About immediate physical phenomena and space as a direct medium of information

Davide Fiscaletti
SpaceLife Institute, San Lorenzo in Campo, Italy
fiscalettidavide@libero.it

Abstract

For several physical phenomena elapsed clock run *t* for them to happen is zero. These events can be appropriately defined as "immediate physical phenomena" and support the view that, at a fundamental level, time exists only as a run of clocks in a timeless space. Immediate physical phenomena are carried directly by space which functions as a direct information medium. The perspective is opened that the quanta of space that build quantum space assume a crucial role as regards these phenomena.

Key words: immediate phenomena, timeless space, clock run, numeric order, symmetrized quantum potential, symmetrized quantum potential for gravity.

1. Introduction

The results of several authors suggest that space is timeless and clock/time exists merely as a measuring system for the numeric order of physical events. Already in 19th century Ernst Mach said: "It is utterly beyond our power to measure the changes of things by time. Quite the contrary, time is an abstraction, at which we arrive by means of the changes of things". The idea of a timeless universe was then discussed by Einstein and Gödel at the beginning of the '50 of the last century. In 1949, Gödel postulated also a theorem that stated: "In any universe described by the theory of relativity, time cannot exist"[1]. Today, the idea that physical time cannot be considered as a primary physical reality is receiving indeed more and more attention. For example, Woodward argues that Mach's principle leads to the conclusion that time, as we normally treat it in our common experience and physical theory, is not a part of fundamental reality[2]. Rovelli proposes the idea that time is not defined at the fundamental level (at the Planck scale), namely that, in the quantum gravity regime, time should be simply forgotten, that the concept of absolute time *t*, as used in Hamiltonian mechanics as well as in Schrödinger quantum mechanics, is not relevant in a fundamental description of quantum gravity[3,4,5]. As regards the view of time Julian Barbour says in *The Nature of Time*: "I will not claim that time can be definitely banished from physics; the universe might be infinite, and black holes present some problems for the time picture. Nevertheless, I think it is entirely possible, indeed likely, that time as such plays no role in the universe"[6].

More and more current research is challenging with the view that space-time is the fundamental arena of the universe. In particular, some theoretical results show that the mathematical model of space-time does not correspond to a physical reality, and propose "state space" or "timeless space" as the arena instead. For example Palmer, in his recent paper entitled *A New Geometric Framework for the Foundations of Quantum Theory and the Role Played by Gravity*, suggests that, since quantum theory is inherently blind to the existence of such state-space geometries, attempts to formulate unified theories of physics within a conventional quantum-theoretic framework are misguided, and that a successful quantum theory of gravity should unify the causal non-Euclidean geometry of space time with the atemporal fractal geometry of state space[7]. Moreover, Girelli, Liberati and Sindoni have recently developed a toy model in which they have showed how the Lorentzian signature and a dynamical space-time can emerge from a non-dynamical Euclidean space, with no diffeomorphisms invariance built in. This toy-model provides an example where time (from the geometric perspective) is not fundamental, but simply an emerging feature[8]. In more detail, this model suggests that at the basis of the arena of the universe there is some type of “condensation", so that the condensate is described by a manifold R^4 equipped with the Euclidean metric $\delta^{\mu\nu}$. Both the condensate and the fundamental theory are timeless. The toy model developed by Girelli, Liberati and Sindoni shows that at a fundamental level space is a timeless condensate, that time as humans perceive it is only an emerging feature and that different solutions of the equations of motion of the fields characterizing this condensate determine different metrics of the space-time background. If in a timeless background different metrics are possible and time represents only an emerging feature, this means just that, at a fundamental level, time cannot be considered a primary physical reality, and thus that the duration of material change has no existence of its own.

On the other hand, Prati has recently shown that Hamiltonian mechanics, both in the classical domain and in quantum field theory, is rigorously well defined without the concept of an absolute, idealized time and that in this timeless framework a physical system S, if complex enough, can be separated in a subsystem S2 whose dynamics is described, and another cyclic subsystem S1 which behaves as a clock[9]. An important result of Prati’s research is that, as a consequence of the gauge invariance, a complex system can be separated in many ways in a part which constitutes the clock and the rest. This implies that the duration of material change provided by a cyclic subsystem cannot be considered a primary physical reality, that each subsystem which acts as clock provides only the numeric order of the dynamics of the other subsystem.

Many relevant experimental results support the view according to which, at a fundamental level, time exists only as a run of clocks in a timeless space. In fact, for several physical events clock/time is zero, since no measurable time elapses for them to happen. These events can be appropriately defined as “immediate physical phenomena”. They are carried directly by a timeless space. In particular, in this article the suggestive idea is proposed that by immediate physical phenomena space acts as a direct information medium.

2. Some immediate physical events and their explanation through the idea of space as a direct information medium

In the article *Attosecond Ionization and Tunneling Delay Time Measurements in Helium* by Eckle et al., a conclusion is drawn that "an electron can tunnel through the potential barrier of a He atom in practically no time"[10]. It is well established that electrons can escape from atoms through tunneling under the influence of strong laser fields, but the timing of the process has been controversial and far too rapid to probe in detail. Eckle and other authors used attosecond angular streaking to place an upper limit of 34 attoseconds and an intensity-averaged upper limit of 12 attoseconds on the tunneling delay time in strong field ionization of a helium atom. The ionization field derives from 5.5-femtosecond-long near-infrared laser pulses with peak intensities ranging from 2.3 x 10^{14} to 3.5 x 10^{14} watts per square centimeter (corresponding to a Keldysh parameter variation from 1.45 to 1.17, associated with the onset of efficient tunneling). The technique relies on establishing an absolute reference point in the laboratory frame by elliptical polarization of the laser pulse, from which field-induced momentum shifts of the emergent electron can be assigned to a temporal delay on the basis of the known oscillation of the field vector.

Moreover, as regards tunneling Whong Chao Wou affirms: "The physical meaning of the zero real time is that the particle instantly jumps from one side of the barrier to the other regardless of the thickness. This leads to the illusion that tunneling particles could actually travel faster than light. The results of recent experiments in quantum optics concerning tunneling time can be thought of as the first experimental confirmation of the existence of imaginary time. Relativity is not violated"[11].

The interpretation here proposed is that tunneling particles cannot travel in mathematical imaginary time *it*, they simply experience no time as they transfer from one measurable location to another. Information transfer of tunneling particle from one side of the barrier to the other is carried directly by the quantum space.

On the other hand, not only tunneling phenomena seem to indicate that timeless quantum communication is a real phenomenon. For example, in the article *The Capacity of a Quantum Channel for Simultaneous Transmission of Classical and Quantum Information*, Devetak and Shor underline: "An expression is derived characterizing the set of admissible rate pairs for simultaneous transmission of classical and quantum information over a given quantum channel, generalizing both the classical and quantum capacities of the channel. Although our formula involves regularization, i.e. taking a limit over many copies of the channel, it reduces to a single-letter expression in the case of generalized dephasing channels. Analogous formulas are conjectured for the simultaneous public-private capacity of a quantum channel and for the simultaneously 1-way distillable common randomness and entanglement of a bipartite quantum state"[12]. In recent years, quantum communication protocols have been extended to the domain of continuous variable systems, i.e., quantum systems, like the bosonic modes of the radiation field, which are characterized by infinite dimensional Hilbert spaces. In particular, these protocols show how a sender (say Alice) can exploit bosonic modes in order to send similar signals to a receiver (say Bob) and then extract a secret binary key from these signals. Beyond the possibility of such a continuous variable quantum key distribution, it has been shown how to use these systems in order to perform a (quasi)confidential quantum direct communication, i.e., the (quasi)private communication of a message from Alice to Bob which is directly encoded in continuous variable systems. In particular, in the recent paper *Quantum direct communication with continuous variables*, Pirandola and others write: "We show how continuous-variable systems can allow the direct communication of messages with an acceptable degree of privacy. This is possible by combining a suitable phase-space encoding of the plain message with real-time checks of the quantum communication channel. The resulting protocol works properly when a small amount of noise affects the quantum channel. If this noise is non-tolerable, the protocol stops leaving a limited amount of information to a potential eavesdropper"[13].

Anyway, according to the authors' point of view, in the quantum domain the fundamental immediate physical phenomenon (which is at the basis of all the immediate physical phenomena regarding the quantum domain in the sense that from it each other quantum immediate event derives) is represented by the Einstein-Podolski-Rosen (EPR) experiment and thus by quantum non-locality. In EPR-type experiments the elapsed time for quantum entanglement is zero. Here it is considered the perspective that in EPR experiment (and in all immediate physical events) information does not move through space-time, but instead moves through a timeless space background, more precisely that space in which particles exist can be considered as a direct information medium between the entangled quanta. In other words, quantum non-locality (and all immediate physical events regarding the quantum domain) introduce the perspective that at a fundamental level space in which particles exist acts as a direct information medium.

According to a recently suggested interpretation, in an EPR-type experiment, physical space assumes the special "state" represented by the symmetrized quantum potential, and it is this special state of space that, according to the authors, determines a non-local, instantaneous communication between the particles into consideration. In the case of a system of N particles the symmetrized quantum potential assumes the form

$$Q=\sum_{i=1}^{N}-\frac{\hbar^2}{2m_i}\left(\begin{array}{c}\dfrac{\nabla_i^{\,2}R_1}{R_1}\\ -\dfrac{\nabla_i^{\,2}R_2}{R_2}\end{array}\right) \quad (1)$$

where R_1 is the amplitude function of the wave-function $\psi=R_1e^{iS_1/\hbar}$ describing the forward-time process and R_2 is the amplitude function of the wave-function $\phi=R_2e^{iS_2/\hbar}$ describing the time-reverse process. On the basis of Eq. 1, we can explain non local correlations in many-body systems – and thus EPR experiments - in the correct way (namely also filming back the process of these correlations). The symmetrized quantum potential (Eq. 1) can be considered the most appropriate candidate to provide a primary physical reality to space as a direct information medium[14]. While the standard Schrödinger equation and the original bohmian theory imply that filming back a physical event it is not possible to see what effectively happens (namely the real interaction which characterizes the system under consideration), with the introduction of the symmetrized quantum potential we can interpret in the correct way both the forward-time process and the time-reverse process and thus the numerical order of a quantum process and the idea of space as a direct information medium can receive a primary physical significance. It is by means of the special state represented by the symmetrized quantum potential, that in the subatomic world at a fundamental level physical space can be physically interpreted as an immediate information medium, as an entity that puts the particles into an immediate contact. In EPR experiment it is just the symmetrized quantum potential that makes physical space an "immediate information medium" which keeps two elementary particles in an immediate contact. We can call this peculiar interpretation of quantum non-locality as the "immediate symmetric interpretation".

It is interesting to observe that space as the "direct information medium" in the form of the symmetrized quantum potential resolves the causality problem of Fermi's two atoms system. Let A and B be two atoms or, more generally, a ''source'' and a ''detector'' separated by some distance *R*. At *t*=0 A is in an excited state, B is in its ground state, and no photons are present. As it has been shown by Hegerfeldt, a theorem can be proved that in contrast to Einstein causality and finite signal velocity the excitation probability of B is nonzero immediately after *t*=0[15].

According to the immediate symmetric interpretation of quantum non-locality, excitation probability of B is nonzero because the physical space in which atoms exist functions as a “direct medium of excitation”. Excitation from atom A to atom B is direct and immediate via space through its special state represented by the symmetrized quantum potential, and not indirect via intermediate particles which move in space from atom A to atom B.

Moreover, as regards the causality problem of Fermi’s two atom system, it is important to point out that standard quantum mechanics can reproduce only the forward-time process of the excitation from atom A to atom B. Instead, in the symmetrized extension of Bohm’s theory, the special state represented by the symmetrized quantum potential allows us to reproduce in the correct way also the time-reverse of the excitation from atom A to atom B, namely just through the idea of the direct information. The excitation from atom A to atom B arrives instantaneously thanks to the direct, immediate action of space in its special state represented by the symmetrized quantum potential, which allows us to explain in the correct way also the time-reverse of this process, namely filming back the process of excitation from atom A to atom B, with the symmetrized quantum potential we can see what physically happens and to explain it in the correct way with the idea of the direct action of space.

If in the subatomic world the symmetrized quantum potential makes physical space the real direct medium of information transfers between elementary particles, in a complete physical theory the possibility is opened that a fundamental arena in which space functions as a direct information medium is the primary element from which every field and every object of physics derives and which is able to reproduce the fundamental interactions and physical fields in a unified way. If non-locality is considered as the essential characteristic of the physical world and the idea of the symmetrized quantum potential seems the most general and consistent way to introduce non-locality, in a fundamental physical theory the symmetrized quantum potential should assume a crucial role and all the objects of physics might emerge from it as special states. In particular, the possibility is opened that there is an important link between this fundamental arena and the Planck scale, in particular with the granular structure of space predicted by loop quantum gravity. According to loop quantum gravity, space is made out of quanta of space[16]. On the basis of the immediate symmetric interpretation, the perspective is opened that direct quantum information transfers run over quanta of space which have the size of Planck length. According to this interpretation, at the Planck scale space acts as an immediate information medium. At this scale information transfers are immediate: elapsed time for them to happen is therefore zero.

Also gravitational interaction can be interpreted as an immediate physical phenomenon. The idea of space as a direct information medium introduces interesting perspectives as regards the interpretation of the gravitational interaction in the general relativity theory context. One can say that at a fundamental level curvature of space can be considered as a direct medium that generates gravitational motion of material objects into direction of higher curvature of space. There is no direct attraction force between material objects. Material object causes curvature of space and curvature of space causes gravitational motion. Gravitational interaction $mass \leftrightarrow space \leftrightarrow mass$ is immediate: presence of mass increases curvature of space that causes gravitational motion. Mass acts on other mass indirectly via curvature of space: $mass \leftrightarrow curvature \leftrightarrow mass$. Curvature of space is defined by Einstein curvature tensor:

$$G\mu\nu = \frac{8\pi G}{c^4} \cdot T\mu\nu \quad (2).$$

On the basis of the interpretation of space as a direct information medium, for example, the elapsed clock run for gravitational interaction between the earth and the sun is zero, the gravitational interaction between earth and sun is immediate in the sense that the curvature of space caused by the presence of the sun (given by Eq. 2) acts instantaneously on the earth determining its motion in its own trajectory. The sun acts instantly on the earth via the curvature of space (determined by the sun) which functions a direct, immediate information medium between the earth and the sun.

In original papers of 1916 Einstein do not mention gravitational waves. This idea arises few months later. Einstein introduces gravitational waves as space-time perturbations[17]. With the introduction of gravitational waves that propagate with light speed gravity is interpreted a non-immediate phenomenon as propagation of gravitational waves requires some "tick" of clocks.

Loinger considers that gravitational waves are only hypothetical and do not exist in the physical world: "The gravitational waves are non-physical sinuosities generated, in the last analysis, by undulating reference frames"[18,19]. In the 1960s, Joseph Weber began his experimental work to detect gravitational waves. He was essentially alone in this field of research. Later, theoretical papers of Wheeler, Bondi, Landau and Lifshitz, Isaacson, Thorne and others, as well as experimental work of Weber, Braginski, Amaldi and others opened a new area of research in this field[20]. However, gravitational waves have not yet been detected. "To search for gravitational waves in a laboratory, classical or quantum mechanical detectors can be used. Despite the experiments of Weber (1960 and 1969) and many others (Braginskij et al., 1972; Drever et al., 1973; Levine and Garwin, 1973; Tyson, 1973; Maischberger et al., 1991; Abramovici et al., 1992; and Abramovici et al., 1996) and theoretical calculations and estimations (Braginski and Rudenko, 1970; Harry et al., 1996; and Schutz, 1997), gravitational waves have never been observed directly in laboratory"[21]. Therefore, we can conclude that no experimental evidence exists until now against the interpretation of gravity as immediate physical phenomenon caused by the curvature of space which acts as a direct information medium.

3. The idea of space as direct information medium in the quantum graviy domain: the symmetrized extension of Wheeler-DeWitt equation and the symmetrized quantum potential for gravity

If at the fundamental level of quantum processes, non local correlations are due to a background space which acts as a direct information medium between the particles under consideration, it is legitimate consider the possibility that also in the quantum gravity domain space functions as a direct information medium.

In this chapter we want to introduce a mathematical model of quantum gravity in which the idea of stage of processes as a direct, immediate information medium can be embedded. In this regard, we take into consideration here the Wheeler-DeWitt equation, which is a sort of Schrödinger equation for the gravitational field. As we know, in quantum gravity and cosmology universe can be described by a wave-functional Ψ which satisfies the Wheeler-DeWitt (WDW) equation (here we have made the position $\hbar = c = 1$):

$$\left[(8\pi G)G_{abcd}p^{ab}p^{cd} + \frac{1}{16\pi G}\sqrt{g}\left(2\Lambda - {}^{(3)}R\right)\right]\Psi = 0 \quad (3),$$

where $G_{abcd}=\frac{1}{2}\sqrt{g}\left(g_{ac}g_{bd}+g_{ad}g_{bc}-g_{ab}g_{cd}\right)$ is the supermetric, p^{ab} are the momentum operators related to the 3-metric g_{ab}, $g=\det g_{ij}$, ${}^{(3)}R$ is the 3-dimensional curvature scalar, Λ is the cosmological constant, *G* is the gravitational constant. In the bohmian approach, decomposing the wave-functional Ψ in polar form $\Psi=R\,e^{iS/\hbar}$ the WDW equation becomes

$$(8\pi G)G_{abcd}\frac{\delta S}{\delta g_{ab}}\frac{\delta S}{\delta g_{cd}}-\frac{1}{16\pi G}\sqrt{g}\left(2\Lambda-{}^{(3)}R\right)+Q_G=0 \quad (4),$$

where

$$Q_G=\hbar^2 NgG_{abcd}\frac{1}{R}\frac{\delta^2 R}{\delta g_{ab}\delta g_{cd}} \quad (5),$$

N being the lapse function. The term Q_G can be defined “quantum potential for gravity”. Moreover, in the bohmian approach, Einstein’s equations – in absence of source of matter-energy - assume the following forms:

$$R^{\mu\nu}-\frac{1}{2}g^{\mu\nu}R=-\frac{1}{N}\frac{\delta\int Q_G d^3x}{\delta g_{ij}} \quad (6)$$

for the dynamical parts, and

$$R^{0\nu}-\frac{1}{2}g^{0\nu}R=\frac{Q_G}{2\sqrt{-g}}g^{0\nu} \quad (7)$$

for the non-dynamical part[22,23]. Equations (4), (6) and (7) show that the term Q_G is responsible of the behaviour of the universe intended as a whole. It seems therefore that the universe has a sort of aggregate, comprehensive “order” which guides it: this order is just determined by this term Q_G, the “quantum potential for gravity”.

This quantum potential for gravity can be considered as a sort of generalization of the bohmian quantum potential to the universe as a whole: since its action is instantaneous, like-space, it can be thus considered an appropriate candidate to represent the special state of space in the quantum gravity domain as an immediate, direct information medium. However, just like it happens in the original Bohm ‘s approach, if we imagine to film the process of the instantaneous communication determined by this quantum potential for gravity backwards, namely inverting the sign of time, in the original Bohm’s approach to quantum gravity there is no guarantee that we obtain something that corresponds to what physically happens. In fact, the standard quantum laws regarding WDW equation are not time-symmetric and therefore inverting the sign of time, the filming of the process could not correspond to what physically happens. Although the quantum potential for gravity has a like-space, an instantaneous action, however it comes from WDW equation which is not time-symmetric and therefore its expression cannot be considered completely satisfactory just because it can meet problems inverting the sign of time. Also the bohmian approach to quantum gravity, although allows us to explain quantum non-locality, cannot be considered completely convincing because it is not time-symmetric.

On the basis of these considerations, in order to develop a more appropriate candidate for the state of space in presence of gravitation namely also in symmetric terms in the exchange of *t* in –*t*, we propose now to introduce a new symmetrized version of the quantum potential for gravity.

In this regard, let us start taking into consideration the standard WDW equation. The standard interpretation of this equation is not time-symmetric. This fact provides an important motivation to search for an interpretation of WDW equation in which a forward-time and reversed-time perspective of the same physical events would be interpreted in the same manner. In this regard, one can think to resolve the problem of time-symmetry in WDW equation, in analogous manner to the considerations made by Wharton in his attempt to develop a time-symmetric formulation of standard quantum mechanics. Let us remember that in Wharton's model the wave function is no longer a solution of the Schrödinger equation, but instead is the solution $|C(t)\rangle$ to the time-symmetric equation

$$\begin{pmatrix} H & 0 \\ 0 & -H \end{pmatrix} |C(t)\rangle = i\hbar \frac{\partial}{\partial t} |C(t)\rangle \quad (8)$$

where $|C(t)\rangle = \begin{pmatrix} \psi(t) \\ \phi(t) \end{pmatrix}$, $\psi(t)$ is the solution of the standard Schrödinger equation, $\phi(t)$ is the solution to the time-reversed Schrödinger equation[24]. In analogous way, we can introduce here a time-symmetric extension of WDW equation of the form

$$\begin{pmatrix} H & 0 \\ 0 & -H \end{pmatrix} C = 0 \quad (9)$$

where

$$H = \left[(8\pi G) G_{abcd} p^{ab} p^{cd} + \frac{1}{16\pi G} \sqrt{g} \left(2\Lambda - {}^{(3)}R \right) \right] \quad (10)$$

and $C = \begin{pmatrix} \Psi \\ \Phi \end{pmatrix}$, Ψ is the solution of the standard WDW equation, Φ is the solution of the time-reversed WDW equation.

Now, since bohmian quantum potential for gravity is the element which can reproduce the like-space, instantaneous action of gravity, in order to assure the symmetry in time needed to interpret also the time-reverse process in the correct manner and thus to find the most appropriate candidate for the state of space in the quantum gravity domain as a direct information medium, we can reformulate the bohmian approach to WDW equation for the time-symmetric equation (9). In this regard, just like in the original bohmian theory, we decompose the time-symmetric equation (9) into two real equations, by expressing the wave-functionals Ψ and Φ in polar form:

$$\Psi = R_1 e^{iS_1} \quad (11),$$

$$\Phi = R_2 e^{iS_2} \quad (12)$$

where R_1 and R_2 are real amplitude functionals and S_1 and S_2 are real phase functionals. Inserting (11) and (12) into (9) and separating into real and imaginary parts we obtain the following quantum Hamilton-Jacobi equation for quantum general relativity

$$(8\pi G) G_{abcd} \begin{pmatrix} \frac{\delta S_1}{\delta g_{ab}} \frac{\delta S_1}{\delta g_{cd}} \\ \frac{\delta S_2}{\delta g_{ab}} \frac{\delta S_2}{\delta g_{cd}} \end{pmatrix} - \frac{1}{16\pi G} \sqrt{g} \begin{pmatrix} 2\Lambda - {}^{(3)}R \\ -2\Lambda + {}^{(3)}R \end{pmatrix} \left(2\Lambda - {}^{(3)}R \right) + \begin{pmatrix} Q_{G1} \\ Q_{G2} \end{pmatrix} = 0 \quad (13)$$

where

$$Q_{G1} = \hbar^2 NgG_{abcd} \frac{1}{R_1} \frac{\delta^2 R_1}{\delta g_{ab} \delta g_{cd}} \quad (14),$$

$$Q_{G2} = -\hbar^2 NgG_{abcd} \frac{1}{R_2} \frac{\delta^2 R_2}{\delta g_{ab} \delta g_{cd}} \quad (15).$$

We obtain in this way a symmetrized extension of bohmian version of WDW equation which is characterized by a symmetrized quantum potential for gravity at two components. The first component $Q_{G1} = \hbar^2 NgG_{abcd} \frac{1}{R_1} \frac{\delta^2 R_1}{\delta g_{ab} \delta g_{cd}}$ can explain the forward-time process of the space-like, instantaneous action of quantum gravity, the second component $Q_{G2} = -\hbar^2 NgG_{abcd} \frac{1}{R_2} \frac{\delta^2 R_2}{\delta g_{ab} \delta g_{cd}}$ can reproduce also the time-reverse of this process, namely the quantum gravity through the instantaneous action. As a consequence, the symmetrized quantum potential for gravity can be considered a good candidate for the state of space in the quantum gravity domain as a direct, immediate information medium. The symmetrized quantum potential for gravity suggests therefore that also in the quantum gravity domain a fundamental stage of physical processes exists which acts as an immediate information medium. On the basis of the symmetrized Bohm's version of non-relativistic quantum mechanics and of the symmetrized Bohm's version of WDW equation, we can therefore conclude that both the wavefunctions of subatomic particles and the wavefunctionals of the gravitational field in the quantum gravity domain determine a space medium, a special state of physical reality (represented, respectively, by the symmetrized quantum potential and the symmetrized quantum potential for gravity) which acts as a direct, immediate information medium.

4. Conclusions

On the basis of several theoretical and experimental results regarding the immediate physical phenomena, space can be seen as a timeless background which acts as direct medium of information and time (the time provided by clocks) represents only a measuring system for the numerical order of the material motions. As regards the idea of a background timeless space as a direct medium of information, the symmetrized quantum potential seems to occupy a fundamental role both in the quantum domain and in the quantum gravity domain. In a complete physical theory the possibility is opened that a fundamental arena in which space functions as a direct information medium and which is associated with the symmetrized quantum potential should assume a crucial role and all the objects of physics might emerge from it as special states. In particular, the perspective is opened that there is an important link between the background space as a direct medium of information and the Planck scale.

References:

1. Yourgrau P., A World Without Time: The Forgotten Legacy of Godel and Einstein, Amazon (2006)
http://findarticles.com/p/articles/mi_m1200/is_8_167/ai_n13595656

2. Woodward J.F., “Killing time”, *Foundations of Physics Letters*, Vol. 9, Num. 1 (1996).

3. Rovelli C., “Time in quantum gravity: an hypothesis”, *Physical Review D*, Vol. 43, Num. 2, 442 (1990).

4. Rovelli C., “Analysis of the different meaning of the concept of time in different physical theories”, *Il Nuovo Cimento*, 110B, 81 (1995).
5. Rovelli C., “Quantum spacetime: what do we know?”, in *Physics meets philosophy at the Planck scale*, C. Callender and N. Huggett eds. (Cambridge University Press, 2001).

6. Barbour J., The Nature of Time, submitted on 20 Mar 2009,
http://arxiv.org/abs/0903.3489

7. Palmer T.N., The Invariant Set Hypothesis: A New Geometric Framework for the Foundations of Quantum Theory and the Role Played by Gravity, Submitted on 5 Dec 2008, last revised 17 Feb 2009, http://arxiv.org/abs/0812.1148

8. Girelli F., Liberati S., Sindoni L., Is the notion of time really fundamental?
Submitted on 27 Mar 2009 http://arxiv.org/abs/0903.4876

9. Prati E., The nature of time: from a timeless hamiltonian framework to clock time metrology, arXiv:0907.1707v1, 10 Jul 2009.

10. Eckle P., Pfeiffer A.N., Cirelli C., Staudte A., Dörner R., Muller H.G., Büttiker M., Keller U., “Attosecond Ionization and Tunneling Delay Time Measurements in Helium”, *Science* **322** No 5907 (2008), 1525-1529.

11. Whong Chao Wu, “The Imaginary Time in the Tunneling Process”, submitted on 1 Apr 2008, http://arxiv.org/abs/0804.0210

12. Devetak I. and Shor P.V., The Capacity of a Quantum Channel for Simultaneous Transmission of Classical and Quantum Information, *Communications in Mathematical Physics*, Volume 256, Number 2, June 2005.

13. Pirandola S. and others, Quantum direct communication with continuous variables, *A Leters Journal Exploring Frontier of Physics* (2008)

14. Fiscaletti D., Sorli A.S., Nonlocality and the symmetrized quantum potential, *Physics Essays*, Vol. 21, No. 4., (2008)

15. Hegerfeldt G. T. , “Causality problems for Fermi’s two-atom system”, *Phys. Rev. Lett.* **72**, 596 – 599 (1994).

16. Rovelli C., A new look at loop quantum gravity, http://arxiv.org/PS_cache/arxiv/pdf/1004/1004.1780v1.pdf (2010)

17. Einstein A., Sitz. Ber. Kon. Preus, Ak. Wiss, p. 688 (1916).

18. Loinger A., “The Gravitational Waves are Fictitious Entities”, available at http://
xxx.lanl.gov/abs/astro-ph/9810137, 1998.

19. Loinger A., “The Gravitational Waves are Fictitious Entities-II”, available at http:/
/arxiv.org/vc/astro-ph/papers/9904/9904207v1.pdf, 2004.

20. Ciufolini I. and Gorini V., Gravitational Waves, Theory and Experiment (An Overview), available at http://bookmarkphysics.iop.org/fullbooks/0750307412/ciufoliniover.pdf, 2004.

21. Schorn H-J., “New Effect for Detecting Gravitational Waves by
Amplification with Electromagnetic Radiation”, International Journal of Theoretical Physics, Vol. 40, No. 8, 2001.

22. Kowalski-Glikman J., “Quantum potential and quantum gravity”, arXiv:gr-qc/9511014 v1 (3 Nov 1995).

23. Shojai A. and Shojai F., “Constraints Algebra and Equations of Motion in Bohmian Interpretation of Quantum Gravity”, arXiv.gr-qc/0311076 v1 (22 Nov 2003).

24. Wharton, K.B. Time-symmetric quantum mechanics. *Foundations of Physics*, **37**, 1, 159-168 (2007).