framework.

This helps diagnose the rhetorical force of claims like "Aristotle was right in everyday conditions." The claim is tempting because it points to a genuine fact about drag and ordinary experience. But it risks functioning as a category mistake: it collapses the

difference between an empirically adequate generalization and an explanatory framework. One can concede the former while rejecting the latter.

6.5 Galileo's restriction of physics and the possibility of progress

The rupture described above can also be framed positively: it clarifies what made progress in mechanics possible. Galileo's refusal of the sublunary–celestial division as constitutive for mechanics, and his restriction of mechanical explanation to non-teleological, mathematizable relations, together amount to a redefinition of what physics is for (Machamer 1998; Wallace 1992). Physics is no longer tasked with preserving purposes in nature or with articulating a cosmos structured by different ontological regimes. It is tasked with articulating general relations of motion that hold across contexts under idealizable conditions.

This restriction is not a “loss” of meaning but a gain in methodological power (Bertoloni Meli 2006). It makes possible a research program in which questions about ultimate metaphysical grounds—creation, divine intention, the moral order—are not treated as conditions of mechanical explanation. Physics may coexist with theological or metaphysical interpretations, but it does not require them to do its explanatory work. In this sense, the emergence of early modern mechanics depends on a delimitation of scientific explanation: the explanation of motion is not expected to deliver proofs about God, creation *ex nihilo*, or moral purpose. It is expected to deliver mathematically articulate laws and models that unify diverse phenomena.

The point here is methodological rather than polemical. To say that mechanics does not aim at proving theological doctrines is not to claim that science and theology cannot interact historically, nor to claim that scientists did not hold theological views. It is to claim that the progress of mechanics depended on a separation between the norms of physical explanation and the demands of teleological or theological justification. This separation is part of the rupture: it marks a shift in what physics takes itself to be doing when it explains motion.

6.6 Consequences for Rovelli's cumulativeness thesis

If the Aristotelian–Galilean transition is understood in this way, then the limitations of a continuity-by-reconstruction strategy become clear. Rovelli's argument invites us to see Aristotle as approximately correct in a certain regime and to treat this as evidence for cumulativeness (Rovelli 2024). But the historical and philosophical significance of the transition does not lie chiefly in whether a kinematic description matches ordinary experience. It lies in the transformation of the explanatory aims and norms of physics: the

exclusion of final causes from mechanics, the mathematization of explanation, and the move toward a unified account of motion.

This does not entail that the history of science is nothing but rupture, or that earlier frameworks contain no insight. It entails a more specific conclusion: the continuity that can be established by domain validity and recoverability is insufficient to ground a claim of deep historical cumulativeness across frameworks whose explanatory aims are discontinuous (Crowther 2020; Palacios 2024). In the Aristotelian–Galilean case, the discontinuity is precisely what enabled the later cumulative development of classical mechanics (Dear 1995; Bertoloni Meli 2006). It is therefore misleading to treat the case as emblematic of continuity.

6.7 What the “returns” reveal

The argument of this section also illuminates the broader comparative claim of the paper. Schrödinger and Heisenberg return to Greek philosophy because modern physics forces a renegotiation of what science can say about reality. Their returns are symptomatic of conceptual openness and foundational tension. Rovelli returns to Aristotle to stabilize a narrative of cumulativeness by smoothing over rupture. But the Aristotelian–Galilean rupture is not an incidental detail; it is constitutive of the emergence of modern mechanics. Recognizing that rupture does not deny that theories can be domain-valid or that later theories can recover earlier regularities. It denies that such recoverability suffices to establish continuity of physics as an explanatory project.

7. The Rhetorical and Epistemic Work of “the Greeks”: Three Returns, Three Functions

Schrödinger, Heisenberg, and Rovelli all “return to the Greeks,” yet their returns do not perform the same kind of epistemic work. The difference is not merely one of personal taste or educational background. It concerns the function antiquity is made to serve within an argument about physics—whether it is mobilized to (i) reopen foundational possibilities, (ii) legitimate a contested interpretation, or (iii) stabilize a historiographical narrative of continuity (Fernández Mouján 2024). This section articulates a typology of these functions and shows how it clarifies both the strengths and the limits of Greek genealogies in modern physics.

7.1 Greek philosophy as a repertoire, not an origin-story

A first guiding observation is that “the Greeks” are not a unitary intellectual source. Greek philosophy is a landscape of tensions—being and becoming, continuity and

discreteness, appearance and reality, mathematization and empirical attention—and a “return” to it is never simple retrieval. It is a selective act that constructs a lineage by choosing which Greek voices count as authoritative for the problem at hand (Fernández Mouján 2024).

This has two consequences. First, Greek genealogies are productive rather than merely descriptive: they help to make certain philosophical stances in modern physics appear intelligible and historically grounded. Second, they are contestable: since Greek philosophy is plural, different invocations can support incompatible conclusions. The appeal to the Greeks therefore positions disputes; it does not by itself decide them.

7.2 Three functions of a “return”: reopening, legitimation, stabilization

The cases examined here suggest three distinct functions.

1) Conceptual reopening under crisis. In a foundational crisis, “the Greeks” can function as a repertoire of conceptual possibilities that precede and exceed modern disciplinary constraints. This is the dominant function in Schrödinger and, in a different register, in Heisenberg. Quantum mechanics disrupted inherited assumptions about objectivity, determinism, and picturability; Greek debates offered a vocabulary for reframing what physics can claim about being, becoming, and the structure of knowledge (Schrödinger 1951, 1954; Heisenberg 1958; Verelst and Coecke 2006). In this function, the Greeks are invoked not to show that science steadily accumulates truths, but because the foundations are open.

2) Interpretive legitimation in contested foundations. A return can also function as a legitimizing strategy: by anchoring an interpretation in venerable lineages, a physicist can present it as continuous with deep rational traditions rather than as an ad hoc response. This is clear in the contrast between Schrödinger and Heisenberg. Schrödinger’s pre-Socratic lineage authorizes an ideal of unified intelligibility; Heisenberg’s Platonic–Aristotelian lineage authorizes a view centered on mathematical structure, potentiality, and epistemic limits. Here “the Greeks” provide not merely ideas but authority for competing conceptions of what physics is entitled to claim.

3) Historiographical stabilization of continuity narratives. A third function, prominent in Rovelli, uses Greek physics less to reopen conceptual options than to stabilize a narrative about scientific development: science is “largely cumulative,” and even Aristotle can be rehabilitated as “right” in an appropriate domain once the relevant regime is modeled properly (Rovelli 2024). Here Aristotle serves as a crucial test case: if the most obvious counterexample can be neutralized, the continuity story gains rhetorical

force. But it is also where the argument is most vulnerable, since the Aristotelian–Galilean transition is precisely a case where rupture in explanatory aims matters most.

7.3 The performative dimension

Across these functions there is also a performative dimension: invoking Greek philosophy signals that one is addressing foundational questions rather than merely technical puzzles. Greek reference serves as a marker of philosophical seriousness and helps frame disputes as reappearances of long-standing tensions in rational inquiry. But performative depth is not historiographical evidence. The fact that modern physicists can recruit Greek concepts to support modern interpretations does not entail that the history of physics is best told as a steady accumulation of retained frameworks.

7.4 What the typology clarifies

The typology explains why Schrödinger and Heisenberg can be philosophically illuminating even when their readings of antiquity are selective: their aim is to renegotiate the conceptual possibilities of physics under pressure, not to supply a genealogy of cumulative development. Rovelli's case is different. Because it draws a historiographical moral, selective reconstruction becomes consequential: what matters is not selectivity as such, but the inference from regime-based reconstruction to continuity of explanatory aims.

The broader moral is therefore restrained. Greek genealogies can legitimately clarify options and legitimate interpretive stances. But they cannot, by themselves, establish continuity of explanatory frameworks across episodes where explanatory aims, norms of adequacy, and ontological commitments are reconstituted. In that sense, a “return to the Greeks” is best treated as a strategic epistemic act whose philosophical value depends on which function it serves and on whether the inferences drawn from it fit that function. This sets up the conclusion's central claim: domain-limited adequacy and recoverability are real virtues of physics, but they do not by themselves warrant a strong thesis of historical cumulativeness across ruptures in explanatory framework.

8. Conclusion: Beyond Cumulativeness—What “Returns to the Greeks” Can (and Cannot) Show

This paper has argued that “returns to the Greeks” in modern physics do not have a single epistemic meaning. In Schrödinger and Heisenberg, Greek philosophy functions primarily as a repertoire for negotiating the conceptual authority of physics under quantum-theoretical strain: Schrödinger's “Greeks” authorize an ideal of unified,

observer-independent intelligibility, while Heisenberg's "Greeks" legitimate conceptual mediation through mathematical form and Aristotelian potentiality. In Rovelli, by contrast, Aristotle is mobilized to support a historiographical moral—cumulativity and continuity—by translating historical claims into modern regime behavior.

The central methodological result is that this inferential move is not licensed. Regime validity and recoverability can establish extensional agreement, but they do not by themselves establish continuity of explanatory aims, conceptual roles, or ontological architecture. Continuity, in the historiographically relevant sense, is a claim about the stability of explanatory norms—not merely about the approximate preservation of outcomes.

The Aristotelian–Galilean transformation is therefore not a marginal complication but a decisive counterexample. Even where descriptive overlaps can be reconstructed, the historical significance of the transition lies in the reconstitution of what counts as a physical explanation: teleology excluded from mechanics, mathematization and idealization made constitutive, and the aim of a unified account of motion brought into view. The broader moral is conditional rather than sloganistic: scientific change can be cumulative in predictive success while discontinuous in explanatory framework, and appeals to “the Greeks” illuminate this only when we specify the epistemic function—conceptual reopening, interpretive legitimation, or historiographical stabilization—they are made to serve.

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From quantum indeterminacy to biological mutation: probabilistic stability across physical and living systems

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Abstract

The classical deterministic worldview that dominated science from the seventeenth to the nineteenth century has been profoundly challenged by developments in modern physics and biology. Quantum mechanics has revealed that indeterminacy and probability are not merely epistemic limitations, but intrinsic features of physical reality. At the same time, evolutionary biology has shown that random genetic variation, filtered by natural selection, is the fundamental driver of biological diversity and adaptation. This article explores the conceptual parallel between quantum indeterminacy and evolutionary randomness, not as a reduction of biology to physics, but as an epistemological reflection on how stability and order emerge from probabilistic processes across different levels of organization. Its original contribution is to formulate a cross-domain account of probabilistic stability, according to which stable macroscopic regularities emerge from indeterminate micro-processes through constraints, selective filtering, and scale-dependent organization. By examining emergence, contingency, historical irreversibility, and the limits of prediction, the paper argues that determinism is best understood as a scale-dependent approximation rather than a foundational ontological principle. The absence of finality in nature does not imply chaos or nihilism, but invites a renewed philosophical understanding of explanation, responsibility, and scientific humility in a probabilistic universe.

Keywords: quantum indeterminacy; evolutionary biology; emergence; contingency; philosophy of science; epistemology.[†]

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1. Introduction: The end of classical determinism

From Galileo to Newton, classical science was structured around the ideal of determinism. The universe was conceived as a vast, intelligible mechanism governed by precise laws, such that complete knowledge of initial conditions would, in principle, allow the prediction of all future states. Uncertainty, within this framework, was interpreted as a limitation of knowledge or measurement, not as a property of reality itself. Laplace's well-known image of a hypothetical intelligence capable of calculating the entire future of the universe from present conditions epitomized this epistemological ideal [1].

This deterministic conception profoundly influenced early biological thought. Even after Darwin introduced variation and natural selection as central mechanisms of evolution [2], biological processes were often interpreted as if they followed necessary or optimal trajectories, an outlook exemplified by Claude Bernard's insistence on strict experimental determinism in physiology [3].

During the twentieth century, however, this worldview underwent a radical transformation. Quantum mechanics revealed that indeterminacy and probability are not merely epistemic artifacts but intrinsic features of physical reality [4, 5]. In parallel, modern genetics and evolutionary theory demonstrated that biological novelty arises from random mutations whose evolutionary fate depends on contextual selection rather than necessity. Together, these developments challenge the classical assumption that scientific explanation requires determinism, replacing it with a framework in which probability and context play constitutive roles.

While these themes have been separately discussed in philosophy of physics and philosophy of biology, they are rarely integrated into a unified framework. The present article proposes such integration by comparing how probabilistic micro-processes generate higher-level stability in both domains.

The central thesis of this article is that determinism is best interpreted not as a fundamental ontological principle, but as an effective higher-level regime emerging from probabilistic processes under constraints of historical filtering, relational dynamics, path dependence, and statistical aggregation. This position also contributes to current debates on reductionism, levels of explanation, and probabilistic causation in contemporary philosophy of science across different domains of nature.

The paper proceeds as follows. Section 2 examines quantum indeterminacy and its philosophical interpretations. Section 3 analyzes randomness and selection in evolutionary biology. Section 4 develops emergence as a key conceptual bridge between levels of organization. Section 5 explores contingency, history, and irreversibility. Sections 6 and 7 address the epistemological consequences of probabilistic explanation, while Section 8 considers broader philosophical and ethical implications. The

conclusion synthesizes these insights into a coherent view of science in a probabilistic world.

2. Quantum indeterminacy: probability as a feature of reality

2.1. Ontological and instrumental interpretations

Quantum mechanics introduced a profound rupture with classical physics by challenging the assumption that physical systems possess well-defined properties independent of observation. According to the standard formalism, the quantum state does not describe an actual configuration of properties but encodes a set of probabilities for possible measurement outcomes. This feature has generated extensive philosophical debate concerning the ontological status of quantum states.

The Copenhagen interpretation, historically dominant, adopts a form of epistemic modesty: quantum theory does not describe reality “as it is,” but provides probabilistic rules for predicting measurement outcomes. In contrast, realist interpretations, such as many-worlds, attempt to preserve an ontological description of quantum reality, though at the cost of revising classical intuitions about individuality, locality, or actuality.

For the purposes of this article, it is not necessary to resolve this debate. What matters philosophically is that most major interpretations of quantum mechanics depart from classical Laplacian determinism in at least one essential respect. Whether indeterminacy is understood as ontological or as a limit of representability, the theory itself assigns probabilities, not certainties, even under conditions of maximal knowledge.

2.2 Indeterminacy is not chaos

It is crucial to emphasize that quantum indeterminacy does not imply disorder or arbitrariness. Quantum systems obey precise mathematical laws, conservation principles, and statistical regularities. The probabilistic nature of quantum mechanics is tightly constrained: not all outcomes are possible, and those that are possible occur with well-defined probabilities.

This distinction between indeterminacy and chaos is philosophically significant. A probabilistic world can be highly structured and intelligible. Statistical laws play a central explanatory role. At larger scales, these regularities give rise to remarkably stable macroscopic phenomena.

This insight prepares a conceptual transition to biology. Just as probabilistic quantum events do not entail physical disorder, random mutations in biology do not entail

evolutionary arbitrariness. In both cases, probability operates within a framework of constraints.

2.3 Decoherence and levels of explanation

The emergence of classical stability from quantum indeterminacy is largely explained by the theory of decoherence. Through constant interaction with their environment, quantum systems rapidly lose phase coherence, leading to the suppression of interference effects and the appearance of classical behavior [6]. Importantly, decoherence does not eliminate indeterminacy; it explains why probabilistic superpositions are not observed at the macroscopic level.

Decoherence thus illustrates a key philosophical point: stability can emerge without determinism. Deterministic behavior appears as a higher-level approximation resulting from scale, interaction, and averaging effects. This lesson will prove central when we turn to biological systems.

3. Random mutation and natural selection in evolutionary theory

Evolutionary biology is structured around a similar interplay between randomness and constraint. Genetic mutations arise from specific causal molecular processes explaining why they occurred, such as replication errors or DNA damage. Therefore, they are causally grounded but undirected in evolutionary terms. This structure mirrors the quantum case: events may be causally embedded while remaining non-deterministically distributed with respect to relevant outcomes.

Randomness in this sense does not imply biological disorder. Natural selection acts as a systematic filtering process, preserving variants that enhance reproductive success in given environments. As Mayr emphasized, variation provides possibilities, while selection confers directionality without foresight [7].

This distinction clarifies a persistent conceptual confusion: evolutionary processes generate adaptive traits with functional organization (teleonomic), yet without intentional design or intrinsic purpose (teleological). Monod's formulation of "chance and necessity" captures this dual structure: chance generates variation, while necessity reflects the constraints imposed by physical laws and environmental conditions [8].

Crucially, selective necessity should not be confused with global determinism. Evolutionary outcomes are contingent, path-dependent, and historically irreversible. The necessity involved is local and conditional, not global or absolute. A comparable situation arises in quantum physics, where probabilistic laws constrain outcomes without fixing them uniquely.

4. Emergence and levels of organization

4.1. Weak and strong emergence

The concept of emergence plays a central role in understanding how probabilistic processes yield stable patterns. Philosophically, a distinction is often drawn between strong emergence where higher-level phenomena break lower-level laws, and weak emergence where higher-level patterns arise from lower-level interactions but require distinct explanatory frameworks.

The position defended here aligns with a conception of weak emergence. Biological phenomena are grounded in micro-molecular processes, including genetic variation and biochemical interactions, yet they cannot be fully understood through micro-level descriptions alone. Concepts such as function, adaptation, and natural selection are indispensable for biological explanation, even though they presuppose molecular substrates. Rejecting brute reductionism at the explanatory level does not imply a denial of physical causation, nor does it entail any appeal to vitalistic principles. Rather, it reflects the necessity of distinct explanatory frameworks capable of capturing the organized, historical, and probabilistic character of living systems.

As Lewontin argued, organisms are not passive outcomes of genes or environments, but dynamic systems constituted by reciprocal interactions across levels [9]. Comparable anti-reductionist arguments have also been developed in recent philosophy of biology and systems science [10, 11]. Stability, in this framework, is not imposed from below but emerges from coordinated processes across scales.

4.2. Epigenetics as a paradigmatic case

Epigenetics provides a particularly illuminating illustration of emergent organization. Mechanisms such as DNA methylation, histone modification, and regulatory RNA activity modulate gene expression without altering nucleotide sequences. These processes demonstrate that genetic information does not function as a fixed causal script, but as a context-sensitive resource shaped by developmental and environmental history.

Recent work emphasizes that epigenetic states can stabilize phenotypes across generations while remaining probabilistic and reversible [12, 13]. This introduces a form of downward or contextual causation, where higher-level organizational states constrain molecular processes without violating physical laws.

Epigenetics thus reinforces a non-reductionist yet rigorously naturalistic understanding of biological stability as an emergent, historically contingent phenomenon.

5. Contingency, history and irreversibility

One of the most profound implications of evolutionary theory is the centrality of historical contingency. Evolutionary trajectories depend on sequences of events that could have unfolded differently. Gould's thought experiment of "replaying the tape of life" vividly illustrates the non-repeatability of biological history [14]. This does not imply absence of pattern, but sensitivity of outcomes to historically contingent branching points.

This historical dimension finds a parallel in the physics of complex systems. As Prigogine argued, systems far from equilibrium exhibit genuine irreversibility, introducing an objective arrow of time into physical processes [15]. While physical and biological histories differ in important respects, both resist reduction to timeless laws.

In both domains, prediction becomes limited. Science can identify constraints, tendencies, and probability distributions, but not precise long-term outcomes. Path dependence implies that small, contingent events can have enduring consequences, reinforcing the role of historical explanation alongside law-based reasoning.

6. Ontological and epistemic randomness

A common objection to probabilistic interpretations is that randomness merely reflects incomplete knowledge. According to this view, a sufficiently complete model would restore determinism. While this argument has intuitive appeal, it faces serious difficulties.

In quantum mechanics, indeterminacy persists even when systems are fully described by their wave functions. In evolutionary biology, even exhaustive knowledge of genetic and environmental conditions does not allow precise prediction of long-term evolutionary outcomes. The complexity and historical openness of biological systems exceed what deterministic modeling can capture.

Distinguishing ontological from epistemic randomness is therefore essential. Ontological randomness refers to genuine indeterminacy in processes themselves; epistemic randomness reflects limitations of knowledge or representation. Modern physics and biology suggest that both forms coexist, and that ontological randomness cannot be eliminated without distorting empirical reality.

Accepting this does not weaken scientific explanation. On the contrary, it clarifies its scope: explanation becomes the identification of structured spaces of possibility rather than the derivation of unique outcomes. The relevant philosophical task is therefore not to eliminate randomness, but to understand the diverse forms and explanatory roles through which randomness operates across the sciences.

7. Epistemological consequences for scientific explanation

The convergence between quantum physics and evolutionary biology invites a reassessment of classical epistemological ideals. Prediction, long considered the hallmark of scientific success, must be supplemented by explanation and understanding.

In probabilistic sciences, explanation often consists in mapping possible trajectories, identifying constraints, and characterizing distributions rather than predicting singular outcomes. Recent philosophy of science increasingly treats explanation as probabilistic, model-based, and context-sensitive rather than purely predictive, particularly in the study of complex systems [16].

Models, scenarios, and simulations play a central epistemic role. They explore spaces of possibility rather than exact futures. This approach preserves the unity of science while respecting disciplinary specificity. Physics and biology share a probabilistic structure, yet operate with distinct concepts and explanatory aims. This supports a pluralist conception of scientific unity grounded in shared explanatory values rather than identical methods.

8. Philosophical and ethical implications

A world without predetermined finality may initially appear unsettling. However, contingency is not equivalent to meaninglessness. On the contrary, contingency makes agency possible. In a fully deterministic universe, action would merely unfold necessity. In a probabilistically structured world, actions can function as genuine difference-makers within open trajectories.

This insight supports an ethics of prudence and responsibility, particularly relevant in domains such as environmental intervention, biotechnology, and public policy. Decision-making under uncertainty requires humility, reflexivity, and awareness of long-term consequences.

Scientific humility follows naturally from this worldview. Recognizing the limits of prediction and control does not diminish science; it situates it within a broader understanding of complexity and responsibility.

9. Conclusion

The comparison developed in this paper suggests that quantum physics and evolutionary biology share a deeper explanatory architecture: indeterminate micro-processes can generate robust macro-regularities under suitable constraints. Determinism is therefore better conceived as an emergent regime than as the primitive grammar of nature.

Life, like matter, unfolds within a structured space of possibilities shaped by chance, law, and history. Embracing this perspective deepens our philosophical

understanding of explanation, freedom, and responsibility. To think the living world probabilistically is not to abandon rigor or meaning, but to recognize contingency as a condition of creativity, humility, and ethical responsibility in an evolving universe.

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Il Dio Onnipotente (The Almighty God)

Rosario D'Amico*

Sommario

Questo contributo si propone di riflettere e indagare su cosa debba intendersi *stricto sensu* con il termine “Onnipotenza”, cioè cosa comporti supporre l'esistenza di un essere reale Onnipotente, il quale non può quindi subire ciò che non vuole o, il che è lo stesso, può realizzare qualsiasi cosa di logicamente possibile voglia, non potendo essere reale né immaginato, né quindi voluto, ciò che è contraddittorio. L'approccio sarà strettamente filosofico, evitando così derive banali, intenti devozionali o giudizi morali a favore della chiarezza concettuale. Sulla base di questa analisi, tratteremo infine ciascuna delle seguenti questioni: è possibile che un essere Onnipotente sia anche buono e comprensibile? Se sì, potrebbe abolire o sacrificare il male nel mondo?

Keywords: Dio; Libero arbitrio; Male; Onnipotenza.¹

Abstract

This paper aims to reflect upon and investigate what is meant strictly speaking by the term "Omnipotence"; specifically, what it entails to posit the existence of a real Omnipotent being. Such a being, therefore, cannot be subject to what he does not will or, in other words, can bring about anything logically possible that he wants, since that which is contradictory can be neither real, nor imagined, nor, consequently, willed. The approach will be strictly philosophical, eschewing commonplace drifts, devotional intents, or moral judgments in favor of conceptual clarity. Based on this analysis, we will finally cover each of the following issues: Can there be an Almighty being who is also good and understandable? If so, could He abolish or sacrifice evil in the world?

Keywords: God; Evil; Free will; Omnipotence.

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*“Così Dio creò gli uomini secondo la sua immagine;
a immagine di Dio li creò; maschio e femmina li creò.”
(Gen 1,27)*

1. Introduzione

Cosa è un essere (reale) Onnipotente? È un dio. Cosa è un dio? È un essere Onnipotente, supremo, il quale non può subire ciò che non vuole, cioè può realizzare subito e fedelmente tutto ciò che vuole, ma senza coinvolgere alcuna antinomia, senza negare il *principium firmissimum*, il principio di non-contraddizione, poiché ciò che è reale, o che è immaginabile e dunque potenzialmente voluto, non può essere contraddittorio. Ne consegue che:

1) L'Onnipotenza non può riguardare vari esseri reali: infatti, se ve ne fossero almeno due e non si identificassero, uno di loro non avrebbe alcun potere sull'altro, essendo limitato dall'Onnipotenza di quest'ultimo. Ma se un tale essere si contraddicesse, se fosse Onnipotente e non-Onnipotente allo stesso tempo, negherebbe sé stesso, poiché ogni essere reale è necessariamente non contraddittorio.

D'altra parte, supporre che l'Onnipotenza sia un attributo accidentale di uno dei possibili $n > 1$ esistenti e perciò una proprietà bilateralmente trasferibile tra due soggetti reali diversi conduce ugualmente ad una lampante antinomia.² Sicché un solo essere, e in sostanza, può caratterizzarsi come Onnipotente (Unicità dell'Onnipotente). In definitiva, l'Onnipotente è Dio e Dio è l'Onnipotente. ■

2) La volontà di Dio è condizione necessaria e sufficiente affinché un qualsiasi ente possibile X esista (sia reale)³; infatti, l'Onnipotente non può subire passivamente alcun aspetto di X , niente di questo che non voglia, neanche la stessa possibilità che esso sia, che non sia o che venga pensato. ■

La realtà dell'ente X non può allora essere una circostanza più o meno contingente che si impone a Dio Onnipotente, ma deve essere qualcosa da Lui creata *ex nihilo* – senza servirsi di niente e di nessuno –, qualcosa di cui Dio è obbligatoriamente e del tutto la *ratio essendi*, il sommo artefice.

Nessun ente, in quanto creatura, può perciò cogliere o manifestare

² Tale Onnipotente potrebbe infatti decidere di destinare definitivamente la sua accidentale Onnipotenza ad un altro essere reale, senza che con ciò venga compromessa l'identità di questi due attori; il soggetto ricevente, divenendo quindi Onnipotente, si porrebbe nella condizione di restituire, di poter respingere a sua volta la somma potenza conferitagli, inficiando così il volere Onnipotente del conferente.

³ Va evidenziato che, data l'impossibilità di pensare il contenuto di una contraddizione, volere l'esistenza di X implica non volerne, al tempo stesso, l'assenza, la non-esistenza.

appieno l'invincibile potenza di Dio e neppure quantificare ciò che Egli crea o ciò che è in grado di creare. Per dirla con Bruno Forte:

*“L’Onnipotenza creatrice non può essere misurata sul metro delle nostre conoscenze, e in ogni caso, non può essere limitata da noi nelle sue infinite possibilità: Dio è Dio e la creatura non è Dio”.*⁴

A buon diritto, quindi, Onnipotente è da secoli anche un titolo usato in varie tradizioni religiose per enfatizzare l'autorità somma della divinità, che viene contrassegnata dal potere e dalla capacità di controllare tutti gli aspetti dell'esistenza. Esso, talvolta, sembra racchiudere Dio come fonte di conforto, giudizio e misericordia evidenziando la sua natura onnicomprensiva e la sua presenza invocata nella preghiera e invitando la spiritualità e la riverenza dei credenti che cercano la guida divina.

Tuttavia, le brevi considerazioni sull'Onnipotenza fin qui esposte sono frutto di una ragione spontanea senza il sostegno di qualsivoglia rivelazione o magistero, sono cioè tali che la loro legittimità non è stabilita o giustificata solo perché deducibile da qualche testo sacro o plausibile nel letto di un dato contesto intellettuale contemporaneo, sia esso laico o religioso.

Disponiamo così di uno strumento teorico libero, svincolato da ogni riferimento alla fede o alla cultura, che si rivelerà utile per guardare da una diversa prospettiva a due problemi basilari che interpellano l'uomo di ogni tempo: la presenza del male naturale, intimamente correlato al nostro impotente stato di «terrenità», e il complesso e affascinante tema dei fondamenti della libertà e responsabilità umana, del male morale che spesso porta nel mondo, nella realtà in cui viviamo ingiustizia, violenza e soprusi.

Proprio questi due interrogativi saranno oggetto di approfondimenti specifici nei due paragrafi che compongono questo scritto.

Nel primo, dopo aver analizzato la cosiddetta «questione del male» in modo sintetico e intuitivamente chiaro, mostreremo che, se esiste l'uomo, Dio non è in grado di impedire il male, essendo quest'ultimo il prodotto dell'intrinseca impotenza che caratterizza tutti e ciascuno dei viventi che popolano il creato.

Nel secondo, cercheremo di capire se e in che termini, in ordine alla perenne e sostanziale gravità del male, il possibile sia in mano ad una volontà buona e comprensibile oltre che Onnipotente, capace di fissare in modo irrevocabile un determinato stato del mondo.

In conclusione, ad ulteriore sostegno delle tesi proposte, formuleremo un'interpretazione della venuta, passione e morte di Gesù – ritenuto buono e nella condizione di Dio – come una valida risposta al presumere infondata l'ipotesi dell'esistenza di un essere Onnipotente e al dramma della sofferenza, cioè al fatto che questa sofferenza venga in qualche modo giustificata.

⁴ B. FORTE, *Piccola introduzione alla fede*. EDIZIONI SAN PAOLO s.r.l., Ed. 9° 2011, pp 33-34.

2. L'Onnipotenza e la questione del male

La sofferenza degli innocenti e specialmente quella dei bambini non rimane soltanto una annosa questione per la filosofia e la teologia, ma è il vero grande mistero tanto pressante quanto inevitabile che da sempre attanaglia l'esistenza umana. Ogni tentativo di spiegazione va dunque fatto con il dovuto rispetto. In quest'ottica, tenteremo di affrontare il problema scomponendolo in termini metafisici, fisici e morali al fine di rispondere alle seguenti domande di fondo:

Qual è la natura della sofferenza e, integrata con il dolore, del più generale male nel mondo? Appurato che il male esiste, in cosa consiste? Come si configura in relazione all'essere vivente?

Certamente, il male non è qualcosa che è o che continua ad essere all'infuori di noi, ma non può neanche essere visto come un prodotto esclusivo della nostra mente, un'illusione, soltanto come una concezione puramente soggettiva. Esso si deve allora identificare con qualcosa che dipende non solo da chi lo giudica, ma anche da una serie di variabili indipendenti da noi, di elementi oggettivi che etichettiamo appunto come male.

A guardare bene, il male può compiutamente definirsi esplicitando le sue due indubbie ed esaustive caratteristiche di base:

- esso è qualunque cosa di dannoso o sgradito da cui difendersi o fuggire;
- esso non può apparire autonomamente in relazione a sé stesso; perché si possa manifestare, il male necessita di qualcuno che sia in grado di concepirlo e ravvisarlo come tale, di qualcuno che sia costretto a sperimentarlo, e quindi anche di qualcosa che possa o arrivi a compierlo. Non vi può essere male laddove manchino una coscienza consapevole e un elemento o un valore che la riguardi e sia ad esso esposto, che ne corra il rischio – e.g., il terremoto nel deserto del Sahara non può considerarsi un male perché in tale luogo non vi sono persone, né beni ad esse legati, esposti al pericolo terremoto. Infatti, nessun vivente vorrebbe sensatamente respingere qualcosa da cui prescinde, che non lo interessi affatto, neanche indirettamente, e, quindi, venendo meno la condizione prevista al punto precedente, ciò non sarebbe un male –.

Senza ledere la generalità, d'ora in avanti ci limiteremo a chiamare *male* ogni cosa o azione reale che coinvolga l'uomo ed è da lui universalmente ritenuta essere restrittiva, dannosa o offensiva per sé stesso o per le proprie opere, e che risulti dunque contraria alla sua volontà; ne sono esempi comuni: i limiti personali, il possibile o concreto verificarsi delle guerre, dei terremoti, della corruzione, della pedofilia, delle malattie etc.

Condizione necessaria e sufficiente perché vi sia il male è la presenza di almeno un uomo impotente, imperfetto, incapace cioè di imporre puntualmente e prontamente il proprio esserci o un proprio volere su un'altra

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o tutte le altre cose del mondo, impossibilitato cioè ad assicurarsi il proprio benessere, ossia a fare le tre cose seguenti:

- a mantenere un qualcosa che si ha e non si vuole perdere;
- a riuscire a realizzare una volontà, qualcosa di preciso cui si punta;
- difendere i valori in cui si crede e ai quali si ispira la propria vita.

Se tutti gli uomini fossero Onnipotenti, cioè se nemmeno uno di questi potesse subire ciò che non vuole, nessun male sarebbe nel mondo e viceversa.

Difatti, se vi è il male nel mondo, deve esserci almeno un uomo che non sia Onnipotente, la cui potenza non sia assoluta, cioè che non possa fare tutto ciò che di non-contraddittorio voglia. Se così non fosse, se ogni uomo fosse in grado di realizzare fedelmente la propria volontà e quindi di garantirsi il proprio benessere, nessun male, nel senso che abbiamo sopra indicato, potrebbe mai presentarsi o essere presente nel mondo.

Viceversa, se ci fosse almeno un uomo non-Onnipotente/impotente, tale persona verrebbe chiaramente esposta alla concreta possibilità di subire qualcosa che non voglia che sia; questa stessa possibilità, unanimemente, sarebbe un suo evidente e sgradito limite, costituendosi così come male.

Vi è quindi equivalenza logica tra la presenza del male nel mondo e l'impotenza umana. Chiaramente ogni discorso su Dio e sul male è qui antropomorfo e quando ne dibattiamo li poniamo in rapporto a noi.

In questo contesto, si può parlare dell'Onnipotente (di Dio) come di un essere buono – i.e., il cui volere è indirizzato al benessere di ogni sua creatura vivente – e in qualche modo comprensibile all'uomo?

Se Dio fosse buono, sembrerebbe inspiegabile il perché non abbia neutralizzato e non neutralizzi il male. Se fosse comprensibile, allora la sofferenza dell'innocente sembrerebbe confutare la sua bontà. Se fosse buono e comprensibile, la gravità del male parrebbe sconfiggere la sua Onnipotenza.

Tuttavia, l'ineluttabile impotenza/imperfezione delle creature umane non mette in discussione l'Onnipotenza divina – Dio, come visto nella introduzione, non avrebbe potuto creare un altro essere reale Onnipotente –.

Se ne deduce che il male nel mondo, poiché conseguenza logica dell'ordine stesso, non è propriamente creato da Dio; Egli non può prevenirlo né arrestarlo senza provocare il completo annientamento della razza umana.

Vi sono dunque degli ostacoli sistematici – quelli dovuti all'insita debolezza ed inadeguatezza della *materia vivente* alla quale apparteniamo –, che impediscono l'integra ed immediata attuazione di quanto ogni uomo desidera o si prefigge di fare, generando immancabilmente il male, che è esattamente sinonimo del nostro essere obbligati a sopportare i nostri limiti o della nostra invidia verso coloro che hanno qualità o beni superiori ai nostri di cui vorremmo godere ma che ci sono vietati dalla nostra connaturata imperfezione, da ogni nostra forma di inabilità.

Ma perché l'uomo non si accontenta di ciò che è, non si adatta al proprio stato e vuole e cerca di trascendere le costrizioni che gli sono imposte dal mondo fisico e che sono radicate nella sua stessa natura? Perché aspira ad avere potenza sulle cose e a poterla accrescere? Perché rivendica il suo bisogno-diritto di essere libero, indipendente da qualunque circostanza o considerazione e da ogni ragionamento? Principalmente perché vuole salvezza, vuole essere al sicuro dalle minacce e dai rischi del mondo e non può essere potente chi non è salvo dalle cose o dalle forze che gli sono ostili e non può essere salvo chi non ha la potenza bastante per ricacciare tali cose o per vincere tali forze.

La ragione per cui a volte ci dilettiamo a guardare le opere tragiche in cui vengono rappresentate situazioni spiacevoli nelle quali non vorremmo mai trovarci nella nostra vita reale sta proprio nell'effetto catartico indotto da quella distanza di sicurezza che la finzione frappone tra lo spettatore e la rappresentazione stessa.

Maggiore è questa distanza, maggiore è il fascino che il negativo esercita sull'astante proprio perché quest'ultimo viene in contatto con qualcosa che avverte sempre più governabile o depotenziata dalla sua pericolosità. La sensazione di impotenza che ci coglie davanti a una forza devastatrice, per esempio, si tramuta presto, se siamo del tutto al sicuro rispetto ad essa, nella sensazione opposta di una energia tale da restarne affascinati, proprio perché l'assenza di rischio e di timore per tale situazione di pericolo è ciò che ci conferisce una potenza commisurata all'imponenza della suddetta forza distruttrice ed è perciò sufficiente ad inibirne i possibili effetti nocivi su di noi, consentendoci di superare quella fragilità che ci fa sentire inferiori rispetto ad essa.

In definitiva, la crudeltà, la terribilità, le sciagure sono caratteri dell'esistenza umana quale essa è in sé, e non possono esserle sottratte senza che essa venga cancellata. Non vi è nessuna liberazione, nessun rifugio, nessuna possibilità di evitare l'assedio di una vita che può assestare colpi talvolta duri. Diversamente dalla chimera suggerita da un certo pensiero più o meno diffuso, Dio non può abolire il dramma, la croce dal mondo, poiché ognuno di noi è imprescindibilmente soggetto al male, soffre. Soltanto nelle produzioni cinematografiche e in altre fantasie del genere, caratterizzate spesso dall'*happy end*, vi sono irreali personaggi che hanno successo in ogni loro iniziativa personale, che non incontrano alcuna difficoltà nei rapporti con gli altri, che sono immuni da qualsivoglia fastidio e delusione della quotidianità. Per quanto si fondino ospedali, si aprano asili, si costruiscano ospizi, si facciano leggi giuste, il dolore e la sofferenza sono nostri compagni di vita e smetteranno di esserci se e solo se l'uomo, l'animale razionale

cesserà di esistere, se uscirà definitivamente dal novero dell'apparire.⁵

Giacché la divinità non implica per forza la deistica *apátheia*, l'impassibilità, il silenzio davanti al male nel mondo, si può salvare la bontà di Dio benché essa non abbia delle ricadute risolutive sull'uomo e sulla sua misera situazione? La bontà è salva per ciò che concerne l'origine e la sussistenza del male, ma resta da chiedersi perché il buon Dio, sapendo che l'uomo nel suo manifestarsi si contamina necessariamente con l'impotenza e il male non ha rinunciato a crearlo? Perché Egli non riesce a mitigare o alleviare gli effetti del male? Proprio questi due quesiti saranno il cuore dell'argomentazione che verrà affrontata e sviluppata nel prossimo paragrafo.

3. Onnipotenza e Volontà

Il male è dunque compreso nell'ordine. È questa impostazione ontologica che da un lato chiarisce da dove venga il male che poi rientra nell'ordine ma dall'altro implica l'emergere di un problema fondamentale: l'intensità del male in relazione alla completezza dell'armonia universale.

Un mondo senza pene fisiche o morali non può esistere, ma il buon Dio non avrebbe potuto almeno evitare che il dolore e la sofferenza raggiungessero l'attuale livello o che colpissero l'uomo nella misura in cui lo colpiscono oggi?

Non c'è infatti giorno che passi nel quale i principali mezzi di informazione non ci notizino del verificarsi nel mondo di eventi riprovevoli e violenti. E spesso capita di chiedersi il perché di così tanta crudeltà e cattiveria.

Potremmo essere tentati di liquidare la faccenda sulla gravità del male attribuendone la causa di fondo al comportamento egoistico dell'uomo, al suo "delirio di onnipotenza", ma dobbiamo per forza di cose ammettere che la responsabilità del mondo e di tutte le sue sventure non può non ricadere anche sull'ipotetico Dio buono e comprensibile, il quale ha creato tutto, assolutamente tutto anche il pensabile, e quindi, sa, da sempre e pienamente, come sarebbero andate le cose per noi; anzi, Egli stesso si configurerebbe come male, in quanto complice delle nostre malefatte e dei disastri naturali.

Fermiamoci a riflettere. Il buon Dio crea ma non sembra riuscire a controllare appieno il creato, vale a dire che la sua bontà può forse prevalere quando il numero degli accadimenti considerati è modesto, ma pare doversi arrendere ad una necessità, ad una sorta di libertà o di evoluzione creaturale quando, invece, gli eventi sono più numerosi.

Sebbene sia pacifico che questo Dio faccia di tutto perché il mondo sia più bello, più dignitoso e più giusto la selezione naturale renderebbe l'universo

⁵ Cfr. R. D'AMICO, *Bellezza e Potenza*, in "Phronein – Comune a tutti è il pensare –" Associazione Professionisti Pratiche Filosofiche, Giuliano Ladolfi Editore srl, n. 8, gennaio 2023, pp. 100-101.

così complicato e iniquo che per attenuarne il peso servirebbero altri tipi di interventi, maggiori in numero o in qualità, che esulerebbero dalla sua portata, contrastandone l'Onnipotenza. Il che sarebbe inconcepibile.

Perché allora Dio non interviene a nostro favore attenuando o togliendo radicalmente il dolore e la sofferenza da questo mondo?

Non possiamo qui esimerci dal pronunciarsi in merito ai motivi di queste scelte, sospendendo il giudizio, affermando, ad esempio, che ciò che è finito e imperfetto, l'uomo, non può capire totalmente l'infinito e il perfetto, cioè Dio.

Se infatti Dio è supposto comprensibile, non ci si può arrendere per manifesta incapacità, rassegnarsi ad un incomprensibile disegno divino, rinunciare alla stessa domanda, cioè non vi può essere alcuno spazio per un approccio che sostenga che la natura dell'Onnipotente è talmente trascendente per il nostro intelletto da dover interpretare questo silenzio come un mistero che può soltanto invitare alla fede o alla solidarietà umana.

Non possiamo nemmeno ritenere che il male sia solo un aspetto marginale rispetto alla bontà dell'opera della creazione, dell'esistenza, perché non sembra esserci alcuna prova che esistere sia meglio che non esistere; per dirla con Bertrand Russell: "*Esiste un'opinione comune (che non ho mai capito) per cui è meglio esistere che non esistere; su questa base si esortano i fanciulli ad essere grati ai loro genitori*".⁶

Una interessante teodicea che invece lascia intravedere una possibile spiegazione razionale al problema della gravità del male passa dall'analisi di ciò che comunemente viene chiamato *libero arbitrio*, ossia della facoltà di autodeterminarsi, di poter scegliere autonomamente i propri fini e le proprie azioni, che Dio avrebbe concesso all'uomo perché depositaria in sé di un bene tale da superare di gran lunga la quantità di male che il suo esercizio più o meno dissennato comporta. In questo caso, Dio buono e comprensibile si sarebbe reso intenzionalmente impotente pagando in termini di peccato il conseguente prezzo per questo incredibile dono fatto all'uomo. Insomma, Dio non avrebbe limitato o modificato la libertà umana perché ciò farebbe parte dei suoi desideri, dei suoi piani salvifici e delle regole che Egli stesso ha stabilito, autoimponendosele. E poiché questa decisione proverrebbe da Dio stesso e non da un'autorità esterna, non contraddirebbe la sua Onnipotenza.

Questa apologia merita però di essere precisata secondo due ambiti.

Il primo è che l'arbitrio non può essere veramente libero. Sentiamo di essere chiamati a scegliere, ma in realtà non siamo in grado di fare scelte concrete, di decidere qualcosa. Siamo infatti ingannati credendo di assumere delle decisioni quando invece, come ci suggeriscono anche le neuroscienze, i provvedimenti che prendiamo precedono le nostre cognizioni, l'agire si

⁶ B. RUSSELL, *History of Western Philosophy*, George Allen & Unwin Ltd, London, 1945, trad. it. *Storia della filosofia occidentale*, Tea S.r.l. Milano, 2017, p. 574.

prepara nel cervello prima della stessa intenzione.⁷ Questa attività non compare spontaneamente, ma è il frutto di condizioni neurofisiologiche, fattori genetici, stati emotivi ed ambientali.

L'altro ambito riguarda il fatto che nessuna creatura può avere un'esistenza contingente rispetto a Dio; ossia, niente può essere oggetto della sua volontà in modo fortuito. Lo si può provare tramite la seguente:

Proposizione 3.1 Siano A e $-A$ due eventi⁸ complementari, ossia due eventi necessari e mutuamente esclusivi. Sia inoltre soddisfatta la condizione:
i) Ciò che esiste è voluto da Dio e viceversa⁹. In particolare, Dio vuole che un certo ente possibile X sia se e soltanto se si verifica l'evento A .

Allora, A è un evento certo o impossibile.

Dimostrazione: Se, per assurdo, A (e quindi $-A$) fosse un evento casuale – ovverosia un evento né certo né impossibile, l'oggetto descritto da una enunciazione soggetta ad incertezza –, allora, per la condizione i, sarebbero possibili e complementari entrambi i seguenti eventi:

B : « X esiste» e $-B$: « X non esiste».

Se così fosse, ciascuna delle due cose reali B_x : «la possibilità che X esista» e $-B_x$: «la possibilità che X non esista» sarebbe allo stesso tempo *non voluta* e *voluta* da Dio, *non reale* e *reale*, essendo B_x e $-B_x$ co-essenti e logicamente interscambiabili.

Per la i, infatti, l'evento B ($-B$) si verifica se e solo se ciò è voluto da Dio, e Dio, al pari dell'uomo, vuole (non vuole) sia (né) l'essere sia (né) il poter essere interessato da ciò verso cui nutre una propensione (avversione)¹⁰. A è così un evento certo o impossibile. La proposizione 3.1 è pertanto provata. ■

Ne segue che Dio non può volere in maniera diversa da come vuole, nel senso che ogni ente non può essere accidentalmente voluto ma è parte essenziale e integrante dell'Onnipotente che lo ha creato. E ciò è in accordo

⁷ B. LIBET – C.A. GLEASON – W. WRIGHT- D.K. PEARL, Time of conscious intention to act in relation to onset of cerebral activity (readiness-potential). The unconscious initiation of a freely voluntary act, in *Brain*, n. 106 (1983) pp. 623 ss

⁸ Per evento si intende qui un accadimento che è descrivibile da una proposizione booleana del tipo «l'ente x ha la proprietà y » dotata di un valore di verità (vero o falso). Cfr. [7], pp. 31-32.

⁹ Cfr. Introduzione, punto 2.

¹⁰ In questo caso, da un lato la realtà – ovvero, per la i, l'essere voluto da Dio – di B ($-B$) implica naturalmente la realtà di B_x ($-B_x$); dall'altro Dio confiderebbe nelle possibilità migliori per Lui temendo quelle negative – i.e., B_x ($-B_x$) se non vuole B ($-B$) –, poiché queste ultime consentirebbero che arrivi ad essere ciò che non è divinamente voluto. La comparsa della cosiddetta medicina preventiva è un esempio emblematico del fatto che la possibilità che si presenti qualcosa di non voluto (dall'uomo e dunque, e.g., da Dio buono) sia essa stessa una cosa non voluta. Nessun individuo infatti intraprenderebbe delle azioni o delle attività precauzionali, come i controlli sanitari, se non volesse contrastare la possibilità di ammalarsi, se non paventasse il rischio di contrarre alcune gravi patologie cercando di eliminarlo o ridurlo il più possibile.

con la nozione di Onnipotenza, che qui può solo indicare l'esito dell'atto volitivo, l'azione e non ciò che ha fissato la volontà divina; *poter fare ciò che voglio* significa difatti *se voglio ciò lo posso fare*.

La proposizione 3.1 ci mostra anche in che maniera l'Onnipotente buono e comprensibile si lascia coinvolgere nel mondo delle sue creature umane. Ciò ci permette di rendere compatibile l'Onnipotenza con la libertà umana, evitando che Dio sia considerato il responsabile del male che vige nel mondo a causa degli abusi dell'umano potere. In altre parole, l'attività umana e le sue istituzioni sono in grado di contribuire non solo alla promozione di un benessere maggiore, ma purtroppo anche all'incubo di un mondo peggiore.

Possiamo invero esercitare il nostro libero arbitrio, che consiste allora nel potere di modificare secondo il nostro stesso essere, i nostri desideri, il nostro carattere e le nostre attitudini l'essenza della volontà divina e dunque le alternative che verranno poste nella realtà. Ognuno di noi, per la sola ragione di esserci e in quanto tale, è per così dire un complesso e complicato generatore di motivi che influenzano più o meno incisivamente l'agire del volere Onnipotente. Tali motivi, che rappresentano nel loro uso pratico, nella loro corrispondenza nel mondo sensibile anche la fonte della moralità, possono quindi variare e variano con il divenire di coloro che ne prendono parte e che contribuiscono a determinarle. Lo status di ogni creatura umana può così non solo indirizzare ma anche e soprattutto ampliare o diminuire gli effetti della scelta divina, trasformandola talvolta in un'ingiustizia più o meno grave – voglio causare un danno lanciando un oggetto. Se sono nella possibilità di scagliare una pietra, posso danneggiare una vetrata, ma se nella condizione di lanciare un missile potrei distruggere una città. La responsabilità che questa seconda opzione comporta è indubbiamente maggiore di quella che avrei se lanciassi solo la pietra –. Quanto più «importante» è il mio status tanto più profondo è il mio impatto sulla realtà (attuata da Dio) e, di conseguenza, minori saranno i miei meriti e accresciute le mie responsabilità. In tal senso l'uomo crea in potenza e Dio in atto, l'uomo propone e Dio dispone.

Veniamo ora alle due domande cruciali che ci siamo posti alla fine del paragrafo precedente. Perché Dio non annienta l'intera umanità, distruggendo così il male per sempre? O meglio perché Dio, pur avvertendo che gli uomini sarebbero stati soggetti inevitabilmente al male, li ha voluti creare lo stesso?

Si osservi innanzitutto che, se Dio rinunciasse definitivamente ad ognuna delle sue creature, nessuna di queste potrebbe esistere proprio perché in antitesi con il suo volere Onnipotente; ciò, a rigor di termini, invaliderebbe l'ipotesi dell'esistenza di Dio non essendoci più un termine opposto a cui contrapporlo.

Si noti anche che, per la proposizione 3.1, l'esistenza dell'umana razza con la sua libertà non può essere stata casualmente voluta da Dio, perché ciò che è da Lui voluto è essenzialmente tale. Eliminare in toto l'uomo, oppure privarlo del suo libero arbitrio o di qualche suo limite intrinseco e, perciò,

rispettivamente, sradicare il male o diminuirne l'intensità, significherebbe per Dio smentire sé stesso, la propria identità, contraddirsi. Il che è impossibile.

Non sorprenderà molto, allora, questa altra notazione del racconto biblico sulle nostre origini. Dei nostri progenitori si dice infatti che in principio furono creati a immagine e somiglianza del Creatore (Gen, 1,27). Un modo sensato per decifrare tale somiglianza è, per quanto detto, quello di ritenere che l'uomo venne creato non soltanto come essere pensante e razionale ma soprattutto come un essere la cui (libera) volontà si combina con quella del suo stesso Creatore, formando un binomio inscindibile.

4. Conclusioni

Proviamo a riepilogare quanto fin qui detto, cercando di trarne le conclusioni più significative. In questa trattazione abbiamo approcciato, da una prospettiva logica e metafisica, quell'unica realtà sostanziale, il Dio Onnipotente, che, in quanto tale, non può subire nulla che Egli non voglia e, dunque, non presenta alcuno degli innegabili limiti che sono congeniti ad ogni altro essere reale. "Onnipotente" si è rivelato essere un nome proprio, non un sostantivo comune, sebbene in questa sede sia stato adoperato dandogli una accezione filosofica, che prescinde totalmente da qualsivoglia credo, religioso o meno. Poiché l'uso linguistico del termine "Onnipotente", o, equivalentemente, "Dio", non fornisce di per sé alcuna prova che l'essere significato esista *in re*, va precisato che l'appartenenza di Dio agli esseri reali non è stata qui verificata ma soltanto presupposta.

Abbiamo poi mostrato che la potenza di Dio, da cui dipende ogni altro potere e che, per definizione, è da Lui detenuta al livello massimale, e il contenuto della sua volontà non sono altro dalla sua sostanza; per dirla con le parole di San Tommaso: *"In Dio la potenza e l'essenza, la volontà e l'intelligenza, la sapienza e la giustizia sono una sola ed identica cosa, di modo che nulla può esserci nella potenza divina che non possa essere nella giusta volontà di Dio o nella sua sapiente intelligenza"*.¹¹

Si è anche sostenuto che, per coerenza logica, non vi può essere alcun ente al di fuori di Dio che esista indipendentemente dal suo volere, rendendo necessaria la creazione *ex nihilo*.

L'uomo è stato infine considerato come il solo essere creato come agente razionale e volitivo, ossia che può pensare logicamente ed è tale che le sue ambizioni e decisioni sono contenute intrinsecamente nella volontà di Dio, la quale, quindi, non può né ignorarle né danneggiarle. Pertanto, ogniqualvolta egli scriva un libro, dipinga un quadro, inventi una tecnologia sta attestando

¹¹ SAN TOMMASO D'AQUINO, *Summa theologiae*, I, q. 25, a. 5, ad 1: Ed. Leon. 4, 297.

che è creatura e partecipa all'essenza dell'Onnipotente. I suoi desideri sono così la base e il limite della sua capacità e libertà di agire e perciò della morale.

Da ciò è derivato che il mondo non è alla mercé del non-senso e del caos né è governato totalmente da Dio; la nostra esistenza si svolge come fosse un cangiante spettro cromatico, generato dal prisma dell'Onnipotenza che scompone la luce bianca nata in Dio dalla sintesi sempre nuova e mutevole di tre componenti indivisibili: la volontà divina, il nostro libero arbitrio e la complessità del reale. Questa forma di panenteismo ci ha spinto poi a domandarci se vi sia una qualche liberazione dal male. Per tentare di rispondere ragionevolmente a questa nota questione, si è proceduto dapprima cercando di comporre logicamente tre assunti apparentemente inconciliabili:

1) C'è il male, i.e., vi sono cose o azioni che l'uomo soggettivamente ritiene siano limitative, dannose o offensive per sé stesso;

2) Dio è buono, i.e., ha sicuramente come valore e fine quello che le sue creature stiano bene e siano felici; quindi, non vuole il male;

3) Dio è comprensibile.

Ne è venuto che la presenza del male nel mondo è inevitabile sia perché, a differenza dell'Onnipotente, l'uomo è necessariamente imperfetto – i.e., è inadatto a tradurre integralmente e all'istante la propria volontà in realtà – sia perché se Dio estirpasse il male, naturale e morale, o ne riducesse la forza negherebbe sé stesso, contraddirebbe la propria essenza. Ovviamente, maggiore è il “grado” di impotenza degli esseri umani, maggiore sarà la durezza o la frequenza con cui il male si verifica.

Ciò che però resta inaccettabile non è tanto il fatto che il male ha pervaso e continua a pervadere tutto il creato quanto la possibilità che questo male e il suo vigore non siano giustificati. Tutto sommato si accetta talvolta il dolore e la sofferenza quando ce ne convincono la medicina o il buon senso; spetta allora all'Onnipotente fornirci un principio generale di spiegazione.

In effetti, non è plausibile pensare che il buon Dio resti impassibile davanti alle assurdità del mondo, contemplando le cose fuori dalla mischia e lasciando l'uomo perduto nella sua condizione terrena segnata dal dolore, dalla afflizione e dalla morte. Determinando l'esistenza, Dio non può non sentirsi responsabile verso gli uomini, cioè vuole il loro benessere, la loro gioia e serenità. Egli ha di sicuro avvertito la necessità di dover fare qualcosa per loro, per non abbandonarli in balia del male nel mondo. Non rimaneva che la via del «sacrificio d'amore» che non poteva non consistere in un qualcosa che Dio ha donato all'uomo in risposta al suo bisogno di felicità, di dare un significato agli eventi negativi che caratterizzano la sua vita. Si traccia così una specie di *itinerarium* dalla realtà del male all'attendibilità dell'essere Onnipotente, il quale sembra potersi interpretare come il Dio Creatore a cui rimanda una delle tre grandi religioni monoteiste: il Cristianesimo.

Il Dio Onnipotente

Infatti, se questo Dio ama l'uomo c'è l'esigenza di condividere il dolore dell'amato, anche il più atroce, nella speranza di renderglielo più sopportabile.

*“Ed è allora, proprio qui che scatta la grande avventura di Dio, che in Gesù Cristo non s'accosta solo all'uomo ma diventa uomo e quindi si avvia a percorrere la lunga galleria oscura della passione e della morte, trasformandosi così in autentico compagno del nostro viaggio esistenziale.”*¹²

*“Con l'«incarnazione» mediante il Figlio Gesù Cristo, divenuto vero uomo, Dio è entrato nella nostra storia e ha attraversato il male, il dolore, la morte assumendone l'essenza e indossandone la pesante livrea, vivendoli e sperimentandoli autenticamente in sé.”*¹³

Forse, l'incarnazione e la passione di Gesù il Cristo sarebbero potuti accadere in un altro periodo storico, con modalità e attori differenti da quelli che conosciamo, può darsi anche che, se l'uomo non fosse soggetto obbligatoriamente al male, Dio non avrebbe assunto e vissuto pienamente la nostra dimensione terrena; ciò nonostante, da un punto di vista speculativo si intravede la ragionevolezza dell'opzione cristiana, del messaggio del Dio che si è fatto uomo, venendo, come uomo e per amore dell'uomo, nella storia.

Sicché, non è assurdo credere che Gesù Cristo abbia scelto la croce, il castigo dello schiavo per ridurre la distanza tra l'uomo vessato e il suo Creatore. Ed è in questa *kenosi*, in questo abbassamento della divinità che la diversità diventa abitabile, che Dio scopre la sua identità, consegnandosi e aprendosi ai limiti che ognuno porta in sé. Egli ha abbracciato volutamente l'estrema ingiustizia affinché la sofferenza giunga anche al cielo.

Giunti a questo punto, appare singolare come la tesi qui difesa – ovvero che tutto ciò che accade e che non accade è espressione puntuale del legame indissolubile tra la volontà divina e quella umana –, conferisca una inaspettata legittimazione alle parole attribuite a Santa Teresina: *“Cristo ha riconosciuto la volontà del Padre dietro la mano dei carnefici che lo inchiodavano alla croce; dobbiamo anche noi riconoscere e adorare la volontà del Padre dietro la cattiva volontà degli uomini che così spesso ci crocifigge”*.¹⁴

In questo scritto, ci siamo limitati a contemplare, studiare, frequentare l'Onnipotenza di Dio. L'analisi su questo aspetto saliente della natura divina è stata condotta secondo un approccio che ha una chiave interpretativa di matrice logico-filosofica, senza escludere un'attenzione verso il trascendente.

Resta senza esito il chiedersi se esista effettivamente l'Onnipotente e, in caso affermativo, se quest'essere si rapporti con noi come un alleato che

¹² G. RAVASI, *Guida ai naviganti. Le risposte della fede*, Arnoldo Mondadori, Milano, 2012, p.75.

¹³ Ivi, p.80.

¹⁴ La citazione non appartiene direttamente agli scritti autografi di santa Teresa di Lisieux, ma è un pensiero attribuito alla sua spiritualità e frequentemente riportato in raccolte di meditazioni o commentari sulla sua “piccola via” dell'abbandono. Il vedere la volontà di Dio anche attraverso le azioni negative degli uomini è un tema centrale della sua dottrina e trova riscontro in testi che analizzano il suo pensiero.

risponde: “Eccomi” quando lo imploriamo perché incapaci di raggiungere i nostri obiettivi, come un nemico che ci avversa o se si mantenga indifferente, sordo alle nostre grida e invocazioni. Ciò non può evidentemente rientrare nell’orizzonte della razionalità, dello sperimentale o della tecnica, ma va ricercato con gli occhi della fede. “Ne è convinto il filosofo danese Kierkegaard che in *Timore e tremore* (1843) afferma che «la fede comincia dove la ragione finisce»”.¹⁵

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What it really is to perceive

Andrea Bucci*

Abstract

With this brief article I shall attempt to arrive at a definition of perception starting from the outlines of the metaphysics currently available to us on the topic. To this end, I argue that at the foundation of the various theorisations in the philosophy of perception there is a general agreement concerning the nature of the perceptual relation, but not concerning the nature of its relata—that is, the objects of perception. Once the transcendent nature of these relata has been established, the nature of the perceptual relation as a whole will become clear, and I will show *en passant* how theories surrounding the discovery of mirror neurons, if properly understood, provide a framework consistent with my discussion of perception and the related definitions.

Keywords: Philosophy of Perception; Perceptual Relation; Objects of Perception; Transcendence; Mirror Neurons.[†]

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1 Introduction

In my studies on perception and its metaphysics, I have had the opportunity to interweave three themes of crucial relevance for contemporary philosophy and science, and in particular for the Italian intellectual context: the functioning of perception, the notion of transcendence, and the theorisation surrounding the discovery of mirror neurons [6, 12].

The main theories of perception agree on one point: there must be some form of agreement between the mind and objects independent of the mind [5]. Beyond this point, however, the degrees of disagreement and the questions concerning the nature of perception as a whole and of its objects vary significantly. Strictly metaphysical theories debate the issue while setting aside the problem of the objects of perception and move closer to the idea that even if mind and world are two distinct things, genuine perception requires the emergence of a direct contact when mind and world are in agreement. In this way, the long-standing dispute between direct realism and indirect realism is also set aside [11].

Indirect realism establishes that mind and world are two distinct things. Direct realism establishes what happens when mind and world come into agreement [1]. This distinction also sheds light on the debate concerning illusions and hallucinations, which arise when the agreement between mind and world is merely apparent rather than genuine [10].

2 Defining Perception

Even when surveying the main theories of perception, we can observe that they presuppose a deep agreement, provided that the nature of the objects of perception is not taken into account. Sense-data theory, once the problem of the nature of the objects of perception is eliminated, does not substantially shift the balance of the metaphysics of perception as a whole [7]. That the world in the mind–world relation is constituted by entities such as sense-data does not violate the rule that, in order to perceive genuinely, mind and world must be in agreement.

Adverbial theory maintains that to perceive is to perceive something in a certain way, and thus holds that a genuine perception occurs when perceiving in a certain way corresponds to the way the world is; otherwise, one is engaged in a different mental activity, such as imagination [2]. *Mutatis mutandis*, according to intentionalism, the content of perception consists in the intentional presentation of the world as being a

certain way, and intentionality grounds an unmediated—naïve—relation to external reality [3].

According to naïve realism, there is no mediation between perception and the world; mediation disappears once the relation between mind and world is correctly intentional [1].

It appears that the metaphysics of perception developed so far is substantially correct insofar as it brackets the nature of perceptual objects. However, without addressing this issue, discourse on perception remains incomplete: while the perceptual relation is intelligible, the relata remain obscure [5]. Ostensive reference alone cannot satisfy metaphysical inquiry into perception.

When addressing the nature of mind and world, we are inevitably confronted with the question of substance [9, 3]: what they are and whether they share a common ontological ground [12]. From an external perspective, one may ask whether the objects of perception are ordinary objects or entities of a different ontological kind.

From such a perspective, it becomes evident that sensory modalities such as vision, hearing, and smell do not involve direct contact with the objects themselves. What interacts with the sense organs are light radiation, sound waves, and olfactory particles, not objects *per se*. To insist that we directly perceive independent objects as they are in themselves leads to the implausible conclusion that sensory stimulation gives rise to the immediate appearance of objects through an unexplained transformation [10].

Since perceptual experience is posterior to sensory stimulation, it follows that the objects of perception are not objects as they are in themselves. Both perception and the perceived world therefore transcend reality as it is in itself [6].

Perception transcends the world in two different senses. In one sense, for the reason just seen, it is separate from the world as it is in itself. In another, much stronger sense of transcendence, our perceptual experience is different from our body because there is no sense in which it can be said that our body, in itself, is having a certain experience. If, as we have seen, our body is separate from how objects are in themselves, then there is no sense in which, for example, it is looking at the sky, as can happen to us in our experience.

It is at this point that theories concerning mirror neurons may be viewed in a new light. The hypothesis that the brain functions as a mirror system reflecting external reality extends beyond the strictly motor properties of mirror neurons [4]. While defining the entire brain as a mirror system may exceed the explanatory scope of the discovery, the idea that the brain constructs a coherent experience of the world through embodied simulation is philosophically significant [8].

This conception aligns with the hypothesis of the transcendence of perception: experience is generated by cerebral activity and, in certain cases, by embodied simulation,

thereby reinforcing the view that the perceived world is not the world *in itself* but a transcendent experiential domain.

What seems to be missing from the theory of mirror neurons, at least from my point of view, is the extension of its domain to the second sense of transcendence that has been highlighted, and a move beyond what has so far been a metaphysics centered on the subject rather than on experience [8].

Returning to the metaphysics of perception, once the transcendent nature of perceptual objects is acknowledged, it becomes plausible to hypothesise that the naïve relation between perception and world is grounded in the fact that mind and world share the same transcendent substance, they are both immaterial. This is supported by higher-order perceptions, such as the perception of oneself perceiving something, which present themselves as unified and incontrovertible experiences [9].

From this perspective, sense-data theory, though approximate, retains merit insofar as it acknowledges that perceptual objects are not objects in themselves. Once the nature of perceptual objects is clarified, the metaphysics of perception becomes significantly more transparent.

This is where the novelty of my approach lies. If we consider the relata of the perceptual relation as transcendent entities composed of the same substance, then theories about perceptual activity become plausible, because it becomes understandable how mind and world can merge together to give rise to experience—something that would remain largely obscure, even to common-sense inquiry, if the relata were objects as they are in themselves.

Perception is thus part of transcendent experience. The mind, in perceptual activity, is the mode through which we align ourselves with the transcendent world and participate in experience as a whole. Although these conclusions may appear distant from common sense, they do not disrupt ordinary experience or our practical engagement with the world. Reality remains independent, though not in the sense presupposed by materialism.

3 Conclusions

This article has attempted to complete the metaphysical discourse on perception by incorporating both classical philosophical accounts and contemporary scientific insights. Understanding what perception truly is requires grasping not only the transcendence of the perceptual relation but also the transcendence of its relata. If this account is correct, contemporary humanity may indeed suffer from a form of spiritual

constriction arising from a culture excessively focused on objects and insufficiently attentive to lived experience.

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