The Concept of “Quantum-Like”

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The birth and spread of the prefix “quantum-” to disciplines other than physics, and the introduction of the term “quantum-like”, reflect the increasing dissatisfaction with the perceived limits and pitfalls of classic Western thought. Of course, the latter remains valuable; what is wrong is its dogmatic use and the claim of its exclusive capacity to comprehend the world. The development of quantum physics has been paralleled by the introduction of paraconsistent logics, such as fuzzy logic and dialetheism, a clear sign of the need for smoothing the inflexibility of Aristotelian logic. There is also a *fil rouge* (viz. an epistemological symmetry) linking the paradigm of quantum physics to ancient pre-Socratic and Eastern philosophies, suggesting the need for reappraising them in the process of reexamination of the classical thought. The increasing use of the term “quantum-like” calls for the defining and sharing of its meaning in order to properly adopt it and avoid possible misuse.

Keywords: quantum physics ; quantum-like ; epistemology ; neurosciences ; psychology ; social sciences ; biology ; philosophy

1. Why a Concept of Quantum-Like: Epistemological Implications.

The increasing appeal of the quantum paradigm, justifying the introduction of the term “quantum-like”, seems to be dependent on the limits of Western classical thought to interpret all phenomena of the macroscopic world properly. Hence, an insight into its limits, as well as its advantages, is an essential step to frame the problem properly. Its detailed discussion is far beyond the aims of this article, but outlining a few fundamental aspects is necessary to envisage the reasons for the introduction of the “quantum-like” concept (for a detailed analysis, see [1][2][3]).

Aristotle is the philosopher that has contributed more to the development of rational thinking in the West. In fact, in his *Metaphysics* and in *Prior* and *Posterior Analytics,* he funded a rigorous logical strategy that aimed to discern the real from the false through a clear distinction of logical and illogical reasoning and, as a result, of facts from fancies. The Western way of reasoning has followed Aristotle’s strategy, based on his tripartite logical system—i.e., the principle of identity, the principle of non-contradiction, and the principle of excluded middle (or Third)—and his metaphysical assumptions, also adopted by modern sciences; this entails that both metaphysics and scientific knowledge are logical and closely connected.

Western philosophy has pursued the ἐπιστήμη (*epistème*, from the Greek ἐπι- and ἱστάναι, that means “what stands above”), i.e., a certain, indisputable knowledge overcoming any doubt and negation, seeking the immutable, the essence, and substance of phenomena. This has led to a static way of reasoning, taking the unchanging for truthful, and, what seems to be contingent, swinging between being and not-being becoming illusory or irrelevant.

Subsequently, the posterity turned the Aristotelian logic into an undiscussed, dogmatic doctrine [1][2][4]. The overestimation of the power of syllogism, induction, definitions, tripartite logic, and the split of reality according to a stiff dichotomous criterion (true vs. false; 1 vs. 0) has led to nature being a priori constrained within one’s mental categories. This, in turn, has led to the relative being taken for absolute and the particular for universal. Given the underestimation of the limits of available knowledge at any given time, one has been inclined to judge truthfulness or falsity according to one’s ignorance, as well as one’s knowledge. As emphasized by Popper, this also entails the possibility of retransmission of falsity by logic in empirical sciences [5], including the risk of deviation from reality yielded by the closure of investigated phenomena within the limits of selected facts, theories, and mental categories—what Edgar Morin defined as the delusion of abstract conceptual coherence [6].

Unlike Socrates and Democritus, Aristotle—referred to by Dante as “Who teaches to all who know”—knows to know, while post-Aristotelian thought has been strongly inclined to believe to know, also taking beliefs for knowledge. In other words, Aristotle introduced a positive knowledge, while Democritus and Socrates were fully aware of not knowing, “for truth lies in the abyss” (Democritus, fragment DK 68 B 117). Their stance is in line with the Greek concept of ἀλήθεια (*alḗtheia*, truth)

—etymologically stemming from the privative alpha in front of -*lḗtheia*, in turn deriving from the term λανθάνω (*lanthano*, concealed, hidden, unknown). Therefore, *alḗtheia* means that knowledge and truth are only truthful fragments grasped from the unknown. Accordingly, they used the *elenchus* (refutation) and *reductio ad absurdum,* rather than the Aristotelian use of induction and syllogisms, to be taken as proofs of positive knowledge.

The century-old Western rationalism paved the way to the outstanding rationalist revolution of the 17th century and the birth of Galilean sciences. Still, they were based on a political compromise with the Church—claiming the exclusive competence on the soul (consciousness)—rather than a free epistemological reflection. The Cartesian dualism, ontologically splitting the *res cogitans* and *res extensa*, aimed to favor the compromise by saving the soul for the Church, although made it unfathomable with the scientific method based on Galileo and Descartes' mathematical–geometrical apriorism. Therefore, it made the *res extensa* and *res cogitans* incommensurable, a sort of metaphysical guillotine, leading to the observer being excluded from the observed facts [1][2].

In broad terms, the classic Western thought has been inclined to commit a sin of naivety, i.e., the illusion to know the reality as it is in itself and possess the truth by a seemingly foolproof method. Nevertheless, despite its undeniable value, it is neither the only possible method, nor the perfect one, to be exclusively adopted. Especially in empirical sciences, its products remain *dóxa* (as for all axiomatic knowledge, as emphasized by Aristotle himself (*Metaphysics* 1005b, 1–5)), providing valuable partial models of the reality, at best. Metaphorically, some brittle bricks have been inadvertently used to build up the inflexible Western rational scaffold, leading to it being cracked by the quantum quake of the early 20th century.

If this is the case, the pre-Socratic and Eastern philosophies may help find a *fil rouge*—or, perhaps better, a sort of epistemological symmetry—between ancient thought and quantum physics, and help restore the cracks. Actually, it is no accident that quantum physicists were the first scientists to take consciousness seriously in the early 20th century, and approached both pre-Socratic and Eastern philosophies, opening their minds to a non-dualist view encompassing the whole world. This issue was well addressed in the 1970s by Frank Capra in his *Tao of Physics* [7], where he stated in the preface that:

> "Eastern mysticism provides a consistent and beautiful philosophical framework which can accommodate our most advanced theories of the physical world".

The topic was also appraised in 2011 by Kaiser, in his book dealing with the activity of the Fundamental Fysiks Group and its interpretation of the quantum entanglement in terms of Eastern mysticism and psychic mind reading [8].

Despite the relevance of ancient Greek and Eastern philosophies having been suggested for almost one century, many (perhaps most) philosophers and scientists are not yet familiar with their paradigms and concepts, and remain firmly anchored in the comfort zone of classic Western thought. Therefore, an outline of some essential concepts of these philosophies, with their close links and epistemic relevance, remains an essential step in terms of discussion, especially when dealing with the concept of "quantum-like", which that extends to disciplines other than physics, and to the macroscopic (e.g., classic) world.

Pre-Socratic philosophers were called φυσικοί (*physicoi*, physicists) as they investigated the natural world, referred to as ὅλης φύσεως (*hólēs physeos*, the whole)—including both the material and (ostensibly) immaterial realms, viz. body and mind, matter and energy, atom and void—with a non-dualistic paradigm contemplating the complementarity of opposites, a paradigm akin to Taoism [9]. Then, following the parricide of Parmenides by Plato and Aristotle, the rational approach to reality was affected by nihilism (i.e., the idea that what exists is doomed to become nihil) [10] and an increasing dualism, the edge of which is Descartes' thought embedded in an inflexible rationalist stance. Hence, the opposites were ontologized and substantialized, making them incompatible, paying the high price of an irreconcilable split of what in nature is united; this has, in turn, led to monist materialism prevailing in positive sciences, although it is an ill-founded, self-contradictory metaphysical stance, a long-term result of Cartesianism [1][3].

Quantum physicists have introduced an entirely new paradigm in the Western cultural landscape, able to explain the realm of the infinitely small and rejoin what classical thought had unduly split; at the same time, it is old as the hills, reappraising the wisdom of the first *physicoi* and Eastern philosophers. Democritus plays a central role in physics for his theory of atoms and void. Like other pre-Socratics, Democritus' theory has been puzzling and considered paradoxical or self-contradictory—swinging between atomism, empiricism, and skepticism—when analyzed through the prism of post-Aristotelian thought [11]. In his theory of atoms and void, he moves a step forward, along with Parmenides' concept of being, by defining the elementary basis of the physical world in its appearance, where the void is not tantamount to nihil

but exists as an essential component of the appearance of being. Void is the complementary counterpart of matter, without which the latter could not exist and be perceived as such. At the same time, atoms serve as the basic units of the manifold, dynamic, ever-changing appearance of the world emanating from the Being. In other words, Democritus allows the merging of the concepts of Parmenides' Being and Heraclitus' dynamic world of becoming, into a whole, where:

> "Opposition unites. From what draws apart results the most beautiful harmony. All things take place by strife"
>
> (Heraclitus, Fragment DK 22B8)

This also accounts for the coherence of Democritus' proto-empiricist approach to nature. In fact, his analysis starts from what is given, where he holds an epistemically sound and outstandingly modern view—compatible with Poppers' fallibilism, the model-dependent realism introduced by Hawkins and Mlodinow [12] as well as the Popper and Eccles' Theory of the Three Worlds and its new neurophenomenological version (NTTW) [3][13].

This model-dependent realism establishes that no concept of reality, independent from descriptions and theories, may exist. Therefore, the sciences may only provide more or less reliable partial models of reality able to make correct predictions. According to the NTTW, world 1 is the physical world, and world 3 is the world of consciousness and mind products, while world 2 is the brain–mind–sense organ unit, the processor allowing one to record information from the outer world and convert it into subjective experiences and all mind products (including philosophy and science). Likewise, in model-dependent realism, the world 3 engenders partial (more or less valid) models of world 1 and, through human creativity, can materialize its products; as a result, the reality, as one knows it, is an inseparable co-creation of world 1 and 3 through the coding rules of world 2. These theories are perfectly consistent with Democritus' argument:

> "…In reality, we know nothing about anything; but for each of us there is a reshaping-belief … to know in reality what each thing is in character is baffling" (Fragment DK 68 B 7, 8)… We know nothing in reality; for truth lies in the abyss"
>
> (DK 68 B 117)

Rather than a skeptic stance, it is a well-founded awareness of the intrinsic limits of rational knowledge of nature, in perfect agreement with Socrates' awareness of not knowing and Kant's "natural illusion" of humankind, taking concept and mental images for the reality in itself [14]. It is worth underscoring the substantial agreement between Democritus' theory and the above-mentioned theories, aiming to overcome the limits of both Cartesianism and monist materialism, and merge both the physical and mental dimensions into an integrated, inseparable whole, a fact pertaining to quantum physics and philosophy at the same time.

Democritus' enlightened view has, unsurprisingly, made him the great father of modern physics and cosmology [15] and, we argue, of quantum physics. In fact, his intuition regarding the atomic structure of matter was confirmed by physics in the 19th century (i.e., 2300 years later), an epoch when matter's discrete or continuous structure was still debated. The subsequent discovery of the atom as a complex, rather than indivisible, entity has seemingly overcome Democritus' theory. On the other hand, one should refrain from simply applying to Democritus' concept of atom the meaning it currently has.

Democritus' ἄτομος (*atomos*) indicated the smallest, unperceivable, indivisible unit of the physical world, which he established by outstanding intuition. Thus, his *a-tom* does not necessarily correspond to what we today refer to as an atom, and may well fit the elementary subatomic particles at the deepest level of reality; if this is the case, the whole of his atom and void may also fit the concept of virtual particles and quantum vacuum. Since (a), energy is subject to transformation but never becomes anything, and (b), matter (as an expression of energy [16]) may disintegrate and disappear but cannot result in an absolute nihil, one can argue that Western nihilism is wrong; it is a result of naïve realism rather than a product of reason, as already established by both Parmenides (*Perì Phýseos*, 2) and Hippocrates:

> "Neither a thing may become nothing nor anything not previously being be may start to be, but everything changes for mixing and separation… It is not possible that what is not may start to be"
>
> (Hippocrates, *De Diaeta* I, 4, 9)

Therefore, the ancient thought was right when establishing that everything in the phenomenal reality appears and disappears by aggregation and separation from a virtual, unknown, and unobservable part of reality, what in quantum physics is referred to as *Grid* [17]. As a result, it seems reasonable to liken the Grid to the concept of *Tao* (*Dao* in pinyin transliteration) and Parmenides' Being, as well as the Hindu deity शिव (Śiva), lord of the timeless cosmic dance that is the origin of the appearance–disappearance–regeneration of the world, a fact making so evocative the statue of Śiva at CERN in Geneva.

2. Why a Concept of Quantum-Like: the Relevance of Eastern Philosophies

A few key concepts of Chinese and Indian philosophies are relevant in this context (for a detailed analysis of their relevance and for a transcultural, metaphilosophical approach in psychology and philosophy of mind, see [9][18]).

Lǎozǐ defines *Dao* in the *Dàodéjīng* as the unnamable, the mother of all creatures; it manifests itself through the *Yin–Yang* principle, i.e., the dynamic, ever-changing reciprocal relationship of two opposite, complementary polarities, neither of which endowed with an autonomous existence. This paradigm allowed Taoism to establish, conceptually, the mutual transformation of matter (*Yin*) and energy (*Yang*) into each other over 2000 years ago, as well as the inseparable relationship of mind–body–outer world.

Likewise, the Veda tradition includes both the dualist school Dvaita Vedānta and the non-dualist school Advaita Vedānta. The former identifies *Jivatman* (the individual soul) and *Brahman* as two separate non-interchangeable entities, while the latter holds the inseparability of individual *ātman* from *Brahaman*. Nevertheless, both the individual soul and *Brahman* remain components of a unique reality, allowing one to solve the ostensible contradiction between these monist and dualist stances in the *Bheda-Abheda* doctrine (where *bheda* means division, separation, and multiplicity, and *abheda* means unity and non-separation), establishing a simultaneous difference–non-difference, its eternal continuity, imperishability, and all-encompassing nature of the ultimate reality behind diversity.

In short, the above-mentioned principles are akin to Parmenides' light and dark and Heraclitus' convergence and harmony of opposites, in a non-dualistic view encompassing complementarity, a principle rediscovered by Bohr in quantum physics.

Four epistemically relevant key concepts of Buddhism are worth mentioning, which are: (a) *māyā* (the mask of illusion of ordinary consciousness); (b) *anitya* (impermanence, *anicca* in Pali); (c) *śūnyatā* (reality as vacuity); (d) *pratītyasamutpāda* (the interdependency of all entities, no one being endowed with autonomous and intrinsic existence). *Māyā* warns against naïve realism and perfectly agrees with the above-mentioned Democritus' and Kant's views, while *anitya* establishes the ceaseless transformation of the world, in line with both Daoism and Heraclitus' view. *Śūnyatā* defines the reality in itself (e.g., world 1) as made of what remains once the modalities of perception, qualia, mental objects, mental images, and categories are filtered out. Nâgârjuna and the Madhyamaka-Prasangika school established the correspondence between *śūnyatā* and *pratītyasamutpāda*, emphasizing that the latter defines a related mode of being, where observable phenomena are halfway between being and not being—rather than autonomous, steady *res* endowed with an immutable essence and related by plain causality.

All the above-mentioned Sanskrit terms are surprisingly modern, perfectly matching the ontology of the relationship and the non-separability held by quantum physics [19]. Indeed, the paradoxes of quantum physics and its ostensible absurdity, which depends on post-Aristotelian Western ontology, can be solved by endorsing these concepts and holding a symmetric relation of co-generation, i.e., the bidirectional relationship of world 1–3 and their co-creation of the world (as it is known). Here, there is no need for claiming intrinsically existent *res* endowed with a definable immutable or enduring substance and essence.

3. Why a Concept of Quantum-Like: mathematical and physical implications

According to Popper and Eccles, physics—the most "materialist" and determinist of disciplines—has been able to transcend itself, leading to the dissolution of the matter–energy classical dualism [13]; furthermore, it has undergone radical criticism of the classical Western thought, leading to a shift from the ontology of properties to the ontology of relationships. The former, adopted by classical physics, conceives things as separate entities endowed with well-definable features with their essence knowable through Aristotelian induction, embedded in a local world where they may undergo reciprocal relationships. The latter, adopted by quantum physics, establishes that things manifest themselves only through

reciprocal interaction, a fact implying their correlation—i.e., their description can only be obtained through the information obtained from the interaction.

The ontology of relationships, as well as the irreducibly probabilistic nature of investigated phenomena, makes quantum physics a non-essentialist discipline able to provide reliable models of investigated phenomena according to the uncertainty and complementarity principles and the inseparable relationship between the observer and the observed, rather than trying to define what things are in themselves. This stance entails the need for leaving the inclination to a static substantialization and ontologization of the *res*, and trying to grasp their relationship through an empirical and mathematical approach able to predict their dynamic behavior.

If the above discussion is correct, the paradigm of the quantum physics may be regarded as a bright (though ostensibly paradoxical) formal way to analyze the *rerum* behavior, where the reunification of observer–observed allows for its application beyond the limits of the physical world; indeed, it may justify its extension to the interpretation of the world of consciousness, cognition, social sciences, and, in general, of human and biological life, to be considered as constitutive parts of the same, single, interrelated world.

Toffano and Dubois [20] recently introduced a *Quantum-like Eigenlogic Program*, an operational–geometric approach moving beyond the limits of Boolean logic and admitting the superimposition of logical inputs, the non-commutativity of operators, quantum probability, and entanglement. It promises a “quantum-like” approach to logic and, being logical, the formal study of functions and laws of reasoning; it is independent of the content of involved propositions, allowing for its extension beyond the limits of quantum physics.

4. The Quantum-Like Interpretation in Neurosciences and Social Sciences

An increasing number of articles have been published in the past two decades on “quantum-like” interpretation of cognition, decision-making, and game theory, especially in uncertain or conflicting situations [21][22][23][24][25][26]. According to Bruza [22], the classical probability calculations are based on Boolean logic, and include a rationale and a heuristic approach. The former is a deductive (e.g., top–down) method based on subjective probability and expected usefulness theories, including Bayesian algebra (taking into account personal beliefs/opinions and their incorporation into the decision-making process). The latter can be considered as a bottom–up method in that it encompasses simple ad hoc rules that humans can learn during the process. At any rate, the Boolean logic is commutative, while human decision-making may be non-commutative in many instances; here, it is of crucial interest the fact that both the additive rules and Bayesian formula are violated in quantum probability calculation, where the existence of incompatible observables is closely related to the uncertainty and complementary principles, and can be managed as non-commuting operators [21]. This suggests that quantum probability calculation might be more suitable for properly confronting human cognition and decision-making processes.

For instance, Wagner et al. [27] tested a quantum probability approach, known as quantum question equality, for non-commutative decisions using data from Gallup survey experiments and two experimental studies, where the same questions were placed in different orders to determine if judgments might depend on their sequence. The results suggested the effectiveness of their quantum approach in social and behavioral science. Similar results have been reported in the two-stage gambling game and Prisoner’s dilemma game, in which participants violated the principle of sure thing of decision theory, and their behavior might be better predicted by quantum probability calculation [28].

More recently, Khrennikov et al. have introduced a quantum model of socio-political processes based on lasing theory, referred to by the authors as social lasing [25]. In short, the quantum-like approach is more and more appealing and has provided valuable models in disciplines other than physics; its use in psychology and neurosciences is probably the most relevant since the observer's mind plays a central role in all disciplines, while human factors are of paramount importance in the dynamic processes of disciplines like economy and finance.

5. Conclusions

The birth and spread of the prefix quantum to disciplines other than physics and the introduction of the term quantum-like reflect the increasing dissatisfaction with perceived limits and pitfalls of classic Western thought. Of course, the latter remains valuable: what is wrong is its dogmatic use and the claim of its exclusive capacity to comprehend the world. The development of quantum physics has been paralleled by the introduction of paraconsistent logics, like fuzzy logic and dialetheism [29][30], a clear sign of the need for smoothing the inflexibility of Aristotelian logic.

The increasing use of the term quantum-like calls for defining and sharing its meaning in order to properly adopt it and avoid possible misuse. Its conceptual definition is essential since the topic involves scientists and philosophers from different disciplines, who may have no or only minimal acquaintance with the mathematical formalism of quantum physics. As a result, the quantum-like approach may be used in different ways entailing three different levels of application:

1. A strong version, where the term quantum-like is used more rigorously i.e., it concerns experimental studies where data are analyzed by the quantum mathematical apparatus, such as the above-mentioned quantum probability calculation or the lasing theory.
2. A weak version, when the problem is approached from an epistemological perspective without using the quantum mathematical apparatus such as in theoretical studies and new hypotheses analyzing the observed phenomena and their similarity with quantum behavior through a sound rational approach meeting the conceptual framework of quantum physics; for example, this may be the case of new hypotheses in disciplines like economy and psychology.
3. A wrong version, when authors not familiar with both the concepts of quantum physics and its mathematical formalism, simply borrow its terminology just for its appeal. Of course, an inappropriate use of quantum-like may only detract from the glory of both physics and the involved discipline.

In this regard, the term entanglement has become more and more fashionable outside the field of quantum physics and may risk being interchangeably used as a quantum-like property (according to quantum entanglement) or an appealing synonymous of a close relationship on a case-by-case basis. In physics, the quantum entanglement defines the condition in which the quantum states of two or more *res* must be described with reference to each other, even when the individual *res* may be spatially separated; it also raises an epistemological issue, i.e., it questions the principle of local realism. In common language, the term entanglement defines a situation or relationship one is involved in, which is difficult to escape from (see the Cambridge Dictionary, https://dictionary.cambridge.org/dictionary/english/entanglement). If this is the case, the term entanglement is endowed with different meanings and encompasses both ordinary and quantum phenomena; as a result, there would be no reason to use its quantum meaning just for its scientific appeal when a simple relationship compatible with the classical view of the world is dealt with. On the other hand, it may be more acceptable when an apparent non-local connection is investigated, such as in some intriguing studies on the entanglement between pair of separated subjects, where a signal (e.g., a flash stimulation) delivered to a subject may be someway detected by the distant partner and activate his/her brain visual areas [31]: in such a case one may arguably consider it as a quantum-like phenomenon since there is no apparent information transmission. . Anyway, the use of the term entanglement according to its common meaning (indicate a close relationship) is not wrong in itself and may be correctly used. The main point is: not bringing up the quantum physic when not necessary and properly using the quantum-like approach when appropriate.

Actually, one should wonder whether the traditional view of individuals as separated, autonomous, independent entities is correct, or, instead, they should be considered as inseparable, interrelated parts of a single world, as already well defined by both the ancient Eastern and Western thought and modern theory of complexity. If that were the case, there would be no need for borrowing the term entanglement from quantum physics. Instead, the ancient thought should be seriously reappraised, submitted to scrutiny through a rigorous transcultural and transdisciplinary approach, and implemented, a fact possibly leading to a shift of paradigm and a new *Weltbild*.

Actually, the appeal of the term quantum-like seems to reflect on the surface a deep unease with the limits of the classic Western thought and a need for moving farther. If 20th-century physics has undergone a radical revolution, other disciplines e.g., medicine and life sciences have remained anchored to Newtonian physics, for it seems to explain quite well the order of magnitude of the investigated phenomena. Nevertheless, the newborn quantum biology and the quantum theories of consciousness are promising fields of investigation [32][33], while several topics in disciplines other than physics, like those mentioned above, seem to be better understandable using the quantum-like approach.

If the above discussion is correct, the quantum-like topic is worth being taken into due account and properly defined. Of course, this is only provisional opinion, hopefully helpful to promote further discussion and achieve a better definition of the topic.

References

1. Facco, E.; Lucangeli, D.; Tressoldi, P. On the science of consciousness: Epistemological reflections and clinical implicat ions. Explor. J. Sci. Health 2017, 13, 163–180.
2. Facco, E.; Fracas, F. L’enigma Della Coscienza; Mondadori Università: Milano, Italy, 2018.
3. Facco, E. A nerurophenomenal theory of the three worlds. Theory Psychol. 2022, 09593543211068426.

4. Russell, B. Wisdom of the West; Rathbone Books Ltd.: London, UK, 1959.
5. Popper, K.R. Objective Knoweldge; Oxford University Press: Oxford, UK, 1972.
6. Morin, E. La sfida della Complessità. La défi de la Complexité; Abselmo, A., Gembillo, G., Eds.; GaiaMente, Le lettere: Milano, Italy, 2011; ISBN 9788860874573.
7. Capra, F. The Tao of Physics; Shambhala: Boulder, CO, USA, 1975.
8. Kaiser, D. How the Hippies Saved Physics: Science, Counterculture, and the Quantum Revival; Norton & Co.: New York, NY, USA, 2011; ISBN 9780393342314.
9. Facco, E.; Al Khafaji, B.E.; Tressoldi, P. In search of the true self. J. Theor. Philos. Psychol. 2019, 39, 157–180.
10. Severino, E. The Essence of Nihilism; Verso: New York, NY, USA, 2016.
11. Bruseker, G.T. Democritus and the Socratic Turn: A Reading of the Democritean Fragments as a Response to the Question of Self. Available online: https://www.academia.edu/4679569/Democritus_and_the_Socratic_Turn_A_Reading_of_the_Democritean_Fragments_as_a_Response_to_the_Question_of_Self (accessed on 1 October 2021).
12. Hawking, S.; Mlodinow, L. The Grand Design; Bantam Books: New York, NY, USA, 2010; ISBN 0-553-80537-1.
13. Popper, K.R.; Eccles, J.C. The Self and His Brain; Springer: Berlin/Heidelberg, Germany, 1977.
14. Kant, E. Critique of Pure Reason; Cambridge University Press: Cambridge, UK, 1998.
15. Kalakhanis, K.; Panou, E.; Theodossiou, E. The cosmological theories of the atomic philosophers, the forerunners of quantum physics, astrophysics and cosmology. Int. J. Phys. Astron. 2013, 1, 30–34.
16. Einstein, A. Does the inertia of a body depend upon its energy content? Ann. Phys. 1905, 18, 639–641.
17. Wilczek, F. The Lightness of Being. Mass, Ether, and the Unification of Forces; Basic Books, Ed.; Basic Books: New York, NY, USA, 2008; ISBN 9780465003211.
18. Facco, E. Meditazione e Ipnosi tra Neuroscienze, Filosofia e Pregiudizio; Altravista: Lungavilla, Italy, 2014.
19. Bitbol, M. Two aspects of Śūnyatā in quantum physics: Relativity of properties and quantum non-separability. In Quantum Reality and Theory of Śūnya; Bhatt, S.R., Ed.; Springer: Berlin/Heidelberg, Germany, 2019; pp. 1–31.
20. Toffano, Z.; Dubois, F. Adapting logic to physics: The Quantum-like Eigenlogic program. Entropy 2020, 22, 139.
21. Khrennikov, A.; Se, A.K. Quantum-like modeling: Cognition, decision making, and rationality. Mind Soc. 2020, 19, 307–310.
22. Bruza, P.D.; Wang, Z.; Busemeyer, J.R. Quantum cognition: A new theoretical approach to psychology. Trends Cogn. Sci. 2015, 19, 383–393.
23. Gonzalez, C.; Lebiere, C. Cognitive architectures combine formal and heuristic approaches. Behav. Brain Sci. 2013, 36, 285–286.
24. Wang, Z.; Busemeyer, J.R.; Atmanspacher, H.; Pothos, E.M. The potential of using quantum theory to build models of cognition. Top. Cogn. Sci. 2013, 5, 672–688.
25. Khrennikov, A.; Alodjants, A.; Trofimova, A.; Tsarev, D. On interpretational questions for quantum-like modeling of social lasing. Entropy 2018, 20, 921.
26. Muthoharoh, L.; Hardhienata, H.; Alatas, H. Modified Asano-Ohya-Khrennikov quantum-like model for decision-making process in a two-player game with nonlinear self- and cross-interaction terms of brain's amygdala and prefrontal-cortex. J. Biol. Phys. 2020, 46, 297–307.
27. Wang, Z.; Solloway, T.; Shiffrin, R.M.; Busemeyer, J.R. Context effects produced by question orders reveal quantum nature of human judgments. Proc. Natl. Acad. Sci. USA 2014, 111, 9431–9436.
28. Pothos, E.M.; Busemeyer, J.R. A quantum probability explanation for violations of "rational" decision theory. Proc. Biol. Sci. 2009, 276, 2171–2178.
29. Priest, G.; Berto, F. Dialetheism. In; Zalta, N., Ed.; 2013; Vol. Summer 201.
30. Cintula, P.; Fermüller, C.G.; Noguera, C. Fuzzy Logic. In The Stanford Encyclopedia of Philosophy; Zalta, E.N., Ed.; Stanford University: Stanford, CA, US, 2021; pp. 1–49.
31. Richards, T.L.; Kozak, L.; Johnson, L.C.; Standish, L.J. Replicable Functional Magnetic Resonance Imaging Evidence of Correlated Brain Signals between Physically and Sensory Isolated Subjects. J.Altern.Complement Med. 2005, 11, 955–963.
32. Poznanski, R.R.; Tuszynski, J.A.; Feinberg, T.E. Biophysics of Consciousness.; World Scientific Publishing Co. Pte Ltd: London, UK, 2017;

33. Tuszynski, J.A. From Quantum Chemistry to Quantum Biology: A Path toward Consciousness. J. Integr. Neurosci. 2020, 19, 687–700, doi:10.31083/J.JIN.2020.04.393.