The Enigma that is Light.

Jeremy Dunning-Davies,
Institute for Basic Research,
Palm Harbor,
Florida,
U. S. A.

j.dunning-davies@hull.ac.uk

Richard Lawrence Norman
Editor in chief: *Mind* magazine, *Journal of Unconscious Psychology*

editor@thejournalofunconsciouspsychology.com

Abstract.

The presently accepted notion of wave/particle duality, especially when applied to light, is undoubtedly a cause of great unease for many. Here the issue is examined afresh in the light of ideas put forward in recent years, especially by Mayants, while not forgetting the contributions of those great scientists of the past. Explanations and interpretations are then offered to account for seemingly paradoxical effects.

Introduction.

What is the true physical nature of light? This is a seemingly simple question which has been around in science for centuries. Newton favoured a particle theory but found difficulty when trying to explain the so-called Newton's rings with this theory; then, Young's experiments appeared to indicate a wave nature. The problem of attempting to reconcile the apparent wave and particle properties of light seemed for years to be an intractable one. However, reconciliation came in the wake of the quantum mechanical notion of wave/particle duality; in other words, light could display both wave and particle properties depending on the physical situation under consideration. Mathematically this might seem an acceptable resolution of this considerable problem but, physically, it seems it has always left people with at least a feeling on unease. In view of material, both experimental and theoretical, which has accrued over recent years, it is perhaps time to look again at this question with (hopefully) a completely open mind. The latter point is vitally important because some material might be considered to cause a 'rocking of the boat' in areas of science deemed sacrosanct by some.

Wave or particle?

Much of the more modern work carried out in addressing the meaning of wave/particle duality has been by Lazar Mayants and this is worth considering in some detail. It probably goes back at least to the appearance of his first book, *The Enigma of Probability and Physics*[1], continues through a number of publications, with one of 1989[2] being of particular relevance here, and culminates in the lucid overall discussion in his second book *Beyond the Quantum Paradox*[3]. To start, it seems worth considering in some detail some of the material contained in Mayants 1989 article cited under reference 2. Here he examines, for example, the phenomenon of particle diffraction but first examines straightforward diffraction which is known to occur when a series of waves of the same frequency encounters obstacles. The resulting diffraction pattern is determined by the geometry associated with the total system involved, together with the wave-length of the wave involved. For a real physical wave process, the detail will be determined eventually by the wave equation and the relevant boundary conditions. The relevant wave equation has the form:

$$\nabla^2\varphi = \left(1/v_p^2\right)\partial^2\varphi/\partial t^2, \qquad \text{(a)}$$

where v_p is the phase velocity of the waves and φ is a quantity whose magnitude squared determines the diffraction pattern.

However, what is the actual position concerning particle diffraction? If the conventional belief that individual particles possess inherent wave properties is true then any such particle should have some property, akin to φ, obeying the above wave equation. If such a property does exist then the diffraction pattern should remain unaltered, regardless of the intensity of the beam, but gradually weakening as the beam does. However, experimentation does not support this. If only a few particles are used, no continuous diffraction pattern appears; a few points on the display are all that do appear. In the case where a large number of particles is used, the picture seems to be a normal diffraction pattern but, in reality, it isn't; it simply consists of a very large number of points which appear to merge together to produce a familiar diffraction pattern seemingly. One might say that the perceived result is essentially a statistical one in the sense that a very large number of particles is involved and such numbers may only be treated effectively by statistical considerations. These remarks have been phrased to refer to particles – any particles – and, therefore, would refer to photons if photons are considered as particles.

In an actual particle diffraction experiment, a beam of *concrete* particles (to use Mayants terminology) is concerned and the experimenter considers the experimental statistical distribution of the coordinates of these diffracted *concrete* particles. However, in the theoretical situation, attention turns to the relevant probability distribution of the coordinates of what are, in effect, corresponding *abstract* diffracted particles. It is this rather subtle distinction between the *concrete* particles of the experimenter and the corresponding *abstract* particles of the theoretician which lies at the very heart of Mayants argument. This seemingly obvious distinction between abstract and concrete objects is an error hiding in plain sight. To see the distinction with clarity, allows the removal of many apparent paradoxical contradictions. As Mayants says[3], "It is these two principle features of abstract objects—the nonexistence in reality and the lack of definite values of many properties—which differentiate them from the corresponding concrete objects." "Which comes first, the chicken or the egg" refers to an abstract chicken and an abstract egg. The question being based on an abstract object can not be answered, but that is not important, as the abstract object "the chicken" does not have particular properties or exist, rendering the question improper and trivial. Each real particular such bird exists in no temporal paradox but comes after the egg in which it was gestated, and before any egg it may itself produce. In like fashion, the subject of "a cat" in Schrodinger's paradoxical experiment, which it must be remembered was outlined in the original case to point up quantum theoretic inconsistencies at macro scale is again, an abstract cat, in this case symbolizing an indeterminate probability distribution, which is itself again, an abstraction with undefined qualities. The resultant paradox, simply does not exist. Probability theory works, and an abstract set adequate to a concrete set gives good results in calculations, but in no case are abstract and concrete objects alike. Paradox itself is not paradox, but misunderstanding. *The world is made of concrete objects.* It is this which the theory in its end *result* must describe, and does.

As has been described in detail elsewhere[2], it follows that the probability distributions of physical quantities for an abstract physical system, which conform to real motion of the corresponding concrete physical system, are determined by the solutions to the Schrödinger equation

$$E\psi = H\psi.$$

For a free real particle, the Hamiltonian is given by

$$H = c(p^2 + m_0^2c^2)^{1/2},$$

where, as usual, m_0 is rest mass and p is momentum. c is the speed of light in a vacuum. However, the operators for particle momenta are $p_\alpha = -i\hbar\,\partial/\partial\alpha$ and $E = i\hbar\,\partial/\partial t$ Then the Schrödinger equation takes the form

$$c(-\hbar^2\nabla^2 + m_0^2c^2)^{1/2}\psi = i\hbar\partial\psi/\partial t$$

which leads to

$$\hbar^2c^2\nabla^2\psi = m_0^2c^4\psi + \hbar^2\,\partial^2\psi/\partial t^2. \qquad \text{(b)}$$

However, diffraction refers to a stationary state of the particle, determined by a specific value E of the energy which corresponds to a definite value of the momentum p and these are linked via

$$p^2 = (E^2 - m_0^2c^4)/c^2.$$

It follows that

$$\hbar^2\,\partial^2\psi/\partial t^2 = -E^2\psi \text{ and } \psi = -E^{-2}\hbar^2\,\partial^2\psi/\partial t^2.$$

Substituting in the first term of the right-hand side of (b) above gives

$$\nabla^2\psi = c^{-2}(1 - m_0^2c^4/E^2)\,\partial^2\psi/\partial t^2.$$

By putting $(E^2 - m_0^2c^4)/c^2E^2 \equiv 1/v_p^2$ in this equation leads to

$$\nabla^2\psi = \left(1/v_p^2\right)\partial^2\psi/\partial t^2,$$

that is, the well-known wave equation (a) with $v_p = E/p$.

At the very least, this would seem to indicate that particle diffraction is not a wave process but is, rather, linked with to the probability distribution of particles in a stationary state with corresponding with well-defined values of both energy and momentum for the particles. Again, it does suggest that the whole notion of wave particle duality should be re-examined with truly open minds. The above outlined theory is due, as stated previously, to Mayants – particularly in his cited article of 1989 - but is work which seems to have been forgotten by much of the scientific community and is certainly deserving of more public acknowledgement.

The Speed of Light.

What is really meant when people speak of the speed of light? What is meant when reference is made to the constancy of the speed of light? Popular talking about issues linked to the speed of light have probably increased since the popularisation of Einstein's theories of relativity. It is a popular misconception that Einstein's theory claims the speed of light to be a constant and that the theory leads to an ultimate speed for everything which is this constant speed of light. This, however, is only an incorrect public misconception.

It is important to remember that Einstein assumed the speed of light *in a vacuum* to be constant. Also, in several subsequent mathematical manipulations, the factor

$$(1 - v^2/c^2)^{-1/2}$$

appears, with v being the speed of the object under consideration and c the speed of light but, as emphasised above, the speed of light in a vacuum. It must always be remembered, though, that Einstein's theory was and is just that – a theory. Like any theory it will only hold when the assumptions made in constructing it hold; if any one of those assumptions ceases to be valid, it cannot be assumed the theory continues to be valid. This is, of course, true of any theory.

These points are important to remember since it is known, and has been known for a long time, that the speed of light is *not* constant; it certainly varies for light passing through different media. The speed of light passing through a medium of refractive index n, is c/n, where c is the speed of light in a vacuum. Hence, for light passing through a medium, such as water, which possesses a refractive index greater than unity, the speed of light will be substantially less than the value in a vacuum. Therefore, the ration v^2/c^2 in the factor mentioned above will be less than unity and so, no mathematical problems are encountered with this factor. However, there are media which appear to possess refractive indices less than unity and, in such cases, light will propagate at speeds in excess of the speed in a vacuum. This, in turn, raises questions about the above relativistic factor since if v is greater than c in this expression, mathematical problems do arise due to the appearance of a negative quantity whose square root is required.

What must be remembered here is that, as Santilli has explained it[4], special relativity was constructed to describe the propagation of light in a vacuum but not within physical media. Many of the results of special relativity have been validated on numerous occasions for point particles or electromagnetic waves moving in a vacuum but the theory is inapplicable for the movement of such in physical media because the speed of light is really a local variable dependent on the properties of the medium through which it is passing.

As with all physical theories, it is important to realise that they are just theories and, as such, are based on certain very definite assumptions. If any theory is applied in a situation where one or more of those basic assumptions is invalid, that theory cannot reasonably be expected to produce a satisfactory explanation of that situation. Note that this does not mean the theory is incorrect, it merely points out that it is invalid.

Axiomatic implications: Uncertainty, EPR, Popper, Bell and gravitation.

Uncertainty as an inherent systemic property and the quantum uncertainty principle we attribute to Heisenberg, as well as the closely related wave/particle duality have been the target of much enquiry and by no means stand on certain and irrefutable ground, nor should they. The Einstein-Podolsky-Rosen (EPR) paradox, is in no way paradoxical. In fact, it reveals the uncertainty relation itself to be "paradoxical." Indeed, this simple thought experiment involving two particles moving along the same linear path in the same direction at the same speed, maintaining therefore fixed relative distance, does allow the precise simultaneous determination of both position and momentum of either particle. The thought experiment refers to concrete particles, and has a non-paradoxical outcome, where the uncertainty principle refers to quantum probabilistic calculations upon abstract objects, yielding a "paradox" when mistakenly applied directly to the particular, 'concrete' world.

Mayants is not the first to advance some of these ideas, which can be seen in the work of Popper in slightly different language[5]. The factual order of historical development points to an initial particle view of EM, with the field then later added as a secondary mathematical abstraction, which subsequently had the particle, the photon, emerge secondary to the field as an excitation[3]. Indeed, it appears we see the same confusion yet again, and perhaps it may be fruitful to restore the proper genesis of theory and realities, place the photon at the base of its collective wave propagation, and understand it is the source of any emergent field effects.

In reference 5 it is stated that:

> "Max Born himself says about his statistical interpretation of wave mechanics: "The solution . . . was suggested by a remark of Einstein's about the connection between the wave theory of light and the photon hypothesis. The intensity [of course, what is meant is the square of the amplitude] of the light waves was to be a measure of the density of the photons or, more precisely, of the probability of photons being present."
>
> "Thus, through Born's statistical interpretation of matter waves even the one problem of quantum theory which appeared not to be statistical - the problem of atomic stability - was reduced to, or replaced by, a statistical problem: Bohr's quantized "preferred orbits" turned out to be those for which the *probability* of an electron's being found on them differed from zero."
>
> "All this is to support my thesis that the *problems of the new quantum theory were essentially of a statistical or probabilistic character*."

However, Popper also draws this unusual, apparently contrary conclusion which will fit into place later:

> "Thus the relativity to specification of which we have spoken is characteristic neither of quantum experiments nor even of statistical experiments: it is a permanent feature of all experimentation. (And a propensity relation might be regarded, and intuitively understood, as a generalization of a "causal" relation, however we may interpret "causality".) For this reason it seems to me mistaken to regard statistical laws, statistical distributions, and other statistical entities, as non-physical or unreal. Probability fields are physical, even though they depend on, or are relative to, specified experimental conditions."

In order to make sense of the above statement, it may be beneficial to take an elliptical pathway and consider the consequences of these insights as applied to one of the basic tenets supporting the current predominant quantum viewpoint: the Bell inequalities. Mayants' commonsense analysis will have come as an unwelcome surprise to some. However, any facts unearthed in a cogent analysis such as his must be accepted and it must be seen where they lead. It may be noted that Bell's inequalities suffer from the same logical error as the other 'paradoxical' constructs considered above: an erroneous substitution of abstract for concrete elements. Bell's inequalities are based on Bell's theorem, which is itself a derivative of Bohm's paradox, and Bohm's paradox confuses abstract quantum elements and concrete objects. It is argued[3], that the basic experiments upon which Bell's inequalities are based can apply only to large numbers of particle pairs and must represent a statistical expression, and so, it is therefore entirely *expected* that Bell's inequalities do not conform to experiments involving the real concrete system in question, as Bell's inequalities confuse abstract and concrete elements to assume simultaneous rotation amongst various axes in the case of *one individual particle*, which is physically impossible. Quantum physics in this light may be rightly seen as representing real non-paradoxical outcomes and Bell's inequalities are thereby revealed as flawed at their axiomatic basis, hence the apparent but nonexistent paradox.

From this new vantage Mayants[3] informs us of the *ordinary view* of the consequences implied which place Bell's ideas and nonlocal faster than light effects on one side of the scales, and on the opposing side of the balance we find realism and the common if incorrect assumption that *nothing moves faster than c*. Recall that Einstein's limit of *c* refers to propagation through a vacuum. Does Einstein's *c* hold good as a matter of consequence to defeat nonlocal theory, if Bell's ideas are not correct? What of nonlocality? What of light? Do physical processes move faster than light in a nonlocal way and, if so, which ones?

In Tom Van Flandern's essay[6], *The Speed of Gravity what the experiments say*, a solid and specific empirical answer is provided:

> "The most amazing thing I was taught as a graduate student of celestial mechanics at Yale in the 1960s was that all gravitational interactions between bodies in all dynamical systems had to be taken as instantaneous.
>
> . . . Yet, anyone with a computer and orbit computation or numerical integration software can verify the consequences of introducing a delay into gravitational interactions. The effect on computed orbits is usually disastrous because conservation of angular momentum is destroyed.
>
> . . . While relativists have always been partial to the curved space-time explanation of gravity, it is not an essential feature of GR. Eddington (1920, p. 109) was already aware of the mostly equivalent "refracting medium" explanation for GR features, which retains Euclidean space and time in the same mathematical formalism. In essence, the bending of light, gravitational redshift, Mercury perihelion advance, and radar time delay can all be consequences of electromagnetic wave motion through an underlying refracting medium that is made denser in proportion to the nearness of a source of gravity. (Van Flandern, 1993, pp. 62-67 and Van Flandern, 1994) . . . The principal objection to this conceptually simpler refraction interpretation of GR is that a faster-than-light propagation speed for gravity itself is required. In the context of this paper, that cannot be considered as a fatal objection.
>
> . . . We conclude that the speed of gravity may provide the new insight physics has been awaiting to lead the way to unification of the fundamental forces. . . . Moreover, the modest switch from SR to LR [Lorentzian Relativity] may correct the "wrong turn" physics must have made to get into the dilemma presented by quantum mechanics, that there appears to be no "deep reality" to the world around us. Quantum phenomena that violate the locality criterion may now be welcomed into conventional physics."

Gravity appears to propagate at extreme super-luminal velocities[6]. It may safely be concluded that the logical inconsistencies of Bell's theorem and inequalities do not in fact preclude non-locality in its super-luminal aspects. Mayants also comes to the conclusion that photons can vary from *c*, and names fundamental sub *c* non-zero rest mass expressions of EM: emons.

Next recall the famous wave function collapse of the double-slit experiment. A photonic interference pattern ‘collapses’ if measured to become something more closely akin to a single particle. This is traditionally ascribed to the effect of “measurement/observation.” What can be made of this paradoxical anomaly where the observer affects the observed to induce wave function collapse and perhaps even 'create reality' ?

Measurement or observation are not the bottom of the process; they are but second order descriptions. Wheeler was highly insightful to posit information at the very deepest level of physical reality. Observation and measurement in terms of a primary informational dynamism then represent: *Informational Exchange*. Information affects physical form. Indeed this is true also in biology, not surprisingly, as biology and its relation to chemistry are founded on a primary physical basis with information at the deepest level[7]. The paradox appears as such, only because the primary role of information and its exchange, which clearly affect form/outcome, has not been understood. Now, it may be seen that there is no wave function collapse in the usual sense; the interference pattern is a complete outcome formed of photons, and the ‘collapsed’ expression is again a different complete outcome formed of photons, both being not in any way uncertain or indeterminate, the differentiation between them being a product of informational exchange which is the dynamic at the bottom of both observation and measurement.

To place this in a human perspective, and suggest a few alterations to the Copenhagen interpretation and some of the more radical theoretic anomalies which have gained predominant sway, such as the deeply troubling many worlds hypothesis, or the equally vexing solipsistic implications of observation, ideas so strange as to have one wonder if an electron is there or perhaps the moon if we are not looking, and place all this into proper relation to probability, attention might turn to some of the more puzzling experiments which are now mounting up and deserve to be addressed.

In these experiments, double-slit interference patterns are seen to change due to thought, and random number and event generators which are properly shielded become more organized in their output. These effects are created at close range, and at *very great distances*[8-13]. Is this inexplicable paranormal activity, or perhaps the cognitive result of resolved uncertainty affecting photonic wave expression? Theory allows an answer: No! This is simply the physics of informational exchange.

In the case of gravitation and also of thought as it affects reality it appears that some nonlocal aspect is needed to explain the effects we observe. Recall the unlikely assertion by Popper, that appears quite clearly to confuse abstract and concrete elements, which states that probability fields must be attributed reality. He had observed experimental effects which required explanation, a real physical explanation was demanded to account for observed phenomenon, hence his supposition. It might reasonably be posited that probability is not at the root of physical form but that information is. Hence it might be hypothesized that the field in question is not a probability field, but a non-probabilistic informational field: *the ‘bit field.’*

Imagine a simple example of probability: one reaches one’s hand into a concealed container to extract a ball or game chip with some particular marking common to a sub-set of the total objects in the container. Probability is used to guess at result prediction, but in fact the hand does not extract the chip or ball by way of probability, each concrete case is that of selecting one particular concrete object, probability is invoked only to allow prediction under uncertain conditions of human observational constraint, and hence reflects a limit in our available knowledge, not the basic dynamic of the system which is not probabilistic but specific. It has been clearly understood and articulated in previous articles[14] that the nature of human perception is by phenomenological necessity and anatomical analysis understood to be entirely probabilistic. Probability is a valuable and necessary consequence of our human limits. It is a second order method and not a descriptor of underlying processes, but instead an admission of our human limits in defining those processes. Wave function is a necessary abstraction.

With this in mind, the many seemingly paradoxical aspects of quantum theory under the current interpretation may now be reassessed:

There are no many worlds, as the wave function is a probability distribution, an abstract thing which does not require its unrealized aspects be accounted for in some imaginary other world, for all outcomes are complete in and of themselves. There is no uncertainty or wave/particle duality endemic to physical dynamism, those are aspects not of the system at its lowest level of operation, but reflect our human limits which are revealed in attempting to ascertain the same. Uncertainty is the product and province of human cognition and phenomenology, not external reality. Human mental effects upon physical reality including observation/informational-exchange entirely within the sphere of mentation are revealed in experiments referenced above to yield a very slight but demonstrable impact on physical systems. It appears that there is an experimentally demonstrable and specific place for human consciousness in quantum theory, but not the solipsistic one supposed. It may rightly be concluded that human observation in no case creates an electron to observe it, any more than human observation itself might create the moon. The appearance of probability alteration in experiments with human mentation indicates specific informational exchange over some actual medium, perhaps one such as the proposed 'bit field.' It may be concluded that

*The wave function itself represents an abstract probability distribution, signifying the **possible effects** of a potential REAL alteration in systemic informational allocation.*

The fact that subatomic particles demonstrate some fuzziness and do not behave as virtual little golf balls but in a way more akin to a wave packet, is then not due to the fact that the particle is somehow wave-like or uncertain, but because it a process, a *specific* process which is informationally interactive, as are the larger emergent structures which they compose en masse.

Future questions:

1. Is the implied connection between gravitation, informational exchange and refraction testable in quantum experiments? Clearly alteration in refractive index can account for faster than *c* propagation speeds for light. If informational exchange over a 'bit field' accounts for the super-luminal aspects of gravity, and gravitation can be accounted for in its effects upon light by way of alterations in the refractive index as suggested above[6], then an experiment could be derived where the hypothesis is tested. Hypothetically: *Micro-gravitational effects created through interactive informational exchange alter refractive conditions yielding specific patterned allocations within the experiment thereby determining the outcome*. Can these theoretical postulations be tested?

2. Is probability at the basis of physical reality or is non-probabilistic information? Does the

uncertainty relation signify an endemic systemic aspect, or a human phenomenological limit in epistemology?

3. Is there a realistic interpretation of quantum theory which allows for the unification of gravitation in an informational model based around the empirical necessity of other than "*c*" electromagnetic propagation speeds and experimentally observed nonlocal aspects? Can a quantum model be derived without uncertainty or duality by way of accepting a central tenant of 'informational gravitation'?

4. Is paradox endemic to reality, or is it simply a misunderstanding based on improper assumptions which confuse abstract and real elements?

5. Is it possible to create sound physics based on a constant vacuum propagation value for c ? Does Lorentzian relativity offer an alternative?

6. Is the 'bit field' real?

7. Can clear and evident effects of informationally encoded photons on morpho-functional outcomes in biological systems[7] be taken as a correct model for a system-wide common informational basis in physics?

8. Does information theory offer us the elusive prize and connect together gravitational effects with quantum theory by placing informational gravitation as a quantum basis?

9. It appears that the 'bit field' (previously aka the temporal field) *mediates specific entangled relational properties and strength* such as that between a mind and an object or *between gravitationally interactive bodies*, and recent experiments and theories have concluded entangled evolution to be the source of time. Then, could the 'bit field' provide a specific mechanism for temporal/gravitational effects such as gravitational time dilation and others?

Concluding comments.

Our understanding of what light is and is not depends crucially on two interrelated things – experiments carried out meticulously and the theory used to interpret those experiments. As discussed earlier, in his work, when Mayants wishes to talk of particles, he carefully distinguishes between what he calls the *concrete* particles of experiment and the *abstract* particles of theory. This is a rather clever and useful distinction to consider. Experiments are involved with actual reality; theory is always the product of the human mind and, as such, only ever attempts to picture reality rather than be reality. As a result of incorporating this distinction into his reasoning, he has reignited the debate concerning the nature of light – is it merely waves or is a beam of light composed of a huge number of particles? His theoretical calculations look again at the uncomfortable notion of wave/particle duality and show that a particulate theory is capable of describing all events concerning light previously thought to be purely wave phenomena. This proves to be particularly interesting given the recent resurrection of the atomistic view of matter[15] in which everything is fundamentally composed of indivisible particles and void. Interesting because that theory also reduces a light beam to a stream of particles.

As a general point emerging from this discussion, it is worth realising that Mayants also seems to be indicating that great care must be taken when considering any so-called thought experiment. Any theoretician contemplating a physical problem essentially builds a model in his mind to describe the system involved. He then uses well-established techniques, often involving mathematics, to try to understand and explain the original phenomenon. In any thought experiment, the entire process of conceiving an experiment and carrying it out is confined to the mind of the person concerned. There is not any direct contact with physical reality such as is experienced by the experimenter in his laboratory. It seems that Mayants distinction between concrete and abstract particles as discussed here may have farther reaching consequences for future scientists.

Whatever the public view of many might be, these considerations primarily due to Mayants, together with some factors already well-known but highlighted publicly by Santilli, must reawaken the wave/particle duality debate because, in truth, they cast real doubts on that interpretation having much, if any, present day validity.

References.

1. L. Mayants, 1984, *The Enigma of Probability and Physics*, Reidel, Dordrecht.
2. L. Mayants, 1989, Annales de la Fondation Louis de Broglie, **14**, 177-189.
3. L. Mayants, 1994, *Beyond the Quantum Paradox*, Taylor & Francis, London.
4. R. M. Santilli, 2006, *Isodual Theory of Antimatter*, Springer, Dordrecht.
5. Quantum Mechanics without "The Observer" Karl R. Popper in: *Quantum Theory and Reality,* Volume 2 of the series *Studies in the Foundations Methodology and Philosophy of Science* pp. 7-44 Springer-Verlag, Berlin. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.473.23&rep=rep1&type=pdf
6. Van Flandern, T., 1989, The speed of gravity what the experiments say, *Physics Letters* A **250**, 1-11 http://www.sciencedirect.com/science/article/pii/S0375960198006501 http://www.metaresearch.org/cosmology/speed_of_gravity.asp
7. Norman, R., Dunning-Davies, J., Heredia-Rojas, J. A., Foletti, A., 2016, Quantum Information Medicine: Bit as It—the future direction of medical science: antimicrobial and other potential nontoxic treatments. *World Journal of Neuroscience*, in press.
8. Jahn RG, Dunne BJ, Nelson RG, Dobyns YH, and Bradish GJ., 1997, Correlations of random binary sequences with prestated operator intention: A review of a 12-year program, *Journal of Scientific Exploration*, **11**, 345-367.
9. Radin D, and Nelson RD., 1989, Evidence for consciousness related anomalies in random physical systems. *Foundations of Physics*, **19**,1499-1514.
10. Radin D, Taft R, and Yount G., 2010, Effects of Healing Intention on Cultured Cells and Truly Random Events. *The Journal of Alternative and Complementary Medicine* **10**, No 1, pp. 103–112
11. Radin D, Michel L, Galdamez K, Wendland P, Rickenbach R., and Delorme A., 2012, Consciousness and the double-slit interference pattern: Six experiments, *Physics Essays*, **25**, 157-171. doi: 10.4006/0836-1398-25.2.157
12. Radin D, Michel L, Johnston J, and Delorme A., 2013, Psychophysical interactions with a double-slit interference pattern. *Physics essays*, **26**, 4, 553-556 http://dx.doi.org/10.4006/0836-1398-26.4.553

13. Tressoldi P, et al., 2014, Mind-matter Interaction at a Distance of 190 km: Effects on a Random Event Generator Using a Cutoff Method. *NeuroQuantology*, **12**, No. 3, 337-343.
14. Norman, R., 2015, Quantum Unconscious Pre-Space: A Psychoanalytic Neuroscientific Analysis of the Cognitive Science of Elio Conte—The Hard Problem of Consciousness, New Approaches and Directions. *Neuroquantology*, **13**, 487-501. (http://dx.doi.org/10.14704/nq.2015.13.4.869)
15. E. G. Haug, 2014, *Unified Revolution,* EGH Publishing, Norway.