PHYSICS ESSAYS, 28, 3 (2015)
Updated Version: April 4, 2018

Connecting and unmasking relativity and quantum theory

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Abstract
The answer lies right in front of us, but we refuse to see it.

Both relativity and quantum theory, the two pillars of fundamental physics, are modified in this paper to make them also *explain* the physical phenomena they describe. With this explanation all current inconsistencies between the two vanish. The modifications relate to the presence of a *medium*, which is in fact *potential energy,* in three dimensional space. This medium acts as a reference system*, in accordance with Mach's principle*. The speed of light therefore is not absolute but relative to the medium and thus to the observer. It is also dependent on medium density. Quantum waves are *real scalar waves* occurring in the potential energy medium, not probabilities of particles being present. Real scalar quantum waves in three dimensional space make up the whole of physics representing *manifest energy*. Particles therefore do not exist; they are local manifestations of real scalar quantum waves. As a result the *Doppler effect* and *wave interference* play a central role in physics. Moreover the dependence of quantum wave velocity (speed of light) on medium density provides the *energy exchange mechanism* that is central to physics because *all* physical phenomena, *including observation*, concern *energy exchange* or *interaction*. The conceptual simplicity of the model of physics proposed in this paper is shown to clarify a series of paradoxes and ill-understood phenomena at the fundamental level of physics such as wave-particle duality, the twins paradox and the double slit experiment. As to entanglement, superposition and non-locality, the model implies that only *weak versions* of these properties exist.

Keywords: Relativity theory, Quantum theory, Galilean relativity, Black Box models, Wave Structure of Matter

1 Introduction

How should we explain or understand antimatter annihilating matter? How should we explain or understand wave-particle duality? How should we explain or understand vacuum fluctuations? How should we explain or understand wave propagations through empty space? How can the speed of light be absolute in relativity theory? These are five questions revealing there is something seriously lacking in our understanding of fundamental physics. On the other hand mathematical models of fundamental physics, representing relativity and quantum theory, predict and calculate associated physical phenomena very accurately. But when trying to *understand* fundamental physics through these models one encounters paradoxes.

Being system scientists this state of affairs is familiar to us. The current models of fundamental physics we call "black box models" because they very well *predict* and *reproduce* fundamental physical phenomena but without *explaining* them. To system scientists it is well known that *different* model structures can describe *identical* relations

between causes and observable effects. A model that produces the observed or predicted results from known or observed causes, but has *a different structure* than the system it describes, is called a "*black box model*". Because the structure is different, black box models are *unsuitable* to *explain* the systems they describe. As we will argue in this paper relativity and quantum theory are currently both "black box models". As to quantum theory this is most obvious since the *system state* within quantum theory has no clear physical interpretation. The system state not having an interpretation is the exact criterion for a black box model within system science [1].

In section 2 the proposed modifications of both relativity and quantum theory are obtained through appropriate inspection of relevant events in the history of physics. That is all that is needed. Section 3 shows that the proposed modifications of both relativity and quantum theory can be found, *but only separately and in parts*, in the existing literature. Among others the modification of relativity clearly shows why the Michelson-Morley experiment does not disprove the existence of a medium. In section 4 the modified versions of relativity and quantum theory are *combined.* This provides the very simple mathematical model of physics proposed in this paper. Section 5 goes on to reveal how the conceptual simplicity of the model clarifies a series of paradoxes and ill-understood physical phenomena. Among others the conclusions consider consequences our proposed model of physics has for future research and education.

2 History

By appropriately selecting key moments in the history related to relativity theory, the proposed modifications of relativity theory will be deduced first in this section. Next in a similar manner modifications of quantum theory will be deduced. The history list of relativity theory does not contain general relativity because it builds on special relativity and that is where our modifications come in. Before we present the lists we first introduce notations in Table I.

Table I: Notation

Symbol / Shorthand	Meaning
E	Energy
E_p	potential Energy
E_p^d	potential Energy density
c	quantum wave/light velocity
h	Planck's constant
f	Frequency
λ	wave length
m	Mass
p	Impulse
x, y, z	spatial coordinates
t	time
Φ_m	scalar wave amplitude
G-relativity	Galilean relativity
G-transformation	Galilean transformation
G-physics	classical physics
E-relativity	Einstein relativity / special relativity

History list revealing modifications of relativity theory

Galilei	1638. Classical physics (G-physics), G-relativity for inertial systems. *c* infinite.
Maxwell	1865. Maxwell equations, not G-relative because *c* is finite and supposed to be a fundamental natural constant, thus absolute (independent of inertial system).
Mach	1883. Principle of Mach: All, seemingly absolute appearances, such as inertia and centrifugal forces, are effects with respect to all mass in the universe (fixed stars).
Michelson	1887. Interferometer, no medium detected, *c* finite and absolute confirmed.
Lorentz	1904. Lorentz transformation. Contradictions between Maxwell equations and G-relativity resolved, i.e. G-physics and Maxwell equations invariant under the Lorentz transformation with *c* finite. Interpretation Lorentz transformation: time dilation/length contraction.
Einstein	1905. Special relativity (E-relativity). When all physical laws *including c* are assumed absolute, the Lorentz transformation comes out as a *consequence* of the finite velocity of light (considered infinite in G-relativity). No medium, space and time no longer independent, simultaneity lost.

Galilei introduced relativity (G-relativity) with respect to inertial systems implying that the physics in any two such systems is governed by the same laws (G-physics). Time in any two inertial systems is identical (simultaneity). Space coordinates are different but follow from a simple transformation (G-transformation). Inertial systems are fundamental to relativity. They are systems in which objects on which no forces act move with constant (possibly zero) velocity. Mach's principle gives a *physical account* of inertial systems. According to Mach's principle they are all those systems not accelerating with respect to all mass in the universe (fixed stars). In this way all mass in the universe (fixed stars) becomes an *absolute reference system*.

Before Mach, Maxwell devised equations meant to fully describe electro-magnetism. But Maxwell's equations were not G-relative because *c* in his equations *was supposed to be a natural constant,* i.e. *absolute* (independent of the inertial system). If *c* is not, Maxwell's equations *lose their mathematical beauty and generality*. *Physical arguments* for *c* to be absolute in any inertial system *oppose* the idea that in space there is a *medium* that *enables propagation* and acts as an *absolute reference system*. In trying to settle this issue Michelson and Morley performed their famous experiment that seemed to deny the presence of a medium. Next Lorentz devised a transformation, different from the Galilean one, *that would make c absolute in different inertial systems*. Applying this transformation resolved contradictions between Maxwell equations and G-relativity. But as opposed to the G-transformation, the physical interpretation of the Lorentz transformation implies *time dilation and length contraction*. Finally Einstein showed that when *postulating an absolute c* in every inertial frame the Lorentz transformation comes out as a *consequence.* In G-relativity *c* is considered infinite. Postulating an absolute *c* in every inertial system leads to a new space-time concept in which there is *no medium, i.e. an absolute reference system.* Moreover *time and space are no longer independent* and *simultaneity in different inertial systems is lost*. To further motivate an absolute *c* Einstein referred to the Fizeau experiment which seemed to confirm this.

Let us take stock. Historically there were essentially three arguments to shift from G-relativity to E-relativity:

A. to take into account the finite velocity of light
B. to uphold the beauty and generality of Maxwell's equations by assuming an absolute *c*
C. experiments that either measure *c* to be absolute or acknowledge the non-existence of a space medium which is considered equivalent

Argument A is a clear physical argument and constitutes the positive contribution of E-relativity. Argument B is a *mathematical* argument, not a physical one. Argument C only *appears* to be a physical argument. This is because the Michelson-Morley and Fizeau experiments (and all similar ones) do not truly measure *c*, but a related quantity that is generally constant, as we shall see and explain in the next section. Therefore the required modification of E-relativity, announced in this paper, is *to abandon the assumption that c is absolute i.e. a fundamental natural constant independent of the inertial system*. As we shall see in the next section, doing so we allow for a medium in space that:

1. acts as an absolute reference in accordance with Mach's principle
2. allows for wave propagation through space
3. can explain vacuum fluctuations which also require a medium
4. restores independence of space and time and simultaneity in different inertial systems

As a consequence *c* is only approximately constant with respect to the medium because it depends on medium density. This explains the bending of light near "massive objects" where medium density is higher. In turn this explains *gravity*. Also the Lorentz transformation as well as Maxwell's equations need modification.

History list revealing modifications of quantum theory

Clifford	1870. Matter is waving.
Planck	1900. Spectrum black-body radiation explained if radiation energy is quantized by units $E = hf$, with h Planck's constant and f frequency of radiation.
Einstein	1905. Explanation photoelectric effect by postulating that light consists of particles (photons) having a single Planck unit of energy $E = hf$. Discovery $E=mc^2$ raised wave-particle duality.
Bohr	1913. Model of atom structure explaining energy quantization.
De Broglie	1924. All matter has a wave character, $\lambda=h/p$. Matter waves, wave-packets.
Born	1925. Matter waves are probability waves of particle presence at different locations.
Schrödinger	1927. Schrödinger equation. Solutions can be matter or waves.
Bohr	1927. Copenhagen interpretation. Matter waves are probability waves of particle presence at different locations. Complementarity principle, observer-object connection, entanglement, non-locality.
Dirac	1928. Relativistic version of Schrödinger equation. Solutions reveal electron spin and predict the positron.

As found by Lorentz and Einstein respectively, black body radiation and the photoelectric effect could only be explained by assuming energy of radiation is quantized by units $E=hf$. Together with Einstein's famous relation $E=mc^2$ this raised *wave-particle duality*. Bohr build the first model of atom structure that explained *quantization of energy exchange*. Already in 1870 Clifford proposed that *all matter is manifestation of waves*. Given wave-particle duality De Broglie suspected that *all matter has a wave character* which seemed somewhat later to be confirmed by experiments on electrons. De Broglie introduced *matter waves* that represent particles by *wave-packets*. Wave-packets are waves that only cover a very small region in

space. This small region of space may be identified with an associated particle. So *wave-packets comprise and therefore explain wave-particle duality*. *Mathematical calculations* however showed that wave-packets which initially cover only a very small region in space spread very quickly to cover very large regions in space no longer representing particles. To circumvent this problem Born proposed to *not interpret matter waves as physically real* but instead as probability waves of particle presence. Next Schrödinger developed his famous, though non-relativistic, *wave equation* determining quantum wave propagation. A little later Dirac developed a relativistic version. This version incorporated electron spin, which had been mysterious until then, and correctly predicted the positron.

Around the same time Schrödinger developed the wave equation, Bohr extended Born's interpretation of quantum waves as probability waves into what became known as the *Copenhagen interpretation of quantum theory*. This interpretation was dominant for a long time and possibly still is. The consequences of this interpretation are however *very hard to understand from a physical point of view* because they involve complementarity, collapse of the wave function to represent observer-object connection (observation), entanglement and non-locality. Therefore the Copenhagen interpretation also faced severe opposition, like from Einstein and Schrödinger. Despite the opposition the Copenhagen interpretation remained pre-dominant. The opposition also continued leading to a series of different interpretations of quantum theory and the associated quantum waves. None of these however considers quantum waves as just *real physical scalar waves in a medium having only three dimensions*. This is the interpretation we propose which has the following important characteristics:

1. It is conceptually very simple and therefore apparently free of paradoxes.
2. It is very easy to understand physically.
3. It allows for wave-packets that comprise and explain wave-particle duality.
4. It removes inconsistencies with relativity theory when the modification proposed in the previous section is applied.

Although very simple *conceptually*, *computationally* our real physical scalar waves are complicated. This is due to the *non-linearity* caused by variations of medium density due to large wave amplitudes that occur, especially at the center of wave-packets. This causes waves to *modulate* one another and constitutes the energy exchange mechanism that underlies all of physics. Also this non-linearity implies that *quantum wave propagation is described by wave equations different from those of Schrödinger and Dirac that are linear*.

Summarizing, proper inspection of the history related to relativity and quantum theory reveals that at some stage *mathematical arguments took over from physical arguments* in developing physical models of both. As to relativity this led to the assumption of an absolute velocity of light irrespective of the inertial system and the idea that a medium in space is not present. As to quantum theory this led to abandoning the idea that quantum waves are physically real. By:

1. reinstalling a medium in three dimensional space that
2. propagates scalar quantum waves that are physically real

in section 4 we will build a conceptually very simple model of physics in which the scalar waves make up the whole of physical reality. In the next section we will show that the ideas 1. and 2. have been proposed before in the literature, but separately. Only when they are *combined* our conceptually very simple model of physics is obtained, free of paradoxes.

3 Literature

When assuming a medium, the velocity of light c is not independent of the inertial frame which seems to contradict experiments by Michelson-Morley and Fizeau. These experiments however all measure what is called the *two-way velocity of light*, i.e. *the average velocity* of light when it travels *back and forth*. The same holds for all other experiments of this type. The reason being that a single clock is always used to perform these experiments to circumvent the clock synchronization problem. Because solving the clock synchronization problem in turn requires knowledge of the *one-way velocity of light* which is to be measured. Einstein *postulated* the *one-way velocity of light* to be absolute irrespective of the inertial frame in E-relativity. Mansouri and Sexl [1]-[4] and Selleri [5] further described and explained this issue and derived transformations between inertial frames that may all replace the Lorentz transformation if the postulate of an absolute one-way velocity of light is abandoned. Using the Sagnac effect in which acceleration plays a crucial role, Selleri [5] singled out one inertial transformation, different from the Lorentz transformation, as the *physically correct one*. This transformation restores the existence of simultaneity in different inertial frames (called absolute simultaneity in the paper) and removes the twins paradox. Restoring simultaneity in different inertial frames basically restores independence of space and time. Still time dilation and length contraction in different inertial frames occur but only as a direct consequence of the finite velocity of light. The situation has become fully compatible with the existence of a medium in space that propagates light/waves. It is another matter to establish the inertial frame associated with the medium. Here relativity complicates matters [1]-[4], [6], [7]. As to the physical model proposed in this paper, establishing the existence of a medium is sufficient however.

Starting from the idea advocated by Clifford in 1870 that matter is waving, *mechanistic models* of fundamental physical particles were proposed by Battey-Pratt and Racey [8] and Wolff [9]. The mechanistic nature of these models relies entirely on the representation of fundamental physical particles by *scalar waves*. Wolff [9] also made the important suggestion that the *non-linear nature of the medium*, especially near the center of wave-packets where the change of density is high, causes waves to *modulate* one another. This leads to shifts of frequency Δf corresponding to *energy exchanges* $\Delta E = h\Delta f$. So the modulation of waves provides a conceptually simple *energy exchange mechanism*. Note that in a medium with constant density waves do interfere but they do no change frequency. Therefore they do not exchange energy while all physical phenomena are based on energy exchange or interaction. Later Wolff introduced the terminology “wave structure of matter” (WSM) [10] which we find highly appropriate and will use from now on.

4 Model of physics

The modifications of relativity and quantum theory presented in the previous two sections lead to a conceptually very simple model of physics that has real scalar waves in three dimensions as a basis. The scalar waves are represented using three dimensional space and time that is independent of space. The dependence of scalar wave velocity on medium density provides the energy exchange mechanism that underlies all interaction. Despite the conceptual simplicity, the mathematical modelling is not straightforward because all physical phenomena *emerge* from potential energy. Therefore we decided to leave the mathematical modelling to a future paper, except for the following formula,

$$\Phi_m(x,y,z,t) = E_p^d(x,y,z,t) - \overline{E}_p^d(x,y,z,t), \quad E_p^d, \overline{E}_p^d \geq 0 . \tag{4.1}$$

In equation (4.1) E_p^d represents *potential energy density*, i.e. the amount of interaction of the medium, and $\overline{E}_p^d$ *average potential energy density*. Furthermore x, y, z represent three spatial coordinates with respect to a frame attached to the potential energy medium and t represents time which is independent of space i.e. x, y, z. $\Phi_m(x, y, z, t)$ represents the *wave amplitude*. As to its propagation several suggestions have been made in the literature. Wolff [9], [10] suggested a scalar wave equation with wave velocity depending on medium density. The latter provides an energy exchange mechanism between the scalar waves. Battey-Pratt and Racey [8] show how Dirac's wave equation describes spherical rotation of part of the medium. This spherical rotation is used by Wolff [9] to explain a scalar wave model of the electron that consists of a single scalar wave moving towards and out of the electron center. Spherical rotation is used by to explain the reversal of the wave in the electron center. Roychoudhuri [11] introduces space as a real complex tension field (CTF) as he calls it. In CTF electro-magnetic waves propagate according to Maxwell's equations while energy exchange occurs with particles that are conceived as material oscillators. CTF has the advantage that electro-magnetic waves are naturally obtained whereas they should emerge from our model. On the other hand CTF does not provide a fundamental energy exchange mechanism. So one could state that our physical model resides at a lower, more fundamental level than CTF.

5 Explanatory power

Due to the conceptual simplicity of the model of physics many paradoxes and ill-understood phenomena in physics disappear. Below a list is presented summarizing the ones that have already been mentioned in this paper as well as some that have not been mentioned yet. The latter will be shortly discussed subsequently.

5.1 List of resolved paradoxes and ill-understood phenomena in physics

1. Wave-particle duality
2. Energy exchange mechanism
3. Gravity
4. Mach's Principle
5. Action at a distance
6. Twins paradox
7. Electron spin
8. Electron radiation
9. Compton wavelength / Zitterbewegung
10. Annihilation particles and anti-particles
11. Vacuum fluctuations
12. Particle zoo
13. Schrödinger's cat
14. Heisenberg uncertainty relations
15. Loss of simultaneity
16. Quantum tunneling
17. Renormalization quantum wave amplitude
18. Inconsistencies between relativity and quantum theory
19. Quantization of energy exchange
20. Double slit experiment, including "single photon" case
21. Continuous spectrum of Bremsstrahlung

As to "action at a distance" the medium propagates and reflects locally the presence of distant objects and phenomena. Electron spin is explained by the model of Battey Pratt and Racey [8] that relies on WSM. Electron radiation could be explained [13] by a model similar to that of Wolff [9] that uses a scalar wave that moves towards and out of the electron center. The WSM models [8], [9], also explain the Compton Wavelength and associated Zitterbewegung. The "particle zoo" refers to the fact that the advance of quantum theory revealed many different "particles" which is in conflict with the philosophical argument that simplicity is expected at the fundamental level of physics. This is resolved by our model because these "particles" are all wave structures that are highly unstable (they exist only for a very short time) relevant only when considering stable wave structure transitions. The same holds for "vacuum fluctuations". Quantum tunneling is simply explained by the spatially distributed nature of "particles". "Renormalization of quantum wave amplitude" is a procedure needed to comply with the Copenhagen interpretation of quantum theory to make sure probabilities obtained from quantum waves add up to one. The wave amplitude has a straightforward definite physical interpretation in our model of physics and need not be renormalized. "Inconsistencies between relativity and quantum theory" are removed by assuming quantum waves to be real scalar waves in a medium that obey locality and causality.

5.2 Double slit experiment

To explain quantization of energy and with it the famous double slit experiment, including the case where "one photon at a time" passes the two slits, consider Fig. 1.

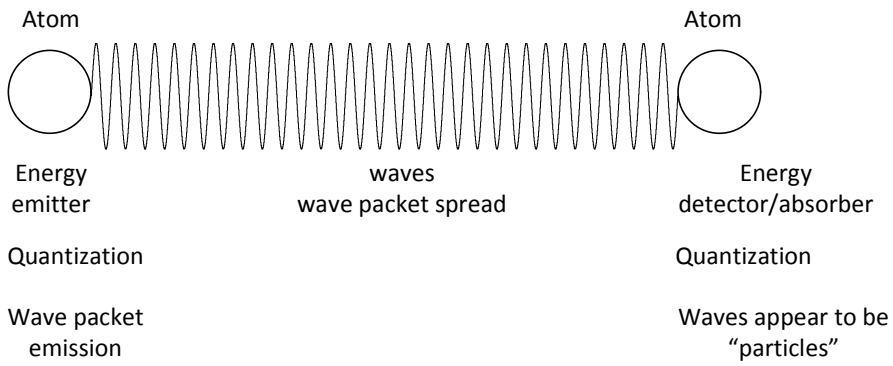

Fig. 1: Quantization of energy exchange and the wave structure of matter

The key to quantization of energy are *properties of atoms* which according to our model are *stable wave structures* (WSM). In physics, almost exclusively, atoms are both the *energy emitters* and *energy detectors* (absorbers/receivers). Their *stability* however dictates *quantized values of wave length* of the wave structures they are made of. These quantized values of internal wave lengths cause the quantized nature of energy emission by atoms through wave-packets. Also they cause the detection (absorption) of wave energy by atoms to be quantized. Because of the quantized nature of energy that is emitted and detected it *appears* as though particles realize the energy exchange. According to our model they are ordinary waves that very quickly spread out in space. The latter provides us immediately with an explanation of the double slit experiment including the case where "one photon at a time" passes the two slits. The latter case is no different from the ordinary case because "single photons" do not exist when they reach the slits. They may be called "single photons" only near the emitter atom where they start as wave-packets (WSM) covering only a very small region in space. But these wave-packets very quickly spread out in space thus *always going through both slits*. Also, whenever a detector is placed at or near one of the slits, it prevents or partly prevents

the waves from passing. This directly influences the interference pattern on the screen, as observed. The wave-packet spread implies that the energy received originates from *several* wave-packets that have been sent. As to the double slit experiment our model shows the same capacity as that of Roychoudhuri [11], [12] that also offers an explanation of the double slit experiment.

5.3 Bremsstrahlung

It is often stated that any energy exchange in physics is always quantized. According to Fig. 1 and the associated wave structure of matter this is only so if stable more complicated wave structures, specifically atoms, are emitting and detecting (absorbing) energy. Compared to atoms, the wave structure of electrons is very simple. According to the "space resonance" model proposed by Wolff [9], an electron is a scalar wave moving towards and out of the electron center. Together these make up a spherically symmetric scalar standing wave-packet. When two free electrons come close to one another, wave modulations, especially at their centers, affect the wave-packets and thereby the positions of the electron wave centers. This interaction is equivalent to the electro-magnetic interaction of two free electrons which changes their kinetic energies. This energy exchange is associated with what is called Bremsstrahlung which is a type of energy exchange that is not quantized (Bremsstrahlung is known to have a continuous spectrum) in accordance with our proposed model of physics.

5.4 Weak and strong properties

Comparing our model of physics with the *current* mathematical formalism of quantum theory, *weak* and *strong* versions of non-locality, entanglement and superposition must be distinguished. The weak versions are properties satisfied by our proposed model of physics. The strong versions are properties satisfied by quantum theory. They are associated with the Copenhagen interpretation. These weak and strong properties are listed below together with their meaning.

Weak properties satisfied by the proposed model of physics

- weak entanglement: Everything depends on everything *through causal local interactions.*
- weak non-locality : There is non-locality but *not instantaneously*.
- weak superposition: Things can co-exist *in a wave interference sense*.

Strong properties satisfied by quantum theory (Copenhagen interpretation)

- strong entanglement : Everything depends on everything, *instantaneously*.
- strong non-locality : There is *instantaneous non-locality*.
- strong superposition : Things can co-exist. *Observer decides what becomes real*.

Many experimental results at the quantum level, such as [14]-[16], seem to indicate that strong properties exist. According to our proposed model of physics they do not. It must therefore be possible to explain the experimental results using only weak properties. Although it is outside the scope of this paper to provide these explanations we believe that these can be obtained by including properly the effect of macroscopic objects that are part of these experiments, such as the measurement equipment. Also the process of generating entangled "particles" (e.g. by parametric down conversion) must be included properly. This process is not at all well understood. Together with the effect of macroscopic objects it is totally ignored, or at best very much simplified, in the current explanations that rely on strong properties.

6 Conclusions

After modifying both relativity and quantum theory the resulting model of physics proposed in this paper becomes almost analogous to acoustic waves mediated by air. Instead of air we have potential energy as a medium. The scalar acoustic waves are replaced with scalar quantum waves. Acoustic waves are all there is in the air like quantum waves are all there is in physics. From a scientific and educational point of view this is of great significance because it leads to a proper and simple understanding of the fundamentals of physics that has been very much lacking. Physics, i.e. wave propagation, occurs in *a medium in three dimensional space* and is *causal* and *local*. Time is *independent* of space. The velocity of light is *not absolute* but dependent on the observer and medium density. The latter creates the *energy exchange mechanism* causing wave frequency shifts equivalent with energy transfer. It also causes the bending of light near "massive objects" explaining *gravity*. Electrons are represented by stable spherical symmetric standing wave-packets created by a single spherical wave moving towards and, after spherical rotation, out of the center [8], [9]. Atoms comprise significantly more complicated stable wave structures. Their stability admits only quantized values of wavelength of parts of the structure. This causes the *quantized nature* of energy release and absorbance *by atoms*. This in turn makes the energy exchange between atoms *look like* mediated by particles. They are actually waves that very quickly spread out in space implying that *photons only appear to exist*. The latter allowed for a simple explanation of the famous double slit experiment, including the case where "one photon at a time" passes the two slits.

Computationally, the proposed model of physics is complicated due to the spatially distributed nature of the model and the non-linearity in the wave equation caused by the dependence of wave propagation on medium density. This non-linearity is vital because it provides the *energy exchange mechanism* in physics. To obtain quantitative results the non-linearity must be *quantified*. It depends on properties of the medium. Also these determine wave propagation. That is why the wave propagation equation of our proposed model of physics was presented as a *candidate*. These difficulties present a huge challenge for future research to see how all currently known physics *emerges* from the model and why the current black box models of physics often give excellent numerical results and predictions. Some results that have already been published may be regarded contributions in this area [2]-[6], [11], [12], [17]-[22].

Historically it appears that at some stage during the development of physical models *mathematical arguments took over from physical arguments*. This applies to the strange postulate of an absolute one-way velocity of light in special relativity. At the quantum level this resulted in highly complicated mathematical models, lacking a proper interpretation while incorporating ever larger numbers of "fundamental particles" and properties like strong non-locality and strong entanglement. According to our proposed model of physics these "particles" are not truly fundamental while only weak versions of entanglement and non-locality exist. One could say that during the last century *physics has been heavily mathematized*. As to obtaining accurate quantitative predictions and results this is fully justified. Only when it comes to *explaining* and *understanding* physics this is not.

References

[1] Ljung L.: Black-box Models from Input-output Measurements. IEEE Instrumentation and Measurement Technology Conference, Budapest, Hungary, May 21-23, (2001).

[2] Mansouri R. and Sexl R.: A Test Theory of Special Relativity: I. Simultaneity, General. Relativity and Gravitation, **8(7)**, 497, (1977).

[3] Mansouri R. and Sexl R.: A Test Theory of Special Relativity: II. First Order Tests, General. Relativity and Gravitation, **8(7)**, 515, (1977).

[4] Mansouri R. and Sexl R.: A Test Theory of Special Relativity: II. Second Order Tests, General. Relativity and Gravitation, **8(7)**, 809, (1977).
[5] Selleri F. :Noninvariant One-Way Velocity of Light. Foundations of Physics, **26(**5), 641, (1996)
[6] Selleri F.:The inertial transformations and the relativity principle. Foundations of Physics Letters, **18**(4), 325, (2005).
[7] Spavieri, G.:On measuring the one-way speed of light. European Physics Journal D, **66**, 76, (2012).
[8] Battey-Pratt E. P. and Racey T. J.: Geometric Model for Fundamental Particles. International Journal of Theoretical Physics, **19**(6), 437, (1980).
[9] Wolff, M.: Fundamental laws, Microphysics and Cosmology, Physics Essays, **6**(2), 181, (1993).
[10] Wolff, M.: Cosmology, the Quantum Universe, and Electron Spin. Gravitation and Cosmology: From the Hubble Radius to the Planck Scale, Proc. Symp. 80th Birthday of Jean-Pierre Vigier, Amoroso R.L., Orinda, C.A., Hunter G., Kafatos M., Vigier J.P., Kluwer Academic Publishers, 2002.
[11] C. Roychoudhuri: Next Frontiers in physics - space as a complex tension field, J. Mod. Phys., **3(**10), 1357, (2012).
[12] C. Roychoudhuri: Causal Physics: Photon Model by Non-Interaction of Waves; Taylor & Francis, 2014.
[13] Wheeler J.A. Feynman R.P: Interaction with the absorber as the mechanism of radiation, Reviews of Modern Physics, **17(**2-3), 157,(1945).
[14] Aspect A., Grangier P., and Roger G.: Experimental Realization of Einstein-Podolsky-Rosen-Bohm Gedankenexperiment: A New Violation of Bell's Inequalities. Physical Review Letters **49**(2), 91, (1982).
[15] Jacques V., Wu E., Grosshans F., Treussart F., Grangier P.: Experimental Realization of Wheeler's Delayed-Choice Gedanken Experiment. Science, **315**, 966, (2007).
[16] Jozsa R., Linden N., On the role of entanglement in quantum computational speed-up, Proceedings Royal Society of London A **459,** 2011, (2003).
[17] Einstein A, Podolsky B, Rosen N: "Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?". Physical Reviews, **47**(10), 777.
[18] Van Willigenburg, L.G. and De Koning, W.L.: Emergence of the second law out of reversible dynamics. Foundations of Physics, **39**, 1217-1239, (2009).
[19] Buonaura, B.: Maxwell equations and inertial transformations, Foundations of Physics Letters, **17(**7), 627, (2004).
[20] Greaves E.D., Rodríguez A.M., Ruiz-Camacho J.: A one-way speed of light experiment. American Journal of Physics. **77(**10), 894, (2009).
[21] Timothy P., Krisher T.P., Maleki L., Lutes G.F., Primas L.E., Logan R.T., and John D. Anderson J.D. Will C.M.: Test of the isotropy of the one-way speed of light using hydrogen-maser frequency standards. Physical Review D, **42**(2), 731, (1990).
[22] Vervoort L.: Bell's Theorem: Two Neglected Solutions. Foundations of Physics **43**, 769, (2013).