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The 2022 Nobel Prize in Physics for Entanglement and Quantum Information: the New Revolution in Quantum Mechanics and Science

Vasil Penchev

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Vasil Penchev, vasildinev@gmail.com
Bulgarian Academy of Sciences: Institute of Philosophy and Sociology
Dept. of Philosophy of Science

Abstract. The paper discusses the 2022 Nobel Prize in physics for experiments of entanglement "establishing the violation of Bell inequalities and pioneering quantum information science" in a much wider, including philosophical context legitimizing by the authority of the Nobel Prize a new scientific area out of "classical" quantum mechanics relevant to Pauli's "particle" paradigm of energy conservation and thus to the Standard model obeying it. One justifies the eventual future theory of quantum gravitation as belonging to the newly established quantum information science. Entanglement, involving non-Hermitian operators for its rigorous description, non-unitarity as well as nonlocal and superluminal physical signals "spookily" (by Einstein's flowery epithet) synchronizing and transferring some nonzero action at a distance, can be considered to be quantum gravity so that its local counterpart to be Einstein's gravitation according to general relativity therefore pioneering an alternative pathway to quantum gravitation different from the "secondary quantization" of the Standard model. So, the experiments of entanglement once they have been awarded by the Nobel Prize launch particularly the relevant theory of quantum gravitation grounded on "quantum information science" thus granted to be nonclassical quantum mechanics in the shared framework of the generalized quantum mechanics obeying rather quantum-information conservation than only energy conservation. The concept of "dark phase" of the universe naturally linked to the very well confirmed "dark matter" and "dark energy" and opposed to its "light phase" inherent to classical quantum mechanics and the Standard model obeys quantum-information conservation, after which reversible causality or the mutual transformation of energy and information are valid. The mythical Big Bang after which energy conservation holds universally is to be replaced by an omnipresent and omnitemporal medium of decoherence of the dark and nonlocal phase into the light and local phase. The former is only an integral image of the latter and borrowed in fact rather from religion than from science. Physical, methodological and proper philosophical conclusions follow from that paradigm shift heralded by the 2022 Nobel Prize in physics. For example, the scientific theory of thinking should originate from the dark phase of the universe, as well: probably only approximately modeled by neural networks physically belonging to the light phase thoroughly. A few crucial philosophical sequences follow from the break of Pauli's paradigm: (1) the establishment of the "dark" phase of the universe as opposed to its "light" phase, only to which the Cartesian dichotomy of "body" and "mind" is valid; (2) quantum information conservation as relevant to the dark phase, furthermore generalizing energy conservation as to its light phase, productively allowing for physical entities to appear "ex nihilo", i.e., from the dark phase, in which energy and time are yet inseparable from each other; (3) reversible causality as inherent to the dark phase; (4) the interpretation of gravitation only mathematically: as an interpretation of the incompleteness of finiteness to infinity, for example, following the Gödel dichotomy ("either contradiction or incompleteness") about the relation of arithmetic to set theory; (5) the restriction of the concept of hierarchy only to the light phase; (6) the commensurability of both physical extremes of a quantum and the universe as a whole in the dark phase obeying quantum information conservation and akin to Nicholas of Cusa's philosophical and theological worldview.
Keywords: classical quantum mechanics, dark and light phases of the universe, dark energy and dark matter, Einstein, energy conservation, entanglement, general relativity, Hermitian and non-Hermitian quantities in quantum mechanics, locality and nonlocality, Pauli's particle paradigm, quantum gravity, quantum information, quantum information conservation, qubit, the Standard model, unitarity and non-unitarity

I INTRODUCTION: THE HISTORY OF NOBEL PRIZES IN PHYSICS, ESPECIALLY IN THE AREA OF QUANTUM MECHANICS: THE NEGLECTED ENTANGLEMENT

"The Nobel Prize in Physics 2022 was awarded jointly to Alain Aspect, John F. Clauser and Anton Zeilinger 'for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science'"[1]. So, it has been postponed for 40-50 years to the experiments at issue and the corresponding publications (Clauser, Horne, Shimony, Holt 1969; Freedman, Clauser 1972; Clauser, Horne 1974; Aspect, Grangier, Roger 1981; 1982)[2]. Meaning that Nobel Prizes can award only alive people, it was delayed maximally and as if presenting it "reluctantly":

One may use the following humorous metaphor: if Nicolaus Copernicus had awarded for its discovery in his age, it would be presented analogically "reluctantly" not mentioning the punishing "awards" of Galileo Galilei or Giordano Bruno (who was expelled from the scientific Oxford: attempting to be recognized before that). As the heliocentric system, the phenomena of entanglement demonstrated by the experiments at issue did not correspond to the general worldview and to even to the social order and hierarchy in the final analysis[3]:

One might trace the French revolution about two centuries later back to Copernicus's discovery which blew up the established order. The revolutions in our age are "velvet" or "gentle" rather than blood as the French revolution was really. Furthermore, the revolution corresponding to the discovery of entanglement and quantum information is yet forthcoming in an uncertain future. However, it is unavoidable and the present paper will try to explain why entanglement and quantum information bode social revolutions along with properly "scientific revolutions": an expression more or less metaphorical in comparison with the real shocks of social revolutions even being "gentle" or "velvet".

Quantum mechanics called for a scientific revolution about a century ago. Anyway, that revolution was "mitigated" in order to remain mainly not more than scientific. That is the revolution induced by quantum mechanics was reinterpreted in a way to be restricted to a quite specific subject studied by that science and referring to scales commensurable with the Planck constant, that is microscopic and not being able to influence our everyday experience directly.

One can utilize a counterfactual comparison to Copernicus's discovery, after which the astronomic sun of the heliocentric system would be absolutely distinguished from the sun visible on the sky so that the former is immovable, but the former is moving and Copernicus's discovery revealed only it not touching in any way the latter or the established social order. Fortunately or

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[1] https://www.nobelprize.org/prizes/physics/2022/summary/. This is the official formulation for the 2022 Nobel Prize in physics.

[2] The publications of the third Nobel Prize winner, Anton Zeilinger were later: about 1997-1998.

[3] Entanglement and quantum information imply a very essential change of our general and philosophical worldview (e.g.: Bilban 2021; Hagar 2017; Kupczynski 2016; Rapoport 2011; Bokulich, Jaeger, eds. 2010; Penchev 2009; Dunlap 2015; Esfeld 2004; Horodecki, Horodecki, Horodecki 2004). There are papers (Crosilla 2022; Şahin 2020; Boge 2019; Ruiz-Perez, Garcia-Escartin 2017; Parsons 2013; Zizzi 2007) discussing entanglement or quantum information in the context of logic, arithmetic, set theory, or the foundations of mathematics and thus in a less or more generalized and philosophical sense.

unfortunately, the Holy Church was not so smart and did not manage to distinguish the astronomical sun from the sun of human experience, the latter being only relevant to the established social order.

About four centuries later, the "error", though admitted to the heliocentric system, to Nicolaus Copernicus, Galileo Galilei or Giordano Bruno, was not repeated in relation to quantum mechanics. Speaking figuratively, the "sun" of the Planck constant scale was reliably distinguished from the "macroscopic sun" visible by everyone. So, the new "heliocentric system" of quantum mechanics was successfully limited only to its specific subject not concerning common sense's worldview or people's life otherwise than by the mediation of technical devices, in which the "human interface" is fundamentally different from the scientific principles on which they rely[4].

Physics nowadays generalizes two fundamental quantities, energy and time shared by anything claimed to be physical, as well as a collection of laws of conservation, among which both energy conservation and correlative temporal Lie groups of translations are featured. One can suggest that Wolfgang Pauli and his contributions to quantum mechanics, his "victory" over Niels Bohr[5] in the debate about the violation of energy conservation[6] and the relevance of the "fourth uncertainty" in quantum mechanics were that "point of bifurcation", after which quantum mechanics was prevented revolutionizing all physics, the general philosophical worldview and social order in the final analysis by self-restricting to a specific own subject however obeying energy conservation and rejecting the inherent "time operator" so that time is a unique quantity in quantum mechanics[7], to which no Hermitian operator corresponds unlike all the rest quantities in quantum mechanics.

Speaking metaphorically, Wolfgang Pauly imposed a "limited autonomy" of quantum mechanics, according to which it obeys a few fundamental laws valid in all physics and corresponding to the hierarchical structure of society and a social order though variable and changeable from a historically certain order to another: however, without any doubt in the necessity of some social order, without any "anarchism". In other and metaphorical words, though the area of quantum mechanics is a "hippy commune" similar to "Freetown Christiania" in Copenhagen, permitted as a "social experiment", nonetheless its autonomy is restricted and the "Danish jurisdiction" is anyway valid in its territory.

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[4] By another metaphor, one can use a smartphone posting "sweet kittens" on the Internet and social networks by his or her widget without any care or trouble about the social order and her or his place within it.

[5] Bohr, Kramers, Slater (1924)

[6] The corresponding history and references are available in: Guerra, Leone, Robotti (2014).

[7] Investigations (e.g. Allori 2019; Khrennikov 2009; Basini, Capozziello 2005) the special position of time in the ontology of quantum mechanics in turn being a subject of other papers (e.g. Berghofer, Goyal, Wiltsche 2021; Harding 2021; Colletti, Pellegrini 2020; Wallace 2020; Bigaj 2018; Lazarovici, Oldofredi, Esfeld 2018; Catren 2017; Esfeld 2017; 2014; Gao 2017; Khrennikov 2017; Auffèves, Grangier 2016; Brock, Harré 2016; Glickm 2016; Dorato 2015; Egg, Esfeld 2015; Lam 2015; da Costa, Lombardi 2014; Esfeld, Gisin 2014; Grössing, Fussy, Pascasio, Schwabl 2014; Roldán-Charria 2014; Bain 2013; Costa, Lombardi, Lastiri 2013; Griffiths 2013; Heelan 2013; Esfeld 2012; Bricmont 2011; Calosi, Fano; Tarozzi 2011; MacKinnon 2007; Wilson 2011; Lewis 2006; Belousek 2003; French, Ladyman 2003; Busch 2002; French 2002; Peacock 2002; Krause 2000; Bartels 1999; Garola 1999; Dürr, Goldstein, Zanghì 1995; Squires 1990; Vigier 1988; Elsasser 1973).

So, Wolfgang Pauli managed to impose a constitution of quantum mechanics arranging its limited freedom in a way much wiser than the brutality of the Holy Church in the Middle Ages to the heliocentric system. Utilizing again the metaphor above, he distinguished quite reliably the "immovable astronomical sun" from the "visible sun of human experience" therefore preventing both social revolutions like the blood French one and cruelties like Giordano Bruno's pyre. So, his "Solomonic" decision seemed to be diplomatic, sage and prescient.

Following the same thalweg, he forecast the new elementary particle, "neutrino" (i.e. "little neutron" in Italian) by virtue of energy conservation[8]. However, that scientific prediction furthermore created the "particle paradigm" of quantum physics, according to which energy (respectively, mass at rest) is to identify what an element, "atom" in quantum physics is: an "elementary particle". Though hundreds or even thousands of those "elementary particles" have been being revealed, the Standard model reduces them to only seventeen most fundamental ones, at that obeying a clear regularity according to three basic physical interactions (excluding gravity). So, the particle paradigm originating from Pauli's "constitution of restricted autonomy" for quantum mechanics received a glowing confirmation therefore preventing any further debate about a greater autonomy of quantum mechanics not speaking at all for its "local laws" to become global and general.

Consequently, the present paper will attempt to explain why the phenomena of entanglement and quantum mechanics, proclaimed to be scientific facts by the Nobel Prize in 2022, contradict Pauli's "Solomonic" constitution of quantum mechanics and the particle paradigm shared by the Standard model also enjoying many Nobel Prizes (that is: rather more than only one). The essence of the contradiction at issue consists in the suggestion that quantum mechanics for entanglement and quantum information is able to violate energy conservation (implicitly introducing a Hermitian or non-Hermitian operator of time, by the by, prohibited after Pauli).

One can liken the particle paradigm (or respectively, the Standard model) to the Ptolemaic "epicycles" added *ad hoc* with the sole purpose to conserve geocentrism reconciling it to the observable motions of the planets in the solar system. If one adds new and new epicycles *ad hoc*, the predictions based on the geocentric system can be not less precise and even more exact than those relying on the heliocentric one since relevant epicycles can reflect effects due to the motion of the whole solar system through the Milky way. Then, our planet can continue to be reckoned as the center of the universe without implying any ideas about changes in the social order and revolutions such as the French one, for example.

Analogically new and new elementary particles similar to "epicycles" might be added conserving the fundamental particle paradigm, the quantities of energy and time as the ultimate cornerstone for the unity of all physics including quantum mechanics in particular. Even more, just as all epicycles can be systemized into a few groups so that one is able to consider any epicycles as composed and derivative from those groups, the analogical Standard model consisting from the seventeen most elementary particles can be built preventing any ideas about the relativity of any order in physic, science or society.

[8] In detail and references by Guerra, Leone, Robotti (2014).

Then, the quantities of energy and time guarantee a strict order equivalent to the concept of well-ordering in mathematics (linked also to the axiom of choice in set theory by the well-ordering theorem). The energies of any system can be compared unambiguously with the energy of any other system so that the energy of just one of them is greater than that of the other one therefore constituting a rigorous hierarchy, in which the physical influence of the system possessing the greater energy is stronger than that with any smaller energy. For example, the physical action of any macroscopic body (e.g. any measuring apparatus) is much, much stronger than that of any quantum entity, e.g. such as an electron or a photon, but much, much tinier than that of any astronomical object such as the sun, the moon or a planet.

So, the quantity of energy generates a physical hierarchy therefore suggesting the naturality of the idea of hierarchy at all, for example that of social hierarchy. Parallelly, the correlative quantity of time generates an analogical strict hierarchy of causality so that the cause influences the effect, but the effect cannot influence the cause in any way. So, another temporal order of causality appears in physics, science, and common sense therefore conditioning social conservatism and the immutability of the established social order and hierarchies.

This means that the constitution invented by Wolfgang Pauli for quantum mechanics and resulted into the "particle paradigm" and the Standard model in the final analysis is consonant and consistent with the concepts of "order", "hierarchy" including social ones. On the contrary and even absolutely oppositely, the phenomena of entanglement and quantum information imply a quantity more general than that of energy (respectively, that of time), at that without any physical dimension: the physically dimensionless quantity of information or quantum information.

In fact, the "classical" quantum mechanics was forced to introduce probability density distribution (and respectively, its characteristic function, what any wave function is) thus substituting by it the exact single value of any variable, meant in physics before it; as well as defining what physical quantity is to be by that change of probability density distribution to which the corresponding Hermitian operator corresponds unambiguously.

Consequently, though implicitly, physical quantity is defined as (quantum) information since information can be defined as a relation of probability density distributions (e.g. following Kolmogorov). In fact, entanglement considers a wider class of operators, e.g. non-Hermitian operators[9] as Einstein's "spooky action at a distance"[10] can be formalized, and thus admits the concept of physical quantity to be relevantly generalized so that it includes entanglement or the "physics of ghosts" sarcastically suggested by Einstein. As to the corresponding physical hierarchy and order of energy and time, entanglement once it has been interpreted to be physical action (as the Nobel Prize in 2022 proclaims indirectly) messes them in an arbitrary way and makes them meaningless.

[9] The paper of Simonov, Capolupo, Giampaolo (2019) investigates the violation of CPT-symmetry in the same context.

[10] For example, the note of Selleri and Tarozzi (1986) synthesizes why quantum mechanics is incompatible with Einstein locality.

However, the “Solomonic” decision of Pauli prohibited in particular that “mess” at issue, and here is why. Energy conservation in quantum mechanics is equivalent to the specific property of unitarity, which in turn is satisfied only for all Hermitian operators therefore excluding all non-Hermitian ones and thus the phenomena of entanglement. The Hermitian operators can be immediately visualized in relation to the pair the initial probability density distributions corresponding to any Hermitian operator as follows:

Any Hermitian operator changes the probabilities of all values of the quantum variable at issue (eventually and particularly not changing some of them), not exchanging the values of the quantum variable. Respectively, this means that the correlative temporal group admissible after energy conservation is able only to be translated thus not violating the sequence of temporal moments or causality. The “spooky actions” at any distances forecast by Einstein, Podolsky, and Rosen (1935) as a refutation of the “completeness of quantum mechanics” need the violation of locality (which is postulated in special or general relativity) and thus admit the violations of both temporal sequences and causality: any quantum entity though being arbitrarily remote can influence a certain quantum entity once both are entangled to each other. The fundamental locality of physics particularly established by the postulate of not exceeding the light speed in a vacuum in both special and general relativity is broken.

Nonetheless, the experiments awarded by Nobel prize in 2022 state those “spooky actions at a distance” as scientific facts though in a quite specific form: as correlations violating Bell’s inequalities (1964) and thus meaning instant interactions of probability density distributions referring to namesake quantities of quantum entities remote from each other at an arbitrary distance. So, a necessary condition for the spooky action at a distance is all physical quantities to be defined by non-degenerated probability density distributions, which is relevant only to quantum mechanics rather than to classical mechanics and thus explains in particular why phenomena of entanglement are not observed in the latter.

However, there is still one reason for Pauli’s “Solomonic decision” to be so successful: any quantum entity can be described exhaustively in its framework. Thus, one can think of all phenomena of entanglement as redundant to quantum mechanics, which Occam’s razor is to cut unavoidably. Indeed, any quantum entity considered to be a single system and accordingly described by a single separable complex Hilbert space obeys Pauli’s constitution absolutely. Only if one means two or more quantum systems (or a system and one or more subsystems), the phenomena of entanglement or quantum information can be registered. So (and particularly), the Standard model is relevant, true and complete if one researches all quantum phenomena to a single whole (i.e., to a single system).

The same opposition of a single physical system versus two or more can be traced back in classical mechanics and especially to the opposition of so-called inertial mass to gravitational mass. Indeed the former refers to a single system, and the latter to two or more ones, but both mean physical descriptions obeying time and corresponding smooth manifolds with their systems of differential equations inherent for classical mechanics.

General relativity postulates the fundamental equity of the two "kinds" of mass and accordingly the equivalence of the corresponding two ways of descriptions: for example, according to Einstein's famous "Gedankenexperiment" about an accelerating elevator[11], after which the descriptions by inertial masses or alternatively, by gravitational masses are indistinguishable experimentally from each other. Thus, the Einstein field equation being the main conclusion of general relativity describes equally well any gravitational field as the variably accelerated motion of a body in an arbitrary force field (e.g., a certain electromagnetic field).

Consequently, the opposition of gravitational field to any other force field (whether only possible or really existent) is *locally* irrelevant since they are *locally* indistinguishable from each other by any *local* experiment (i.e., "within the elevator" of Einstein's "Gedankenexperiment"). Thus, the gravitational field can be interpreted to be the generalized description of the entire class of any force fields, which are reduced to be only three after the Standard model: strong, electromagnetic, and weak.

In other words, if the conception of "quantum gravity" is meant that there exists a relevant quantum variant of gravitation so that it can be included among the rest three, properly quantum infractions of the Standard model, it is fundamentally wrong since gravity refers only to the global description just only by virtue of its globality and regardless of the nature of the force field at issue, therefore being relevant to all the class of physical interactions ("force fields").

Nonetheless, a generalized "thought experiment" in a manner of Einstein referring to "quantum-gravitational field" rather than to the classical gravitational field as the original "Gedankenexperiment" remains initially alien to all researches and huge literature in the area of quantum gravity. One can utilize the historical metaphor or precedent about the numerous inventions of "Perpetuum mobile" until the decision of the French academy established that it is impossible since it contradicts the principles of thermodynamics[12]:

Analogically, new and new "theories" of quantum gravity have been permanently being invented regardless of the sketched thought experiment about an "elevator in quantum-gravitational field" demonstrates that gravity cannot be another physical quantum interaction along with those of the Standard model: weak, electromagnetic, and strong since it is another expression of them.

Even more, the nature of gravitation can be traced back even to the fundamental logical distinction of "property" versus "relation". Gravitation is to be related only to the later and thus it can be relevant only to the parts of a whole (and to their relations) rather than to a single whole (and to its properties), however to which the description by the Standard model continues to be still relevant.

The way in which the Standard model restricts itself only to quantum "properties" consists in the consideration of a single and universal separable complex Hilbert space relevant to any quantum system as a single whole. Indeed, one can consider any quantum system as a whole

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[11] Einstein (1920) himself described his idea in an unpublished document now available as a digital edition at: https://einsteinpapers.press.princeton.edu/vol7-trans/ .

[12] For example in the book of Ord-Hume (2005).

without any subsystems (i.e. "parts"), and accordingly, the Standard model is absolutely exact: thus its predictions, as well.

Nonetheless, a huge realm of phenomena relying on the "parts" and internal structure of all quantum systems remains "dark" just as "dark matter" and "dark energy", which are estimated by experiments and observations to be approximately 95% or 96% of all mass and energy of the universe[13]. Common sense tends to interpret that fact wrongly just according to its prejudice searching for quantum gravity as a *property*: and now, for a special kind of "dark stuff" resulting in the observed phenomena of dark matter & energy. So, one investigates whether some unknown additional particles might not complement the Standard model in a way to explain both dark matter and dark energy as originating from them or from their interactions to each other, or from the known "light" and established matter and particles of the Standard model.

One can feature a special property of the human mind that penetrates science in an unhindered way: it continues to research "tree by tree" without stopping to see the "forest". So and particularly, quantum science tends to search for new "dark" particles after the usual "light" ones of the Standard model. In other and more metaphorical words, the quantum physicists are not philosophers: they do not stop to see the "wood" of the Standard model realizing the fact that it inherently fits to study the fundamental physical interactions only as properties:

On the contrary, both dark matter and dark energy are confirmed and even can be established in principle only in astronomical observations and relatable to gravitational interactions, that is, to properties of the parts of a whole after the considerations above likened many "theories" of quantum gravity to the offerts for "Perpetuum mobile" in the past therefore neglecting the fundamental scientific, even logical distinction of "properties" versus "relations" and meaning the Standard model in the framework of the former, and gravity, respectively, dark matter and dark energy, to the latter.

Then, one can think of the following problem. Which is the counterpart of the gravitational, inherently *relational* (whether in special *relativity* or in general *relativity*) interaction, but to the Standard model considering the physical interaction rather as properties than as relations as, on the contrary, the gravitational theory of relativity does? Can that counterpart at issue be interpreted as the cherished "quantum gravity" though in a generalized meaning (e.g., not allowing for any second quantization as all the rest three interactions of the Standard model can be introduced)?

The subject and context of the present paper already suggest the answer: the phenomena of entanglement and quantum information can be considered to be that quantum counterpart of classical gravitation and thus, quantum gravitation in a generalized meaning corresponding to the thought experiment of an elevator in a quantum-gravitational field sketched above. Indeed, entanglement needs at least two quantum subsystems of a quantum system to be defined as a relation just as general relativity determines gravity to be a relation though that of classical physical systems rather than of quantum ones.

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[13] There are many publications, e.g.: *Ade et al 2016*, or the papers meant by the Nobel Prize for physics in 2011.

Indeed, entanglement is defined as to the case of a quantum system and two or more quantum subsystems of the former, obeying the following condition: the quantum system cannot be factorized to any tensor product of its subsystems. In other words, this requires for the subsystems to be "orthogonal" to each other in an exact meaning: the separable complex Hilbert space of each subsystem is orthogonal to any other of those. Speaking loosely, the entangled quantum system is an inseparable whole which cannot be reduced equivalently to the set of its parts since the interaction of the parts is nonzero in general, and entanglement is defined (also it can be quantitatively) as that interaction at issue.

One can check that entanglement cannot be introduced in any description obeying classical mechanics in virtue of the following reason. Any quantity in quantum mechanics is defined as a Hermitian operator in the separable complex Hilbert space corresponding to the unitary change of probability density distributions of all possible measurements of that quantity. If one considers two or more namesake quantities, each of which refers to entangled quantum entities, their corresponding probability distributions can *overlap*:

However, this is absolutely excluded in any description in classical mechanics, to which the rule "tertium non datur" is valid: any quantities in two or more classical physical subsystems are either the same or they are absolutely different; the "third" of any degree of overlapping each other is not available even in the definition of "quantity" in classical mechanics and unlike the case of quantum mechanics.

So one can conclude that what entanglement means is the case of those quantities relevant only to quantum mechanics which refer to relations of two or many subsystems rather than the properties of single one. Thus, the fundamental contribution of the experiments awarded by the 2022 Nobel Prize in physics consists in the establishment of quantum interactions which are inherently and definitively relational: oppositely to the "philosophy" or "logic" of the Standard model or Pauli's constitution of quantum mechanics interpreting all quantities in quantum mechanics to be properties, energy conservation to be inviolable, and no operator corresponds to the quantity of time. Thus, the relational essence of entanglement seems to be analogical to that of Einstein's gravitation even in the name of his theory: general *relativity*.

Even more, one can admit the analogical shared "relativity" of entanglement and Einstein's gravitation relies on the same essence only expressed in two different ways corresponding to the discrete quantum formalism of quantum mechanics, on the one hand, and to the smooth formalism of classical mechanics, on the other hand. So and as a hypothesis, one expresses the same phenomena: (1) in the separable complex Hilbert space created to unify the proper *discrete* description relevant to the investigated quantum system "by itself" with the *smooth* description the readings of the macroscopic apparatus[14] inherently obeying the laws of classical mechanics; and

[14] Though the emergent interpretation of quantum mechanics (e.g., Adler 2012 or Allori, Goldstein, Tumulka, Zanghi 2014) is essentially different from that by quantum information (or entropy and information as in: Resconi, Licata, Fiscaletti 2013) and its unification of discreteness and continuity as here, they are consistent with each other. The unification of quantum mechanics and relativity (e.g., Kryukov 2011; 2006; Korotkikh 2009; Garuccio 2000; Aerts 1996) can be considered to originate from the former (featuring only quantum mechanics) if continuity is identified to be local versus discreteness (or any

(2) the four-dimensional pseudo-Riemannian space of general relativity, in the framework of which the investigated gravitational system and the apparatuses measuring it, both are described by smooth differential equations[15].

Indeed, the Schrödinger equation is also a smooth differential equation appropriate to describe quantum reality, however at the cost of introducing a so non-classical element as "wave function" being the characteristic function of a probability density distribution substituted the exact single value of a certain quantity in a certain moment of time (which is the only possible case in classical physics). In fact, though the Schrödinger equation is commonly and universally accepted nowadays for the exhaustive description of any quantum systems, being technically more convenient, Schrödinger (1926) himself has demonstrated the equivalence of his "undulatory mechanics" with Heisenberg's "matrix mechanics" and thus, that of the descriptions by smooth wave functions or by Heisenberg matrices. The latter can be interpreted as the description from the discrete viewpoint of the investigated quantum entity unlike that (though absolutely equivalent) from the viewpoint of the macroscopic apparatus sharing the smoothness featuring classical mechanics.

Consequently, one can conjecture that entanglement and gravitation are the same, but described in two different formal languages even literally complementary to each other: i.e. complementary in the narrow sense and exact meaning of quantum mechanics since the description as entanglement considers their shared essence to be discrete "by itself" versus that of general relativity, according to which it is continuous and smooth, though the apparatus in both cases is macroscopic and thus obeying the smooth (consequently continuous) classical mechanics being furthermore deterministic rather than inherently probabilistic as the quantum description by the Schrödinger equation.

That essential complementarity, fortunately, admits to be reduced to the formal and mathematical opposition of the separable complex Hilbert space of quantum mechanics and the pseudo-Riemannian space of general relativity[16]: and then their eventual unification as far as the conjecture is that they share some though unknown common structure. At first glance, the two

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quantum leap) as nonlocal (also in a rigorous mathematical meaning). Further, but without being necessary, the same unification can be continued to quantum gravity even in an abstract mathematical sense (e,g. Sorkin, Yazdi 2018; Kleinschmidt, Hermann 2010; Baianu, Brown, Glazebrook 2007; El Naschie 2008; 2004; 2004a): an approach comparable with that of the present paper.

[15] In fact, many papers (e.g. Cafaro, Alsing 2020; Caticha 2018; Kim 2018; Cafaro 2017; Hyatt, Garrison, Bauer 2017; Banchi, Giorda, Zanardi 2014; Bodendorfer 2014; Reginatto 2014; Cafaro, Mancini 2012; Mullick Bandyopadhyaya 2012; Kumar, Mahapatra, Phukon, Sarkar 2012; Major 2012; Kryukov 2011; 2006; Goyal 2010; Kim, Kim, Bae 2010; Avron, Kenneth 2009; Bertram 2008; Cafaro, Ali 2008; Iwai 2007; Mosseri, Ribeiro 2007; Zanardi, Giorda, Cozzini 2007; Mallios 2006; Grabowski, Kuś, Marmo 2005; Lévay 2005; 2004; Streater 2004; 2004a; 1996; Ay, Tuschmann 2003; Coecke 2003; Zhotikov 2003; Chen, Ungar 2002; Jenčová 2002; Ghikas 2001; Zizzi 2000; Ashtekar. Schilling 1999; Fine, Fine 1997; Coquereaux 1989; Souriau 1983; Ingarden 1981), the subject of which is quantum mechanics geometry, quantum information geometry or entanglement geometry, pioneer, though more or less implicitly, a pathway to quantum gravity and general relativity, analogical to the approach advocated in the present paper.

[16] Their correspondence or mapping is investigated in detail in another paper (Penchev 2022 February 4).

spaces, though both being vector ones, are so different as possible: the former is infinite-dimensional, complex, convex, and "straight" (i.e., "not-curved"), but the latter is four-dimensional, real, "concave" (i.e., "not convex"), and "curved". Nonetheless, quantum information as "pioneered" by those Nobel Prize awarded experiments is able to suggest the same viewpoint to both spaces, namely that of a usual ball in Euclidean space now interpreted as a quantum bit, "qubit", the unit of quantum information analogically to the way for a bit to be a unit of "classical" information.

Then, pseudo-Riemannian space is that qubit, permanently extending and arbitrarily deformed in the course of extension, in which its current value outlines a world line under the condition for the value of the qubit to be smoothly variable in the extension at issue. The qubit Hilbert space (as the separable complex Hilbert space can be equivalently reformulated under a few conditions rather technical) is an infinite series of the same qubits somehow flattened not to be curved and situated "one after one" rather than "one within one" as in the the former case.

The case of the single extending deformed qubit as the quantum-information model of the world line of pseudo-Riemannian space can be always decomposed into two world lines into two Minkowski spaces[17], "orthogonal" to each other, so they can be conventionally named to be "covariant" and "contravariant", accordingly. Then, each of the covariant and contravariant Minkowski spaces containing a world line can be equivalently represented as two qubit spaces though by the mediation of the axiom of choice. The latter two qubit spaces can be interpreted, for example, as dual to each other, on the one hand, or as corresponding to two quantum subsystems.

Anyway, one can conclude that the experiments of entanglement and the theory of quantum information pioneered by it can be the key for the unification of quantum mechanics and general relativity. The consideration sketched above, rather logical, ontological and philosophical, may be an approach to their unification.

II WHY ENTANGLEMENT WAS NEGLECTED

The introduction suggests a few reasons for entanglement or the studying it theory of quantum information to be partly neglected in the foundations of quantum mechanics being rather developed as an applied physical discipline though in the general quantum framework. The "classical" quantum mechanics, Pauli's "paradigm", and the Standard model can exhaustively describe any single quantum system without any necessity to involve quantum information or entanglement. On the contrary, the relation of two quantum systems eventually entangled seems to be relevant to applications according to the practical use for them to be separately studied.

Thus, three sub-areas in the theory of quantum information[18] are developed: quantum cryptography, quantum computer, and quantum communication. All the three are directed to technical implementations, quantum counterparts to the corresponding classical applied disciplines. They can be justified only by the success of the invented devices therefore not needing

[17] A conceptual "synonym" is quantum gravity without Lorentz invariance violation as in: *Bonder 2018*; *Bonder, Sudarsky 2009; 2008*; *Corichi, Sudarsky 2005*; *Dowker, Henson, Sorkin 2004*.

[18] The "theory of quantum information" or "quantum information science" is frequently abbreviated into only "quantum information" just as the "theory of general relativity" as only "general relativity".

entanglement to be established as a fundamental scientific fact furthermore confirmed by the corresponding Nobel Prize.

However, its recognition is essential for fundamental theoretical research, including the foundations of quantum mechanics, since the results are abstract theories, which cannot be corroborated like technical devices, in which quantum cryptography, quantum computer or quantum communication might be implemented regardless of the status of entanglement.

Entanglement and quantum information refers to a general problem being central for science in the beginning of the 20th century: for philosophy, logic, mathematics and even physics after special and general relativity. This is the question whether relations can be considered as a special subject of research, being more or less irreducible to properties. Russell, for example, insisted that the relations should be considered as independent of properties in general in logic, mathematics, and philosophy[19].

Einstein's special and general relativity extended the same approach to physics: more precisely to mechanics and its basic concept of motion (being unified with the concept of electromagnetic field originating from Maxwell's theory) and to the theory of gravitation and the concept of physical interactions what gravitation is. Mechanical motion is only a relation of two or more reference frames rather than a property of any reference frame including that hypothetical one linked to the not less conjectural "ether".

Nonetheless, all possible reference frames (or at least the inertial ones in the scope of special relativity) share the same *property*: the maximal speed of light in a vacuum corresponding to the experiments of Michelson and Morley and the postulate in special relativity (and then transferred into general relativity). So, special relativity distinguishes mechanical motion, being always relative, needing two reference frames (which are inertial in its case) to be defined, from the electromagnetic field: a universal medium replaced the dethroned "ether".

In fact, the electromagnetic field and the ether are very similar as to the logical construction of mechanics, since both are to be meant to the whole of two or arbitrarily many reference frames attachable to all possible parts of the whole at issue. The difference consisting in the definitively zero speed of the ether from the constant of light speed in a vacuum "c" is not essential: for example, one can grant the magnitude of that constant to be zero so that the velocities "v" of all bodies possessing any nonzero mass at rest to be interpreted as negative to it, e.g., as: $ln(\frac{v}{c})$ since $v < c$.

So, the usual perception of special *relativity* emphasizing the *relativity* of mechanical motion needing at least two referential frames to be able to be defined just as a *relation* between them, on the one hand, and the dethronement of the "ether", one the other hand, was rather psychological and historical because those were the newly introduced elements for the mechanical description of reality in comparison with the established (before it) picture of the world considering motion rather

[19] For example, as after his "logical atomism" (e.g., Russell 1956): the paper of Pakaluk (1992) suggests a detailed investigation of Russell's viewpoint to the fundamental place of relations in logic; that of Grattan-Guinness (2002) means Whitehead's philosophy of mathematics in an analogical context. Cordovil's article (2015) discusses quantum physics in the context of relational metaphysics.

as a property of the moving body rather than as a relation to another body also moving to the former with a certain velocity.

So, two facts outlined a little above remained hidden in the "blinding light" of the newly introduced relativity since they originated from the inherited past considering motion to be always a property of a certain moving body. Those two facts are that (1) electromagnetic field occupied the "throne" of the "ether"; and that (2) any motion can be anyway again interpreted as a property of the moving body, but now to the electromagnetic field rather than to the ether due to the postulate of not exceeding the speed of light in a vacuum.

Consequently, the revolution of special relativity consists in the complement of relative motion to the concept of motion as a property, inherited from classical mechanics, rather than in the replacement of the latter by the former, which is a misunderstanding able to be illustrated by the "paradox of the twins"[20]. In fact, that misunderstanding is available if and only if that paradox is interpreted to be a true logical paradox questioning the foundations of special relativity. If, on the contrary, it is only a challenge to the usual prejudice surprised by the fact that the twin space-traveler will be younger than the other twin "homebody" after returning on earth, the misunderstanding at issue is absent.

However, the present paper is interested not in the paradox by itself or its solution (by the by, being so obvious for Einstein himself that he refuted at all to discuss that "paradox"[21]), but just in the way for special relativity to be misunderstood and its foundations to be questioned if it is granted to be a true logical antinomy. Indeed, if the space-traveler has been moving to the homebody, and motion is only relative, one can state not worse that the homebody has been moving oppositely to the space-traveler. If one accepts the former viewpoint (to the reference frame of the homebody) the space-traveler should be younger after returning to earth. However, if one grants the latter viewpoint (to the reference frame of the space-traveler), the homebody should be younger

[20] There are many papers (e.g. Ben-Ya'acov 2016; Franson 2016; Fung, Clark, Lewis, Wu 2016; de Wolf 2016; Garcia-Escartin, Chamorro-Posada 2015; Gasperini 2014; Lindkvist, Sabín, Fuentes, Dragan, Svensson, Delsing, Johansson 2014; Moreau, Devaux, Lantz 2014; Sokołowski, Golda 2014; 2014a; Grøn 2013; Carvalho 2012; Friebe 2012; Ord 2012; Sfarti 2012; Sokołowski 2012; Boblest, Müller, Wunner 2011; Grøn, Braeck 2011; Lichtenegger, Iorio 2011; Székely 2010; Grandou, Rubin 2009; Müller, King, Adis 2008; Roukema, Bajtlik 2008; Abramowicz, Bajtlik, Kluźniak 2007; Boccaletti, Catoni, Catoni 2007; 2007a; Grøn 2006; Kohler 2006; McCall 2006; Madarász, Németi, Székely 2006; Ghosal, Nepal, Das 2005; Pesic 2003; Soni 2002; Uzan, Luminet, Lehoucq, Peter 2002; Barrow, Levin 2001; Dolby, Gull 2001; Weeks 2001; Cranor, Heider, Price 2000; Schön 1998; Debs 1996; Renshaw 1996; Chang 1993; Vandyck 1991; Dieks 1990; Dray 1990; Harpaz 1990; Rodrigues, Oliveira 1989; Rodrigues, Rosa 1989; Cornille 1988; Sachs 1985; Good 1982;Unruh 1981; Fremlin 1980; Perrin 1979; Greenberger 1972; Muller 1972;) , the subject of which is that paradox.

[21] Einstein had formulated the analogical "clock paradox" since 1905 and preferred to speak of it rather than of that of the twins. In fact, only the former corresponds to the spatial-like and thus reversible interpretation of time in special relativity because the latter means time to be irreversible as aging. The link to the interpretation in the present paper is the following: the irreversible time can be only a property, for example featuring either twin unlike the reversible time inherent for special relativity and then for general relativity as the (conservative) generalization of the former. The reversible time of relativity is tautologically just *relational* and thus the aging of either twin being a property of either of them is irrelevant to it.

after meeting the twin space-traveler. So, a directed logical contradiction is ostensibly generated thus as if questioning the foundations of special relativity. Not at all and here is why:

In a single sentence, only the space-traveler has been moving to the newly introduced "ether" of electromagnetic field, and the homebody has been immovable all the time until they meet each other on earth and just as in the case of the "classical" ether. Indeed, the speed of electromagnetic field in a vacuum is the same from the reference frame of each of both twins. Nonetheless, only the space-traveler has been moving with some variable non-zero speed "$v = f(r)$" where "r'' is the distance between them in the course of the space trip to the newly introduced "ether" of electromagnetic field though the speed of the "electromagnetic ether" to both is always the same, "c''.

In other words, who is immovable to the "classical" ether is still immovable to the "electromagnetic ether" (and this is the homebody in our case) because the latter substitutes the former in special relativity conserving all features of it, and especially, any motion to be only a property of the moving body just moving in it as in a medium, which is now an electromagnetic field rather than the ether as before. One may say that no reference frame is attachable to the electromagnetic field since this would imply the relativity of the reverence frames of the moving body and the electromagnetic field and that misunderstanding featuring special relativity so that the paradox of the twins to be a true logical paradox. Indeed, any reference frame needs a body with nonzero mass at rest to serve as its beginning (zero point). However, this is impossible as to any electromagnetic field because its mass at rest is definitively zero.

As this is well-known, Einstein himself and practically all physicists after him have considered general relativity as the generalization of special relativity after referring to arbitrarily accelerated systems rather than to only inertial reference frames. One can immediately notice that the ether of electromagnetic field should remain the same just as in the case of special relativity because it is not able to be accelerated by virtue of the constant speed of light in a vacuum to any reference frame, thus being arbitrarily accelerated to another: the speed of light in a vacuum to both reference frames is the same. So, the ether of electromagnetic field cannot be accelerated in any way (since its velocity is always the same), but just the classical ether (though its velocity to any reference frame, whether accelerated or inertial, is definitively zero unlike the newly "light" ether, but the *constant* speeds of both to any reference frame is what is essential).

So one can state quite reasonably, that the ether of the electromagnetic field is the same of both theories regardless of the constant or variable relative speed of any reference frames, to which is the same universal and absolute medium as the original ether of classical mechanics. Thus, it is able to embody the logical viewpoint of property remaining unaltered in both special relativity and general relativity, and their distinction can mean only the opposite logical viewpoint of relations so that inertial reference frames can be differed from accelerated ones. One can object that any light ray should propagate following the relevant geodesic line of the global pseudo-Riemannian space, consequently deviating from the geodesic line of Minkowski space as it were to do if it did not depend from the curvature of space-time. In fact, that objection belongs to the same misunderstanding of relativity described to the paradox of the twins:

One can distinguish the relative motion of two or more independent reference frames from the viewpoint of the ether of electromagnetic field (just as from that of the "classical" immovable ether), and then, of the "curved" pseudo-Riemannian space, in which they are situated. Nonetheless, the ether of electromagnetic field remains the same from the viewpoints of both and can be described exhaustively and mathematically by the "straight" Minkowski space being identical in both cases rather than by the "curved" pseudo-Riemannian space as in the former viewpoint, that of the electromagnetic "ether" itself.

So, the misunderstanding analogical to that sketched above to the "paradox of the twins" consists in the misleading expectation that the picture of the world should be the same from any reference frames in relative motion to each other, on the one hand, and from the single viewpoint of the electromagnetic "ether" (in fact, analogical to the classical one due to the "absolute" viewpoint though that "absolute viewpoint" is now moving with the velocity of light in a vacuum). On the contrary, the two pictures of the world are really opposite: the former is "curved", described by pseudo-Riemannian space, but the latter is "straight", described by Minkowski space.

Since the former is linked to gravitation by general relativity, and the case of Minkowski space can be thought as a description of the absence of gravitation, one can conclude that the misunderstanding, "started" from the paradox of the twins, then "passed" into the ostensible universality of pseudo-Riemannian space (wrongly implying that the velocity of light in a vacuum should be different to reference frames accelerated to each other), can be naturally continued in the incorrect postulate about the analogically universality of gravitation including untruly the ether of electromagnetic field "by itself".

The misunderstanding may be also interpreted by the principle of general relativity (sometimes called "general covariance"), according to which all physical laws are to be invariant to any reference frames, including arbitrarily accelerated to each other. The misunderstanding consists in attaching ("illegally") a reference frame to the electromagnetic "ether". Then, gravitation, really being universal according to the principle of general relativity, is wrongly postulated to the electromagnetic "ether" ostensibly by virtue of the same principle: though this is false since the principle relates to all reference frames, but no reference frames can be assigned to the electromagnetic "ether" definitively.

One can think that the misunderstanding "continued" as above is rather artificial. Not at all and here is why. Gravity is not more universal than the principle of general relativity prescribes. So, the usual understanding of "quantum gravitation" (i.e., as an interaction to the other three ones described by the Standard model and particularly, allowing for "secondary quantization") falls in the class of that misunderstanding. This is so because the Standard model can be related to the electromagnetic "ether" alone (without any reference frame attached to it), but not to the case of two or more reference frames in any relative and arbitrarily accelerated motion to each other, necessary to be defined their physical interaction as gravitation.

Speaking loosely, gravitation needs "parts" to be defined and thus being irrelevant to the case of a single one, what the Standard model describes. However, the Standard model itself (and in turn) needs a single one whole and thus being irrelevant to the case of "parts" and their gravitation

to each other. Thus, one can immediately notice that "quantum gravitation" is literally an oxymoron since "quantum" can relate to a single whole, and "gravitation", on the contrary, only to the parts of that whole, but not to its parts.

One may see that the interpretation of "quantum gravitation" is not quite correct since it identifies "quantum" and the "adjective of the Standard model" (using it attributively). In other words, an oxymoron is only "the Standard model gravitation" rather than the wider class of "quantum gravitation" therefore considering the complement of the former to the latter, in the framework of which both entanglement and quantum information fall.

Indeed, the unit of information, a bit, means the elementary division of a whole into two equal parts. Then, information (and quantum information as far as it is a generalization of "classical" information whether "conservative" or not) can be accordingly interpreted to be a quantity referring to the division of the whole to parts or unifying them. Consequently, one conjectures that just the theory of quantum information (describing particularly all phenomena of entanglement) is able to overcome the seeming contradiction of quantum gravity by elucidating that the Standard model (or the "classical" quantum mechanics obeying Pauli's paradigm) does not exhaust all claiming to be quantum.

Thus, the investigation for that kind of quantum gravitation which can be included in the conservatively generalized Standard model is meaningless, a mistake in definition just as "the Standard model gravitation" is an oxymoron in the sense above: it can be thought as a corollary from the continuation of relativity, started from the paradox of the twins as a true logical paradox. Vice vesta as well: the absence of any theory of quantum gravity in the aforementioned framework is still one corroboration that the misunderstanding at issue is really a misunderstanding of relativity.

Another illustration can be the zero curvature of the universe[22]. Indeed, if the universe is interpreted to be a single one (even admitting the multiverse theory), gravitation, respectively any nonzero global curvature of it should be irrelevant just again by virtue of the same misunderstanding of relativity. The numerous experiments confirming that the global curvature of the universe is zero witness that the discussed misunderstanding of relativity is a real misunderstanding.

Sometimes, the "thought experiment" of Einstein, Podolsky, and Rosen (1935) is called to be a "paradox" though not in a proper logical meaning. The authors themselves suggested it as *reductio ad absurdum* granting initially that quantum mechanics is complete and then inferring by it that, on the contrary, it is incomplete. However, in the present context, the EPR argument can be unified with the paradox of the twins being dual or complementary to each other in a generalized sense[23]:

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[22] For example, Rees (1984); Pierpaoli (2000); Masi et al (2002); Wang, Gong, Su (2005) Vardanuan, Trotta, Silk (2009); Ahmed, Bamba, Salama (2020); Efstathiou, Gratton (2020).

[23] The idea for the mutual duality of the "paradoxes" of the twins and EPR is suggested in another paper (Penchev 1997).

Indeed, the paradox of the twins is not a real logical paradox, but only opposable to the expectation of common sense's prejudice. Its interpretation as a true logical paradox is a misunderstanding of relativity as this is elucidated above in detail. The "ether" of the electromagnetic field conserves the privileged viewpoint of the classical ether, abandoning only the option of any reference frame attachable to it.

As a result, the viewpoints to or from the electromagnetic "ether" turn out not to be reflexive. Mechanical motion is always relative, but nonetheless what the electromagnetic ether seems to be is the same from any reference frame and thus can be interpreted as the same shared property of all reference frames. The theory of relativity whether special or general being just a theory of relativity cannot be extended to the electromagnetic "ether" exactly in the same way, in which it is applicable to any reference frame. The modified ether of the electromagnetic field keeps the absoluteness of its classical predecessor though in an also relevantly modified sense.

One can consider both theories of relativity from a proper logical viewpoint, according to which motion is inherently a relation as *relative* motion of two or more reference frames. Nonetheless, the electromagnetic "ether" is postulated to be an absolute "property" relevant to any reference frame remaining the same (which is natural after it is a property rather than a relation). One can conjecture an alternative (or "dual") theory of "propertial" motion to the original one of relative motion, and then demonstrate that quantum mechanics is in fact that theory though not placarding to be "propertial".

Then, it might not describe motion relatively analogically to the opposite trouble of both theories of relativity to consider it "propertially" (i.e., as property just as classical mechanics tends or at least admits for it to be meant). The absence of quantum gravitation, originating from Einstein's general relativity as its generalization, within the strict framework of the Standard model is a corroboration. Nonetheless, in both theories of general relativity and the Standard model, the quantity of mass able to mediate between the two dual viewpoints to motion is available: accordingly, the principle of equality of "inertial mass" and "gravitational mass"[24], on the one hand, and the Higgs mechanism of the spontaneous violation of symmetry, on the other hand. Both will be considered sequentially to be demonstrated their duality in the sketched above sense:

In fact, "inertial mass" means mass as a property of any moving body. Thus (and particularly), one can define "mass at rest" as the mass of any body at zero velocity. That mass at rest is determined to be identically zero for the newly introduced "ether" of electromagnetic field, but nonzero for any particle moving with any velocity less than that of light in a vacuum (however not equal to it). The quantity of "speed" (and therefore that of acceleration) is necessarily relative if it features any body with any velocity less than that of light in a vacuum. On the contrary and as this is elucidated above to the "misunderstanding of relativity", it is necessarily "propertial" (or attributive) to the electromagnetic "ether" as a direct corollary from the postulate of the speed of light in a vacuum.

[24] For example, Einstein's principle of equivalence is modified to quantum mechanics in the paper of Nauenberg (2016); that of Börner and Schlieder (1980) discusses it with respect to quantum mechanical one-particle state.

One can conclude by combining both considerations in the previous paragraph that the quantity of mass at rest appears in both theories of relativity if and only if one commutes the description "by property" and that "by relation" after postulating their equivalence by virtue of the fundamental equality of inertial and gravitational masses. Then, Einstein's famous equation "$E = mc^2$", utilized in mass culture as an "emblem" or presentiment of the atom bomb, can be deduced again in virtue of the same equivalence as to the particular case of mass at rest able to be transformed into "pure energy" replacing the "propertial" viewpoint to a relative one, inherent for both theories of relativity.

As a transition to the dual consideration of the Standard model to the spontaneous breaking of symmetry by the Higgs mechanism, one might analogically speak of the spontaneous breaking of the "propertial" symmetry of the electromagnetic "ether" by a newly coined "Einstein mechanism of relativity" able to generate mass at rest. Even more, one can infer it only logically, after commuting "property" and "relation" corresponding to a fundamental, maybe ontological "breaking of symmetry" passing from the one to the other.

Indeed, any property and even any single entity is symmetrical to itself by itself. Any identity is identical to itself and thus it is able to be interpreted to its identical twin if it is somehow "halved". On the contrary, the relation "breaks" the initial symmetry of two identical twins after admitting for them not to be identical, but only similar to each other in general, just as siblings to identical twins. Speaking figuratively, one can think of breaking the symmetry, after which mass at rest appears in both theory of relativities to the initial electromagnetic "ether", by the metaphor as the way of any siblings to differ from any identical twins as the distinguishability featuring classical mechanics to the indistinguishability of quantum entities.

Following the suggested analogy to the Higgs mechanism, one can interpret the way, in which it admits breaking the symmetry, to fall in the same class of the logical mapping of "property" into "relation" therefore "expelling" the non-identical pair in general, being in any relation to each other, from "Eden", where they had been "identical twins" in a perfect harmony to each other.

Returning the proper description of the Higgs mechanism in the Standard model, one interprets it as the destruction of the initial "electro-weak" interactions into two ones, electromagnetic and weak however so that the same mechanism for appearing mass at rest is shared by strong interaction (for example or as an illustration to be considered as two independent or "orthogonal" electroweak interactions, each of which obeys the Higgs mechanism). So (and particularly), both weak and strong interactions in the Standard model are able to describe mass at rest in the proper language of quantum mechanics, the separable complex Hilbert space, and borrowed by the Standard model: now interpreted to be analogical to the "propertial" language of the electromagnetic "ether" of relativity.

Meaning that, one may say that the following four descriptions can be equated in a sense; namely those: (1) weak and strong interactions in the Standard model and sharing the Higgs mechanism; (2) the alleged or suggested "quantum gravity" turning out to be beyond the Standard model; (3) Einstein's theory of gravitation by general relativity; (4) the entanglement phenomena described by the theory of quantum information. All of them mean the same, however describing

it in its proper language, resulting totally in four descriptions in four languages so different from each other that it is as if they wish to describe four absolutely independent and non-intersecting areas of phenomena.

So, the problem consists, in fact, rather in the translation between them and in the discovery of a "Rosetta stone" allowing for the "inscriptions" of each of them to be compared and the corresponding quadrilingual dictionary to be created. That metaphor allows for rethinking the link of Einstein's general relativity to the hypothetical theory of quantum gravity, the pair of which is used to be likened to Maxwell's electromagnetic theory and quantum electrodynamics.

However, accepting the idea about the quadrilingual translation of the same phenomena after the electromagnetic analogy, one is to conclude: (1) general relativity corresponds to the theory of quantum information describing entanglement; however (2) both are equally exact unlike the less precise or approximative theory of Maxwell to quantum electrodynamic. The only distinction between the former two descriptions consists in the corresponding mathematical formalism: pseudo-Riemannian space in the case of general relativity versus non-Hermitian operators in the separable complex Hilbert space in the case of quantum information. So, the metaphor of a "translation" between them means in fact the absolute formal meaning of mappings between them eventually obeying additional conditions determined after physical considerations.

As to the usual interpretation of quantum gravity, following literally the analogy with Maxwell's theory and quantum electrodynamics, it is rather a misunderstanding relying on the misreading of the way for general relativity to connect to the Standard model, because this is possible only by the mediation of quantum information. So, one of the four languages, namely that of the hypothetical quantum gravity is rather auxiliary since it can be thoroughly reduced to the other three ones:

General relativity is dual or complementary to the alleged quantum gravity: as to the macroscopic, astronomic or cosmological phenomena, to which general relativity is formulated. Quantum information for entanglement describes what quantum gravity should mean[25], but using a different thesaurus of concepts since it is inherently beyond the Standard model, and common scientific sense's "quantum gravity" was expected to be within its framework though somehow generalized.

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[25] The link of quantum gravity and quantum information or entanglement is an idea not unexpected for contemporary physics: on the contrary, a series of papers (Kay 2018; Ma 2018; Qi 2018; Donnelly, Giddings 2017; Marletto, Vedral 2017; Ruiz, Giacomini, Brukner 2017; Lee, Kim, Lee 2015; 2013; Bruschi, Sabín, White, Baccetti, Oi, Fuentes 2014; Nomura, Varela, Weinberg 2013; Resconi, Licata, Fiscaletti 2013; Dvali, Gomez 2009; Fursaev 2008; Girelli, Livine 2005; Moffat 2004; Peres 2004) discusses it, including information conservation (e.g. Guo, Cai 2018) or information theory (Kempf 2018; Kempf, Martin 2008; Sato 2007; Carol 2005). Furthermore, the pathway to quantum gravity by the mediation of information or quantum information is often traced (as in the present paper) by more or less philosophical considerations or arguments (e.g. Norton 2020; Marletto, Vedral 2017; Torromé, Letizia, Liberati 2015; Vassallo, Esfeld 2014; Amelino-Camelia 2013; 2004; 2003; 2002; Slowik 2013; Liberati, Maccione 2011; Smolin 2011; Major 2010; Rosen 2008; Sudarsky 2007; 2005; Weinfurtner, Liberati, Visser 2006; O'Hara 2005; Srikanth 2001; Prugovečki 1996; De Sabbata, Sivaram, Borzeszkowski, Treder 1991; Sibelius 1989; Rayski 1982; Rosen 1982; Neumann 1978; Boulware, Deser 1975; Reuse 1974).

Finally, the Standard model itself and even within its rigorous and non-generalized framework means again what would be to be the proper subject of quantum gravity though by different names, notions, and conceptions: by the Higgs mechanism allowing for mass at rest to appear in both weak and strong interactions, by the weak and strong interactions themselves, and by confinement in the latter not allowing for the experimental observations of free quarks recognizable by their fractal electromagnetic charge and corresponding behavior in an electromagnetic field.

In fact, "confinement" is an "illegal" or at least "semi-legal" interaction in the Standard model admitting "legally" only the well-known three ones: weak, electromagnetic, and strong. It does not possess its own field or boson(s) transferring it though at a super-short distance conditioning a huge mass of its one or more bosons. Even being extremely exotic, those properties are not yet an obstacle for the theory of confinement consistent with the Standard model. The real unsurmountable contrariety is its paradoxical property to be stronger at a greater distance (though tiny even to the size of an atom) so that the mass of its boson(s) should be negative (at least effectively) and unlike all the other three interactions therefore allowing for "anti-gravitation", i.e. "gravitational repulsion" instead of cosmic attraction, which has been recognized to be universal since Newton's age. Just that "gravitational repulsion" of the hypothetical boson(s) of the not less hypothetical "confinement field" might hold and keep the quarks from "flying free". However, no experimental confirmation of anti-gravitation or the fractal electromagnetic charges featuring quarks[26].

All ideas about the confirmation or refutation of the similarity of confinement to the three basic interactions of the Standard model face the problem about the colossal energies as well as the corresponding accelerators able to give those energies to elementary particles for relevant experiments. However, the translation from the language of the Standard model into that of quantum information and entanglement allows for cheap experiments not needing huge energies and exceptionally expensive technical devices (e.g., as the Large Hadron Collider at CERN) for giving those to quantum entities. It would permit for the reinterpretation of all problems of the Standard model, connected with the implementation of experiments, sophisticated and too difficult practically, to be resolved by means of their equivalent reformulation in terms of quantum information.

However, the translation between four (or rather only three) languages runs into a fundamental theoretical obstacle: the relation and unification of energy and information. It is comparable with the famous historical precedent symbolized by the cited already equation of Einstein, $E = mc^2$, and consisting in the analogical unification of mass (or mass at rest) and energy. The later remains anyway in the framework of physics or philosophy of physics ("at best"), but it has not shaken up the fundamental organization of cognition in Modernity as the translation at issue and which can be eventually induced by the Nobel Prize in 2022 for physics, particularly explaining why it was postponed so long; the "reluctance" to be awarded:

Indeed, two fundamental philosophical essences are initially opposed in it and called by Descartes "body" and "mind" or "object" and "subject" by German classical philosophy. They are

[26] At least, sufficiently repeated and known to me.

inherently gapped by an abyss surmountable only by humans (or humankind as a whole) and its unique capability to think, conditioning the domination of *homo sapiens sapien*s over the world. In other words, both are the philosophical basis of human chauvinism, which all the cognition of Modernity obeys.

However, if both mass and energy unified by Einstein are on the side of "body" or "object", information including quantum information is to be situated on the opposed "shore" of the Cartesian or modern "abyss", that of "mind" and "subject" therefore questioning human chauvinism itself and even the justification of the human domination over the world, i.e., an obvious "heresy" comparable or even outweighing that of heliocentrism or Giordano Bruno's pyre. Of course, our epoch is much more civilized so that all those excesses are excluded nowadays. Nonetheless, what the Nobel Prize at issue proclaims to be a scientific fact contradicts common sense's prejudice or the establishment of the society and social order even more than heliocentrism:

It hints that "mind" and "body", at least particularly as information and energy, are to be unified, and an equation, though maybe in a generalized sense, analogical to Einstein's famous "$E = mc^2$" should exist to link them quantitatively. This can be said more precisely by the distinction between classical information measured by bits and quantum information, the unit of which is a qubit. The intersection of the two alternatives of a bit is zero, however that of a qubit and its dual counterpart is definitively nonzero and limited by the Planck constant as its low bound. Its physical dimension is action (just as that of the Planck constant) though any single qubit is physically dimensionless, seeming too paradoxical at first glance.

Indeed, just as classical information, quantum information is dimensionless, but the intersection of the two dual counterparts of the latter, unlike those of the former: being zero, is *nonzero and finite*, with the physical dimension of *action* and underneath by the Planck constant. So, one might infer the physical world, as far as it obeys quantum laws, from the duality of a certain mathematical structure, whether the separable complex Hilbert space of classical quantum mechanics or the qubit Hilbert space of quantum information, equivalent to the former under a few rather technical or conventional conditions. Furthermore, and being really paradoxical, the intersection of two dimensionless quantities, both being quantum information, turns out to be physically dimensionful, and said more exactly, being the physical quantity of action.

Then speaking more or less loosely, one might state, that the origin of the world, the universe or the being itself is mathematical in the final analysis, and the "dark phase of the universe" meant by entanglement and quantum information is that smooth transition, or the "bridge over the Cartesian abyss" between mathematics and physics, unlike its "light phase", in which they are absolutely divided from each other, but being only the visible tip of the iceberg, the underwater foundation of which is the dark phase of the universe being in turn both physical and mathematical simultaneously; and dark matter and dark energy are granted to be properly physical by contemporary physics. The concept inherent to the dark phase is information including quantum information since the latter is both mathematical and physical simultaneously, and its conservation can describe quantitatively the relation of mathematical and physical entities in the single and indivisible "ocean" of the dark phase of the universe.

The universe appears “ex nihilo” not by means of the mythical Big Bang, only an expression of humankind’s superstition and originating rather from religion than from science, but from its dark phase, and thus, “from mathematics” and obeying mathematical laws in the final analysis. The Big Bang is only a “shadow” on the wall of Plato’s “cave”, however the real source of that shadow, which people chained in their ignorance, prejudice, superstition and "common sense" interpret as the “Big Bang”, is a certain mathematical and thus nonmaterial structure, a particular case of which is the physical world.

Unfortunately, and following the same analogy to “$E = mc^2$”, one can immediately admit or choose the eventual option of a new weapon, which can be tentatively named “I-bomb”, “informational bomb”, which would be related to the existent nuclear weapons as the latter to the conventional ones. Humankind might be able to destroy not only itself or the life on earth, even not only the planet Earth itself, but the being at all, at least in the neighborhood, e.g., within a considerable part of the Solar system. Of course, only future investigations might elucidate whether this is theoretically possible or that idea belongs only to the sci-fi area. Science can offer only stronger and stronger instruments: humankind decides whether to utilize them for good or evil; and usually for both.

III QUANTUM INFORMATION VERSUS QUANTUM MECHANICS

As this is well-known, quantum mechanics appeared to rethink mechanical motion after the discrete limit of the Planck constant needing inherently to be a conservative generalization of classical mechanics since the apparatus measuring any quantum entity is always described by its smooth differential equations and moreover: “it is discrete” and “it is continuous” (being a necessary condition for “smoothness”) can be interpreted as a proposition and its logical negation (since “it is continuous” is equivalent to “it is not discrete”).

So, the inherent duality or “complementarity” of quantum mechanics can be thoroughly described only logically: by the condition for a conservative generalization of any proposition in a way to include its logical negation. Indeed, complementarity (though historically appeared in the specific form embedded in quantum mechanics) features all the class definable as a conservative generalization of any proposition to its direct logical negation.

Abandoning temporarily the historical pathway, in which the conception and interpretation of quantum mechanics is really generated, one can notice that definition of a bit of information is isomorphic (or more precisely, “anti-isomorphic” in the sense that the corresponding “directions” are opposite to each other) to that of the class at issue. So, still even the complementarity of quantum mechanics or its wave-particle duality (or respectively, the duality of its basic formalism of the separable complex Hilbert space, which follows from it) involve information in quantum mechanics though in an implicit way.

Furthermore, information in quantum mechanics can be considered as a corollary from the definition of physical quantity as a Hermitian operator into the separable complex Hilbert space, to which an unitary mapping of a probability density distribution and thus a certain quantity of

information can be attached to it since information can be defined to any pair of probability density distributions (e.g. as in Kolmogorov's definition of information[27]).

However, the real introduction of quantum information in quantum mechanics was due to entanglement and those phenomena, to which it is relevant. The unit of quantum information can be interpreted as a "unit of entanglement" being referable to the quantum correlation of two "namesake axes" of two entangled separable complex Hilbert space (i.e. $C_n^1 e^{in\omega}$ and $C_n^2 e^{in\omega}$) belonging correspondingly to the one or to the other of them since it is defined as the normed superposition of two orthogonal subspaces of the separable complex Hilbert space (i.e. as $\alpha\,|0\rangle + \beta\,|1\rangle$ where α, β are two complex numbers so that: $|\alpha|^2 + |\beta|^2 = 1$).

Nonetheless, a qubit can be not worse interpreted by two successive "axes" of the separable complex Hilbert space namely $C_n\ e^{in\omega}$ and $C_{n+1} e^{i(n+1)\omega}$ therefore allowing for the representation of the separable complex Hilbert space as an equivalent qubit Hilbert space. Furthermore, one can demonstrate that the cited "canonical" definition of a qubit is equivalent to the generalization of information to infinite sets or series, i.e. to quantum information as far it is measured in qubits just as information by bits (Penchev 2020 July 10):

Indeed, a qubit is the choice of a single alternative between an infinite set of alternatives just as a bit is the choice between two equally probable alternatives, and the quantity of "classical" information means the number[28] of those elementary choices, each of which is a bit of information. Consequently, the concepts of both "qubit" and "quantum information" measured by it necessarily involves the axiom of choice, for the choice between an infinite set of alternatives to be always possible in turn in order to be any qubit unambiguously definable.

The necessity of the proper mathematical axiom of choice implied by the concept of "qubit" suggests that the theory of quantum information should be a mathematical discipline, eventually applied or applicable to quantum mechanics, but divided from physical reality by the Cartesian abyss just as any mathematical model from reality according to the fundamental organization of knowledge, for which the name and concept of "episteme" coined by Michel Foucault can be utilized. Not at all, and here is why:

The theorems about the absence of hidden variables in quantum mechanics (Neumann 1932; Kochen, Specker 1967) imply that quantum mechanics itself, though being an experimental physical science, implies the axiom of choice, furthermore in a way quite elementary and obvious.

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[27] In fact, the fundamental contributions of Kolmogorov (e.g. Cover, Gacs, Gray 1989) are two explicit ones and an implicit one consisting in the eventual equating of the former two ones known correspondingly as: (1) the definition of information as the relative entropy of two probability density distributions and (2) "Kolmogorov's complexity", which is really another algorithmic and discrete definition of information. Their implicit equating involves the main idea of quantum mechanics: the unification of the discrete and continuous (or smooth) descriptions of mechanical motion and even that of quantum information since both definitions refer to the same essence, that of information, on the one hand, and to the unification of discrete motion with continuous motion, on the other hand.

[28] That number is a rational one at least because it can be interpreted as the result of an actual measuring procedure by the unit of a bit of information.

One considers any quantity of any quantum system before measurement. It cannot be well-ordered in any way since any well-ordering is equivalent to a hidden variable, which is impossible to exist by virtue of the theorems at issue.

On the other hand, the same quantity is well-ordered after any measurement of it, for example by the parameter (variable) of "time of registration" by the readings of the apparatus. So, one is to identify the states before measurement and after measurement for quantum mechanics to be able to be an objective experimental science just as all the rest within the framework of physics. That identification in turn implies the well-ordering "theorem" because the state before measurement can be well-ordered only by means of it, which is necessary for one to be able to measure it and thus to transform it into the same state after measurement[29]. As far as the well-ordering "theorem" is equivalent to the axiom of choice, the latter is also deduced.

In other words and speaking loosely, the concept of quantum information (since it follows from the theorems about the absence of hidden variables in quantum mechanics) in turn implies that an experimental physical science such as quantum mechanics implies the axiom of choice, belonging to a fundamental mathematical theory such as set theory and involving a too controversial concept of "actual infinity" often alleged to be the source of true logical paradoxes in mathematics.

Interpreted philosophically, this means that quantum information (respectively, the awarded by the Nobel Prize experiments demonstrating entanglement) makes obvious the fact that yet even quantum mechanics has linked mathematical model and reality: a "heresy deserving a pyre" from the viewpoint of the episteme of Modernity by violating the "sacral" dogma of the Cartesian "abyss" gapped "mind" (for "mathematical model") and "body" (for "experiments"). Particularly, this can also explain the resistance and reluctance in relation to the Nobel Prize for experiments demonstrating entanglement: one might say metaphorically that "model" and "reality", "mind" and "body" turn out to be "entangled" by the fact itself of the Nobel prize for physics in 2022. The development of science breaks the "wise" constitution suggested by Pauli as the particle paradigm of energy conservation in quantum mechanics, which culminates in the Standard model in the final analysis.

The separable complex Hilbert space can be interpreted as the free variable of quantum information once it has been modeled by the qubit state. Any physical state as far as it can be realized to be a quantum one is a certain value of that variable, but furthermore it is fundamentally indistinguishable from its mathematical model. Involving non-unitarian and non-Hermitian operators as a generalization of what is to be "quantity" in quantum mechanics, now forced by quantum information and relevant to entanglement (i.e. Einstein's "spooky action at a distance"), physical quantities belonging to abstract mental entities such as mathematical models can be assigned in an absolutely rigorous and scientific way by sharing the concept and quantity of information.

[29] The study of Doplicher (2019) means measurement in quantum mechanics in relation to the "EPR paradox" and that of Muynck (1995) links it to the simultaneous "interpretation of quantum mechanics and relativity theory".

The theory of quantum information is sometimes granted to be another, still one interpretation of quantum mechanics along with Born's probabilistic interpretation, that of many worlds originating from the PhD thesis of Hugh Everett III, Bohm's "realistic" interpretation, the initial Copenhahgen interpretation, for example advocated by Niels Bohr in his debates with Einstein, etc., etc. However, quantum information is much more than still one interpretation of quantum mechanics among many others. It predicts new phenomena, those of entanglement and their existence can be really confirmed, now already established to be absolutely recognized by the virtue of the authority of the Nobel prize.

Until now, it has been recognized as an applied and technical area of quantum mechanics including three main subdomains: namely, quantum communication, quantum computer, and quantum cryptography justified by virtue of their implementations. Nonetheless, quantum information has been developed into a huge deposit of fundamental ideas relevant not only to the foundations of quantum mechanics (and thus relevant to those of physics, chemistry, and natural science), but also to the theory of information, the foundations of mathematics as well as to a series of philosophical disciplines such as epistemology, ontology, philosophy of science, philosophy of mathematics, philosophy of physics and chemistry, and especially, of quantum mechanics, philosophy of probability and information, etc.

However, the contributions in the enumerated domains rely on the phenomena not ultimately confirmed experimentally, admitting more or less possible "backdoors" for "advocates of the devil" to question the numerous available results in experiments of entanglement. Those "backdoors" for the interpretation of the experiments and their results by causes and reasons different from the confirmation of entanglement were much more than usually due to the fact that the only observable effects of entanglement (or of any quantum correlations) consist in the deviation from the statistic correlations expected in the case if entanglement did not exist in nature. For example, if one observes some ostensibly inexplicable correlations between two groups of experiments arbitrarily remote from each other, one can suggests some unknown hidden shared basis in them and able to explain absolutely classically, trivially or as a technical imprecision of the joint experiments rather than by involving that "mystical spooky action of a distance" seeming to contradict the principle of scientificity at all and rejected by so great minds as Einstein.

One can say that too prolonged (about a century) scientific "legal trial" started by the debates of Einstein and Bohr (described, e.g., by the latter in: *Bohr 1957*), in which the former was the "plaintiff" and the latter was the "defendant", finally ended by an ultimate judgment as to what the awarding by the Nobel Prize can be interpreted. Though literally and formally that judgment seems to be in favor of Bohr, many objections of the "plaintiff" Einstein are also meant, achieving a reconciliation of them as many legal judgments or scientific resolutions and decisions tend.

Indeed, the exceptionally famous article of Einstein, Podolsky, and Rosen (1935) frequently cited as the one of the sources of the idea of quantum information and transformed by means of Bell's equations in the experiments awarded by the Nobel Prize in 2022 can be interpreted not only "apophatically", but also "cataphatically" in the following exact meaning. "Apophatically", the paper means that quantum mechanics is "incomplete" as a proof by the method of *reductio ad*

absurdum. However, the same missing complement of quantum mechanics, named as that "spooky action at a distance", which is renamed nowadays as "quantum correlations" or "entanglement" and established as indisputable scientific facts, and demonstrated explicitly, i.e. in a "cataphatic" way in the cited paper.

Furthermore, the "spooky action at a distance" contradicts the principle of locality embedded in the postulate that the speed of light in a vacuum is the maximal possible one in the physical world and only at the cost of zero mass at rest (i.e., only for "pure energy"). The epithet "spooky" is pejorative, corresponding to the statement that quantum mechanics admits nonlocality unlike special and general relativity identifying the physical with the local and according to which any nonlocality implies "ghosts" in physics. The usual "apophatic" interpretation of the paper means that those "ghosts" are not described in quantum mechanics, therefore remaining incomplete, in a "respectable" (i.e., local) way relevant and "befitting" in physics.

Then, if special relativity can be linked to the *local* "half" of quantum mechanics since the two theories are quite consistent to each other as quantum electrodynamics demonstrates explicitly, the other, nonlocal or "spooky" part of it should by identified with general relativity able to describe the same mystic phenomena in virtue of their nonlocality in an absolutely "venerable" way only "worthy" for the honest reputation of physics. That interpretation of the "triple paper" can be called "cataphatic" and thus corresponds to physics in the 21th century and the establishment of entanglement and quantum correlations. In other words, once that scandalous "spooky action at a distance" is anyway a scientific fact, it might be alternatively described also locally, which general relativity does in fact, following the "cataphatic" approach to the article at issue.

So, the present paper shares and restates that reading of it since the last Nobel Prize in physics establishes entanglement as an absolutely confirmed scientific fact. Then, the interpretation of entanglement as the cherished "quantum gravity", though in a sense discernibly different from the usual one and elucidated in detail in the present paper, has been pioneered. Or by synthesizing in a single sentence and rather aphoristically, the "smooth" gravity described by general relativity is only the local mapping of the hypothetical "quantum gravity", which turns out to be nonlocal and identifiable with entanglement.

Here, the "local" and "nonlocal" are supplied by exact mathematical and physical meanings: within or out of the "light cone" though being generalized and "curved" being homeomorphically transformed from Minkowski space into pseudo-Riemannian space; and even more, the mapping at issue is properly quantum gravitation by identifying operators in pseudo-Riemannian space with non-Hermitian operators in the qubit Hilbert space and therefore necessarily involving the medium of qubits and quantum information as the relevant basis for their unification.

In other words, if the first "half" of that mapping, namely operators in pseudo-Riemannian space has been established to be a very well confirmed scientific fact since the experiments confirmed general relativity i.e. for more than one century, the second "half" of the mapping, namely non-Hermitian operators in the qubit Hilbert space (or equivalently, in the separable complex Hilbert space of "classical" quantum mechanics) remained "branded and reviled" not so

much by Einstein's "spooky action at a distance" as by Pauli's "particle paradigm" of quantum mechanics, furthermore professed and decreed to be its "official religion" by the Standard model.

Thus, the Nobel Prize for entanglement and quantum information in 2022, by the by, 101 years later than Einstein's Nobel Prize in 1921 though shyly formulated to be "for his services to Theoretical Physics, and especially for his discovery of the law of the photoelectric effect"[30], establishes the second "half" of that mapping, namely non-Hermitian operators in the qubit Hilbert space as an indisputable, very well confirmed scientific fact. Though only the second half of the mapping is explicitly established, the mapping itself, anyway rather implicitly, too, since its first half has been recognized for about one century.

One can accordingly conclude that though the explicit significance of the Nobel Prize for entanglement and quantum information refers to themselves explicitly, the much more important significance of it is implicit and consists in pioneering the pathway to the mapping itself, i.e., to the interpretation of that gravitation of general relativity as a nonstandard (or more precisely anti-nonstandard[31]) interpretation of the cherished theory of quantum gravitation as what the theory of entanglement and quantum information turns out to be.

An unexpected, but very instructive "back reflection" (including philosophical) in the "picture of the world" is the understanding of gravitation, respectively mass at rest, initially the gravitational one, but then also the inertial one in virtue of their equivalence postulated in general relativity, as the local counterpart of nonlocality. If physical time needing and giving rice to a certain well-ordering (therefore necessarily implying the well-ordering "theorem" and the axiom of choice if both are equivalent to each other), mass at rest turns out to be its shady or dual counterpart where their product has the physical dimension of action, which is a smooth quantity (and only smooth as to classical physics), on the one hand, but nonetheless and simultaneously, a discrete quantity being necessarily quantized for the fundamental Planck constant.

So, though both mass (respectively, energy after Einstein's "$E = mc^2$") and time are continuous quantities, their product having the physical dimension of action is that "meta-quantity" in which the synthesis of the discrete and continuous quantities is already possible and which leads to involving information, whether classical or quantum, as physical quantity, even the most fundamental one.

One can involve the following metaphor or visualization: the quantity of action as the product of mass (respectively energy), as if "back in time", and time itself in its proper direction can exist only in the quantum superposition where or when both directions of time are "mixed". Then or there, time and mass (energy) cannot be differentiated from each other yet, when or where the real

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[30] https://www.nobelprize.org/prizes/physics/1921/summary/

[31] The sense of the newly coined adjective "anti-nonstandard" is the following. If one means "nonstandard", for example, as in the meaning of Robinson's "nonstandard analysis" or more generally as any countable model of any uncountable infinite mathematical structure after the Löwenheim - Skolem theorem, then the corresponding reverse mapping (if any) can be called to be just "anti-nonstandard", always in the final analysis touching the "problem of the nonstandard bijection", or more loosely speaking, weather a bit of information is a bijection or not. The problem is discussed in detail in various contexts in other papers (e.g. Penchev 2021 July 8; Penchev 2021 March 9; Penchev 2021 August 24).

"Big Bang" occurs permanently, and in an omnipresent and omnitemporal way, therefore violating energy conservation and Pauli's particle paradigm of the "classical" quantum mechanics.

The mythical Big Bang of the ostensible beginning of the universe is not an actual event, but the hypothetical and integral projection back in time of the permanent, omnipresent and omnitemporal real pico-"Big Bangs" in any point of spacetime, where or when energy constantly appears "ex nihilo" only in virtue of its division from time (or respectively spacetime), only after which the standard physical picture of the world is valid and energy conservation as well. That picture means two main parts: the stage of spacetime, only within which, i.e., only locally, anything claiming to be physical and possessing mass and energy can exist.

The real medium of those pico-"Big Bangs" being always and everywhere in any point consists just in that division of the two dual counterparts of spacetime and energy-momentum, where-when the process itself of division can be exhaustively described by the Einstein field equation of general relativity as the gravitational interaction, in fact, by means of the spacetime tensor yet not absolutely distinguishable from the corresponding energy-momentum tensor, where-when the quantity of their indistinguishability is just that of gravitation, furthermore being smooth.

Nonetheless, the emancipation of the physical being, featured by energy-momentum, from its inherent stage of spacetime can be described alternatively, but equivalently as a discrete leap and due to this, outlined by quantum mechanics. Then, the entanglement of spacetime and energy-momentum is the alternative, but equivalent representation of the gravitational interaction in the former case. In other words, entanglement is the quantum counterpart of gravitation, usually meant to be quantum gravitation, but essentially different from the standard idea of quantum gravitation denoted to be similar to the other three interactions of the Standard model. However, those three refer to Pauli's paradigm corresponding to the ultimate state of their division, unlike entanglement being identified as one among the class of nonstandard quantum gravity relates to any intermediate stage of that division and even being equivalent to the former three by virtue of the equivalence of inertial mass (relevant to the former case of the ultimate division) and gravitational mass (relevant to the latter case of the intermediate process of the division at issue).

Accordingly, the real omnipresent "Big Bang" (or the medium of the "Small pico-Bangs") corresponds to all processes of decoherence in the universe including in the past, i.e., due to the decrease of entanglement. If one returns to the standard picture of the mythical Big Bang in the beginning of the universe, an initial maximal entanglement preceding the Big Bang would correspond. The mythical "Big Bang" would be the process of the decoherence of that "Big Entanglement", and the expansion of the universe should be gradual decoherence of that "Big Entanglement". Of course, that "Big Entanglement" is not less mythical than the "Big Bang" and represents, just as the latter, an integral back projection of the real omnipresent and omnitemporal entanglement.

IV FORCES AND PROPERTIES VERSUS INTERACTIONS AND RELATIONS

In fact, the problem about quantum gravity, as it is articulated above, refers to the relation of "forces" and "interactions" in modern physics after Galileo Galilei and Isaac Newton, on the one hand, and that of properties and relations (for example after Russell who emphasized the necessity

of the reformulation of the medieval predicate "logic of properties" on their basis). Indeed the principle of the equivalence of inertial and gravitational masses discussed above in detail in the framework of the present context can be interpreted as the quantitative link between the "physics of actions" and the "physics of interactions".

Though the common scientific opinion is that contemporary physics at all and quantum mechanics in particular belongs to the latter, in which any physical influence is due to some interaction, in fact the Standard model supports the opposite viewpoint, that of physical forces. Indeed, the Standard model means weak, strong, and electromagnetic "interactions", but it interprets them essentially as forces. The distinction between (1) forces and (2) interactions consists in referring to: (1) a single system, to which any force acts, setting it in a motion, which can be considered to be a property of the system at issue according to another property of it, its inertial mass expressible by the relation (or mathematically, ratio) of the physical quantity of force and that of acceleration, featuring the caused motion. Of course, this is the famous second principle of Newton, "$F = ma$", defining the concept of "inertial mass"

(2) As to the case of interactions, one means more than one system, but the systems can be granted to be two for the simplicity of discussion. Then, the concept of relative motion is relevant, on the one hand, and that of gravitational mass, on the other hand. The physical influence as an interaction is a relation of the two physical systems at issue. Any interaction generates two accelerations, which can be granted to be equal, but opposite in direction. Thus, any interaction can be reduced to two equal forces opposite in direction, according to Newton's third principle. Gravitational force or interaction, though obeys the third principle as well, represent in fact a correction to the influence of any other force (respectively, interaction), therefore inherently being a relation and thus an interaction[32].

So, any force, which is not gravitational, can be also considered to be a relation, that of it to the caused acceleration according to the second principle or the concept of "inertial mass". The peculiarity of gravitational force consists in the fact that the acceleration of another body acts as a force if the framework in the previous proposition is followed. Then, gravitational force can be represented as a correction to any other force from the same viewpoint of the first sentence. For example, that correction can be due to the Higgs mechanism "spontaneously" violating the immanent symmetry established by Newton's third principle between action and reaction: mass at rest can be defined by means of their mismatch. That mismatch of the acting force and the reaction force is a resultive force representable as an additional mass called "mass at rest". One can notice that such a consideration means only an inertial mass, eventually corrected by another inertial mass

[32] Furthermore, mass at rest is equivalent to the violation of CPT-invariance. Indeed, "C" (for "charge" in "CPT") means "force", and "CP" (again there) notates "energy": thus CPT-invariance is "action" and therefore touching its counterpart of quantum information obeying quantum information conservation. Consequently, quantum information conservation implies CPT-invariance, but not vice versa: since quantum information conservation is a conservative generalization of CPT-invariance including the case of its violation by gravitation anyway equivalently representable on the "wall of Plato's cave" by the pair of the general CPT-invariance and the corresponding mass at rest, specific for any particle and being the necessary correction for the relevant violation of CPT-invariance.

called mass at rest and able to represent gravitational forces being due to all the accelerations of all other entities in the universe.

Thus, the Standard model remains thoroughly within the framework of the "physics of forces" considered to be properties, after which even gravitational force, being inherently relative, is nonetheless reflected as still one inertial force generating a "spontaneous" asymmetry of action and reaction and meant by the Higgs mechanism generating "mass at rest". The adjective "spontaneous" is very instructive: it cannot but be "spontaneous" since its "unspontaneous" cause is gravitational mass being inherently out of the inertial framework originating from Pauli's particle paradigm of energy conservation.

So, one can reinterpret the conflict between general relativity and the eventual future theory of "quantum gravity", on the one hand, and the Standard model corresponding to the classical quantum mechanics and Pauli's "particle paradigm" of energy conservation, on the other hand, as another collision of the "physics of interactions" versus the "physics of forces" featuring the whole course of modern physics, but now resumed on the quantum stage.

Then, the EPR argument[33] about the incompleteness of the "classical" quantum mechanics culminated in the theory of quantum information and the 2022 Nobel Prize can be realized in the confrontation of those two "physics": that of interactions versus that of forces. This means that the mathematical formalism of quantum mechanics by the separable complex Hilbert space implies a relational counterpart, which is the missing complement of the "classical quantum" mechanics to its eventual completeness implicitly suggested by its mathematical formalism.

Though the triple article itself involved only the "pure existence" as an abstract logical necessity of that relational "shady" counterpart to the "forceful" quantum mechanics (what the "classical" one is), Bell's inequalities (1964) gave it a constructive and experimentally testable form. The experiments awarded by the Nobel Prize were just what confirmed that the hypothetical relational counterpart really exists by means of the demonstration of quantum statistical correlations exceeding any possible classical correlations, i.e., violating the limit established by Bell's inequalities. The sense of the Nobel Prize is epochal since it decrees the existence of the relative counterpart of classical quantum mechanics as a scientific fact and thus the theory of quantum information as a legal "twin" or at least "sibling" of the Standard model.

Then, still one conjecture is pioneered by following the "logic of the EPR argument" once "E" in "EPR" denotes Einstein, the creator of general relativity. The newly discovered territory, before being a "terra incognita", can be anyway recognized as Einstein's general relativity only rewritten in a different language, that of quantum mechanics by the crucial mediation of quantum information.

One can involve a counterfactual metaphor to Columbus's discovery[34] of a new sea route to India, sailing west to reach India from the other side because of the spherical shape of the earth.

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[33] It is often called, but being misleading, the "EPR paradox". Its three authors did not consider it to be a paradox, as well. It is only a contradiction common sense's prejudice of locality. The paper of Tartaglia (1998) discusses its ostensible paradoxicality.

[34] For example, following the EPR argumentation interpreted to be "counterfactual" (as in Bolotin 2019 or Forster 1986), "statistical, but in a quasi-classical sense" (Fano, Macchia, Tarozzi 2019), respectively

On the contrary, one can suggest that another Columbus, in a counterfactual universe where no America (on earth there), started to reveal a new continent, the counterpart of our America which however does not exist there, reached really India thinking that this is the new continent of America (however in fact, India), i.e. a fallacy opposite or counterfactual to that of our real Columbus.

Then, the conjecture for the identification of entanglement and quantum gravity can be likened to the fallacy for India to be discovered as America (rather than vice versa), but in the counterfactual universe sketched above. If general relativity describes gravitation as the relational counterpart of classical mechanics, the theory of quantum information is the analogical relational counterpart of quantum mechanics, and finally quantum mechanics establishes the apparatus and its readings, both as its necessary condition, all those three premises imply the identification of general relativity and the theory of quantum mechanics and entanglement. Even more, the identification at issue implies an additional hypothesis about dark matter and dark energy as originating from entanglement:

One can point out that dark matter and dark energy, though predominating in the universe as about 95% or 96% of its entire mass and energy[35], are established only by gravitational interaction whether based on the common general relativity or on any alternative theory of gravitation. In other words, not even one experiment demonstrating any of the "three canonical interactions" (in fact, forces in the actual meaning refined above) recognized by the Standard model as an eventual source of dark matter and dark energy. So, no quantity in the framework of the "classical" quantum mechanics, obeying Pauli's "particle paradigm" of energy conservation and unitarity and thus restricting all possible quantities in quantum mechanics to Hermitian operators in quantum mechanics, is able to generate dark matter or dark energy[36].

So, the only possible remaining cause and source of dark matter and dark energy consistent to both experimental considerations above can be non-Hermitian operators still relevant to quantum mechanics, but not to Pauli's particle and unitary paradigm of energy conservation. Thus, the 2022 Nobel Prize pioneers the pathway to the extended (or "non-classical") quantum mechanics of quantities describable by non-Hermitian operators and not obeying energy conservation in the framework of its eventual generalization conjected to be a law of quantum information

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"classically rooted" (Lando, Bringuier 2008), or even "wrong" (Holland 2005). The eventual "solution" of EPR is easily linkable to the generalization of probability (e.g., Pykacz 2006); The ideas of Lee (2014) or Szabó (2000) for the eventual solution of EPR correspondingly by special relativity or by Reichenbach's "common cause" correspond to the distinction of locality versus nonlocality by the light limit, as it is meant in the present paper. In fact, one can relate the EPR argumentation for quantum mechanics to be incomplete to a future and complete quantum mechanics and the Gödel incompleteness of arithmetic to set theory (Penchev 2009) and then unify them on the ground of the "nonstandard bijection" (e.g., Penchev 2021 March 9), or the "philosophical bit of information" (e.g., Penchev 2021 August 24), or "scientific transcendentalism" (e.g. Penchev 2021 April 12) in the final analysis.

[35] This is a very confirmed fact including in the scientific popular and mass culture, for example in "NASA science": https://science.nasa.gov/astrophysics/focus-areas/what-is-dark-energy (seen on 28 February 2023).

[36] As this is discussed above, the semi-legal and too exotic confinement as an additional fourth interaction and thus partly out of the strict framework of the Standard model might be anyway the basis of a possible theory of dark matter or dark energy.

conservation to the Lie groups of action (rather than to the Lie groups of time as the non-generalized case of energy conservation).

The complement of the Lie groups of time to the Lie groups of action (or respectively that of energy conservation to quantum information conservation) consists in the physical influence of coherent states of quantum superposition, i.e. Einstein's "spooky actions at a distance" or speaking loosely and partly figuratively it consists in the physical influence of the "state of the universe before the Big Bang" after its demystification into an omnipresent and permanent medium "Pico-Bangs" of decoherence, projectable also as a single common Big Bang back in time (ostensibly 13-14 billions of years ago) on the cognitive screen of Pauli's paradigm and the seemingly inviolable energy conservation being in fact an unscientific prejudice of religious origin.

Related to the problem of dark mass and dark energy, this means that both are due to the coherent phase of the universe: i.e. the vast majority of the universe is yet in a coherent state corresponding to the experimentally observed 95-96% of dark matter and energy, and only 4-5% of the universe are in an absolutely decoherent state, to which Pauli's paradigm of energy conservation is really relevant. So one can estimate the scope of the Standard model to that of the forthcoming theory of quantum information approximately as 1:20 according to the ratio of the "light" mass and energy according to the Standard model in relation to the "dark" ones, the investigation of which has been pioneered by the experiments confirming entanglement and awarded by the 2022 Nobel Prize.

That crucially prevailing coherent state of the universe can be described though more or less figuratively as the indistinguishability of time and energy or being in the state of "Schrödinger's cat" so that 95-96% of it are in the coherent superposition of being both alive-and-dead simultaneously, and only 4-5% of it are in an ultimately state of either alive or dead. That coherent state is furthermore reversible in time or one might say that the two directions of time (conventionally definable as forwards and backwards in time) are not yet divided or at least they are not absolutely or ultimately divided. A quantum computer calculates just in that reversible state unlike any Turing machine (what all our contemporary computers are) processing only in a state of an absolute decoherence where Schrödinger's cat can only be either "alive" or "dead" therefore constituting a bit of classical information by conventionally denoting "alive" as "1" versus "dead" as "0".

V QUANTUM MECHANICS WITH THE STANDARD MODEL VERSUS GENERAL RELATIVITY

One should distinguish the "classical" quantum mechanics obeying Pauli's "particle paradigm" of unitarity and energy conservation where all possible quantities are Hermitian operators from quantum mechanics at all, though common sense tends naturally to identify them. The EPR argument[37] in fact demonstrates only that the "classical" quantum mechanics is incomplete to quantum mechanics as (e.g.) Niels Bohr's viewpoint (1935; 1957) to the triple article can be

[37] Involving its "angular version" (Götte, Franke-Arnold, Barnett 2006), the link between it and the curved spacetime of general relativity is already obvious. One can pay attention to Einstein's version of the EPR thought experiment for spin variables (Sauer 2007) as a possible link to general relativity

interpreted. On the contrary, Einstein, Podolsky, and Rosen rather identified the classical quantum mechanics and quantum mechanics at all after Einstein's insight into the eventual nonempty complement of the former to the latter[38] as producing the outrageous "spooky action at a distance", more outrageous than which only the 2022 Nobel Prize can be for the reason that it awards experiments consecrating those nonlocal "ghosts" in physics as a respectable scientific truth.

Even more, the conjecture nowadays that almost all the universe is "spooky" if one identifies its "dark" part as nonlocal as above seems to be quite believable. The identification of the "dark" with the "nonlocal" can be justified rather elementarily and elegantly though not absolutely rigorously. Locality is "light" since it is within and only within the light cone, i.e. within and only within the imaginary domain of Minkowski space. Respectively, nonlocality should be "dark" since it is out of and only out of the light cone, i.e. within and only within the real domain of Minkowski space. So, if locality is "light" by virtue of the postulate of the maximal light speed in a vacuum, nonlocality is to be dark on the same ground.

"One more thing" (in "Steve Jobs's manner"): though "dark", what is "dark" is not absolutely "invisible" experimentally, but "visible" only in gravitational observations since the word "experiments" is rather inappropriate in the case at issue. So, the associative chain "nonlocal - dark - gravitational" suggests the conjecture to be interpreted as a series of equivalences rather than as one more or less metaphorical and thus quite loose argument. In other words, what is nonlocal can be identified with what is gravitational.

Meaning the precious mathematical language of Minkowski space for the "nonlocal" in the meaning of being within and only within its real domain, on the one hand, and that of pseudo-Riemannian space for the "gravitational" in the meaning of being curved or "bifurcated" into two Minkowski spaces, the one of which is conventionally granted to be the contravariant one unlike its counterpart forced by virtue of the same convention to be its covariant "shade" however under the necessary condition to overlap each other in any nonzero intersection dissimilarly to the case of the "straight" Minkowski space where that intersection is either zero (for some authors) or limited to the surface of the light cone (for other authors), but also zero as the quantity of "spacetime distance" since the surface of light cone is the set of all points in Minkowski space for that spacetime distance is zero.

So, if one means homeomorphism of Minkowski space and the qubit Hilbert space (discussed in detail in other papers, in which its origin from the separable complex Hilbert space is also explained: *Penchev 2022 February 4*) the unification of entanglement and gravitation seems to be almost obvious and thus trivial. Indeed, gravitation after general relativity describing it as the

[38] The study of Held (2005) makes clear that incompleteness of quantum mechanics in Einstein's manner can be deduced without any "separation principle", i.e., without distinguishing nonlocality and locality. The latter statement would contradict one of the main ideas of the present paper. However, the author's approach means something different: the opposition of locality and nonlocality can be equivalently represented only locally, which corresponds exactly to the approach here: in other words, one can add an additional dimension therefore curving locally spacetime just as general relativity does in order to represent just only locally the opposition of locality and nonlocality. or excluding the "separation principle", in terms of the cited research.

variable of pseudo-Riemannian space and thus as any variable nonzero overlapping of the two counterparts of covariant and contravariant Minkowski spaces which also can be denoted to be the local "half" of its imaginary domain and the nonlocal "half" of its real domain. If that is the case, gravitation is zero: on the contrary, it appears as a result of any nonzero overlapping of them usually represented in Einstein's general relativity by the formalism of pseudo-Riemannian space being isomorphic to the overlapping of the "covariant half" of Minkowski space with its "contravariant half" (an issue of a conventional choice of which to be the local one and which to be its nonlocal twin).

Well, if one passes from the overlapping of the two halves of Minkowski space to the overlapping of two halves of the qubit Hilbert space by the mediation of the aforementioned homeomorphism, gravitation relevant to the former case is now equivalent to entanglement in the latter case; or vice versa as well. That is and using an appropriate slogan: "entanglement is gravitation, and gravitation is entanglement". They are the same only described in two languages: the one is that well-known one of general relativity, the other one is that of quantum mechanics (but not that of only the "classical" quantum mechanics), and finally, the "Rosetta stone" for their mutual translation is the theory of quantum information.

The mapping of Minkowski space into the separable complex Hilbert space can be also, though rather loosely, represented by Fourier transform formally substituting the variable of "time" with that of "frequency", respectively a continuous motion described by the smooth differential equations of classical mechanics with a quantum leap by the Schrödinger equation. Indeed, the latter is formally also a smooth differential equation, but in relation to the variable of wave function in turn being the characteristic function of a relevant probability (eventually, density) distribution thus substituting a quantum leap by that probability distribution over all possible measurable values of the variable after the quantum leap at issue and thus equivalent to it.

Accordingly, the mapping of the separable complex Hilbert space into Minkowski space corresponds to reverse Fourier transform and thus to the replacement of "frequency" by "time"; or this means: the description by the Schrödinger equation to be substituted by the smooth equations of classical mechanics though in its relativistic version. If one describes the same reverse transition from "frequency" to "time", but now meaning "frequency" as the Fourier equivalent of a relevant probability density distribution, one may notice that all possible values, conditionally meant to be "simultaneous" in a probability density distribution representing any quantum leap, would be run one by one consistently over time after the mapping of the separable complex Hilbert space into Minkowski space, now visualized by reverse Fourier transform.

The case of pseudo-Riemannian space at any point (of it) corresponds to a pair of Minkowski spaces "overlapping" each other and corresponding to the pair of the covariant and contravariant Minkowski spaces being "tangential" at any certain point. Then, the mapping by Fourier transform would correspond to two entangled separable complex Hilbert spaces so that the gravitational interaction acting in any point of pseudo-Riemannian space is unambiguously meant by the entanglement of the two corresponding Hilbert spaces. Or vice versa by means of reverse Fourier transform: entanglement of any two separable complex Hilbert spaces will be represented by a

point of pseudo-Riemannian space and a certain value of gravitational interaction at the point at issue.

Meaning the fundamental epistemological structure of quantum mechanics unifying the discrete motion of any quantum system and its mapping onto the readings of the macroscopic apparatus thus described by the smooth differential equations of classical mechanics, one may say that the pair of entanglement and gravitation (meant exactly according to general relativity) are also unified just in the same way. So, the theory of quantum information describing entanglement can be granted to be the relevant theory of quantum gravitation since entanglement is equivalently represented by gravitation in Einstein's theory and following the inherent epistemological postulate of quantum mechanics (mentioned above).

In other words, if one measures the global effects of entanglement at any point of space-time, the description of general relativity is absolutely exact. So, if the Copenhagen interpretation of quantum mechanics, restricting it only to propositions about observable effects and to the theory able to predict precisely enough those observable effects, general relativity is really the theory of quantum gravity since it foresees the results of any measurements very well. The hypothesis that entanglement underlies gravitation on the quantum scale is out of the Copenhagen interpretation[39] since it does not imply any measurable macro-effects different from those according to general relativity. `

Finally, one can consider the transition from the description according to quantum mechanics by two entangled separable complex Hilbert spaces and that by pseudo-Riemannian space (equivalent to two Minkowski spaces variably overlapping each other at any point of pseudo-Riemannian space thus equivalent to variable entanglement at it), as a generalization of the concept of reference frame, being inherent for the latter (discussed in detail in another paper: *Penchev 2021 June 8*).

The concept of reference frame is fundamental for the definition of relativity, more exactly, for the relativity of mechanical motion. Special relativity means the particular case of inertial reference frames (established since Galileo's age), however under the additional postulate for the maximal speed of light in a vacuum thus being the same to any inertial frame. In fact, the latter condition can be reinterpreted as the replacement of the classical, absolutely immovable ether, the relative motion to which can be considered to be a "propertial" motion, i.e., as a property of any moving body or reference frame linked to it, by the newly introduced "light" ether of electromagnetic field. That approach is also elucidated in detail above in the present paper. The single difference to the classical absolutely immovable "ether" consists in the fact that the privileged "ethereal" velocity is not zero, but that of light in a vacuum, both being however equally the same to any inertial frame.

As this is very well known, general relativity can be considered as a conservative generalization of special relativity, for which all physical laws are postulated to be the same to or

[39] Paty's research (1995) summarizes the "nature of Einstein's objections to the Copenhagen interpretation of quantum mechanics" and that of Redei (2010): "Einstein's dissatisfaction with non-relativistic quantum mechanics and relativistic quantum field theory,"

in any inertial reference frame. Then, general relativity postulates an analogical proposition for any reference frame interpreting it to be moving with any variable acceleration rather than with a zero acceleration as in the case of all inertial frames. Once that is the case, gravitation is an interaction due to any nonzero mutual acceleration or respectively its change resulting in (or caused by) the change of gravitational interaction by virtue of the equality of gravitational and inertial mass. Under the postulate of not exceeding the speed of light in a vacuum, this seems to be the maximal possible generalization since the postulate at issue implies the inherent locality of the concept of reference frame, however quite natural in classical mechanics referring always to smooth differential manifolds.

If Einstein's "spooky action at a distance", i.e., entanglement is established to be a keystone of physical knowledge awarded by the 2022 Nobel Prize in physics, locality including the locality of reference frame can be relevantly generalized in a way to comprise "discrete" or "external" reference frames as well as "partly discrete" or "partly external" reference frames, as those are introduced in the cited above paper (Penchev 2021 June 8). The transition between them is not local since it can be granted to be "instantaneous" or at least featured by a velocity exceeding that of light in a vacuum and thus out of the locality of both special relativity and general relativity. The case of an infinite relative speed of two "discrete reference frames" means properly a quantum leap, which can be relevantly described by a single separable complex Hilbert space, i.e. by classical quantum mechanics in the framework of Pauli's paradigm.

However, the case of a finite relative speed, but exceeding the speed of light in a vacuum, corresponds to *partly* discrete or *partly* external reference frames, i.e., to entanglement in all of its phenomena. If the case meant by classical quantum mechanics can be liken to inertial discrete reference frames: thus, the counterpart of the standard inertial reference frames of special relativity, the case of partly discrete reference frames would correspond to the quantum counterpart of the generalized reference frames moving to each other with any variable acceleration. Respectively, the quantity of acceleration is the counterpart of the newly introduced quantity of an arbitrary and variable entanglement as in the case of decoherence (as well as in the reverse case of appearing of a single coherent whole or in any combination of alternating phases of decoherence and of "coherence').

The newly introduced principle of "quantum relativity"[40] (or a principle of relativity more general than that of general relativity) can be formulated in a way to comprise the case of nonlocality, i.e., any degree of entanglement or the process of decoherence. Inserting the case of nonlocality, since it is the negation of locality, which in turn follows from the postulate that the

[40] Papers (Minic, Tze 2004; Finkelstein, Gibbs 1993) discuss "quantum relativity", but in a way partly similar, but essentially different from that in the present paper, and that of Rossler, Weibel (2001): "post-quantum relativity"; others (Pissondes 1998; Nottale 1995): "scale relativity" being similar to the "principle of cyclicity" promoted here in cited already papers; the study of Pitowsky (1991) discusses the "relativity of quantum predictions". "Quantum relativity" can be also considered in a generalized sense to papers examining the compatibility of relativity and quantum mechanics (e.g., Kong 2008; Macías, Camacho 2008; Kar, Kunkri, Choudhary 2006; Gambini, Pullin 2005; Fleming 1995; Mayants 1995; Harding 1977) or quantum nonlocality and relativity (e.g. Flores 1996).

velocity of light in a vacuum cannot be exceeded, the postulate at issue is rejected by virtue of those experiments awarded by the Nobel Prize establishing that what Einstein called to be a "spooky action at a distance" is a real natural phenomenon very well confirmed by experiments.

The principle of quantum relativity should state another conservative expansion of the principle of relativity from any reference frames in the sense of general relativity, i.e. obeying locality in virtue of the postulate of not exceeding the speed of light in a vacuum, to nonlocal reference frames, the relation of which can be described in a way isomorphic to entanglement. Literally, it says that all physical laws are the same in all reference frames, now including those in states of relative quantum leaps to each other where entanglement should be interpreted as a partial quantum leap.

Meaning that the laws and thus any physical description should be the same in any reference frames in any relative *local* motions to each other, on the one hand, thus subjected to gravitational interaction, on the other hand, those subjected to entanglement, i.e. moving to each other nonlocally and considered to be also reference frames only due to the principle of quantum relativity, one has to establish that *gravitation is entanglement described locally just as entanglement is gravitation described nonlocally*. The principle of quantum relativity is what implies their equivalence.

In other words or speaking loosely, in the manner of social constructivism to science, the Nobel Prize for entanglement experiments pioneering quantum information science is a necessary condition for the eventual future Nobel Prize for "quantum gravitation" because it relies on quantum information and thus on the Nobel Prize in the final analysis though in a wider sense properly meant by social constructivism.

However, the principle of quantum relativity being a necessary condition for the eventual theory of quantum gravity is accompanied by a series of philosophical troubles partly described above (for example destructing or deconstructing the Big Bang as a myth) and resulting into a new viewpoint to the universe (e.g. corresponding to "scientific transcendentalism" as it is described in other papers, e.g.: Penchev 2020 October 20; Penchev 2021 April 12), the slogan of which may be the universe within a quantum[41] or the universe within any quanta. That viewpoint as if challenging common sense (which, by the by, has been the usual or favorite deal of science since Galileo Galilei and Giordano Bruno's age) is inconsistent to energy conservation or to Pauli's "particle paradigm" confessed by the Standard model in particular:

Indeed, it is nonsense for the universe to be equated to a single quantum since the energy of the universe "and" the energy of a single quantum is monstrously different once the unit of time is postulated to be the same for both. Nonetheless, if energy conservation is generalized as quantum information (justified in detail in other papers: *Penchev 2020 October 5*), a quantum and the universe can be compared as to the "dark" and nonlocal phase where the quantities of energy and time cannot be distinguished from each other whether absolutely or partly, i.e. this is relevant only in the terms of the "light" and local phase incorrectly identified to be all physics until (speaking rather figuratively) this year's Nobel Prize…

[41] For example, after the "principle of cyclicity" (Penchev 2020 August 7).

VI THE PUZZLE OF QUANTUM GRAVITY: PHILOSOPHICAL RATHER THAN ONLY PHYSICAL

So, one can speak of the "puzzle of quantum gravity" as a fundamental philosophical problem rather than as a particular one referring only to physics and to the relation of two fundamental physical theories: quantum mechanics and general relativity[42]. At least a few very important philosophical consequences from the sketched above solution about the problem of quantum gravity by the mediation of entanglement and quantum information are to be noticed:

Causality being fundamental for scientificity at all at least in natural science rather than only in physics should be generalized in a way able to include "reverse causality" rather than only probabilistic causality already legitimized by classical quantum mechanics, the Standard model or Pauli's particle paradigm of energy conservation. The reverse causality is out of the scope of the latter, inconsistent to it, but a corollary from the eventual solution about quantum gravity by means of entanglement and quantum information:

The prevailing part of the universe (about 95-96% according to the current experimental data) should be related to its "dark" phase registrable only by gravitational phenomena whether in the dominating framework of general relativity or in those of its rivals though rather marginal. The reverse causality along with the "normal", "straight" causality so that both can be unified into reversible causality are inherent for the "dark" phase at issue and unlike the "light" phase featured only by the latter type of causality furthermore being fundamentally local:

Indeed, any physical cause can be only local, propagating as a physical interaction limited to the speed of light in a vacuum once general relativity has been granted. If that was the case, Einstein's epithet "spooky" is quite appropriate: any nonlocal cause can be in the area of "ghosts", admitted only by spiritualism rather than studied by physics and natural science. Nonetheless, the 2022 Nobel Prize legitimizes indirectly those physical causes being only nonlocal and for example allowing for the following metaphor or philosophical speculation about the "Fermi paradox":

"Why are the aliens not here?" In fact, they are maybe here, but nonlocally.

One can figure, for example, though counterfactually nowadays, some tribe in some isolated and remote island in any ocean where the global civilization has not reached yet. The thinkers of the tribe wonder and dispute: "Are we alone or there exist other human tribes on other islands among the boundless ocean?" To resolve that puzzle, they decide to transmit signals by fires lit on the ocean shore. No any answer for many years! "Consequently, we are alone", the thinkers there conclude while radio waves at all frequencies are propagated all over the island carrying terabytes by terabytes of information, which might be exceptionally useful for the tribe as long as it was not completely inaccessible to the islanders according to their level of technical development. Even one might admit that the fires lit by the tribe are noticed by somebody, but there exists some world convention protecting the originality of the tribe and prohibiting any contact with it before reaching maturity, the only possible witness for which might be the fact of a self-built radio and thus its self-inclusion in the global community.

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[42] A series of papers by Borzeszkowski and Treder (1991; 1989; 1982; 1982) anticipates the idea of Einstein's general relativity to be interpreted as a "nonstandard" theory of quantum gravitation.

Well, humankind is to build that nonlocal "radio" to certify its maturity by the self-inclusion in the community of the universe. The space abysses are obviously unsurmountable by any physical moving obeying local causality, but they vanish in thin air once nonlocal communication has been mastered, by which the "Wikipedia of the universe" has become accessible for us and thus the option for an almost vertical progress of humankind appears only after reading that "Universe-pedia".

Quantum communication, the importance of which is illustrated above by a possible "nonlocal" solution of the "Fermi paradox", is inherent to the universe due to the prevailing of its "dark" phase, but it needs reversible causality. Nonetheless, both quantum communication and reversible causality were out of the scope of physics obeying Pauli's paradigm in quantum mechanics and even out of natural science at all, since it restricted itself only to the "normal", "straight" causality in fact valid to the "light" local phase of the universe estimated to be not more than 4-5% of the total mass and energy of the universe.

Furthermore, quantum communication and reversible causality feature the concept of quantum computer, or that of a quantum Turing machine, in which its tape consists of qubits rather than of bits as in a Turing machine usually defined[43]. So, the investigation of reversible causality, the conditions and qualitative laws for its transformation into the "normal", "straight" causality are directly related to any quantum computer and the notion of its technical implementation.

The problem about reversible or nonlocal causality, particularly inherent to quantum communication and quantum computers, is also representable locally as the interaction of gravitation, and the representation itself (i.e., the mapping of nonlocality, featured by superluminal velocities[44], into locality with subluminal velocities) can be interpreted as a theory of quantum gravitation grounded on entanglement and quantum information, as this is described in detail above. All dark mass and dark energy crucially prevailing in the universe are to be explained as the local counterpart of nonlocality, i.e. as corresponding to the mapping of nonlocality into locality, and thus confirming the theory of quantum gravity by elucidating it as originating from entanglement and quantum information.

Furthermore, entanglement and quantum information, though inherent to the "dark" phase of the universe, allow for rethinking of its "light" or local phase exhaustively described by the Standard model as to quantum mechanics. For example, the principle of complementarity or that of wave-particle duality can be reinterpreted though still restricted to the light phase studied by classical quantum mechanics. If one of the two dual or complementary counterparts are interpreted to be relevant to time (or to well-ordering, mathematically), the other one can be related to "reverse time" and equated to mass and energy. Then, the quantity of physical action, or respectively the link between conservation of any quantity and the Lie group of the translation of its conjugate quantity according to the first theorem of Emmy Noether (1918), means the product of the physical changes in both directions of time, which can be also distinguished into local, subluminal ones and

[43] For example, as in the context of another paper (Penchev 2020 August 5).

[44] For example, the papers of Berkovitz (1998) or Zbinden, Brendel, Tittel, and Gisin (2001) consider the link of nonlocality, superluminal causation, and relativity.

nonlocal superluminal ones. The former is described by kinematics and the quantities relevant to mechanical motion such as time, position, velocity, and acceleration.

The physical changes of both under the additional condition to be thoroughly represented locally are described by dynamics where all kinematic quantities are complemented by their dynamic counterparts due to the featuring quantity of mass (or mass at rest): such as action, energy, momentum, force, work, etc. Meaning the theory of quantum gravitation as originating from entanglement and quantum information[45], but now applied to the "light" phase alone, one can suggest that mass or rather mass at rest is an integral quantity able to represent the effect of all relevant physical changes in the reverse direction of time. It cannot but be integral since it would violate the well-ordering of "straight" time otherwise.

Speaking quite loosely, one may involve the following visualization. Decreasing the mass of any physical entity, the interval of reverse time, relevant to that entity, decreases accordingly; and vice versa as to increasing its mass as well. The fundamental Planck constant determining the low bound of any physical actions and connected to that interpretation of action as representing the physical changes of both directions of time would mean that those two directions of time are inherently linked: they cannot be absolutely divided from each other since the relevant physical action would be identically zero and thus less than the Planck constant, which is impossible. Consequently, both directions of time are necessarily joint so that their "intersection" is a finite quantity limited by the Planck constant.

Respectively classical information can be absolutely rigorously distinguished from quantum information as follows. The intersection of the two alternatives of a bit of classical information is zero, but that of the two dual counterparts of a dual pair of qubits of quantum information is a finite quantity possessing physical dimension of action and limited by the Planck constant as to our universe. No physical action corresponds to the processing of classical information, e.g. in our computers really existent. In other words, the processing of classical information does not influence in any way on the physical processes relevant to the physical carriers of that classical information[46].

Reflecting philosophically, one may say that the Cartesian picture of the world is relevant only to the "light" phase of the universe, but it is only an insignificant part of the universe at all. Quantum information and physical action are linked by the Planck constant so that quantum information is physical action as well as vice versa as to the prevailing "dark" or nonlocal phase of the universe. Accordingly, "mind" and "body" cannot be absolutely divided from each other, as the Cartesian picture of the world needs, as to the latter.

One can reflect the inherent "dark" link of "mind" and "body", though the "light" abyss is still valid, but it is now restricted by the prevailing "entanglement of mind and body". According to the Cartesian paradigm about the organization of cognition in Modernity, "mind" and "body"

[45] The term "quantum gravitation" is intentionally utilized versus the usual one, "quantum gravity" in order to distinguish the unique approach of the present paper among the huge class of various hypotheses about *quantum gravity*.

[46] Many papers consider arithmetic operations on a quantum computer (e.g. Zhang 2020; Vedral, Takahashi 2009; Van Meter, Nemoto, Munro, Itoh 2008; Barenco, Ekert 1996).

regardless of being gapped out of human minds, constitute a “black box” in any human brain, the work of which obeys the “postulate of free will”, so that the “input of mind” is able to manage the “output of body” within the “black box” at issue, somehow available in any human brain. The “mechanism” hidden within that “mind - body black box” is still inaccessible to science and philosophy. Furthermore, that black box obeying free will is a necessary condition for the transformation of “mind” into “body”: so that they are fundamentally gapped in all nature out of human brains (to which eventually can be added the brains of certain higher animals more less approaching the fact or postulate of the black box of human brain). In particular, the creation “ex nihilo” cannot be observed anywhere in nature universally obeying the conservation of matter, respectively energy.

So, the universal Cartesian paradigm endows humankind with a unique and monopolistic position all over the world. Only human beings are gifted by free will featuring them from all others in nature. They can change nature by virtue of free will, i.e. in any way chosen by their free will as long as those changes obey all natural laws, which humankind has gradually mastered. This conditions the human domination all over the world.

The concept of God, whether a “postulate of belief” or a conjecture yet not confirmed enough, is an expression of that human domination eventually shared with or obeying God. So, the secret of the “black box” somehow available within and only within any human brain (and that of a few higher animals, eventually, but inconsiderably) endows with the authority to rule the physical world at will in due observance of the “constitution of all natural laws” established in advance not by humankind. However, that fundamental constitution of Modernity can be now related only to the “light” and local part of the physical world, and the secret of human mind, in particular allowing for humankind to govern the world like a collective “constitutional monarch” in fact, is to refer to the prevailing dark and nonlocal side of the physical world, originating from there.

The model of neural network relevant to any human brain can be interpreted as a finite approximation to the duality of the separable complex Hilbert space so that neural network is able to model it, though more or less approximately in practice, to be entangled with its physical carrier or “body” (according to the Cartesian “slang”) so transforming non-material thoughts of human mind into physical actions of the material “body”. Furthermore, quantum entanglement is able, though it is yet unknown how, to underlie directly the work of the human brain, rather than only to be approximately modeled by means of neural networks, i.e., only indirectly to manage human minds.

Whether directly or indirectly the internal “mechanism” of the “mind-body black box” cannot but obey quantum entanglement because this is the only way, allowed by natural laws, for the transformation of “pure information” into physical action featured by any nonzero quantity of action greater than the Planck constant.

So, entanglement, established by the Nobel Prize to be a scientific phenomenon recognized by human society, is a key for deciphering the mechanism of the “brain black box” rather than only to quantum gravitation as this is sketched in detail above. So, the secret of the “mind-body black box” relies on the dark phase of the universe in the final analysis and thus to the generalized

reversible causality inherent for entanglement though eventually only approximately modeled by neural networks in the real human brains.

There exists one more fundamental and philosophical consequence from establishing entanglement and quantum information as absolutely recognized and legitimate areas of human cognition, concerning the concepts of hierarchy, well-ordering, or the distinction between classical information measured by bits and quantum information measured by qubits.

Indeed, the concept of hierarchy can be tracked even into so important practical areas such as that of human society and the way for it to exist and function reliably by means of any institutions or social order. In fact, the hierarchy inherent for human society is a necessary condition for social peace destroyed by any revolution, during which an essential change of social hierarchy and order can occur. Thomas Kuhn's very famous book (1962) interpreted in the present context equates the social revolutions to the newly introduced "scientific revolutions"; and the periods between those, featured by an established scientific hierarchy and order, as "normal science" obeying its own legal codex, called "paradigm", able to arrange almost all scientific disputes.

Physics and quantum mechanics are also embodied in relevant scientific institutions obeying the general rules of social institutions and order. If one interprets Pauli's paradigm in terms properly social, it proclaims the conservation of social hierarchy and order since energy conservation is a necessary condition for the natural hierarchy of physical influence grounded on the magnitude of energy under the requirement for the quantity of time to be universal.

The establishment of the dark phase of the universe as prevailing, in which the "anti-hierarchical" and "revolutionary" entanglement and quantum information dominate, shakes and waves back the philosophical concept of hierarchy and order at all and then and in particular those of social hierarchy and order. The eventual relevant social change would mean a state of Mao's or Sartre's "permanent revolution" including "permanent cultural revolution" rather than the replacement of an "old" or "politically reactionary" social hierarchy and order by another, "new" or "politically progressive" ones by the mediation of a longer or shorter historical period of social and political revolutions, during which the replacement at issue can occur or be accomplished intentionally.

Though the appeal for permanent revolution might seem to be a "war-cry for permanent chaos and destruction" (as an illustration of what the age of Mao's "cultural revolution" in China can serve), the society of permanent revolution in which the "dark phase of missing social hierarchy and order" prevails crucially is not more an oxymoron or nonsense: for example, being embodied in the social domination of the World Wide Web as the technically possible implementation of the "dark social phase", in which no hierarchy and the corresponding social order is "fluid". Nonetheless, the light phase of an incomparably more sustainable social order and hierarchy can appear permanently, again and again, from the dark phase of "www" and following the pattern of nature, and the way for the well-known and very sustainable light and local universe to be generated from the prevailing crucially dark phase, that of the entangled universe of quantum information.

The aforementioned historical parallel and the social impact of the heliocentric system can be now justified in detail. If the social projections of Nicolaus Copernicus, Galileo Galilei, and Giordano Bruno's worldview anticipated forthcoming social revolutions (as those in the Commonwealth of England, the Netherlands or the French republic initially and then all over the world), the Nobel Prize (along with the observations of dark matter, dark energy, etc.) prophecies a new epoch of the www domination as the ultimate source of any legitimacy relevant to the usual "light" social order and hierarchy.

One can compare the transition to that new legitimacy of the political power with the previous analogical transition in the age of those revolutions when the legitimacy of the monarch originating from God was replaced by that from people by the mediation of representative democracy. The World Wide Web allows for the "people" (as the new "sovereign" replaced the "monarch") to govern the state both directly and permanently. However, this is much more than a transition from "representative democracy" to "direct democracy" as far as the latter is to be assigned to the "light" phase just as the former.

The World Wide Web as the real sovereign of the political power, furthermore inherently global, is able to exercise its power actually and permanently even "in real time" rather than only symbolically, e.g., as the monarch of Great Britain: who "reigns but does not rule". The dramatic political conflict about "who rules" between the www network and the political "class" constituted by virtue of representative democracy seems to become unavoidable in the future just as that between the monarch versus "people", represented by the political class of representative democracy, in the past.

So, the Nobel Prize pioneers not only the pathway to the theory of quantum information, but furthermore and maybe more important, that to the direct political domination of the World Wide Web in the future: just as the heliocentric system had pioneered the pathway to representative democracy rather than only to a new astronomy. That revolutionary social potential of the heliocentric system was the reason for Giordano Bruno's pyre built for him by the Inquisition of the Catholic Church.

The "fluid" or "dark" phase of the World Wide Web featured by missing any hierarchy and being a necessary condition for any "light" and "solid" hierarchy, as if "crystallizing from the liquid network", tends certainly to dominate the existing hierarchies and it may be traced back to the generalization of energy conservation into quantum information conservation relevant also to any degree of entanglement or coherent state. Only the "light" phase admits for any two material or physical entities to be compared according to their amounts of energy so that the energy of the one to be less, equal, or greater than that of another and thus the natural hierarchy of all physical entities in the universe to be able to exist.

On the contrary, the quantity of quantum information or its physical counterpart of action, generalizing energy conservation and thus any hierarchy relied on it by its complementary hierarchy furthermore "entangled" with the former so both constitute an inseparable or coherent state, allows for entities on both extremes of the energetic scale, for example the universe and a

quantum if one cancels the unified time unit shared by both, to be comparable in their dark phase exchanging quantum information.

If one translates the language of entanglement and quantum information inherent for the "dark" phase of the universe into the usual one of its "light" phase and rigorous hierarchies originating from energy conservation and ordering, a worldview recollecting that of Nicholas of Cusa appears. All many, many quanta on the one extreme and the definitively single one of our universe as a whole on the other extreme are identified to be the same in a shared cyclicity, in the transition of which (that is where both extremes of the energetic scale are "glued" just for the cyclicity) what is "many" becomes "one", a what is "tiny" as a quantum becomes "huge" as the universe itself. Energy conservation can be kept since the energy of the colossal number of all quanta in the universe can be equated to that of the universe after sharing the same time unit.

However, one refers to the "dark" phase itself in which time is reversible and thus comparable with mass and energy under condition of quantum information conservation, the distinction of the universe and a single quantum does not make sense any more, since the dark "phase" is global, and the distinction at issue is relevant only to its light and local phase. A single quantum and the universe as a whole are able to exchange quantum information nonlocally though the exchange of energy being inherently local is nonsense due to the fact for both to be at the two opposite extremes of the energetic scale.

VII ENTANGLEMENT AS THE KEY FOR QUANTUM GRAVITY (EVEN FROM A PHILOSOPHICAL VIEWPOINT)

The sketched above rather ontological reflection can be continued to a level belonging to philosophy of physics or quantum mechanics than to "first" philosophy or theology, for example, such as Nicholas of Cusa's worldview mentioned above. In other words, gravitation described by general relativity is only local (by virtue of the postulate of not exceeding the speed of light in a vacuum), entanglement is only global (for which Einstein attached the pejorative epithet "spooky" to it), and quantum gravitation means the mapping between the local gravitation of general relativity and the definitively global entanglement according to the theory of quantum information. So, if the Nobel Prize were not a fact, the one "half" of the mapping which quantum gravitation needs obligatorily, that of entanglement would remain still "spooky" and out of physics, "respecting itself" as in Einstein's age at least in his own eyes.

However (and fortunately), the Nobel prize is a fact at last, and the pathway to quantum gravitation grounded on entanglement is finally pioneered. Meaning just the viewpoint of philosophy of physics and quantum mechanics, the frontier at issue consists in the relation of the local to the global (or respectively, vice versa) postulated to be an identity by the Standard model or by those gauge theories consistent to it.

In particular, this explains immediately why quantum gravity is fundamentally inaccessible to the Standard model: because it postulates for the relation to be an identity and thus any quantity relevant to the relation of the local and global to be zero. On the contrary, quantum gravitation implies a variable and thus nonidentical relation of the local and global, so the mathematical structure of quantum gravity is to describe just that relation in a quantitative way rather than only

qualitatively as here. However, that only qualitative consideration is absolutely sufficient for the objective of philosophy of physics and quantum mechanics intended to be the proper subject of the present section.

Entanglement and resultatively quantum gravitation are "glocal": thus, out of the local general relativity, but also out of the gauge symmetric Standard model obeying Pauli's paradigm and energy conservation in quantum mechanics. In other words, general relativity is only local just as classical mechanics though the latter did not postulate that the velocity of light in a vacuum is the maximally possible one, but by virtue of the consideration only of smooth manifolds in its framework.

The Standard model can be called also local though in a generalized sense in which the local and global are granted to be the same by the identification of the local separable complex Hilbert space and the global one, for example, by means of gauge symmetry. However, quantum gravity is inconsistent with locality whether in its narrow sense confessed by general relativity or its wide sense inherent for the Standard model. It needs *glocality*, with which only entanglement or quantum information can supply.

The same consideration about the locality of general relativity, the generalized locality of the Standard model, and the eventual immanent glocality of quantum gravitation can be translated into the language of subluminal and superluminal velocities. Obviously, the locality of general relativity means only subluminal velocities, the generalized locality of the Standard model is able to discuss only an abstract infinite superluminal speed rather than any finite superluminal velocity, but the glocality of quantum gravitation is to consider just those finite superluminal velocities as the real source of gravitation thus inherently inaccessible to the Standard model. Or said by a more or less philosophical slogan: *quantum gravity is a theory of glocality*!

Then, one can notice that the language of superluminal and subliminal velocities as fit to describe the relation of locality and globality as well as glocality as a transition between them is borrowed only from the Einstein theories of special and general relativity, but this is not the proper language of quantum mechanics[47].

The problem is: let a smooth variable of velocity traversing all values from zero to infinity be granted. Furthermore, it will necessarily pass through the special point of the speed of light in a vacuum. Of course, the locality of special and general relativity postulates that only the subliminal values of it can make any physical sense, which Einstein expressed by the pictorial pejorative epithet "spooky" attached to all values which are not subliminal. Nonetheless, the Nobel Prize neglects Einstein's warning and legitimizes the "ghosts' nonlocality" in physics. So, that variable of speed (running also over all possible superluminal speeds) is already quite reasonable.

Then, the problem should be paraphrased in relation to quantum mechanics: which is the counterpart of the above smooth "speed variable" in the proper language of quantum mechanics, being inherently discrete? As to all superluminal velocities, the answer is known: a probability density distribution of all possible localizations all over the space (or the spacetime) is the relevant set so that the corresponding probability density distribution is more and more uncertain and its

[47] The idea is discussed for the first time in another paper (Penchev 2013).

maximum less and less outlined as the superluminal velocity is greater and greater. A decreasing degree of decoherence (respectively an increasing degree of coherence) can be unambiguously mapped on the set of all continuously increasing superluminal speeds (as the definitive area of that mapping).

The difficult problem concerns the continuation to all subliminal values since the same Dirac δ-function corresponds to all of them. Anyway, one might introduce unambiguous relevant infinitesimal distinctions in the Dirac δ-function initially alleged to be the same and then, the relevant infinitesimal variable originating from the function at issue to be recognized as the area of all superluminal values. One can conjecture a rectangle with infinitesimally small "base" and and a reciprocally infinitesimally great "height". Then, the infinitesimal small "base" of the Dirac δ-function can be unambiguously mapped into the finite subliminal velocity under the condition that the mapping (just as the Dirac δ-function itself as its source) is a generalized function in the following rigorous meaning: it is a transfinite bijection since the one set of it consists of finite values but the other one of it consists of infinitesimal small values.

Alternatively, the same bijection can be described in terms of Robinson's nonstandard analysis where the same set of infinitesimally small set is described in two complementary or dual ways: as Cauchy's only potentially infinitesimally small variable obeying the axiom of Archimedes versus the same, but now by Leibniz's actually infinitesimally small differentials not obeying that axiom once they have been interpreted after Robinson (1966).

Meaning that nonstandard bijection of all subluminal velocities into the "base" of the Dirac δ-function, by which it is generalized to a class so that the class of equivalence of the former class is the usual (or non-generalized) definition of the Dirac δ-function, one can reinterpret the quantity of velocity in terms of the dual language of positions relevant to quantum complementarity. Then, all subliminal velocities can be realized as different infinitesimally small neighborhoods about any position so that its geometric area though being infinitesimal small is mapped by some relevant bijection into all subluminal values so that the quantity of velocity is defined to be the infinitesimal fussiness of any position proportionally corresponding[48].

Utilizing the above more or less conventional reinterpretation of velocity in classical mechanics as the infinitesimal "fussiness" of any position, one can consistently continue to the quantum counterpart of the speed variable spanning all values from zero to infinity also in relation to all subliminal values so that the Dirac δ-function is realized otherwise: as a normal, non-generalized function for which the relevant probability density distribution is spanned over an infinitesimally small segment of admissible values, and velocity is the finite and bijective counterpart of the infinitesimally small length of the segment at issue.

A visualization of that bijection might be the physical measurement of an infinitesimally small variable by any value belonging to that infinitesimally small variable as a standard reference unit for that measurement. Indeed, the results of that measurement would be finite and thus constitute

[48] One can interpret the infinitesimal unification of general relativity and quantum mechanics by adding an additional "fifth" space-time dimension (e.g., as in: Wesson 2011) also interpretable as a second time dimension (Fidelman 2008).

a finite variable by a bijection. One can immediately notice that velocity thus defined is the derivative of the infinitesimally small variable of the "base" of the Dirac function.

Then, the fundamental constant of the speed of light in a vacuum, expressing the bound of locality to nonlocality physically, is reinterpreted as the corresponding mathematical limit dividing any infinitesimally small neighborhood about any point from any finite neighborhood about the same point, and the physical quantity of velocity (whether subliminal or superluminal) corresponds unambiguously to the first derivative of the variable geometric area of the neighborhood at issue. However, the so-defined velocity would be infinitesimally great in the case of superluminal velocities, due to which is replaced by its finite counterpart: for example, by the physical measurement with relevant standard reference unit rather than with an infinitesimally small reference unit borrowed from the subliminal area.

So, two seemingly inconsistent descriptions of the same variable of speed appear: the one from the viewpoint from relativity, the other from that of quantum information and the suggested theory of quantum gravitation underlain by entanglement. According to the former, locality and the corresponding limit of the speed of light in a vacuum are only postulated so that nonlocality is physically prohibited. On the contrary, the "spooky" nonlocality is allowed for the latter, but the areas of subluminal and superluminal velocities are complementary to each other due to the following: either (1) their reference units are infinitesimally different, or (2) the values of both corresponding speeds are infinitesimally different if the unit is postulated to be the same. In other words, locality or the restriction of the speed of light in a vacuum is only a physical representation of the mathematical, philosophical or even possibly theological bound between finiteness (respectively, "finitude") and infinity. So, the solutions of general relativity and the alleged quantum information theory of gravitation seems to be ostensibly quite different, at least at first glance:

Speaking loosely, general relativity postulates for all claiming to be physical to be local and finite, and accordingly, it "anathematizes" and "curses" nonlocality or infinity to be "spooky" and out of science and physics[49]. Quantum gravitation by entanglement accepts both nonlocality and infinity, but it establishes that the reference units of locality and nonlocality should be infinitesimally different if one would like both descriptions to be empirically or experimentally accessible, i.e finite, and logical consistency conserved. Thus, complementarity inherent for the entire quantum domain is reinterpreted to be isomorphic to the mathematical duality of finiteness and infinity, for example, by means of the distinction of finite sets versus infinite sets in set theory. However, that viewpoint is absolutely relevant only to classical quantum mechanics, Puali's paradigm, and the Standard model

Quantum information takes two crucial and very important steps beyond them. Anyway, it allows for both infinitesimally different reference units or respectively both conjugate classes of quantities measurable by each of them to be considered simultaneously in a way for quantum

[49] For example, the paper of Blaylock (2010) interprets the relation of the "EPR paradox" to Bell's inequalities as the "question of locality". On the contrary, other articles (Bricmont 1996 or Cook 2009) link nonlocality and relativity.

mechanics not to be “incomplete” in Einstein’s sense. Here is how. The transition over the “abyss of complementarity” is probabilistic so that a certain probability (density or not) distribution and correspondingly its characteristic function (called “wave function” in classical quantum mechanics) features any passing over that precipice. Moreover, that passing over the chasm of duality is mathematically isomorphic to a certain state on the other “shore”, that of nonlocality or infinity in a way ostensibly “magical” or “tricky” for common sense but quite relevant to the “insanity” of quantum mechanics:

For example, Alice falling down the rabbit hole turns out immediately in Wonderland so that her adventures in Wonderland and her falling down the rabbit-hole are the same rather than following one after the other as common sense (unlike quantum mechanics and information) needs. So, Einstein’s incompleteness is avoided “magically”: though classical mechanics (as if) does not describe “Alice’s falling down the rabbit-hole”, but only “her deeds in Wonderland”, the description is not incomplete, though amazingly, since the former and the latter are the same.

Nonetheless, quantum gravitation and its theory by entanglement and quantum information is able to distinguish them from each other so that and continuing the metaphor, quantum gravity would correspond to “Alice’s following down” and classical quantum mechanics to “what happens in Wonderland”. Then, Einstein’s general relativity, though describing only the former and only locally, is anyway able to describe “Alice’s travel through Wonderland” though in a different language. Abandoning the metaphor, one can stare at the proper way for general relativity to describe somehow and implicitly Wonderland.

It adds, anyway, a new dimension by distinguishing or quantitatively mismatching covariant description (interpretable also as a description only of reference units) from contravariant description (inherent for classical mechanics and interpretable to mean only the quantities measured by those reference units now granted to be the same). Speaking inherently qualitatively as here, on may say that the curvature of space-time as well as its counterpart of energy-momentum both being tensors in any point of pseudo-Riemannian space, furthermore able to describe absolutely gravitation according to the Einstein field equation, originate from that mismatching between two descriptions, where the one is covariant and the other is contravariant.

Now and following the infinitesimal distinction of the areas of subluminal and superluminal velocities as above, one can ascribe either of both areas to contravariant or covariant descriptions correspondingly, but conventionally in fact, since any of both descriptions can be assigned to the domain of subluminal velocity or not worse, to that of superluminal speed. Regardless of that newly interpreted mathematical structure therefore remaining isomorphically the same, it can be still reckoned to be the source of gravitation just as in the former case of the interpretation inherent for general relativity.

In other words, the curvature of pseudo-Riemannian space as the source of gravitation according to the mathematical formalism of general relativity is now reinterpreted as originating from adding a new dimension regardless of its interpretation: whether by mismatching the covariant description to its covariant counterpart just following general relativity literally or by the

isomorphic mismatch of two infinitely different domains, the subluminal and superluminal ones as above.

The former case refers immediately to entanglement and quantum information and thus, to the Nobel Prize since the domains of subliminal and superluminal velocities (for example representable as the real and imaginary domains of Minkowski space ant then as the two dual qubit spaces as well as the two dual separable complex Hilbert spaces of classical quantum mechanics), however now linked to each other by any nonzero degree of entanglement.

Meaning the latter interpretation though being nonstandard to or for Einstein's general relativity, one can speak of gravity in an abstract meaning referring directly to the foundations of mathematics[50], e.g. classically, i.e by the triple of propositional logic, arithmetic, and set theory[51] and thus to Gödel's classical completeness (1930) and incompleteness (1931) papers. Then, gravitation would be a result of the Gödel dichotomy of the relation of arithmetic to set theory: being either inconsistent or incomplete to each other as two first order logics to classical propositional logic. The reason is the following. Gravitation in the latter interpretation means an infinitesimal relation being isomorphic to that of finiteness to infinity (or vice versa) as well as that of arithmetic to set theory after Gödel's consideration.

In other words, gravitation interpreted set-theoretically realizes the Gödel insoluble statement otherwise transforming it from a proper logical statement similar to that of the paradox of the Liar into a rather physical statement so that it and the paradox of the arrow are alike. Of course, though the two paradoxes are somewhat alike in their logical structure, the latter means a mechanical motion, the cause of which can be (or at least can be granted to be) gravitation. That is: the arrow is "both here and not here" since a force or interaction, interpretable as gravitation after the principle of the equivalence of inertial and gravitational masses, moves it.

So the Gödel tension between arithmetic and set theory, between finite and infinity, in the final analysis even as that between mathematics and physics, can be also reinterpreted as a physical force or interaction and then identified with gravitation in a way absolutely consistent with the conception of "scientific transcendentalism" discussed in detail in other papers (e.g. Penchev 2021 April 12; Penchev 2020 October 20).

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[50] One can reveal that idea as implicit in the investigation of Honig (1976).

[51] That approach can be considered as a continuation of a series of papers, the subject of which is the relation of quantum mechanics (or quantum information) to logic, or more generally, to mathematics and its foundations (e.g. Parsons 2013; Palmer 2011; Baltag, Smets 2011; 2006; Liberati, Maccione 2011; Marchetti, Rubele 2007; Ozawa 2007; Zizzi 2007; Lindenstrauss 2006; Planat, Rosu 2004; Barnum 2003; Santos 2003; Titani, Kozawa 2003; Krause, Sant'Anna, Volkov 1999; Schlesinger 1999; Tappenden 1995; Stairs 1985; Takeuti 1981; Nickerson 1975). The proper relation of the mathematical formalism of quantum mechanics and logic can be interpreted following papers (Plotkin 2013; 2006; Palmquist 2012; 2007; Schmidt 2010; Schwarz, Shapiro 2006; Schmeikal 1998; Wynn, Bloom 1992; Otte 1990; Sarnak 1983; Misner, Wheeler 1957), discussing the link of geometry and physics and logic, or even arithmetic, since the former can be interpreted as a generalization of Euclidean geometry to arbitrarily many or infinite dimensions, furthermore over the field of complex numbers rather than that of real numbers. The study of Krause, Sant'Anna, Volkov (1999) can be specially featured since it translates the Gödel dichotomy about the relation of arithmetic to set theory into the quantum language of distinguishability (for "fermions") versus indistinguishability (for "bosons").

VIII INSTEAD OF CONCLUSION: THE 2022 NOBEL PRIZE AS A PREMONITION OF THE FORTHCOMING NOBEL PRIZE FOR QUANTUM GRAVITY

The main conclusion of the paper can be: the 2022 Nobel Prize for entanglement and quantum information pioneers the pathway for the future Nobel Prize for quantum gravitation since any theory of quantum gravitation is impossible within the framework of classical quantum mechanics, the Standard model (where it is anyway available indirectly and implicitly by the Higgs mechanism, spontaneous breaking of symmetry resulting into any nonzero mass at rest), or Pauli's "particle paradigm" of energy conservation and unitarity since the quantum information theory of quantum gravity involves non-unitarity and nonlocality[52], respectively generalized physical quantities referring to non-Hermitian operators, and the violation of energy conservation after the more general law of quantum information conservation.

So, the recognition of entanglement and quantum information as an absolutely reliable scientific fact by the Nobel prize is a necessary condition for the theory of quantum gravitation by entanglement since it is inconsistent with the too narrow restrictions of classical quantum mechanics. Then, its link to Einstein's general relativity is inherent by the bijective transformation of pseudo-Riemannian space into two entangled qubit Hilbert spaces following the approach for the homeomorphic identification of Minkowski space and the separable complex Hilbert space. As a result, the gravitation described by the formalism of general relativity by pseudo-Riemannian space can be equated as isomorphic to the entanglement of qubit Hilbert spaces. Then and particularly, "dark matter" and "dark energy" confirmed experimentally as prevailing in the universe can be linked to the equivalence of Einstein's gravitation by general relativity (and thus attachable to the light and local phase) and the theory of gravity by entanglement being inherent for the dark, nonlocal phase.

A few crucial philosophical sequences follow the break of Pauli's paradigm:

(1) the establishment of the "dark" phase of the universe (corresponding to the experimentally corroborated dark matter and dark energy as prevailing in the universe) as opposed to its "light" phase, only to which the Cartesian dichotomy of "body" and "mind" is valid (respectively, that of "object" and "subject" in classical German philosophy);

(2) quantum information conservation as relevant to the dark phase, furthermore generalizing energy conservation as suitable only to its light phase, productively allowing for physical entities to appear "ex nihilo", i.e., from the dark phase, in which energy and time are yet inseparable from each other, therefore substituting the mythical one-time Big Bang with an omnipresent medium of decoherence, by which the dark phase is transferred into the light one, only integrally being equivalent to the mythical Big Bang;

(3) reversible causality as inherent to the dark phase, including reverse causality as inseparable from common sense's "straight" causality, in fact relevant only to the light phase;

[52] The paper of Chose (1997) discusses the same idea about the nonlocality and non-unitarity if one unifies quantum mechanics and general relativity.

(4) the interpretation of gravitation only mathematically: as an interpretation, originating from physics, of the incompleteness of finiteness to infinity, for example, following the Gödel dichotomy ("either contradiction or incompleteness") about the relation of arithmetic to set theory;

(5) the restriction of the concept of hierarchy only to the light phase of the universe permanently appearing from the crucially prevailing dark counterpart comparable with a "fluid medium" in which many various different hierarchies are simultaneously available, but only latently;

(6) the commensurability of both physical extremes of a quantum and the universe as a whole in the dark phase obeying quantum information conservation and akin to Nicholas of Cusa's philosophical and theological worldview.

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