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From Light in Space to Space in Light, the Complete Relativistic Revolution

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Abstract: This paper addresses, from a logical point of view, the conundrum of an observational relativism mediated by an 'absolute speed of light'. We reinterpret the space-time constant *c* in the way we feel Mach might have done in order to put Einstein's theory into its proper philosophical perspective.

For anyone who might like to think about it, the dimensions of space are not those of a vacuum or void. How could they possibly be? Basically, they are the dimensions of the world that we *see*. In other words, they are the dimensions of *light*. By 'light', here it is not meant that very narrow band in the spectrum that is visible to human beings, nor even to animals that can see in what is to us complete darkness. Rather, it is the whole spectrum of light, without which there would not even be the concept of darkness, far less the *dimensions* of anything. In other words, with no light at all, what remains is not even a void, which means no space, no time, nor *anything* that it makes sense to speak about.

This implies, of course, that light is *everything* and that *everything* is light. This, in effect, was what the philosopher George Berkeley meant with his famous dictum *esse* is *percipi* or 'to be is to be perceived' – except, of course, that by 'perceived' Berkeley meant perceived by human beings if not, specifically, oneself. Not surprisingly, this got Berkeley into bad odor with physicists, who regarded his theory as a form of subjective idealism – which, of course, it was. What the physicists wanted to know was not so much about light as about *matter*, which they regarded as something fundamentally real and to which the light by which we see things is no more than incidental. This is why, in response to Berkeley's dictum, Samuel Johnson contemptuously kicked at a stone, saying 'Sir, I refute thee thus!'

The physicists' first consideration, then, is matter and space, and only secondarily light, which may or may not travel in the space between those various bits of matter. This was anathema to Berkeley. How, he would say, could we know of those bits of matter and the space they occupy other than in the light by which we see them? And as for any idea of light travelling in that space which is nowhere but in the light, what else could that be but pure nonsense?

If only Berkeley had not stated his dictum 'to be is to be perceived' in the subjective way he did, the history of modern physics might have been very different. For instance, if by 'perceived' he had quite legitimately included not only human perception, with particular emphasis on the sensation of sight, but also the observations scientists make by means of instruments in all the ranges of response that instruments are capable of, then since just about anything is an 'instrument' in

this sense, nothing whatever would be excluded. 'To be is to be perceived' would thus have been the tautology he intended it to be. For physicists 'the boot' would then have been 'on the other foot'. That is, it would have been they, not Berkeley, who were on the defensive. They would have been hard put to it to explain what sense could be made of the idea of a *void* – literally, a *nothing* – underlying all possible physical phenomena, with a length of its own, a breadth of its own, a depth and duration of its own, perceived by nothing and no one but itself and/or some tacitly imagined ubiquitous spirit or deity.

In contrast to that absolutist or fundamentalist view of dimensions, the inseparable interrelation implicit in Berkeley's theory between space, time, matter, and the observer (as eventually established by Einstein) was emphasized by Berkeley's phenomenalist successor, the physicist, Mach. So far as Mach was concerned, space exists only in relation to matter, and any one bit of matter exists only in relation to other bits of matter in some specified observational framework. To make the space that we know about only in observation independent of that observation and then think of the observation as mediated by light travelling in that observational space was therefore, for Mach, to turn common sense thinking inside-out.

Unfortunately, the stereotype of 'subjective idealism' which stuck to Berkeley's phenomenalist approach to physics ended any chance of Mach's physics colleagues seriously considering it as a valid alternative to their classical absolutist approach, even though it now seems to provide a far more suitable basis for understanding modern relativity and quantum theory than their absolutism ever could. In following their own metaphysical brand of idealism that, in the Johnsonian way, they presumed to call 'realism', modern physicists have been forced to abandon logic itself in contriving solutions to such problems as how light can travel both as particles and waves, and how relativistic time-delay can be squared with quantum instantaneity (the so-called 'EPR paradox'). So now students of Physics are taught, as a condition of entry into the subject, to 'leave common sense at the door' and accept, as the object of study, a 'nature' in which the light by which we see things travels inscrutably in a vacuum, in little bullet-like light-particles called 'photons' which travel more like waves than particles, clairvoyant as to their destinations, at a speed which is relative not only to the vacuum itself but also to all the various bits of matter within it, whether relatively moving or stationary.

What bedevils the situation is the easy facility of the idea that 'light travels'. We see beams of sunlight slanting through clouds and across dusty rooms. We see them cast shadows on walls, we reflect those beams with mirrors, focus them with lenses, direct them with lasers and so on, in all those ways known to the science of optics. Nothing, we think, is more obvious than 'the fact' that light travels. When scientists after Römer established that there is a constant ratio of distances in metres to times in seconds now known as *c*, it seemed just 'plain commonsense' to interpret that as the discovery of what Einstein eventually called 'the constant speed of light *in vacuo*'. But as it turns out, that 'easy facility' was just a trap. The first hint that this was so emerged towards the end of the 19th century in the notorious experiment by Michelson and Morley which revealed that this 'speed' does not behave in anything like the way a speed should behave. It *should* have dawned on us, there and then, that *c* couldn't possibly be a *speed.* If it were, then that 'speed' would be different for different observers moving about in the space in which the light 'travelled'. What had transpired, however, was that the constant *c* is the same for all observers in the same

way that the constant ratio of inches to meters or pounds to kilograms is the same for all measurers in all situations. In other words, *c* had shown itself to be not a 'velocity' but just a *constant* relating the two sets of conventional units, meters, and seconds, being the same, needless to say, for all observers, no matter what.

However, because all speeds are distances divided by time it was generally assumed that because *c* is distance divided by time it has to be a speed. This was like saying that because all humans are mammals, all mammals have to be humans. One of the first to recognize this fallacy in the 'speed' interpretation of *c* was Herman Bondi who declared, in 1964 [1], that so far as he was concerned, the discovery of *c* was no more than the discovery of the length of the standard meter in standard seconds.

Such, however, has been the social momentum of the 'speed of light' concept that despite its being so obvious a fallacy, and despite the continual piling-up of perplexities associated with it, the concept has resisted all attempts at interpreting it in any other way, far less in the much simpler and more logical way indicated by the likes of Bondi. Why is this? It is because despite all the problems it creates, the original idea that light 'travels' remains for most of us, the easy option. Not only that, but since Einstein, the concept has become embedded as an axiom of Special Relativity. This Second Postulate is, of course, that 'light travels *in vacuo* at the constant speed *c*'. The fact that Bondi and others (including this present writer [2]), have shown that all the practical consequences of relativity can be deduced *much more simply* on the basis of *c* being no more than a constant ratio of units has remained all but completely ignored.

The trouble is, of course, that it is not so easy to see how light can form beams, cast shadows and so on, when thought of in that non-velocity way. Even Bondi himself, whilst concurring with this present author that relativity can be expressed much more easily without the 'speed of light', did not wish to be involved in any philosophical discussion about it. He said he was content to accept *c* on that non-velocity basis purely for the sake of simplicity in the teaching of relativity.

People of that non-philosophical disposition, and that includes most physicists, particularly experimentalists, would not wish to revise a whole comfortable tradition of thought just for the sake of logical tidiness in thinking about light. So, while all experiments and observations point to the fact that light is not something travelling in space, we are stymied to think of what else it might possibly be. And in these frenetic times, most people are just too busy to think about it, anyway.

Berkeley, however, did think about it. In 1709, his book *Towards a New Theory of Vision* sought to explain all the principles of optics in this purely phenomenological way. In its time, this was hailed as a brilliant piece of writing on our perceptions of space, and its conclusions became widely accepted by modern perception-psychologists. The work, though, had no impact on physicists, who regarded it as a piece of pure psychology. The time was simply not ripe for a theory of that kind to be considered as a contribution to physical science.

Undoubtedly, Berkeley's theory would have had more impact if it had been written contemporaneously with the current situation involving relativity and quantum theory where the old hard-line division between matter and our observations of it has become more and more blurred. For instance, Berkeley could have argued that what Einstein called 'photons' are not little space-travelling light-corpuscles but the ultimate bits of quantum *information* which allow us to know about the universe. Also, he would scarcely have failed to notice that there is no possible way of

describing what these ‘photons’ *do*, how they ‘exist’, ‘behave’, or whatever in the distance between what we classically think of as the ‘emitter’ and the ‘absorber’. As Gilbert Lewis pointed out in 1926 [3], so far as the ‘photon’ is concerned, its ‘emission’ and ‘absorption’ are one and the same event, its intrinsic or ‘proper’ time of transit being exactly zero according to relativity. In that case, Berkeley would surely have declared that this made nonsense of any idea that light travels in space, and that the simpler and most logical way to interpret these facts would be to think of the space as an informational read-out from patterns and sequences of these quantum ‘blips’ in a manner similar to that in which video scenarios are projected by the viewer out of purely digital information. This ‘relativises’ matter, space, and time with as much facility in the context of modern physics and technology that is surely comparable with that of ‘light-velocity’ in the context of the classical paradigm. In this relativist, or relationist way of thinking, in observation we are in *direct interrelation with objects themselves* – and so, by the same token, are all objects with one another. This makes all talk of a material reality remote from all our perceptions of it entirely unnecessary. [4]

For Berkeley’s phenomenalist successor, Mach, this implied a universal holism in which everything is directly and instantly connected to everything else, a consequence which relativists have embraced as ‘Mach’s Principle’, although not necessarily accepting – or even understanding, in many cases – the philosophy on which it was based. One of the physical consequences of this holistic principle is that masses do not move independently of one another, with free momentum *mv*, in straight lines, as Newton assumed, but are automatically paired and balanced in angular momentum cycles of the sort we observe in the orbits of all astronomical bodies [5]. This makes redundant the idea that all masses are connected by an *in vacuo* ‘gravitational force’ without which, travelling independently of one another in straight lines, they would inevitably disperse towards infinity.

Another physical consequence of this phenomenological holism is as follows. Angular momentum is *action* divided by 2π, and since action (the product of energy and time) is irreducible below the quantum limit set by Planck’s constant *h*, the angular momentum that manifests itself in the motions of planets, stars, and galaxies is ultimately *atomic*, that is, it is irreducible below the quantum limit $h/2\pi$. These ultimate angular momentum cycles correspond to the ‘atoms’ of traditional chemistry after Dalton. Furthermore, their inner constitutions, at their simplest, are precisely as described by the elementary hydrogen model of Niels Bohr [6]. And in the same way that *in vacuo* ‘gravitational force’ is made redundant by angular momentum, so is *in vacuo* ‘electrostatic force’. This is because the ‘electric charge’ of the electrodynamical tradition is replaced by the intrinsic spin angular momentum of elementary masses which, as part of the overall angular momentum equation, form orbits around one another that are much tighter than those of ordinary non-spinning or slow-spinning masses. Indeed the parameters of these atomic angular momentum orbits, when calculated, match precisely those of the Bohr radius and Bohr velocity – but, of course, without involving any of the usual electrodynamical hypotheses [7].

This neo-Berkeleyan approach to physics, then, matches point-for-point the purely practical findings of classical physics but is much more conceptually economical. It is also more apposite as a basis for modern theoretical physics. Matter, for instance, is now *relative*, not absolute, and *atoms* are not remote, self-sufficient objects but the terminals of reduction of the phenomenal space-time scenario of mass, time and motion. As well as being relative, these measures are quantised. At these

terminals of reduction, motion is no longer motion, mass is no longer mass and time is no longer time, as ordinarily understood. The quantities with which we start on the ordinary level converge into inseparable and irreducible packages of these basic measures in which the further reduction of any one of them increases another, and vice versa, so that the overall package remains the same. These packages of dimensions are the quanta of angular momentum $h/2\pi$.

Unlike the 'atoms' of yore, these quanta, in themselves, have no causal interconnections. This by no means implies that mechanical causality has to be abandoned. The atoms are automatically linked insofar as they are parts of the original whole. These 'links', however, are not mechanically determinate. That is to say, they do not *cause* the whole to be what it is. The *whole* is the cause of the parts rather than the *parts* being the cause of the whole. For the phenomenalist's top-down approach to atomic physics, therefore, the Democritan approach to causality is upside-down.

But if the parts of bodies are not Democritan atoms, then what are they? The answer phenomenalism gives is that they are the ultimate informational bits into which all phenomena analyze. As such, their linkages are not mechanical but *stochastic*, as all informational elements have to be in information-theoretical contexts. For instance, if there were mechanical rules determining how the letters of the alphabet followed one another, there could nothing like newspapers conveying news or writings conveying any sort of information. For there to be *information*, all informational elements have to be intrinsically free of one another. That is to say, on their normal, non-informational level their linkages are completely random, their sequences being governed by nothing more than the statistical law of probability. In our neo-Berkeleyan context, the most probable – *i.e*. least informational – linkages are those that take place in accordance with the statistical Second Law of Thermo-dynamics. In accordance with this law, in any concentration of atoms which is statistically of higher energy than another – as, for instance, in the sun with respect to the Earth – the energy will 'flow' (statistically speaking) from the higher to the lower. In this process there is also, in the case of the sun and the Earth, the phenomenon of photosynthesis in which the statistical law is reversed in favour of less probabilistic, more informational, processes, like that of the construction of the sorts of molecules on which all life is based. In this context, the traditional schism between Physics and Biology disappears and is replaced by a single Informational science in which Mechanics deals with phenomena such as machines at one end of the probability-scale and the Life-Sciences deal with organisms such as man at the other.

Yet another way, then, in which phenomenalism is more suitable than classical absolutism as a basis for modern physics is that it puts indeterminacy right at the root of the subject in the way that Heisenberg has established. This makes it clear that in the language of physics, words and phrases such as 'position', 'motion', 'mass', 'distance', 'duration' 'cause', 'effect', and so on, take their meanings from our ordinary macrophenomenal level of experience, not from some presumed 'God's-eye-view' knowledge of absolute atoms in an absolute space. It is in this ordinary-language sense (*pace* Wittgenstein) that we speak of atoms as 'emitters' and 'absorbers' of light-energy. The transactions of light-energy between these atoms take place, as already stated, in *action* units *h*, in which some quantum of angular momentum disappears from one body to appear in another. These atoms are best thought of, therefore, as accumulators of angular momentum, absorbing and emitting stored energy (action) in the systematic way that is described in the Balmer-Rydberg formula for the light spectrum. Since angular momentum is a conserved quantity,

these exchanges of angular momentum between one quantum accumulator (the emitter) and another (the absorber) in action-units *h*, have to be instantaneous and unmediated. There is, however, no conflict of the alleged 'EPR' kind between this quantum instantaneity and Einstein's portrayal of the constant *c* as a finite velocity-limit on all forms of physical interaction. This, of course, is not only because *c* is *not* a velocity – far less a limiting velocity – it is also because in the relativistic time-equation the transition-time of the quantum (misnamed the 'photon') is, as already stated, intrinsically zero.

To rethink these 'photons' of Einstein's as purely stochastic elements of phenomena provides, in this modern age of computers and information-technology, a conceptual model of light that is at least comparable in ease of understanding with that of 'light-velocity' during the mechanical era of the clock and the steam engine. All that is needed – although far from easy – is a radical change of *habit*.

Now this, it will be said, is all very well, but how, in these new quantum-informational terms, do we explain the phenomenon of light forming beams, casting shadows and so on, that was so easy to understand in terms of 'light travelling'? So far as shadows are concerned, the answer is that since the light-quanta are irreducible, they cannot be shared between more than one recipient at a time. This means that if between, say, the sun and a wall, an opaque object is interposed, the atoms in that intervening object will absorb the quanta that would otherwise be absorbed by the wall. No problem there! What about light-beams? It is well known that in clear atmospheres no such beams are visible, that it is only when particles of dust or moisture are introduced between light-sources and sinks that the 'beams' become visible. This of course, is because in absorbing light quanta the atoms (quantum accumulators) in the dust particles are energised, and in reverting (very quickly) to their more normal states the particles release that stored light-energy, becoming sources in themselves. In this way, the particles of dust or whatever between the sun and the wall, particularly in smoke-filled rooms, appear as the familiar 'rays' or 'beams' without any implication whatsoever that light 'travels'.

Why, then, do these rays or beams take time to travel from a source to a mirror and back in the classical experiments that were used to determine 'light velocity'? The answer is that in these experiments, nothing *travels*. The distance/time relation that the experiments measure is not the *velocity* of anything. As already explained, it is *the distance-time relation itself*, in the constant ratio of units *c* between any one point in space and any other. It is like the distance-time relation between events in a video scenario, where no matter how or at what speed the objects and actors move about relatively to the viewer, the rate at which the informational blips on the magnetic tape are processed remains the same throughout [8].

As for the 'wave'-like character of light in experiments on refraction, diffraction, interference, and so on, every quantum has its characteristic period which determines its place in the light-spectrum. The period is the inverse of the quantum energy divided by Planck's constant *h*. This, of course, is a measure of time, and so is the distance-divided-by-*c* between the interacting atoms. It is only when these two measures are resonant that the atoms interact, as witnessed in the Mössbauer effect involving gamma interactions [9]. This condition is the same as applies to waves, which characteristically resonate with oscillators that are 'tuned' to them. The vital difference, however, between these quantum interactions and wave-interactions is that whereas waves cannot exist without a supporting medium in which they travel at a finite speed, quanta are instantaneous and non-mediated in the way that has been

described. This means that in quantum interaction there is no question of waves having to be particles and particles having to be waves. In our neo-Berkeleyan way of thinking, that notorious conundrum of 'wave-particles', which has bedevilled modern physics, is a conceptual non-starter.

Nor do we have to think of waves being responsible for refraction. Refraction is classically conceived as a slowing of the speed of light-conduction in a medium such as glass or air, being proportional to the density of the medium. As we have seen, this does not logically imply a 'speed' of anything through the medium. The whole process can be easily conceived as purely 'cinematic', or time-sequential, in the same way that the impression of motion which perception theorists call the '*phi* phenomenon' is created, for example, by the light-bulbs that we see flashed in series on advertisement hoardings. The difference with light-mediation is, of course, that being reducible to atoms instead of lightbulbs; the phenomenon is much more fine-grained. Also, each stage in the relaying-process is a proper-time instantaneous, one-to-one connection involving no more than just two atoms at a time. The delayed or refracted speed is then the distance through the medium divided by the time taken for the relaying atoms to absorb and re-emit the transferred energy. Since this is a function of the frequency of the relayed energy and the atomic energy-density of the medium, the time of the relayed light-energy, hence its direction, will be 'slowed' in the way that is well known in the science of optics [10].

Conclusion

There is very little practical difference, then, between the sorts of explanations of optical phenomena that are supplied by our phenomenalist, or information-digital theory and classical wave-theory. This saves us the bother of having to transcribe every last detail of classical wave-theory into the quantum-digital mode. It is sufficient for present purposes simply to note that the science of geometrical optics can be replicated in the same way as in standard wave-dynamics, except that the 'waves' are not *waves* but pure wave-like probability-functions of series of quantum events as described by Schrödinger.

But if there is so little practical difference between the two, then what advantage can there be in switching from the classical mechanistic into the neo-Berkeleyan, quantum-informational way of thinking? One might as well ask what were the advantages of switching from the original Ptolemaic to a Copernican world-view. The answer is the same: that reversing the order of 'light in space' to 'space in light' is at least as significant as cancelling the idea that the sun goes around the Earth and replacing it with the modern view of the Earth going round the sun. Such conceptual shifts fundamentally change man's relationship with nature. In the Copernican case the earth lost its Biblical uniqueness and became no more than just a very small body among countless others in the universe. In the neo-Berkeleyan, quantum-informational case the change is from thinking of the world as a machine to thinking of it as something more like an organism.

No longer then, can we blame our atoms for what we do or don't do. The responsibility for our actions and their outcomes is well and truly ours, both individually and corporately. No hard and fast cut-off point separates physical laws and moral laws, nor is there any remaining schism between sciences such as Physics and Chemistry on the one hand, and the natural sciences such as Biology, Psychology and Sociology on the other.

In short, the result of switching from the classical mechanistic into the new quantum-informational mode, if it should ever be allowed to take place, would be to make science altogether more humane. The science that began as the *physis* of Democritus would be replaced by the *logos* of Heraclitus, and anyone who thinks that such a wholesale shift in world-outlook would be inconsequential, will be very much mistaken.

References:

[1] Bondi, H., Assumption and Myth in Physical Theory, CUP. 1965, 28.

[2] Pope N. V. and Osborne A. D., 'A New Approach to Special Relativity', *International Journal of Education in Science and Technology*, **18**, 2 (1987); also, Pope, N.V., 'Relativity is Kids' Stuff' School Science Review, **70**, 253 (1989) 86-87.

[3] Lewis, G. N., 'Light Waves and Corpuscles', Nature, **117** (1926) 256.

[4] This notion of an absolute material reality remote from all our perceptions and ideas of it was introduced into Western physics by the 17th century French philosopher Descartes. Called *dualism* the idea was rejected by later philosophers on the irrefutable logical grounds that we cannot sensibly claim to *know* of a world that is beyond all possible direct knowledge of it.

[5] See Pope, N. V. and Osborne, A. D.: 'Instantaneous Gravitational and Inertial Action-at-a-Distance', *Physics Essays* **8**, 3, 384-397 (1995).

[6] Osborne, A. D. and Pope, N. V.: 'An Angular Momentum Synthesis of "Gravitational" and "Electrostatic" Forces': *Galilean Electrodynamics*, **14**, Spring Special Issue 1, (2003), 9-19. See also www.poams.org

[7] *Ibid*.

[8] The relativistic space-time equation shows very clearly, that when the intrinsic or 'proper' time of the quantum transition is zero, the relative time, or observer-time of that same transition is the delayed time, which is the distance in metres divided by the constant *c*.

[9] See also Pope, N. V.: 'The Tantalising Two-Slit Experiment', in *Recent Advances in Relativity Theory*, *Vol. 2: Material Interpretations*. M.C. Duffy and M. Wegener, eds., Hadronic Press, (2002) 218-227.

[10] See correspondence with Karl Popper, June 24, 1985, in *Philosophical Glimpses*, Vol. 8, 2957, Swansea City Archives, ref. D/D NVP/1-17, http://www.swansea.gov.uk .

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