

Chapter 1

Introduction

Black holes are well-studied theoretical compact objects invoked both to explain the powerful emissions observed from the centres of galaxies and to describe the final evolutionary state of sufficiently massive stars.

In the classical black-hole picture, the central density and curvature formally diverge, indicating the breakdown of the classical spacetime description. The event horizon is not a material surface but a causal boundary that prevents signals from reaching distant observers. Yet this purely causal boundary plays a thermodynamic role: semiclassical black-hole physics associates with it the Bekenstein–Hawking entropy. For an astrophysical black hole, this entropy vastly exceeds that of the progenitor, and horizon formation marks a classically irreversible transition.

Furthermore, neither classical general relativity nor quantum field theory provides a fundamental upper mass limit for black holes: in principle, they may grow indefinitely provided that the feeding process is unlimited.

A further difficulty is observational. Modern instruments can detect radiation from nearby matter, gravitational effects, and shadow-like structures, but they cannot directly observe the region at or beyond an event horizon. Thus, observations may indicate an extremely compact massive object, but they do not uniquely prove the existence of a classical black hole with a true event horizon and a singularity.

At a deeper level, these difficulties raise the question of whether our current mathematical framework is complete. There is little reason to assume that our current mathematics represents the ultimate framework for describing the universe in a fully self-consistent manner.

Despite its remarkable successes, its predictive power remains limited: singularities, divergences, and multiple mathematical solutions without clear physical counterparts continue to emerge.

In this sense, it would be premature, and perhaps intellectually arrogant, to assume that the present marriage of physics and mathematics already provides a complete conceptual framework for describing

reality across all scales, from the microscopic to the cosmological.

In the context of black holes, however, the issue is more specific. The persistence of mathematical pathologies, the existence of physically ambiguous solutions, and the inherent limitations of observations raise a fundamental question as to whether the combined theoretical, mathematical, and observational foundations of contemporary physics are sufficiently mature to establish classical black holes as inevitable physical constituents of our universe:

Are the present foundations of physics and mathematics, together with the available observational evidence, sufficient to establish that classical black holes are inevitable physical objects in our universe?

A striking paradox underlies this question: the standard framework admits the formal possibility of infinite density, yet largely excludes a finite universal maximum density; likewise, it accommodates both attractive gravity and effective repulsion, while leaving little room for an intermediate gravitationally neutral state. Such asymmetries warrant caution before regarding classical black holes as unavoidable outcomes of gravitational collapse.

More broadly, the black-hole problem may be viewed as one manifestation of a wider tension between mathematically successful theoretical frameworks and their underlying physical interpretation.

This tension becomes particularly evident in modern cosmology, where a growing number of auxiliary hypotheses have been introduced to reconcile theoretical models with observational data. Frameworks such as dark matter, dark energy, and cosmic inflation have been proposed, although their underlying physical nature remains unidentified and their mathematical implementations are often phenomenological or model-dependent. Rather than leading to a decisive physical explanation, this accumulation of auxiliary assumptions has left several foundational questions unresolved. Increasingly sophisticated models are developed, but often without a fully convincing physical foundation.

Scepticism about the existence of black holes extends beyond the scientific domain.

The possibility that nature may avoid pathological gravitational end states has been discussed since the earliest development of the black-hole concept. Albert Einstein himself, the founder of general relativity, questioned whether such objects could be realised in nature.

Moreover, if black holes are understood as irreversible destroyers of matter and information, they raise a deeper compatibility problem. They appear difficult to reconcile with the physical elegance of natural laws, with philosophical reasoning about the intelligibility of nature, with theological worldviews centred on mercy and renewal, and with the entropic principle governing the emergence and persistence of ordered structures. This leads to the question:

Are classical black holes truly compatible with the physical,
philosophical, theological, and entropic structure of nature?

Irrespective of the debate concerning their physical nature, an immense volume of observational data related to black-hole candidates has been accumulated over the past six decades, and these data are repeatedly invoked to portray the existence of black holes as an observationally established fact.

At the same time, the enormous success of the black-hole paradigm has created a scientific environment in which alternative interpretations may face considerable resistance, rendering the search for new ideas increasingly difficult. Against this background, the present work explores an alternative physical pathway for gravitational collapse.

The central thesis developed in this book is that matter in massive neutron stars (MNSs) should undergo a transition to a previously unrecognised state, fundamentally distinct from known forms of *baryonic matter*.

On the basis of theoretical considerations and observations of glitching pulsars, we are led to identify this state as supranuclear-dense, incompressible, and superconducting, and to designate it as **SuSu matter**. Under such extreme conditions, we propose that the cores of massive neutron stars form **gravitationally inert, false-vacuum-like condensates, confined by holographic boundary surfaces**. As will be argued throughout this book, macroscopic configurations of SuSu matter exhibit collective quantum behaviour, effectively constituting coherent quantum systems on macroscopic scales. The associated holographic boundary surfaces are proposed to provide a confinement mechanism while encoding and preserving information about the state of matter in the bulk.

In this framework, these boundaries effectively isolate the SuSu cores from the external universe, suppressing electromagnetic communication across the interface and thereby rendering the cores electromagnetically non-radiative and observationally inaccessible to distant observers.

Theoretically, *SuSu matter* is shown in this book to correspond to an effectively trivial solution of the field equations in general relativity, namely $\langle T_{\mu\nu} \rangle = G_{\mu\nu} = 0$. These properties have profound consequences for the long-term evolution of compact objects.

As MNSs cool and fade over cosmic timescales, their trapped SuSu cores¹ are proposed to grow progressively in mass and size through continued accretion and/or repeated mergers. Over super-universal timescales, this evolutionary pathway may give rise to supermassive DEOs² (SMDEOs) that ultimately evolve into Big-Bang-like progenitors.

¹SuSu cores are frequently referred to throughout this book as **Dark Energy Objects (DEOs)**. This designation is intended solely to emphasise their observational invisibility and should not be interpreted as implying any physical connection with the dark energy invoked in contemporary cosmology.

²See footnote 1.

The formation and ultimate evolution of DEOs constitute integral stages within closed cosmic cycles. Within this framework, sufficiently massive stars undergo gravitational collapse and supernova explosions, leaving behind neutron stars that harbour embryonic DEO cores.

As demonstrated in this book, the holographic boundary surfaces confining supermassive DEOs (SMDEOs) become unstable once the enclosed mass exceeds a critical, Big-Bang-scale threshold. This instability ultimately triggers the decay of the confined SuSu matter into ordinary baryonic matter through a hadronization process that is predicted to proceed over a timescale of several hours.

Unlike classical black holes, which represent terminal gravitational endpoints, DEOs therefore play a constructive cosmological role: they recycle ultra-dense, gravitationally inert SuSu matter into the material basis for new stars, galaxies, chemical complexity, and, under suitable physical and environmental conditions, possibly life.

The essential difference is therefore not merely technical but conceptual. This sharp contrast may be summarized as follows:

Black-hole framework	DEO/SuSu framework
Infinite density and singular objects	Finite universal maximum density
Unbounded growth	Finite, self-limited growth
Irreversible formation process	Regenerative cosmic cycle
Inaccessible interior	Horizonless, regular SuSu core
Terminal gravitational endpoint	Gravitationally inert compact object

This contrast raises a broader astrophysical and philosophical question:

Why do the laws of nature appear to favour the formation of long-lived, life-supporting structures over life-destroying objects, and how could this affect our understanding of quantum fields and cosmology?

This question motivates the need to examine the physical properties that distinguish DEOs from classical black holes. In the DEO/SuSu framework, embryonic DEO cores are metastable. Their masses may grow steadily as neutron stars fade over cosmic timescales, gradually transforming the dense stellar interior into a stellar DEO.

The novelty of this proposal becomes clearer when viewed in historical context. When general relativity was formulated, neither neutron stars nor black-hole candidates were known observationally, and the extragalactic scale of the universe had not yet been firmly established. Moreover, superfluidity, macroscopic quantum coherence, entropy-free condensates, and collective many-body quantum states were not part of established physics.

A further possibility, unavailable to Newton and Einstein, is that fields may become confined. The strong interaction provides a familiar example, acting only over nuclear length scales rather than decaying asymptotically to arbitrarily large distances. In the DEO/SuSu framework, the gravitational influence of the false-vacuum-like condensate is likewise assumed to terminate abruptly at the holographic surface, which confines and isolates the core from the external universe.

Gravity was naturally regarded as a universal field sourced by matter and energy, making it almost impossible at that time to imagine a form of matter that could become effectively gravitationally inert. This historical limitation also echoes the asymmetry noted earlier: while gravitational theory accommodates both attractive and effectively repulsive regimes, the possibility of a gravitationally neutral state has received comparatively little attention. Such a state, however, lies at the heart of the DEO/SuSu framework developed here.

Thus, it is unsurprising that GR did not explicitly address matter phases such as SuSu matter or DEO cores. From this viewpoint, DEOs do not contradict the spirit of general relativity; rather, they extend the possible matter sector beyond what was physically conceivable when the theory was formulated.

Building on this framework, the book examines the implications of DEOs for neutron-star physics, compact-object astrophysics, quantum condensates, and cosmology. In particular, it explores the possibility that repeated mergers of DEOs may lead to the formation of Big-Bang progenitors, ultimately giving rise to Big Bangs (BBs), thereby motivating the Unicentric Model of the Observable Universe (UNIMOUN): a cosmological framework in which our observational position lies at or near the centre of the finite observable domain, while this domain is embedded within an infinitely large parent universe. The theoretical foundations of this proposal are developed through mathematical analysis, physical arguments, numerical modelling, and observational considerations.

In contrast to the DEO framework, string theory treats black holes as physically real objects and assumes that the laws of physics effectively permit or even accommodate the formation of such irreversible compact gravitational end states.

The holographic principle is then invoked as a rescue mechanism: information is assumed not to be lost but to be encoded in microscopic degrees of freedom associated with the black-hole horizon. In the DEO framework, by contrast, this premise is rejected at a more fundamental level. Here, the laws of nature are hypothesized to favour the emergence and persistence of regular, coherent, and habitable environments rather than irreversible and destructive configurations. Thus, the central question is not how black holes can be saved from their own paradoxes, but whether classical black holes are physically unavoidable in the first place.

The existence of DEOs provides a framework for addressing several long-standing questions in astrophysics and cosmology, including:

- How is matter organized within the cores of massive neutron stars?
- How does SuSu matter, which constitutes DEOs, arise as the saturation state of baryonic matter in the asymptotic-freedom regime of quantum chromodynamics (QCD)?
- How can the energy density of the universe be both lower- and upper-bounded?
- How can DEOs be understood as false-vacuum condensates?
- How are DEOs fully compatible with the field equations of general relativity?
- How can glitch observations in pulsars and young neutron stars support the existence of DEOs?
- How can the absence of glitches in certain rapidly rotating massive pulsars be explained?
- How can DEOs account for the remarkably narrow mass range exhibited by neutron stars?
- How does the DEO scenario alleviate the Bekenstein–Hawking entropy problem associated with black holes?
- How does holography metastabilize DEOs, and under what conditions does it trigger their hadronization?

Within the framework of DEOs, black holes, dark matter, dark energy, and cosmic inflation need not be regarded as fundamental or unavoidable ingredients in the nature and evolution of the universe. The DEO/SuSu framework therefore offers a mathematically regular and physically more unified alternative to singular objects, dark energy, dark matter, and cosmic inflation.

This perspective leads naturally to UNIMOUN, in which the observable universe is interpreted as a finite Big-Bang domain embedded within an infinitely large parent universe containing countless similar domains. *On such cosmic scales, the distinction between geocentric and heliocentric descriptions becomes largely irrelevant*, since both concern only the observer’s location within a very small local system. UNIMOUN therefore does not exclude the possibility that we occupy an apparently central position within our observable domain. Such local centrality would not imply that Earth, the Solar System, or our domain occupies the centre of the infinitely extended parent universe; it would merely reflect our observational position within the particular expanding domain to which we belong.

Within the UNIMOUN framework, several fundamental questions in cosmology may be revisited, including:

- ◆ How could repeated mergers of DEOs lead to the formation of a Big-Bang progenitor?
- ◆ How could the supergiant DEO in M87 give rise to the next Big-Bang-like event?
- ◆ How could the collapse of the holographic surfaces enclosing supermassive DEOs trigger Big-Bang-like explosions?
- ◆ How can our apparent location at the centre of the observable universe be understood within a physically consistent cosmological framework?
- ◆ How can the FLRW metric be generalized into the newly proposed $\mathcal{H}$ -metric while still preserving homogeneity and isotropy?
- ◆ How can the Unicentric Model of the Observable Universe (UNIMOUN) account for the observed accelerated expansion of the universe?
- ◆ How can the origin of the power driving the recession of high-redshift galaxies be explained within the UNIMOUN framework?
- ◆ How could currently observed high-redshift galaxies, quasars, and other compact objects have existed prior to the Big Bang?
- ◆ How can our observable universe be interpreted as a tiny subdomain of an infinitely large parent universe in which Big-Bang-like events recur across space and time?
- ◆ How can the cosmological version of the DEO scenario alleviate the Hubble tension?
- ◆ How does cosmic coincidence emerge naturally if our universe is a small subdomain of a much larger parent universe?
- ◆ How can the apparent “magic” temperature of 2.73 K be explained, and why does the cosmic background temperature never fall below this apparent floor?

A logical consequence of embedding our finite Big-Bang domain within an infinite parent universe is that the physical constants acquire a super-universal status. Hence, the conditions for chemistry, structure formation, and life are not restricted to our observable universe. At the same time, this scenario reopens deeper questions concerning the origin and nature of matter itself, since the emergence of baryonic matter must ultimately be traced back to the decay, transformation, or prior existence of

physical states in the parent universe. In this context, the classical notion of *creatio ex nihilo* is also reconsidered. Rather than interpreting the universe as emerging from absolute nothingness, the present framework relates the origin of matter, life, and mathematical structure to pre-existing physical conditions within the infinite parent universe.

The scope of the book extends beyond compact objects and cosmology to include the origin and evolution of mathematics and its limited effectiveness in the natural sciences. Rather than treating mathematics simply as a pre-existing Platonic structure, the book traces the development of human proto-mathematical mental operations and their gradual transformation into symbolic forms. This process eventually led, for example, to early Babylonian quadratic problem-solving around 1900 BCE, represented in modern notation by

$$x(x + 7) = 60.$$

Finally, the book also discusses the apparent tension between the black-hole paradigm and theological notions of divine mercy, renewal, and the preservation of creation. In particular, it questions whether objects that irreversibly destroy matter and information can be reconciled with a worldview in which creation is understood as meaningful, ordered, and ultimately preserved rather than annihilated.

This book is intended for academically oriented readers with some background in mathematical physics, theoretical physics, numerical mathematics, and cosmology. It introduces them to problems at the forefront of modern research in physics and cosmology, especially where quantum fields, vacuum states, dense matter, numerical modelling, and strong gravitational fields intersect.

Chapter 2 explores the historical and cognitive roots of humanity’s quest to understand the cosmos, emphasising how observational limitations and conceptual frameworks have shaped astronomical interpretation from prehistoric times to the present. It thereby establishes the philosophical and epistemological background for the scientific developments that follow.

Chapters 3 and 4 establish the theoretical basis of the book. General relativity is first presented through its core principles, mathematical structure, and physical interpretation. The discussion then turns to classical gravity and its role in shaping gravitational interactions. Together, these chapters prepare the ground for a critical examination of the black-hole hypothesis, with particular emphasis on the distinction between mathematical solutions and physical reality.

Chapter 5 turns to neutron stars and their internal structure, highlighting observational evidence for their remarkable uniformity and the unresolved mysteries of their cores. Chapter 6 examines the narrow observed mass range of neutron stars and the physical origins of their lower and upper mass bounds. Chapter 7 then broadens the discussion to vacuum states in physics and cosmology, introducing SuSu matter as a possible false-vacuum state.

Together, these chapters form a conceptual bridge between compact stellar objects and cosmological evolution, while motivating the need for physical principles beyond standard collapse scenarios.

Chapter 8 contrasts supermassive DEOs with supermassive black holes, examining observational degeneracies and the limitations inherent in horizon-based interpretations.

Chapters 9 and 10 focus on cosmological implications. The decay of the Big-Bang progenitor and the emergence of the fireball are analysed, followed by a detailed treatment of the hadronization and flattening phases of spacetime. These chapters aim to provide a physically consistent explanation for the observed large-scale flatness of the universe without invoking cosmic inflation.

Chapters 11 and 12 connect this framework to observational cosmology by discussing a possible direct link between the expanding fireball and the observed acceleration of distant galaxies, as well as by offering a new perspective on the Hubble constant and the Hubble tension.

Chapter 13 introduces the UNIMOUN scenario, presenting its mathematical and physical foundations and critically comparing it with the standard Λ CDM cosmology.

Finally, based on UNIMOUN and the concept of an infinite parent universe, Chapter 14 revisits the notion of *creatio ex nihilo* and re-examines the origin of matter and life, as well as the origin of mathematics, while addressing deeper questions concerning physical law, emergence, and meaning.

Taken together, the book proposes a unified and non-singular framework that challenges conventional interpretations while seeking to remain firmly anchored in physical consistency and observational evidence.