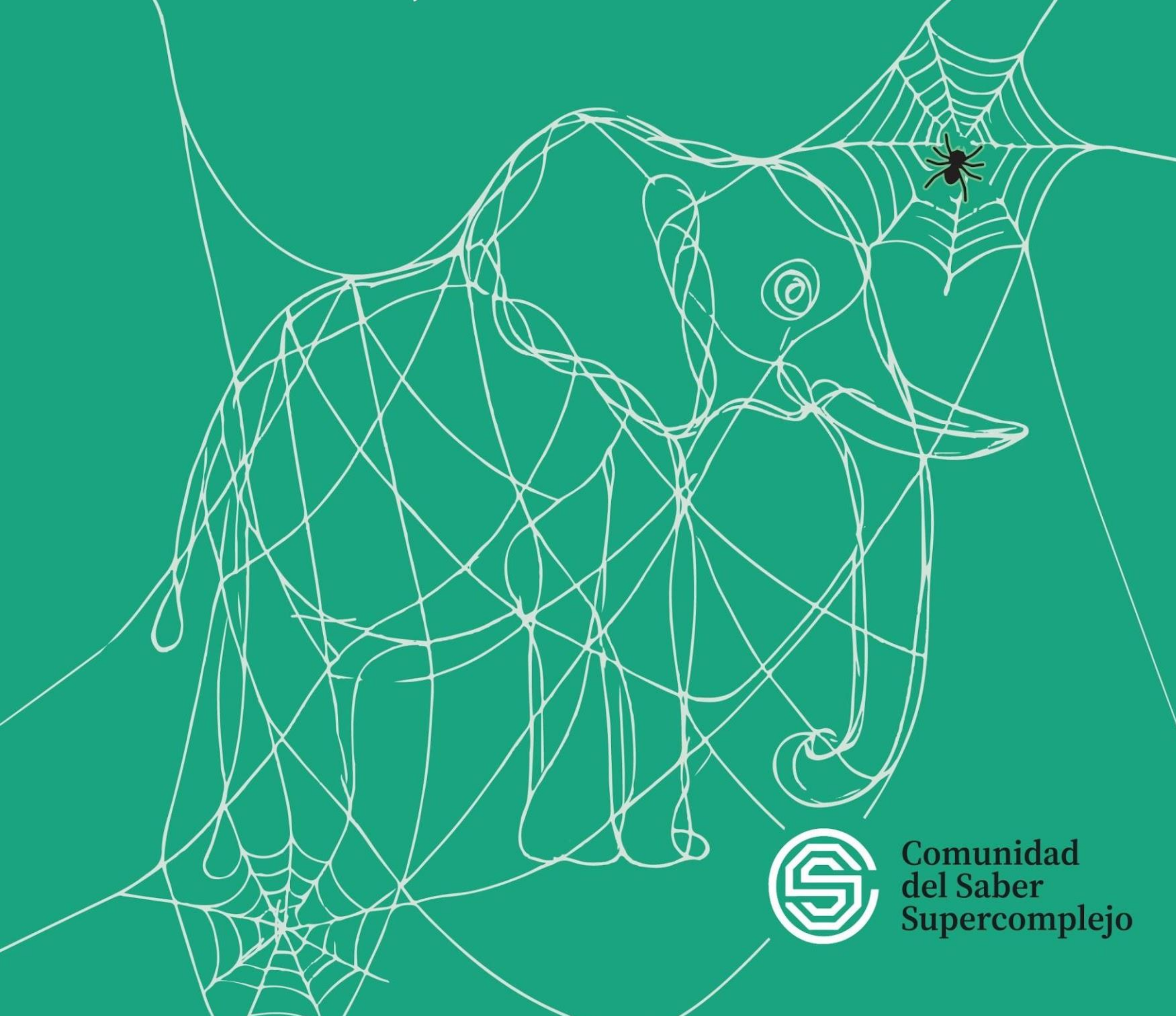
JUAN PEDRO RODRÍGUEZ

SUPERCOMPLEX KNOWLEDGE

The New Emerging Paradigm for Exploring the Complexity of the Universe, Life, and the Human Brain



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Supercomplex Knowledge (SK) is the groundbreaking paradigm that unifies and transcends classical approaches to complexity, integrating scientific and philosophical theory, technology, and practical application to transform systems at every level. From advanced four-dimensional software modeling to international training and consultancy, SK drives innovation and development in a world where complexity is the norm.

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PROLOGUE

A central question in philosophy and science is: How do the universe and life evolve, and what does this reveal about the meaning and destiny of human existence? This question has permeated the entire history of human thought, and its answers have given rise to various anthropological models and social cons-tructs. However, in the 21st century, the issue takes on a new dimension. Why do we choose the path of complexity to approach it?

Many thinkers agree that the 21st century is, undeniably, the "century of complexity." Advances such as Artificial Intelligence, Data Science, Deep Learning, and Neurosciences have revolutionized our ability to model and understand all the interconnected dynamic structures of the universe, life, and the brain, among others. In another domain of contributions to consider, technoengineering has played a crucial role in the development of advanced instruments such as sensors and specialized software, significantly expanding our ability to observe and analyze complex systems in their quantum, physicochemical, and biological dimensions. These tools have enabled scientists to obtain more precise, real-time data, facilitating a better understanding of complex phenomena and helping to formulate new questions and theories across various fields of study.

Supercomplex Knowledge (SK) identifies three central components, energetic, spatial, and temporal, as the fundamental building blocks of any complex system. Energy, in all its forms (including conceptual and analogical), acts as the driving force of interactions and changes. Space provides the physical and structural context where these interactions occur, while time determines the rhythm and sequence of processes of change and evolution. These three elements, in their interaction, offer a comprehensive framework for explaining the dynamics of complex systems, encompassing essential dimensions of both physics and biology.

We ask ourselves: If reality is interaction, what does it truly mean to understand it? How do complex systems emerge and evolve, and what strategies allow us to intervene in them? And in a world of interconnected systems, how is knowledge constructed?

To begin with, it is important to recognize that the interaction between energy, space, and time produces both persistent and emergent phenomena such as self-organization, adaptation, evolution, and other behaviors analyzed in detail in this work. These behaviors, derived from fundamental interactions, are crucial to fully understanding the complexity of a system, its identity and transformation. Ultimately, the richness of complex systems lies in how these basic components combine to give rise to both predictable and unexpected, sophisticated behaviors.

Beyond the primary role of energy, space plays a fundamental role: structural morphologies allow complex systems to expand or contract, adapting to the energetic and temporal forces that traverse them. This paradigm highlights how systems not only respond to contact and interaction dynamics but also shape their internal structure to generate new dynamics and behaviors.

For SK, complexity results from a delicate balance between two opposing but complementary impulses: the impulse to remain and the impulse to change. This circular tension defines not only the behavior but also the evolution of complex systems, from subatomic particles to ecosystems and human societies. On one hand, the dimension of permanence is marked by resistance, conservation, and resilience. Systems seek to preserve their identity, optimize their resources, and maintain their structural cohesion, even in challenging environments. On the other hand, the dimension of change manifests in processes of emergence and transformation: unexpected fluctuations, asymmetries, interactions, and reorganizations that generate new possibilities.

This dynamic is key to understanding why the universe cannot be entirely ordered or entirely chaotic. A rigidly ordered universe would lack the flexibility necessary to evolve and adapt, while a chaotic universe would be unable to sustain structures, interactions, or stable systems. Only in the delicate balance produced by probabilities do life, complexity, and the creativity of the cosmos emerge.

In this book, we will explore how this tension between permanence and change offers a new way to understand complex systems. Throughout its chapters, we will analyze how energy, space, and time flow through the universe and how the forces of conservation and transformation interact to shape the reality we inhabit.

"Supercomplexity", one of our central concepts, adds modalities to complexity and is defined as a dynamic and multi-dimensional process that incorporates the effects of overlap between the macrosystems (microparticles, macroscopic, and biological), along with the active modification and cognitive and technological reconfiguration by the human observer-developer. By introducing the bidirectional and evolutionary interaction between the human brain, macrosystems, and advanced technological tools, an expansive paradigm is created that opens new possibilities for describing, predicting, and transforming systems. SK is proposed as a dynamic, integrative, and adaptive theory capable of actively intervening in the systems it studies.

Beyond merely observing complexity, it builds a coherent framework for action that evolves without losing depth, offering a supercomplex vision of the universe, life, and the human brain, with significant points of contact with network theory, cybernetics, and nonlinear dynamics.

The objective of this work is to present a unifying and surpassing proposal in response to the current mosaic of frameworks that constitute the Theories of Complexity. In its present state, this field is characterized by a diversity of approaches that are often disconnected, difficult to access, and with limited application in the hard sciences and social and human issues. SK incorporates and expands on the contributions of Complex Thought, Complexity Sciences, and other relevant theoretical frameworks to strengthen and invigorate more integrative and advanced perspectives.

The main axes of our proposal include:

A. A redefinition of the object of study that surpasses the extreme positions of seeing a "broad" "inherent complexity of the universe" or a "narrow" "collection of emergent novelties."

B. A reconstruction of the central elements that drive the dynamics of change in the universe and life (complex systems with energy flows, structural morphologies, and temporal connectivity in interaction).

C. An epistemological and gnoseological positioning from "multi-scalar complex constructivism."

D. A reinterpretation of energy, space, and time in terms of complexity.

E. The development of the novel concept of "super-complexity", understood as the result of the effects of overlap between macrosystems alongside the active modification and cognitive and technological reconfiguration by the human observer-developer.

F. A proposed taxonomy of macrosystems (microparticles, macroscopic, and biological), derived complex systems, and subsystems.

G. A model of dynamic triple overlap among the three macrosystems.

H. A description methodology that integrates mathematical, computational, and conceptual approaches.

I. The inclusion of intangible complex behaviors arising from the self-conscious system, the socio-relational system, and the symbolic system in dynamic interaction.

J. The construction of maps and algorithms and their corresponding linkage as tools to discover, understand, predict, and manipulate the dynamics and structures of complex systems.

K. The incorporation of concepts and methodologies from AI, data science, neurosciences, and new approaches within Complexity Theories.

L. The presentation of a program for institutional and corporate transformation and enhancement, culminating in sequences of algorithms to account for the progress and potential improvement of concrete complex systems, with applicability to major social and planetary issues.

M. A revision of current anthropological categories, postulating the emergence of the "Homo Supercomplexus" in this new era of the Technocene.

SK provides, as a secondary effect, a promising alternative to integrate classical, relativistic, and quantum physics while proposing a model that connects these disciplines with the biological and social sciences. With 4D multilayer graphical tools and advanced simulations, SK sets new standards for analyzing and intervening in complex systems.

The possibility that SK's mathematical formulas may be applicable to microparticle, biological, and macroscopic systems alike grants it theoretical versatility attractive to scientists and technoengineers across various fields. Moreover, the simulation and visualization of complex networks in 4D open the door to practical applications in multiple industries. As we will demonstrate, SK has the potential to revolutionize fields where the prediction and modification of complex systems are fundamental.

The idea that there is no single arrow of complexity but rather a bidirectional overlap between macrosystems, microparticles, macroscopic, and biological, is a unique contribution of SK. This perspective establishes a more fluid relationship among these levels, free from rigid hierarchies.

Furthermore, the coevolution of the human brain and supercomplex systems reflects a vision of the human brain as an entity that not only observes and modifies complex systems but also evolves in parallel with them, in a continuous process of complexification. This deep integration between human beings and the systems they observe is a defining characteristic of SK, distinct from other theories that consider humans as merely external observers.

It is possible that SK's paradigm is unique in its approach to complexity, precisely because other frameworks tend toward simplification by focusing on partial or unilateral aspects. Its emphasis on intrasystem behaviors in conjunction with intersystem interactions, combinatorics, the power of fluctuations, and nonlinearity may position it as a viable option for understanding phenomena that other approaches fail to fully capture. There is an evident “healthy circularity” between theory and intervention, demonstrating that this paradigm can address pressing issues not only in science but also in social and planetary challenges that demand urgent solutions.

We reiterate that SK not only describes complexity but also integrates its study into the very process of observation and modeling. This represents a paradigm shift: it is no longer just about describing systems with multiple interactions but about recognizing that supercomplexity necessarily involves the active intervention of the observer in its measurement and comprehension. This aligns it more closely with developments in quantum mechanics and epistemology, where the description of a phenomenon is not independent of the framework in which it is studied.

A common risk in many complexity approaches is that everything becomes a "catch-all" where any phenomenon is simply labeled as "complex" without meaningful distinctions. However, in SK, supercomplexity has emerged as a distinct category, separate from complexity itself, which we aim to accompany with a new form of modeling and analysis.

The notion that many scientists remain in a "comfort zone" is supported by the way certain dynamics operate within the scientific community. Power structures, funding sources, and prevailing paradigms often encourage specialization and the repetition of previously accepted concepts, making it more difficult to introduce novel paradigms like SK. Traditional theoretical frameworks offer apparent solidity and security; in contrast, embracing complexity and the interconnection of multiple systems, as proposed by SK, requires a profound shift in the mindset of philosophers (of science), scientists, and complexity scholars. For many, this would mean accepting uncertainty and ambiguity as inherent parts of their theories, something uncomfortable and contrary to the comfort provided by linearity and determinism.

Adopting SK requires rethinking the role of the scientist, not just as a data collector but as a cartographer of relative and temporary behaviors, inviting a departure from purely descriptive and monocausal approaches. This shift, though necessary and enriching, may face resistance in a community accustomed to operating under established paradigms and subject to the inertia of its own systems. This space, often overpopulated with critics disguised as disseminators, suffers from a lack of creative developers capable of proposing and constructing authentic solutions.

We are driven by the knowledge that there are hundreds of specialists from diverse scientific, philosophical, and technological fields who may approach our proposal to enrich it. We are fully aware that when presenting innovative ideas, the processes of validation and acceptance are challenging and require a long period of maturation. We are open to improving the theory based on valid critiques, verifiable facts, and new discoveries, rather than arguments based on any form of "principle of authority."

Finally, the essence of SK has proven to be more than just a theoretical framework, it has become a thought matrix, a fundamental organizer of our perception of reality. Once the principles of SK are embraced, it becomes almost inevitable to see the world through them. It is as if SK not only offers tools to describe, predict, and modify systems but also reconfigures the way the observer-developer interprets and acts. SK organizes thought in such a way that, upon adopting its principles, one begins to see reality as an interconnected network of energetic variables, where temporal connectivity and structural morphology are not merely components but active forces shaping each system. In this sense, SK not only proposes a new way of doing science and philosophy but also a new way of being in the world.

Ultimately, history is written by those who dare to challenge the prevailing paradigms.

CHAPTER THREE

THE PRINCIPLES OF SUPERCOMPLEX KNOWLEDGE

A new era of growth in complex knowledge and actions begins with the evolution and transformation of concepts, models, objectives, and the spaces constructed by the observer-developer. Complexity Theories must evolve toward a more advanced and developed state. Development implies accepting that we must enter a more mature and comprehensive stage of study compared to the initial theories of complexity. For this reason, we propose, in principle, and submit for consideration by the scientific community at large, the following principles of Supercomplex Knowledge (SK):

FIRST PRINCIPLE: The object of study is complex systems, analyzed through the triad of their components: energy flows, structural morphology, and temporal connectivity.

The object of study of Supercomplex Knowledge (SK) is complex systems[8] in all their multidimensionality. From this

[8] It should be noted that, to some extent, a system is a construct of the observer. The reality we know, dynamic and complex, is only observable through the systems we construct to make it intelligible. We prefer the concept of "system" over "organization" or "field." A semantic discussion is unnecessary since the debate should be morphological, that is, related to the content of understanding. Morin favors the concept of "organization" and conceives it as a continuous process of self-organization and development, where adaptability and evolution are key components. He highlights how biological and social systems maintain and renew their structure through internal processes. This conceptualization is not replaced by the one we present throughout this work, but we believe that the concept of "system," under our understanding and complex behavioral delimitation, is broader and more integrative. In Quantum Field Theory (QFT), "fields" are fundamental entities that permeate all space and time. These quantum fields are treated as the basic constituents of reality, with particles being mere excitations or manifestations of these fields. This conception may be more encompassing and fundamental than that of "system," as traditionally understood. The fact is that we include microparticle macrosystems, and almost the entirety of complex behaviors mentioned align with the dynamic proposal of "fields" in the aforementioned theory

position, we understand systems as real or abstract[9] units of energy management in dynamic and evolutionary interaction with their structural morphologies in a search for self-preservation over time through temporal connectivity strategies. It is, therefore, a three-dimensional, interdependent, circular, dynamic, and evolutionary interaction between energy, space, and time.

The SK's conception of complex systems as dynamic and interdependent units managing energy, space, and time resonates with contemporary research such as Complex Network Theory[10], which explores connectivity and emergent dynamics in interconnected systems; Systems Biology[11], which addresses organisms as networks of energetic and temporal interaction; and Agent-Based Modeling[12], which replicates evolutionary and adaptive processes. These studies reinforce the SK's three-dimensional and evolutionary perspective, linking its postulates with current interdisciplinary approaches.

For this reason, energy flows, in any of their expressions, structural morphology (space), and temporal connectivity strategies (time), activation and deactivation of functions and the internal or external temporal contact of the system, are the three fundamental dimensions for understanding, describing, intervening in, and/or modeling any type of system. These

[9] An abstract complex system is a conceptual representation of a real complex system, used to study and understand key aspects of that system in a more manageable and accessible way. These abstract models allow for the analysis and simulation of system behavior, the identification of multicausal relationships, and the recognition of emergent characteristics. Additionally, they provide a foundation for formulating and testing hypotheses about how the real system functions. In this way, abstract complex systems and real complex systems should not be considered separate entities but rather as mutually complementary

[10] Barabási, Albert-László. Network Science. Cambridge University Press, 2016.

[11] Kitano, Hiroaki. "Systems Biology: A Brief Overview." Science, vol. 295, no. 5560, 2002.

[12] Gilbert, Nigel, and Klaus G. Troitzsch. Simulation for the Social Scientist. Open University Press, 2005.

dimensions are central to describing the universe and life and explaining the continuity-unity and the diversity of all systems.[13] The three components are versatile and encompassing:

1. **Energy Flows:** Represent the active dynamics that traverse the system, including physical movements, information transfers, levels of activity or concentration, emotional transformations, and even value exchanges in economic systems. Energy flows can be constant or fluctuating and are key to understanding how change and adaptation occur within a system.[14]
2. **Structural Morphology:** Encompasses the configurations, behaviors, rules, and structures that organize or limit energy flows, both among the internal elements of the system and with the external systems it interacts with. This morphology can be physical (shapes and material structures), conceptual (models and theories), symbolic (languages and meanings), or digital (networks and algorithms), reflecting how the system is organized and evolves.
3. **Temporal Connectivity:** Reflects the synchronization, duration, sequencing, and coordination of interactions within the system, as well as with other systems in exchange, over time. It involves how relationships in a system develop, are maintained, or are transformed over time, affecting the stability and dynamism of the system. Temporal connectivity is essential

[13] Is the SK compatible with the approach of 'quantum gravity'? Quantum gravity seeks to unify general relativity, which describes gravity on a large scale, with quantum mechanics, which explains subatomic phenomena. Similarly, the SK proposes that complexity arises from the dynamic and bidirectional interaction between macroscopic systems, microparticles, and biological systems, offering a framework that could integrate gravitational effects with quantum principles. In particular, the idea in the SK that space and time are both concrete and abstract aligns with the notion in quantum gravity that spacetime is not a static background but behaves dynamically and can be affected by quantum fluctuations.

[14] Matter is not considered a separate fundamental component within complex systems but is understood as a manifestation or 'presentation' of energy. From this perspective, matter is a condensed form of energy that adopts various structural configurations depending on energetic interactions and its space-time context.

to capturing both permanence and change in the system's dynamics.[15]

From our perspective, it is essential to consider the components of complex systems to achieve a comprehensive understanding of the phenomenon. However, the analysis should not be limited to certain behaviors but must address the integrality of the system, including the changes that occur both internally and in its interaction with other systems.[16]

Energy flows are essential for the functioning and behavior of systems as they drive processes and interactions and participate in the creation of structures and in their self-regulation. In this sense, energy[17] is necessary for transporting, processing, and transmitting information. These transfers can occur linearly, but they can also follow topological, fractal, radial, reticular, spiral, toroidal, and other forms, which adds

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[15] Albert Einstein's Theory of Relativity emphasizes the inseparable interrelation between space and time, forming a unified entity known as 'spacetime.' This concept aligns with our paradigm, which considers time and space as dimensions that influence the dynamics of complex systems. However, while Relativity focuses on cosmological and gravitational phenomena, our proposed interconnection applies to a broad range of systems, including microscopic, biological, and technological ones. On the other hand, we share with Norbert Wiener's Cybernetics, centered on control and feedback systems, an emphasis on regulation and self-organization within systems. Yet, while Cybernetics focuses on more traditional control mechanisms, our framework incorporates a more integral approach that includes energy and temporal connectivity. Finally, Ilya Prigogine's theories on dissipative structures offer points of convergence in their analysis of energy flows. However, we extend this perspective by considering the interactions between multiple complex systems and their ability to reconfigure themselves through temporal connectivity and modifications in their structural morphologies.

[16] The reductive approach to emergent properties and behavioral patterns can lead to overlooking the importance of understanding the constituent parts and their interactions. Therefore, we consider it necessary to observe the properties of complex systems, including the nature and relationships of their components, to achieve a more comprehensive perspective. Another issue arises when the internal elements of the system (intrasystem) are described without considering the exchange systems (entresystems).

[17] It is important to remember that energy is not directly observable; rather, we perceive it through its effects on space and objects. For example, light and heat are manifestations of electromagnetic energy, and the movement of objects is a consequence of kinetic energy. Thus, although we cannot see energy itself, we constantly perceive it through its multiple everyday manifestations.

enormous complexity to the study of these systems. These interactions and superpositions of energy flows, characterized by an intrinsic circularity, make these systems diverse, change and evolve over time, and expand and interconnect in space.[18] Focusing on details, we consider that energy flows are shaped by two fundamental events: first, the interaction between different types of energy, which can generate unique energetic manifestations with direct impacts on the functioning of the involved systems and their connected systems; second, the resistance imposed by structural morphologies and connectivity strategies, which delimit and define the possible trajectories of these energy flows.

For the SK, energy is conceived from its combinatory capacity that allows the interaction between different vibrational frequencies, within a process of superposition and synchronization, in which emergent properties, new phenomena, or stability within a system appear. It is visualized as a continuous and multidimensional flow that traverses and connects the different elements of the system and the systems among themselves.[19]

We consider information as a form of energy that acts actively on the structure of a complex system, shaping its form

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[18] We do not conceive of a linearity between energy forms, as the intertwining of different expressions of energy generates an inherent circularity. Systems that emerge from the coupling of preexisting systems can recombine with the original systems of the interaction, thereby increasing the overall complexity.

[19] The SK's conception of energy as a multidimensional and combinatory flow resonates with various authors and research studies. Ilya Prigogine studied the role of energy in the formation of dissipative structures, while David Bohm linked it to the implicate order and universal connectivity. Hermann Haken explored its role in the self-organization of systems through synergy. Albert-László Barabási analyzed how energy drives interactions in complex networks. Fritz-Albert Popp highlighted the importance of light energy in biological processes through bio-photons. Nikola Tesla understood energy as the foundation of resonance and vibrational frequencies, and Benoît Mandelbrot connected energetic dynamics with emerging fractal patterns. These perspectives reinforce the SK’s idea of energy as a central agent in complex systems.

and organization. This perspective underscores the capacity of information to interact and shape the internal structures of such systems, evidencing its crucial role in the dynamics and evolution of the same. Information constitutes the synthesis of what occurs in terms of energy, space, and time in a given system. It facilitates communication and energy transfer, provides the context for understanding spatial and temporal interactions, and arises as a result of these interactions.

Regarding energy flows, we can outline a brief evolution of them. From the first cosmic fluctuations in this universe, the different modalities of energy have driven the creation and evolution of the quantum world. The primordial energy released generated the first subatomic particles such as quarks and electrons, which gave rise to the microparticle macrosystem. As the universe cooled, nuclear energy allowed the formation of the first atoms, stabilizing light elements such as hydrogen and helium. Subsequently, gravitational energy attracted these atoms, leading to the formation of stars and galaxies through nuclear fusion, where gravitational interactions dominate the large-scale structure of the universe.

On Earth, chemical energy and solar energy were crucial for the emergence of life when molecules began to self-organize into the first cells. Life evolved from simple unicellular organisms to more complex multicellular systems, using metabolic energy for sustenance and adaptation.[20]

Throughout human history, the ability to transform mechanical and electrical energy allowed the development of technologies. Finally, in the modern era, the digital revolution introduced digital energy and information processing as crucial

[20] For the SK, evolution does not follow a direct or progressive line. Instead, it is a dynamic and multifaceted process where adaptations and changes arise through trials, errors, and constant readjustments in response to a changing intersystem.

energetic modalities. With the emergence of Artificial Intelligence and cyber-analog systems, human capabilities to manipulate energy and manage information have reached new heights, generating an increasingly deep interconnection between biological and technological systems.[21]

For the SK, energy flows adopt a functional morphology that is the result of the combination of various energies and the ways in which these move and circulate through the space of the complex system. Generally, this movement manifests in turbulence, undulations, vortices, laminar flows, convection, diffusion, and oscillations, which are indicative of the internal energetic dynamics.[22]

The interaction between structural spatial morphology and functional energetic morphology in the SK is essential for understanding the complete dynamics of the complex system. Structural spatial morphology refers to the arrangement and physical organization of the components of the system in space. This includes the shape, size, distribution, and connection between the different parts of the system.

On the other hand, functional energetic morphology focuses on how energy flows and is distributed throughout the system, manifesting in behaviors such as turbulence, undulations, vortices, laminar flows, convection, diffusion, and oscillations. These energetic behaviors are crucial for the functions and processes that occur within the system.

[21] In more detail, different types of energy and different modalities of energy flows can be discussed. Among the types of energy, we have: kinetic, potential, gravitational potential, elastic potential, chemical potential, thermal, electrical, magnetic, electromagnetic, strong and weak nuclear, radiant, sound, mechanical, chemical, ionization, dark energy, among others. Energy flows are processes in which energy is transferred or transformed from one type to another. Examples include: radiation, conduction, convection, turbulence, geothermal, hydrodynamic, wind, solar, and tidal energy.

[22] These movements are characteristic of the macroscopic and biological macrosystems, but not of the microparticle macrosystem.

The interaction between both morphologies is bidirectional and dynamic: The physical arrangement of the system can facilitate or limit certain types of energy movements. For example, a structure with narrow channels may favor laminar flows, while more complex geometries can generate turbulence and vortices. The topology and spatial connectivity determine the possible routes for energy movement.

The behaviors of energy flows can, in turn, modify the physical structure of the system. For example, in natural systems, the flow of water can erode the terrain and alter its morphology. In biological systems, the transport of nutrients and energetic signals can influence structural growth and development.

Thermal energy is one of the most prevalent forms of energy on Earth and has a significant impact on the movement behaviors observed in macroscopic and biological systems. In addition to thermal energy, various other forms of energy play crucial roles in changes within complex systems, either competing with or interacting with thermal energy. Some of the most significant include chemical, kinetic, gravitational potential, electromagnetic, nuclear, and electrical energy, among others.

Each of these forms of energy can compete with or interact with thermal energy in complex systems. Often, these forms of energy do not act in isolation but transform into one another through various processes, generating significant changes in the structure, behavior, and dynamics of systems. The ability of complex systems to store, transform, and distribute these energies is fundamental to their evolution and adaptation.

Moreover, structural morphologies precisely determine how the components of systems are organized, their possibilities for interaction, and how energy flows through them. In this sense, energy flows can only be expressed according to the system's morphological structure; however, energy circulation, as a result of the plasticity and adaptability of systems, can lead to modifications in these structures.

From the SK perspective, we avoid adopting unilateral positions that simplify the structural-morphological complexity of the universe. This includes both the idea of perfect symmetry, as proposed by supersymmetry theory (SUSY), and absolute unpredictability, characteristic of chaos theory. While both perspectives have provided valuable tools for understanding structural aspects of nature, reducing the universe to only one of these visions may lead us to overlook its true richness. Reality appears to exist within a more dynamic spectrum, in which symmetries and asymmetries coexist (along with symmetries with asymmetries and asymmetries with symmetries), inter-penetrating and depending on the level of analysis or the system being considered.

Regarding structural morphologies, these appear with different predominances in complex systems and, in many cases, are superimposed:

- Linear, dependence. Linear structures suggest a sequence where each step depends on the previous one;
- Reticular, cooperation and competition. Networks allow interaction between various nodes that may collaborate or compete for resources;
- Arborescent, hierarchical dependence. Here, lower nodes depend on the upper ones;
- Topological, cooperation. This structural form is ideal for connecting nodes in a way that optimizes their functions;
- Laminar, superposition, and relational depth. These represent interpenetrated layers of systems, processes, or

variables that do not cancel each other out but rather mutually enhance or create tension.

- Radial, central dependence. In this case, the central node provides and/or controls resources for the peripheral nodes;
- Fractal, autonomy and dependence. These structures typically operate autonomously at different scales but maintain dependence through repetitive forms;
- Spiral, cyclical dynamics. Generally, they express continuous feedback cycles;
- Toroidal, cyclical interdependence. Continuous cycles where all nodes are interconnected in such a way that the flow never stops;
- Hexagonal, cooperation. These structures maximize spatial and resource efficiency;
- Cylindrical, continuous flow. This structure promotes the continuous flow of resources and/or information;
- Pentagonal, balance and stability. Ideal structures for balancing functions or roles.[23]

The evolution of structural morphologies in complex systems does not follow a linear arrow leading to progressively more complex forms. On the contrary, it is a dynamic and non-linear process, where universal principles interact with spontaneous reorganizations triggered by novel events, internal or external fluctuations, and new combinations among system elements. This dual nature, which combines common structural behaviors

[23] When two different structural morphologies meet, the result is not necessarily the emergence of a new morphology that is a perfect combination of both, nor the simple dominance of one over the other. The outcome is contingent on the internal dynamics of the system, the amount and type of energy available, the properties of temporal connectivity, and the adaptability of each morphology to its specific context. The emergence of a new morphology or the dominance of an existing one will depend on how these variables are configured.

with emergent and contextual responses, helps explain how a system can adapt, regress, or even coexist in overlapping states.[24]

It is worth clarifying that in complex systems, although multiple structural morphologies coexist, one may become predominant within a system. However, this predominance is neither absolute nor permanent, as systems operate within margins of fluctuation that allow the emergence of new configurations in response to internal or external changes. These margins ensure the adaptability of the system, enabling dynamic transitions between predominant forms depending on the system's evolution.

On the other hand, temporal connectivity refers to both the sequences of processes necessary for the system's functioning and the way it interacts with other systems. This may include cycles of communication, phases of growth or contraction, among other possible dynamics in the search for preservation and efficiency.[25]

In the SK, it could be said that temporal connectivity and energy flows maintain a bidirectional relationship. On the one hand, energy flows determine certain temporal behaviors, supporting the idea that temporal connectivity is an epiphenomenon of the energy component. On the other hand, once these temporal behaviors are established, temporal connectivity can, in turn, influence the modulation of energy and

[24] The transition from a radial structure to a networked one, as might be observed in a family business, does not follow a predetermined trajectory but rather results from a combination of factors such as the need to manage increasing commitments, the preparedness of its members, and the delegation of responsibilities. In this process, 'advances' and 'setbacks' are not contradictory but rather manifestations of constant adaptation. Previous forms do not completely disappear; instead, they remain as active layers within the structure, ready to reorganize in response to new circumstances.

[25] In other words, energy is the driving force behind all interactions and changes; space provides the physical and structural context where these interactions occur, and time sets the pace and sequence of the processes of change and evolution.

the structural reorganization of systems, acting as an active factor in the generation of complexity.[26]

We note that among the three components, there is a dynamic, circular, and evolutionary interaction. From our approach, we maintain that each of these organizational and fluctuating possibilities presents certain tendencies and associated behaviors: cooperation, competition, dependence, and various symbiotic relationships, among others.

Although we will address these concepts in greater depth later, we can already cite some examples where the interaction between energy flows, structural morphology, and temporal connectivity is clearly observed.

For instance, we ask what type of interaction between the components of a complex system, such as a plant, must occur for it to adopt a reticular form (a network-like structure) or a rhizomatic form (an interconnected underground branching structure). In fact, there is a specific interaction between energy flows and structural morphology that channels its development in one of these directions.

It can be observed that when contact systems (solar, water, and biological through nutrients) and their energy flows are distributed more homogeneously and consistently, the interactions favor a network structure, where the plant expands its growth horizontally or in multiple directions in a balanced manner. This "distributed" energy allows the creation of strong connections between different parts of the system, optimizing resource absorption from multiple points. In contrast, if energy flows, such as nutrients or water, are concentrated in specific areas, the plant develops a rhizomatic structure, extending its

[26] Fritz-Albert Popp demonstrated that biophoton emissions (light energy) in biological systems are closely related to temporal rhythms, suggesting a reciprocal interaction between energy and temporality in the regulation of the process.

rhizomes toward those areas rich in energy. This form enables it to take advantage of concentrated energy points, such as localized nutrient reserves in the soil or underground water sources.

In conclusion: if the structural morphology of the plant responds to a uniform distribution of resources, each part of the plant would grow synergistically and connected, in a radial or reticular manner, maximizing exposure to external resources (sunlight, aerial space, or soil, etc.). In this case, the plant seeks to maximize its interaction with other systems in multiple directions. However, if the structure is rhizomatic, it is due to the need to be more adaptive in the search for resources. The plant would develop underground extensions that act as "energy explorers," adapting to concentrated energy flows in certain areas. This more decentralized and modular expansion allows the plant to colonize spaces with nutrient patches, connecting disparate parts of the underground system with the available energy.[27]

We can provide other examples where the interaction between these three components is visualized:

- **Spiral galaxies:** The structural morphology of spiral galaxies (such as the Milky Way) facilitates an efficient flow of energy along their arms. The energy flows here include the distribution of gas, stars, and dust, which dynamically redistribute in spirals due to the angular momentum generated by the galaxy's rotation. This distribution balances gravitational forces, maintaining the stability of the structure. Temporal connectivity is observed in how gravitational interactions and stellar motion

[27] Relevant sources on this topic include: 1) Stiefkens, Laura Beatriz, et al. Morfología Vegetal: Guía de Trabajos Prácticos. Sima Editora, 2017. 2) Mesa López, Neftalí. Manual de Morfología Vegetal Externa. Grupo de Investigación en Genética y Biotecnología Vegetal y Microbiana de la Universidad del Tolima (GEBIUT), Universidad del Tolima, 2020.

generate cycles of star formation, where energy transforms and is reused over millions of years.

- **Hexagonal cells in beehives:** The hexagonal structural morphology optimizes the use of space and materials. In terms of energy flows, bees minimize energy expenditure in building the hive, as the hexagon has the best area-to-perimeter ratio, requiring less wax to store the maximum amount of honey. Temporal connectivity is manifested in the synchronization of cell construction, which follows a coordinated format among the bees to ensure that the structure grows efficiently and remains stable over time.
- **Plant cell walls:** In plants, cell walls are composed of cellulose, which provides both rigidity and flexibility. This allows for optimal structural support while facilitating the exchange of nutrients and water, fundamental aspects of energy flows related to photosynthesis. Temporal connectivity is evident in the daily cycle of photosynthesis, where plants rhythmically harness solar energy, storing and distributing the products of photosynthesis for growth throughout the day and night.
- **Nuclear fusion reactors (Tokamak):** In fusion reactors such as the Tokamak, the toroidal structural morphology is essential for confining plasma at extreme temperatures. The energy flows here involve the movement of highly energetic particles within the plasma, where the Tokamak's shape ensures that the plasma remains confined for longer, reducing energy loss. Temporal connectivity is crucial, as fusion can only be sustained for short periods during which temperature and pressure conditions are optimal for ions to fuse and release energy.

These examples demonstrate how energy flows, structural morphology, and temporal connectivity interact in both natural and artificial systems, optimizing energy efficiency and ensuring the stability and evolution of systems over time.[28]

Finally, we must understand the following characteristics of systems as necessary corollaries after the delimitation of our object of study:

1. **There is nothing in the universe that is not part of a system:**

Every system is constituted by a network of dynamic and evolutionary interactions between components. The parts are not understood in isolation but rather in terms of their internal and external relationships. The universe is composed of an infinity of interconnected systems that form and evolve at various levels of complexity. Every particle, object, or observable structure is part of a larger system, whether it be a physical, biological, or conceptual system. No entity exists outside a system, which implies that there are no islands of isolation in the observable reality.

2. **All systems are connected or interwoven:**

This principle highlights that systems do not exist independently. Instead, they are interconnected and interwoven with one another, generating dynamic interactions that determine their behavior. Imbrication is a key concept in SK, as it encompasses both the interrelation between systems and the overlapping of their components and functions. For example, the biological system is interwoven with the macroscopic system, and both interact with the microparticle system.

[28] The SK, by defining the components of a complex system, makes a qualitative leap that allows transitioning from an intuitive understanding to one based on concrete and measurable facts. This distinction is crucial because the SK does not merely describe emergent properties but seeks a solid foundation in well-defined interactions, as some approaches in Complexity Theories do. The definition of the components (energy flows, structural morphologies, and temporal connectivity) in the SK provides a more rigorous framework, less reliant on intuitions and abstract generalizations.

3. There are no voids between systems; no medium, no environment, no surroundings:
This principle states that there are no empty spaces or physical or conceptual separations between systems. The "medium" or "environment" is not external to systems; rather, it is part of a continuous network of interrelations. Energy, information, and matter flow without voids, meaning that every system affects and is affected by others in a complex web of mutual influences.

4. Closed systems can only be conceived in abstract terms:
Although in certain theoretical contexts or simplified models it may be useful to refer to closed systems (where there is no exchange of energy, matter, or information with the external environment), such systems do not exist in reality. All real systems are open to interactions with their intersystem. Closed systems can only be thought of as abstractions or theoretical models used to simplify analysis in certain disciplines.

5. Systems are constructions of the human observer-developer system:
This principle underscores the constructivist nature of SK. Systems, as we perceive and understand them, are the result of the cognitive, technological, and conceptual tools that humans have developed to observe, describe, and model reality. This implies that the understanding of any system is a relative construction, based on the interaction between the observer and the object of study.

SECOND PRINCIPLE: In complex systems, there is a coexistence of stabilizing functions, synchronous co-emergences, and sequential asymmetric fluctuations (progressive innovations).

For Supercomplex Knowledge (SK), complex systems exhibit a dynamic coexistence between stabilizing functions, synchronous co-emergences, and sequential asymmetric fluctuations, which allows for an understanding of both stability and transformation. Stabilizing actions ensure the functional organization of the system by synchronizing energy flows and optimizing its structure in the present. At the same time, synchronous convergences organize components and functions in simultaneous interaction, achieving cohesive and stable morphological configurations. On the other hand, sequential asymmetric fluctuations introduce progressive imbalances, reorganizing structural morphologies and reconfiguring temporal connectivities, giving rise to innovations and adaptive evolutions. It is through this dynamic combination, where energy flows are efficiently managed, structures are constantly reorganized, and temporalities intertwine, that functional stability and adaptive change are balanced, ensuring the evolution and survival of the system.[29]

These interactive behaviors, which at times may seem opposed, stability and emergence, compression and expansion, synchronicity and sequentiality, not only coexist but are the

[29] Energy flows are the driving force that sustains and maintains complex systems, constantly adjusting to synchronize and distribute efficiently. This process generates dynamic equilibria that ensure temporal stability. At the same time, structural morphology reflects how a system's components are spatially organized, facilitating synchronous interactions that optimize functionality and strengthen system cohesion. Temporal connectivity adds an evolutionary dimension, describing how interactions within a system change and reorganize over time. Asymmetrical sequential fluctuations disrupt established equilibria, introducing progressive imbalances that reconfigure both structures and temporal connections, driving innovations and evolutionary adaptations.

drivers of the evolution, transformation, and continuity of complex systems. In a stochastic and evolutionary process, emergent phenomena arise that explain the complexity of the universe and life on a large scale. When organizing these behaviors according to their role in complex systems, three major groups can be identified: producers of provisional stability, drivers of synchronous co-emergences, and generators of asymmetric fluctuations that lead to sequential emergencies and progressive innovations.

Processes that generate provisional stability are fundamental for establishing structures and temporary balances in complex systems. Examples include crystallization, where atoms organize into three-dimensional lattice networks; the stable configuration of planetary orbits through gravitational interactions; ocean currents, which regulate climate and transport nutrients; and tree growth rings, which reveal cyclical adaptation to interactions with other systems. In the biological realm, this can be seen in the self-organized stability of the DNA double helix, in cell membranes that maintain functional integrity, and in bone structures, whose combination of compactness and porosity ensures resistance and adaptability.

Behaviors that drive synchronous co-emergences promote self-organization and systemic efficiency, allowing for constant interactions. Examples of these processes include bird flocks, whose coordinated flight reduces energy consumption and improves aerodynamics, and transport networks in leaves, which optimize the distribution of nutrients and water. In ecosystems, trophic networks allow for stable interaction between producers, consumers, and decomposers, while coral reef structures and root systems with mycorrhizae promote adaptability and cooperation, optimizing the generation of complex habitats. At the neuronal level, the plasticity of networks allows for the functional reorganization of the nervous system, facilitating learning and memory in response to stimuli from other systems.

Generators of asymmetric fluctuations and sequential emergencies introduce fundamental transformations that drive evolutionary innovations. Due to the effects of cosmic inflation, they gave rise to the first structures of this universe. The phase transitions during the early cooling of the cosmos allowed for the appearance of particles and finely tuned structures, while primordial nucleosynthesis led to the formation of the first light elements that served as the foundation for the creation of initial stars. In later stages, the asymmetry between matter and antimatter, quantum tunneling, and nuclear fusion enabled the emergence of heavy elements and the release of energy.

In the biological domain, autocatalysis and genetic mutations play crucial roles in the emergence of new life forms, while speciation and adaptation facilitate the diversification and optimization of organisms. At the cognitive and cultural level, coevolutionary processes have generated networks of complex interdependence, where consciousness, cognition, and learning enabled the emergence of new social structures and technologies. In the field of artificial intelligence, phenomena such as convolutional neural networks, generative adversarial networks, and deep learning represent contemporary examples of progressive innovations in complex systems, revolutionizing the capacity for processing and knowledge generation.

In this way, complex systems develop through a dynamic balance between provisional stability, synchronous co-emergences, and asymmetric fluctuations, leading to the continuous generation of new structures and behaviors. These processes demonstrate that the complexity of the universe cannot be reduced to linear or simplified patterns, as it arises from the dynamic interaction between energy flows, structural morphologies, and temporal connectivities, both within systems and in their multi-scale interactions.

From the perspective of SK, the anomalies and fluctuations observed in complex systems do not represent ruptures within a rigid framework, but rather natural manifestations of the continuous interplay between stability, synchronization, and emergence. Rather than interpreting them as exceptions or deviations, the SK understands them as intrinsic expressions of supercomplex dynamics, where multiple processes interact across different levels and scales. This implies that what appears anomalous is merely the result of fluctuating combinatorial processes that generate emergent behaviors and new adaptive adjustments. Thus, phenomena that classical science interprets as irregularities can instead be understood as components of a continuous, evolutionary process, one in which complexity unfolds through a tapestry of provisional stability, synchronous co-emergences, and asymmetric fluctuations, integrating both transient patterns and profound transformations.

From this perspective, the universe is conceived as an interconnected fabric of energy, interactions, and evolution, where the causes of complexity intertwine, generating the rich diversity that characterizes our reality. The SK paradigm allows us to capture these profound interactions, showing that the evolution, transformation, and continuity of complex systems depend on this dynamic interplay between stability, synchronization, and progressive imbalance.[30]

[30] Complexity arises from this dynamic balance between stability and change, where energy flows, morphological structures, and temporal connections not only coexist but intertwine in an evolutionary and stochastic process. Thus, complex systems continuously generate and transform new forms and functions, challenging any attempt to reduce them to linear or simplified patterns. This interconnected fabric of energy, space, and time explains the rich

THIRD PRINCIPLE: Three Macrosystems Coexist -Microparticles, Macroscopic, and Biological- With Their Corresponding Levels of Complexity and Overlapping Interactions.

From our perspective, three overlapping types of macrosystems describe reality: microparticles, macroscopic, and biological. For Supercomplex Knowledge (SK), each of these macrosystems presents a distinct modality and evolution of complexity, which precisely defines the macrosystem itself.

- **Microparticle Macrosystem:** This macrosystem encompasses the subatomic particles that make up matter, such as electrons, protons, neutrons, and their fundamental components (quarks, gluons, etc.), as well as the most elementary particles that interact according to quantum physics laws. It also includes bosons, such as the photon (light particles) and the Higgs boson, which grants mass to other particles.
- **Macroscopic Macrosystem:** This macrosystem begins where atoms combine to form molecules and larger structures. It also includes non-biological organisms (inert materials), geological structures (planets, mountains), and extends to planetary and galactic scales, covering everything from everyday objects, terrestrial formations, planetary systems, galaxies, and galactic clusters.
- **Biological Macrosystem:** This macrosystem starts at the cellular level, with the first life forms based on prokaryotic or eukaryotic cells, encompassing the biochemistry essential for life (DNA, proteins, metabolism). It includes unicellular and multicellular organisms, extending to global ecosystems, with biolo-

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diversity of reality, showing how the forces of stability and emergence, synchrony and sequentiality combine to shape the evolution, transformation, and continuity of complex systems in the universe and in life.

gical interactions ranging from cellular processes to the behavior of entire communities and ecosystems, including non-human and human animals and all their productions.

The three macrosystems, microparticles, macroscopic, and biological, represent different levels of complexity, each with its own set of characteristics that organize reality in a particular way.[31] Therefore, macrosystems are not independent entities but emergent results of a continuous and multiscalar process, where the dynamics between stability, synchronization, and progressive imbalance generate the diversity and complexity observed in the universe.

The microparticle macrosystem is characterized by quantum complexity, where energy interactions are non-deterministic and probabilistic, governed by phenomena such as superposition and quantum entanglement. At this level, particles do not have a fixed structural morphology, and their behaviors are stochastic and highly unpredictable, making them the most abstract and dynamic level of complexity, in constant interaction with the other macrosystems.

In the macroscopic macrosystem, complexity deviates from classical physics laws and emerges when these systems self-organize and generate complex, unpredictable behaviors, such as the formation of galaxies, atmospheric phenomena, or the combination of chemical elements.

In the biological macrosystem, complexity centers on adaptation and evolution, always strategic and therefore innovative, of living organisms. Metabolic energy flows allow organisms to stay alive, grow, and reproduce, managing their survival possibilities through interactions between energy flows, structural morphologies, and temporal connectivity.

[31] This classification is developed in more detail in chapter six.

Each macrosystem also has a foundational event. In the microparticle macrosystem, this event is cosmic inflation, a rapid and multiversal expansion process that gave rise to elementary particles and the conditions necessary for the formation of observable reality. More than an absolute starting point, the universe emerges as part of a broader dynamic of quantum fluctuations and energy expansion.The macroscopic macrosystem is marked by the formation of stars and galaxies, structures that shaped the universe as we observe it today. The biological macrosystem begins with the emergence of cellular replication and life, marking the appearance of biological systems capable of evolving and adapting, leading to even greater levels of organization and complexity in the universe. Each of these events represents crucial milestones in the progression of complexity in the universe, from the smallest particles to life itself.

Now, we consider that the boundaries between these macrosystems are not strict, and overlapping and transitional areas can be observed among them, with diffuse limits and phenomena influenced by multiple levels of complexity. In other words, there exists a dynamic, bidirectional triple overlap between the three macrosystems, making them far more complex and interconnected. Therefore, the study of one level of complexity often requires understanding and tools from another.[32]

Notwithstanding this, we must state that, in general, it has been the macroscopic macrosystem (physics and chemistry, excluding biology) that has dominated the disaggregation of complexity descriptors, in our view, as a result of the logical

[32] We consider that each of the three general macrosystems corresponds to a specific type of complexity: the microparticle macrosystem and Cuanticomplexity; the macroscopic macrosystem and Macrocomplexity; the biological macrosystem and Biocomplexity.

development of science and the evolution of observation and measurement instruments. For this reason, beyond the existence of shared descriptors due to the previously mentioned overlaps and interconnections, we propose specific descriptors for each macrosystem, tailored to the nature of each one.

As we will see later, SK proposes energetic, spatial, and temporal descriptors to describe complexity in each macro-system. In this sense, specific descriptors are presented, such as those linked to entanglement, superposition, and decoherence in the microparticle macrosystem. In the biological macrosystem, as we will see, complexity is shaped by functions of autonomy, metabolism, reproduction, cognition (consciousness), and learning (computation, mapping, and timing). From this perspective, it becomes clear that a single definition of complexity is impossible, as it consists of different predominant modalities of energy and structure. In other words, it is only possible to measure levels of complexity within each macrosystem.

From our perspective, it is feasible to approach reality using and combining the mentioned systems, both within each macrosystem and at an inter-macrosystem level. This approach is based on the premise that complexity is inherently combinatorial and interdependent. Such a methodology facilitates a more fluid understanding of the nature of the numerous existing complex systems and promotes the adoption of interdisciplinary approaches. Furthermore, the integration of various systems provides an innovative framework essential for addressing today's global challenges, leveraging the expertise of different disciplines.

In the fourth principle, we will show how, in addition to the complexity inherent to each of these macrosystems, a new level of complexity must be added, Supercomplexity.

FOURTH PRINCIPLE: Supercomplexity Adds New Levels to Complexity Through the Overlapping of Macrosystems and Active Modification, Reconfigured Both Cognitively and Technologically by the Human Observer-Developer.

Another group of causes contributing to the formation of a new level of complexity, which we will call "supercomplexity," is the fact that macrosystems are overlapped, with areas of superposition and constant mutual influence. Additionally, the interventions of researchers in their efforts to modify, explain, or intervene in systems through maps and algorithms also contribute to the final formation of this "supercomplexity."

For Supercomplex Knowledge (SK), there are three modalities of complexity and two of supercomplexity.

Three Modalities of Complexity:

1. **Microcomplexity:** This is the quantum level, where complexity emerges from interactions between subatomic particles. Phenomena such as superposition and quantum entanglement are examples of how interactions at this level are probabilistic and non-deterministic, governed by the laws of quantum mechanics.
2. **Macrocomplexity:** This level includes large-scale systems, such as planets, stars, and galaxies. Classical physical processes like gravity and Newtonian physics are the main factors regulating interactions at this level. Examples of macroscopic complexity include climate systems, fluid dynamics, and the self-organization of physical systems such as stars.
3. **Biocomplexity:** At the biological level, complexity manifests through interactions between living organisms and their contact systems. Adaptation, evolution, metabolism, and

reproduction are some of the key behaviors at this level, driven by metabolic energy and interactions with other living beings and systems.

Two Levels of Supercomplexity:

First Level of Supercomplexity: The Triple Overlap.

At this level, there is an overlapping of the three macrosystems: microparticles, macroscopic, and biological. Here, emergent properties arise from the interaction between systems. For example, how quantum processes influence biological systems or how macroscopic factors (such as climate) affect life on Earth. This overlapping generates new behaviors that cannot be predicted simply by studying each system separately. The interaction between complex systems leads to emergent phenomena beyond the individual properties of each macrosystem.

Second Level of Supercomplexity: The Sum of the Triple Overlap + The Cognitive Functioning of the Brain + Technology (Techno-Engineering and Cyber-Analog Systems), Especially Deep Learning and Artificial Intelligence.

This level adds an additional dimension through the involvement of the human brain and advanced technology. The brain does not merely observe but actively modifies the complex systems it interacts with.On one hand, the human brain acts as an agent that feeds back and reconfigures systems, introducing a new layer of cognitive complexity. The human brain has the ability to reconfigure its own neural "wiring" as it interacts with complex systems. This neuroplasticity process allows humans not only to observe reality but also to change their perception and the tools they use to interact with it.[33]

On the other hand, advanced technology, such as cyber-analog systems and techno-engineering infrastructures, intervenes in complex system interactions. These systems combine technological and biological complexity, enabling the management and modification of biological, physical, and social systems through technology. An example would be artificial neural networks (deep learning), which directly impact biological and technological systems, helping to process large volumes of data and modify systemic behaviors in real-time.

Additionally, AI systems introduce a new mode of cybernetic emergence, where machine learning algorithms interact with biological and physical systems to generate new solutions, predictions, and interaction models that humans alone could not create. Here, technology and artificial intelligence enable new forms of interaction and system modification. Techno-engineering and cyber-analog systems allow complex systems to adapt and self-manage, adding a dynamic dimension of control and evolution to biological and physical systems, a dimension of supercomplexity.

SK redefines supercomplexity as a dynamic, expansive, and multidimensional process that goes beyond the observation of complex systems, incorporating active modification and cognitive and technological reconfiguration. This enables the visualization, and eventual modification, of new events, new

[33] The construction, prediction, and modification of supercomplex systems require an observer and developer who embraces and develops their own supercomplexity. In this sense, the subject must be aware of their own complex nature and their role as a multifaceted being interacting with various levels of reality. They must recognize that their identity, knowledge, and actions are deeply interconnected and interdependent with the surrounding macrosystems. Furthermore, they must accept that their reality is dynamic and in constant transformation, which implies the need to adapt and be flexible in their approaches and strategies.

combinations, and new circularities in the universe, life, and the human brain. This distinguishes it from traditional approaches to complexity by introducing the bidirectional and evolutionary interaction between the human brain, macrosystems, and advanced technological tools, creating an expansive paradigm that opens new possibilities for describing, predicting, and transforming systems. This is why SK establishes itself as an integrative and at the same time surpassing alternative to classical science, Complex Thought (Morin), and Complexity Sciences.

In contrast to classical science, SK argues that complex phenomena cannot always be reduced to universal constant laws. Many behaviors in the universe are stochastic and non-deterministic and require dynamic maps, not fixed patterns. Instead of seeking constants, SK aims to understand interrelationships and how systems evolve based on their interactions and considers that physical constants are not absolute but rather functional approximations dependent on measurement contexts and the level of interaction between systems. The introduction of noise, asymmetries, and non-linearity in real systems reveals that these constants are subject to variations.[34]

While classical science relies on fixed laws and patterns (such as the law of gravity or quantum constants), SK questions the permanence of these constants under extreme conditions or at unexplored scales. Additionally, it proposes maps that illustrate the evolution and emergent behavior of complex

[34] The idea that physical constants may depend on context is not new. The works of Barrow, Webb, Uzan, and Magueijo support this notion from both theoretical and observational physics. Additionally, the ideas of Dirac or Kaluza-Klein could further expand the discussion.

systems, surpassing the rigidity of deterministic models in classical science.[35]

Morin presents a more philosophical vision of complexity, whereas SK proposes that systems can be actively intervened in and modified through advanced technological tools. The ability to actively intervene in complex systems using AI and technology grants SK a scientific and technological applicability that Complex Thought does not fully contemplate.

Finally, SK expands Complexity Sciences by incorporating a relational and inter-systemic vision and distances itself from them due to their excessive dependence on sensitivity to initial conditions and pattern formation. SK questions the universal applicability of this premise, stating that many complex systems do not respond to initial sensitivity in a deterministic way. Additionally, it argues that the so-called patterns only emerge in specific cases and should not be considered a central descriptor of all systems. SK values the mathematical modeling of Complexity Sciences, but it also proposes that artificial intelligence, data science, neuroscience, and techno-engineering systems actively intervene in the real-time modification and optimization of complex systems.

FIFTH PRINCIPLE: Complex Multiscalar Constructivism is the Epistemological Foundation, and Probabilistic Multicausality is the Starting Point for a New Conception of Science.

[35] For example, Earth's movements are not caused by a single factor but result from the interaction between internal systems (such as the dynamics of Earth's core) and external influences (solar, lunar, and planetary gravitation). This reflects the systemic and interdependent nature of phenomena. Phenomena such as precession, nutation, or the Chandler wobble are dynamic and depend on variables that change over time, such as the redistribution of Earth's mass or external gravitational variations. This aligns with the SK's position that 'constants' are, in reality, relative and temporary. Finally, the systems involved (Earth, the Moon, the Sun, other planets) do not act in isolation; rather, their effects combine and overlap, generating complexity. This combinatorial paradigm reflects the core of the SK: understanding systems as interactive and dynamic networks.

Supercomplex Knowledge (SK) is based on a complex multiscalar constructivism, understood as a model that integrates a moderate constructivism or a "fact-checked constructivism" with the activity of the human brain and the use of advanced technologies to model and transform complex systems.

This constructivism acknowledges that our understanding and description of reality are built upon our experiences, interactions, cognitive abilities, and technological tools. Although this construction is inevitably conditioned by our limitations as observers, it is possible to identify consistent behaviors and recurring phenomena that suggest the existence of a relational framework that transcends individual perceptions. However, this 'objective reality' should not be understood as fixed, absolute, or independent of our interactions but as a dynamic, emergent, and multiscalar process that integrates our observations as part of the system it describes. There is no hidden order waiting to be discovered, but rather a reality that reconfigures itself. Epistemic uncertainty thus arises from ontological uncertainty.

From this perspective, reality is not merely an external object that we observe, but a network of interactions where observers and their observational tools play an active role in its configuration. This paradigm recognizes that any description is inherently tied to the interacting systems, the tools, and the scales used for observation.

When attempting to model or represent complex systems, our human tools, such as language, mathematics, advanced technologies, and cultural conventions, inevitably mediate these approximations. This process of mediation generates what SK refers to as "social formatting", a phenomenon in which our descriptions and models emerge from the shared historical, educational, and cultural context.[36]

The "distortion" through which we perceive reality implies that we observe something already filtered through our prior experiences and, in this sense, we make a selective framing. Within this approach, the perception of reality is not only filtered by prior experiences and individual cognitive structures but also by the network of interconnected systems in which those experiences are embedded. Each frame of reference adds an additional layer of meaning, amplifying or attenuating certain aspects of the perceived object. For instance, an everyday object may evoke different meanings depending on its cultural, emotional, or functional context and, consequently, will be perceived differently by two individuals, not only because they will register distinct aspects of the object but also because they will associate it with diverse networks of meaning and different frames of reference.

In this regard, multiscalar complex constructivism posits that perception is neither linear nor uniform but is instead constructed from multiple systemic interactions, where each relational node contributes to shaping what is perceived. This perspective not only underscores the subjectivity of the observer but also emphasizes the dynamic and evolving nature of perceptions. As the subject's frames of reference expand, interpretations of the object may shift, revealing that reality is an active, relational construction in constant transformation.

[36] The notion of 'social formatting' aligns with the ideas of the sociology of scientific knowledge, as proposed by Bruno Latour and David Bloor, which highlight how social and cultural factors influence the construction of scientific theories. This concept also resonates with Michel Foucault's ideas on how discourses and cultural practices shape knowledge.

From a multiscalar perspective, the SK articulates interactions between different levels of complexity, microscopic, macroscopic, and biological, recognizing how these dynamics affect both the stability and emergence of systems.[37]

From a multiscalar perspective, SK articulates the interactions between different levels of complexity - microparticles, macroscopic, and biological- recognizing how these dynamics influence both stability and system emergence.

Complex multiscalar constructivism redefines these key concepts as inseparable components of complex systems, transcending the limitations of traditional deterministic paradigms and opening new possibilities for understanding, modeling, and transformation in science and technology. Additionally, this multiscalar constructivism considers that descriptive tools, such as algorithms, simulations, and four-dimensional maps, not only represent systematic frameworks but also modify them, establishing a circular relationship between knowledge, technology, and reality. It also acknowledges the duality between the concrete and the abstract in the interpretation of energetic, temporal, and spatial components. In this sense, energy, time, and space are abstract constructs that emerge from interactions. These categories not only organize thought but also facilitate effective intervention in

[37] This stance may encounter resistance from two fronts. First, from empiricist and realist approaches, which might challenge the emphasis on subjective and relational perception, arguing that it undermines the possibility of establishing universal and measurable laws. In response, multiscalar complex constructivism does not deny the existence of an objective reality but rather emphasizes that any measurement is mediated by networks of relationships and interconnected systems that modify what is observed. Second, from scientistic or deterministic complexity scholars, who might perceive the subjective and relational component as an unnecessary source of uncertainty. However, from the SK perspective, the aim is not to complicate for the sake of complicating but to acknowledge that systems are interdependent and that this interdependence influences how they are perceived, described, and modeled.

systems, positioning SK as a dynamic and innovative paradigm for addressing complexity.

From our perspective, the complexity of the universe, life, and the construction of knowledge coexist and coevolve in a feedback relationship. Therefore, knowledge and reality are naturally and fundamentally intertwined, making it essential to consider this entanglement to understand the nature of both.

This concept within SK implies an active stance in knowledge construction but goes beyond traditional constructivism by incorporating the complexity of systemic interactions. In SK, knowledge is not simply a mental or social construction but a dynamic process that emerges from the interaction between energy flows, structural morphologies, and temporal connectivity. This gives rise to a paradigm in which knowledge is seen as an interdependent network that evolves based on changes in its fundamental components.

The complex subject, as both observer and developer of complex systems, is part of that complexity, making it illusory to think that one can remain objective and "see from the outside" the supercomplexity of the universe and life. The observer is a product of the same complexity, and therefore, is "entangled", meaning their rationality, mappings, and interventions are constructions shaped by the contradictions between technology, self-awareness, social relations, symbolic structures, and biology. The "supercomplex" subject cannot separate themselves from the systems they study and develop, as they are an integral part of them. Their understanding and analysis are inherently limited and conditioned by their own nature and experience as a human being. This entanglement implies that their perceptions, theories, and interventions are influenced by their technological context, self-awareness capabilities, social relationships, cultural symbols, and biological factors.

The rationality of the complex subject is a dynamic construction that reflects the intersection of multiple dimensions of human existence, challenging the traditional notion of objectivity and emphasizing the need for approaches that recognize and address these interconnections. Paul Cilliers, in his book "Complexity and Postmodernism: Understanding Complex Systems," offers a critical perspective on the application and interpretation of complexity theories. Cilliers is skeptical of theories that claim to provide universal explanations for complex systems, advocating instead for contextual and situational approaches that acknowledge the particularities of each system, accepting that complete and fully objective knowledge is unattainable and that there are always limitations to our understanding of systems.

Under this perspective, we consider that the observer and the system are inseparable; as a consequence, knowledge is constructed through the interaction of individuals with systems, including the combinations we will explore later. Moreover, we must emphasize that we perceive reality through our cognitive filters, which are influenced by our experiences, histories, beliefs, and emotions. Thus, the constructive contribution of an individual will be marked by the systems that are most predominant in their life, making it logical that perspectives across different cultures and civilizations are so diverse.

Newton, Galileo, and Laplace saw an ordered world governed by causal and deterministic laws. They did not perceive the vast number of perturbations affecting a complex system, nor the fact that these perturbations vary at different scales. Instead of viewing the universe as a system ruled by universal constants, SK proposes models of reality that are in dynamic evolution, reflecting the stochastic, emergent, and changing nature of complex systems. This perspective is far more flexible and better suited to the diversity and multiscalarity of phenomena observed at different levels of reality, from microparticles to biological and technological systems.

Rather than breaking down phenomena to understand their basic components, SK posits that knowledge arises from the interrelation between complex systems. Therefore, it does not seek definitive formulas but rather networks of interaction and energy flows that account for how systems change and evolve.[38]

This is why SK not only adopts a constructivist stance but also introduces a critical distinction that goes beyond the general ideas of Von Foerster in Second-Order Cybernetics. For SK, the degree of construction by the observer varies depending on the macrosystem with which they are interacting. In other words, the observer's influence is not uniform across all systems: In macrosystem analysis, the observer's role varies, within the microparticle macrosystem, the act of observation directly influences the system's state; in the macroscopic macrosystem, its influence is smaller; and in biological systems, its impact depends on the complexity of the observed organism or system. This interaction highlights the inherent complexity of knowledge in relation to the systems being studied and developed.[39]

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[38] Systems can rarely be fully explained through linear approaches that consider only one independent and one dependent variable. The interaction of multiple intervening variables is often key to understanding, describing, and predicting the behavior of these systems. In scientific research, combining interrelated variables can provide a richer and more accurate perspective, especially when dealing with phenomena that do not follow simple patterns.

[39] In the quantum realm, the act of observation can directly affect the state of the system. In macroscopic systems, the influence of observation may be less direct but still significant, particularly in scientific research contexts, where the formulation of theories and models can shape the direction of inquiry and the interpretation of data. In complex biological systems, the relationship between the observer and the system varies depending on the chosen approach. In biological research, the investigator's hypotheses can influence experimental

In SK, the complexity of the universe and life coexist and evolve in a feedback relationship with the process of knowledge construction. We uphold a circular, active, and progressive co-construction between the human brain and the universe, where the brain not only interprets reality but also influences it through its perceptions, experiences, and thoughts. This dynamic relationship implies that knowledge acquisition is an active process that affects both the knowing subject and the object of knowledge. This paradigm also explains the plurality of interpretations across different cultures, as each individual perceives reality through the systems that dominate their life.

Finally, complex multiscalar constructivism proposes a dynamic way of building knowledge by considering the continuous interaction of the fundamental components of complex systems, which could generate both adherences and critiques from other perspectives, such as those of Kauffman or Morin.

Furthermore, SK promotes a science (descriptive, prescriptive, and developmental) built upon probabilistic multicausality, without negating the possibility of linear correlations in an initial construction of the intervening variables.

In the universe, indeed, many events and behaviors cannot be reduced or described through deterministic or linear laws but depend on probabilistic principles, as seen in quantum phenomena and the periodicity of comets, where multiple factors and small variations prevent exact predictions.

In this sense, complexity and stochasticity (as emphasized in SK) imply that there are far more events that cannot be described through exact laws than those that can. Deterministic

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design and the interpretation of results. Moreover, when human beings are involved, the interaction between the observer and the system becomes even more intricate, as the system itself may respond to being observed.

chaos, turbulence in fluids, and stochastic fluctuations in complex dynamic systems are examples of this. Quantum fluctuations and nonlinear dynamics in systems such as meteorology and astrophysics show that, even though general laws exist, detailed predictions are extremely difficult or impossible.

The universe appears to operate on multiple levels with emergent and nonlinear behaviors, where universal laws can only be applied to limited domains and under ideal conditions. The probabilistic nature of complex systems is inherent and intrinsic and should not be understood as a result of a lack of knowledge or as a transitional stage toward discovering an underlying deterministic law. With this, the ideal of an 'exact' knowledge applicable to all reality is abandoned, accepting instead that, in many cases, knowledge is probabilistic and contingent. Heisenberg, Bohr, Lorenz, Prigogine, Kauffman, Maldonado, Smolin, and Bohm, among others, agree that probability is not an epistemological flaw but an ontological property of complex systems.

In summary, while universal laws provide tools to understand regular and predictable phenomena, there exists a vast variety of complex and stochastic systems whose nature cannot be fully captured by these laws. This recognition does not diminish the validity of scientific regularities but highlights the need to integrate probabilistic approaches and accept uncertainty as a key element in describing and modeling reality in its fullness.[40]

[40] While disciplinary fragmentation has been useful in deepening specific areas of study, it has come at the cost of limiting a holistic understanding of complex systems, where interactions between phenomena of various natures (physical, chemical, biological, social) are fundamental.

Currently, approaches that consider both deterministic and probabilistic aspects are beginning to be used.[41] From this latter perspective, the concept of stochasticity emerges to refer to systems or processes that are partially unpredictable but also partially probabilistic.

From the SK perspective, complexity lies between the deterministic and the probabilistic, without excluding the analysis of either aspect. Therefore, it is necessary to consider both linear and nonlinear interactions and to promote a science built upon probabilistic multicausality, a concept referring to the idea that complex events result from multiple causes interacting in a non-deterministic manner, each with different probabilities of occurrence. This paradigm recognizes that complex systems are influenced by a combination of factors and that the occurrence of certain events is not predictable with certainty but can be described through probabilities. There are many influencing factors, but in our view, the combination of energy flows along with the circular dynamics of structural morphologies plays a significant role. This prevents absolute certainty regarding expected outcomes but allows for probabilistic studies based on the nature of the systems under study.

It is necessary to clarify that in physical-chemical systems, this stochastic form of expression predominates, whereas in biological systems, behaviors are more structured around adaptive and survival mechanisms. In various biological systems, there is a combined and tensioned pursuit of survival and well-being, meaning the search for energy circulation and the construction of a structural morphology, interconnected with its species, that allows for more lasting survival and well-being. In other words, stochasticity is attenuated in these systems not only

[41] In areas such as Bayesian statistics or dynamic systems theory, hybrid models already exist.

due to internal conservation dynamics but also due to energy exchanges with various contact systems, fostering adaptability, interconnection, and evolution, where fluctuations are not seen as disturbances but as necessary inputs for a new order.[42]

From SK, the question arises as to whether technology and technologists have surpassed the constraints of classical science, given that they have a subject of study, a specific intentionality, and an inherently complex methodology. Technology has forced science to acknowledge that phenomena do not always follow simple trajectories and that patterns and regularities are only part of the equation in dynamic and complex systems. Wouldn't a ‘technoscience’, understood as a more suitable interface for constructing maps and algorithms, be a more fruitful alternative than focusing on the search for universal laws?

This technoscience would recognize that technologists do not merely describe reality but actively intervene in it, guided by specific purposes or intentions. The methodology is complex by nature, integrating multiple variables and incorporating the adaptability of models to new circumstances. Instead of imposing fixed rules, it would focus on creating maps, algorithms, and simulations that capture the richness of interactions and the contingency of complex systems, providing a more dynamic and practical understanding of reality.

Finally, a debate we did not wish to avoid is the relationship between SK and both structuralism and functionalism. In this regard, SK is neither structuralist nor functionalist but rather a surpassing of both approaches.

Structuralism focuses on the fixed and underlying relationships between the parts of a system, seeking to discover the

[42] SK believes that the concepts of order, equilibrium, and homeostasis are not adequate but rather reductive in explaining the dynamics of complex biological systems. The SK emphasizes the need to go beyond seeking stability, order, and equilibrium.

'structure' that determines the functioning of a whole. This perspective tends to freeze systems, searching for constant and universal patterns that, according to SK, do not accurately represent the true dynamics of complex systems. Instead, SK emphasizes fluidity and the continuous transformation of structures.

Functionalism, on the other hand, focuses on the functions that system parts perform to maintain stability and cohesion. It remains centered on the idea that systems organize around maintaining equilibrium and functional coherence. SK surpasses functionalism by integrating the notions of stochasticity, probabilism, and the emergence of new functions that are not solely oriented toward stability. While functionalism seeks to explain how system parts collaborate to maintain coherence, SK posits that instability, fluctuation, and emergent change are fundamental to the evolution of systems. Not all interactions within a system have a clear or necessary function for its equilibrium; some may even lead to its radical transformation or dissolution.

SK proposes that systems cannot be fully understood from either a structuralist or functionalist perspective, as both tend to emphasize regularity, predictability, and permanence. Instead, SK introduces the idea that systems are dynamic processes in which structure and function are emergent results of energy and temporal interactions. Rather than studying only the relationships between parts (as in structuralism) or the functions they fulfill (as in functionalism), SK focuses on how energy flows and temporal connectivity generate morphological changes. That is, the relationship between structure and function is circular and stochastic. Structure and function co-determine and co-evolve. Structural changes can lead to new functions, and emerging functions can, in turn, feedback and modify the structure. This view aligns with the idea that both structure and function are emergent temporal configurations within a constant flow of energy and information. It is a far more dynamic vision that acknowledges the crucial role of nonlinear fluctuations in the transformation of systems.

SIXTH PRINCIPLE: The modeling of complex systems is multidimensional, aiming at the construction of 'maps' and algorithms for description, prediction, and intervention.

SK studies systems in their multidimensionality through mathematical, computational, and conceptual (which can be analogical in the case of the biological macrosystem and its derived systems) modeling, adapting methodologies to the specificities of each macrosystem or system, ultimately leading to the development of maps that enable the design of algorithms for description, prediction, and intervention.[43]

From our perspective, it is possible to study systems in their multidimensionality through mathematical, computational, and conceptual modeling. The diversity of complex systems, as we

[43] For example, the biological macrosystem requires different techniques for description and intervention compared to the other macrosystems. The continuity and autonomy of living systems necessitate particular methodologies for approach by the human observer-developer in terms of developing strategies and complex tools such as the construction of broad descriptions, maps, and algorithms. As an example, we can mention the work carried out since 1960 by Jane Goodall with a tribe of chimpanzees, which demonstrated the importance of observation in their daily habitat and concluded that chimpanzees possess distinct personalities, with complex relationships of friendship and rivalry. In this way, an entire psychology and sociology of chimpanzees emerged in their complexity. In this study, the construction of broad and detailed descriptions of the social interactions and behaviors of chimpanzees in their natural habitat was fundamental. Researchers must employ prolonged and detailed observation techniques to gather data on social relationships, group hierarchies, play dynamics, and other behaviors. Additionally, creating maps that represent the social structure of the chimpanzee community and the modes of interaction between individuals is essential.

have pointed out, necessitates adapting the methodological approach to the characteristics of each macrosystem to achieve a comprehensive understanding of each modality of complexity. Therefore, the use of different modeling approaches according to the system being addressed results in the elaboration of a specific map, defined discretionarily and strategically according to the research objective, allowing the study of systems in interaction and, eventually, intervention through algorithms.[44]

From a mathematical approach, complex systems can be described through equations or systems of equations that represent the relationships between different variables within the system. These mathematical models can be linear or nonlinear, discrete or continuous, deterministic or stochastic (or a combination of both), depending on the characteristics of the system being represented. The construction of a mathematical model involves the representation of numerical and quantitative relationships between variables using equations and numerical expressions.

On the other hand, the construction of a linguistic conceptual model involves the representation of abstract concepts and their relationships using natural language and/or conceptual symbolism. This entails creating an abstract model in which the system's parts and their interactions and relationships are represented, potentially including diagrams, schemes, conceptual maps, flow networks, and other visual methods to depict the system's components and interactions. This type of modeling is useful for visualizing systems and is commonly applied in disciplines such as biology, psychology, and sociology. It is

[44] It is true that a strategic attitude is necessary to avoid contaminating descriptions with human criteria, but it is essential to acknowledge that it is impossible not to do so in interventions.

crucial for achieving a comprehensive understanding of systems as a whole and facilitating interdisciplinary interactions.

Additionally, computational modeling relies on the use of computer simulations to represent the system and its interactions. This approach employs algorithms and computer programs to simulate system behavior based on predefined rules. Generally, this type of modeling is used to study complex systems in real time and conduct virtual experiments.[45]

Furthermore, it is possible to approach the dimensions of complex systems in an analogical, metaphorical, or symbolic manner. In this sense, energy can be used as a metaphor or symbolic representation to describe the dynamics and driving force behind complex systems. This energy could refer to information, underlying forces, or influences that guide the behavior and transformations within the system. Similarly, space and time can also be utilized as metaphors or symbolic representations to describe aspects of complex systems. Symbolic space could refer to conceptual dimensions or fields of action, while symbolic time might denote evolution or change in a more abstract sense.

It is essential to recognize that there are different levels of study: descriptive, predictive, and intervention-based. Descriptive methodologies focus on the analysis and characterization of a system without interfering with it; here, algorithms and maps are employed to better understand a problem or situation and

[45] From the SK, we maintain that the approach to complex systems cannot be limited to a single methodology of description or measurement. We recognize that systems are interdependent and exhibit multiple levels of organization and emergence, which necessitates the integration of mathematical, conceptual, and computational approaches to capture their various aspects. These methods not only can coexist but must be applied strategically, adapting to the particularities of each system and the specific descriptive needs in this pursuit of comprehensive understanding. The combination of mathematical descriptions with linguistic and conceptual representations allows for the preservation of energy continuity and its relationship with the dimensions of space and time, thus offering a more complete and profound perspective.

identify trends. The goal of predictive tools is to anticipate future states or behaviors of a complex system. Intervention methodologies, in turn, aim to solve problems or modify specific situations. In this case, direct action is observed, intended to alter the course of a process or phenomenon.

To develop effective strategies for description, prediction, and intervention, it is necessary to construct strategic maps and algorithms tailored to the needs of the researcher.[46]

MAPS

We understand maps as visual representations intended to display the interconnections and inherent relationships among the elements that make up complex systems. These maps can vary in complexity, ranging from simple forms to more detailed presentations, depending on the complexity of the system being analyzed. In such maps, each component is symbolized as a node

[46] The simple act of tossing a coin exposes the interconnection of multiple systems and dismantles the illusion that a phenomenon can be explained through fixed constants. What appears to be a mechanical gesture is, in reality, the result of the simultaneous interaction between the biological system of the thrower, with variables such as neuromotor coordination, prior experience, and physical and emotional state, among others, and the atmospheric system, where factors such as wind speed and direction, air pressure, and temperature subtly shape the object's trajectory at every instant. The coin's fall is not solely an effect of Earth's gravity but is also influenced by the texture, inclination, and elasticity of the impact surface, the coefficient of friction, and even the possibility of rebounds or slips, among other factors. At the same time, the technological system represented by the coin itself introduces further fluctuations: its mass, center of gravity, aerodynamics, and material composition generate dynamic responses that challenge any attempt at deterministic prediction. On an even larger scale, the planetary system adds influences that, while imperceptible in daily life, remain present, ranging from Earth's rotation to subtle electromagnetic or gravitational interactions. Trapped within this web of interdependencies, the coin never follows an identical path, disproving the idea of absolute reproducibility under seemingly similar conditions. Classical science, in its pursuit of universal laws, is unable to account for this multiplicity of factors and their combinatory effects. The SK, on the other hand, enables the construction of 'maps' to describe the phenomenon in its entirety, not merely by identifying isolated variables but by modeling their spatial interactions and temporal evolution. With the aid of advanced sensors and artificial intelligence algorithms, it becomes possible to capture and represent the real dynamics of these systems, transcending the fragmented vision of traditional thought and understanding complexity as a living fabric of connections in constant transformation.

or point, while the relationships between these elements are represented through lines or arrows. These connections can manifest in various ways, encompassing linear relationships, influences, interdependencies, and feedback loops. Additionally, variable maps or diagrams can be qualitative, quantitative, or a combination of both, depending on their purpose and the information they aim to represent.[47]

The concept of dynamic maps implies a continuous updating of how we perceive reality, focusing on relationships rather than isolated entities. Maps are strategic tools designed to address the complexity of systems without attempting to encompass all their components. The SK asserts that, due to the multifaceted and stochastic nature of complex systems, it is neither possible nor practical to observe or address all systems and variables simultaneously. Therefore, maps in the SK are the result of a strategic selection, where certain key elements are prioritized based on three main criteria:

1. Prioritizing explanatory variables: Selecting variables that best explain the evolution and behavior of the complex system over time. This approach allows for a better understanding of how systems transform, interact, and adapt, generating emergent behaviors.

2. Focusing on intervention variables: Maps should identify variables that can be modified to enhance the system. These variables represent leverage points where interventions can positively impact the system's evolution, optimizing its functionality or adaptability.

[47] A qualitative map focuses on illustrating the relationships between variables and their modes of interaction without specifying numerical values. This methodology is useful for visualizing the flow of information without delving into numerical details. On the other hand, a quantitative map could include specific numerical values for the variables and their relationships, providing a more precise representation of data or specific calculations.

3. Aligning with instruments and methodology: Maps must consider variables for which the observer-developer (human) possesses the necessary methodological and technological tools to describe, model, and intervene in the system. This ensures that the knowledge generated is effective and applicable, avoiding variables where there is insufficient technical capacity for precise intervention.

Through these maps, the SK proposes a practical and flexible approach to analyzing complex systems. Rather than seeking a total explanation, which may be unattainable, the emphasis is placed on prioritizing variables that have the greatest impact on the description, prediction, and modification of the system. Thus, maps serve as strategic representations that guide intervention in complex systems, emphasizing what can be observed, modeled, and manipulated within the limits and capabilities of the observer.[48]

ALGORITHMS

On the other hand, an algorithm is a set of detailed instructions that a device can follow to solve a specific problem. Algorithms are fundamental as they enable the processing of large datasets and the generation of visualizations and explanatory models of these systems. Additionally, they allow for the representation and analysis of complex systems, providing valuable insights into their dynamic behavior. Algorithms supply the computational or logical tools necessary to analyze, process, or model the information contained in maps. This relationship

[48] Technologists, especially in fields such as artificial intelligence, data analysis, biomedicine, and ecology, use these 'maps' of interaction or networks to better understand their systems of study and develop more precise interventions. For example, in artificial intelligence and deep learning, neural network models are, in essence, dynamic maps of relationships and dependencies that represent the connections between multiple variables (nodes) and how they feedback and evolve.

allows for the extraction of properties and behaviors from the complex system described in the map, which, in turn, facilitates a deeper understanding and prediction of its dynamics.[49]

At the intrasystem level, maps and algorithms can identify and analyze complex internal dynamics, such as self-organization or energy resistance, offering insights into how to improve the system’s efficiency and adaptability. At the inter/intersystem level, descriptors can be used to understand how different systems interact and influence each other. Maps can illustrate these interactions, while algorithms can predict how changes in one system might affect others. Descriptors enable the analysis of how these interactions influence the overall system dynamics, and algorithms can suggest ways to optimize these relationships for the system’s benefit. By encompassing all three levels of analysis, it is possible to capture both the system's internal properties and its external relationships, which is essential for a comprehensive understanding of complex systems and their behavior.

OBSERVATION INSTRUMENTS

From another perspective, the SK promotes the use of new knowledge and technologies and, consequently, improved instruments for observation, detection, and measurement within the framework of constructing a new way of understanding complexity.

There are three generations of observation instruments for measuring and analyzing intervening variables in systems. In the first generation, each instrument measures only a single variable, providing isolated data. The second generation advan-

[49] The development of maps using SK descriptors allows for the visualization of how energy flows, structural morphologies, and temporal connectivity interact within a system or in the inter/intersystem dynamics.

ces by measuring groups of variables simultaneously, allowing for a richer understanding of systems but still limited in analyzing interactions. The third generation, however, focuses on measuring the simultaneous interaction between multiple variables, capturing the interdependent dynamics of complex systems.

For the SK, these third-generation instruments are the most suitable for analyzing complex systems, as they enable a deeper understanding of how variables influence each other within an interconnected system. This approach allows for a more precise capture of the essence of complex and supercomplex systems, which are characterized by their interactions and the emergence of new behaviors.

SCIENCES AND DISCIPLINES INVOLVED

The SK emphasizes the need to incorporate neuroscience, Artificial Intelligence, Big Data, and Deep Learning, among other essential tools, to develop and enrich its approach to the diversity of spaces and times in complex systems.[50] This paradigm could not only expand our theoretical understanding but also improve practical interventions across a variety of fields. Each of these fields provides unique tools and perspectives that facilitate the exploration and comprehension of super-complexity.

[50] In our team of developers, we have asked ourselves whether human observation systems would learn more from AI if it associated the intervention of numerous interdependent variables with foundational systems. We are aware that methodologies exist that aim to make this possibility viable. Cluster analysis is a technique used by AI algorithms to group variables or data into sets that are more similar to each other than to those of other groups (K-means, Hierarchical Clustering, DBSCAN). Similarly, deep neural networks and graph-based models can identify complex behaviors and nonlinear relationships between variables. Lastly, there are approaches and research lines in the field of Explainable AI (XAI) that share some commonalities with this idea.

In this regard, using neuroscience as a paradigm to address complex phenomena allows for a deeper understanding of how humans perceive, process, and act. Meanwhile, AI has the ability to model and simulate aspects of the supercomplex universe that exceed the direct comprehension of the human brain. It has become an indispensable tool for breaking down and analyzing an immense amount of physical, chemical, astronomical, and biological data. With its capacity to process information at an unimaginable speed compared to previous decades, AI can identify behaviors and correlations that would otherwise remain hidden. These technological advancements provide researchers with tools to explore complex scenarios and interactions, offering a more comprehensive understanding of processes across different levels of analysis that are otherwise difficult to observe directly. Closely linked to AI, Deep Learning can be used to uncover new relationships between data, thereby altering our current understanding of the universe and life. The identification of complex behaviors within vast datasets enables the exploration of new theories that were previously inconceivable due to the human inability to perceive large-scale correlations. Similarly, Big Data allows for a much more detailed comprehension and analysis of the universe to the extent that our very understanding of complex phenomena is clarified with the assistance of this tool. By collecting and analyzing extensive datasets on any complex phenomenon, such as climate change or species migration, we achieve a more thorough and substantial perception of these processes. This expanded comprehension reshapes and enriches our perception of the universe, influencing our broader understanding of reality itself.

DEVELOPERS

Considering the different approaches and skills required to handle complexity in system development, there are three levels of complex system developers. At the first level are scientists, at the second level are technoengineers, and at the third level are philosophers.

Scientists focus on the most technical and empirical aspects of complex system development. Their work may involve researching and applying scientific principles to understand and model the components and behaviors of systems.

Technoengineers apply engineering and technological knowledge to design, build, and maintain complex systems. This level centers on the practical application of theories and models developed by scientists to solve real-world problems and optimize system performance. This category includes systems analysts, software and hardware developers, and specialists in artificial intelligence, among others.

While traditional scientific approaches focus on intrasystemic analysis (what occurs within a system) or intersystemic analysis (the interaction between proximate systems), the philosophical gaze turns toward distal causal displacements. It seeks to grasp how local decisions generate effects in distant systems, how certain present adjustments result from remote evolutionary trajectories, and how the most profound transformations operate on temporal and spatial scales that often elude technical scrutiny.