

Revised, Second Edition, 2006 from the original publication, *Recent Advances in Relativity Theory 2*, Hadronic press, Palm Harbor, FL 34682-1577, USA. Eds. M.C. Duffy & M. Wegener. pp. 218-226

THE TANTALIZING TWO-SLIT EXPERIMENT

*Viv Pope, "Llys Alaw", 10 West End, Penclawdd, Swansea, SA4 3YX, UK
Affiliation: Keele University Mathematics Department, Keele, . Staffs., UK.*

From a talk delivered to the PIRT (Physical Interpretations of Relativity Theory) Conference at Imperial College, London, in 1996, held under the auspices of the BSPS (British Society for the Philosophy of Science).

ABSTRACT

The continued inability of physicists to explain the mysteries of action-at-a-distance without invoking metaphysical hypotheses about 'superluminal' influences and so on, suggests that something is radically wrong with our present ways of thinking about nature. If that is so, then nothing less than a radical overhaul of those current ways of thinking may be necessary. Accordingly, this paper analyses the standard historical conceptions of distance, time and motion that have created these conundrums and presents a radical, ahistorical alternative to the present conceptual course. It is claimed that this is more logical, more direct and more conceptually efficient than the usual historical route and that nothing less than this radical overhaul of our ideas about nature – this paradigm switch, in effect – will suffice to explain the chronic enigma of the two-slit experiment. The point of departure for this new paradigm is a logical revision of the customary 'velocity *in vacuo*' interpretation of light and the constant, c .

1. NECESSARY PRELIMINARIES

For every motion there are *two* velocities. One is the distance a body travels between A and B in the time measured by the observer of that motion; the other is that same distance as seen by the same observer, but registered by the time, called the proper time, of the body itself as viewed in the telescope, say, of the observer of the motion. The first of these is what we may call the Einsteinian velocity, which tends to the finite limit c . The other is precisely Newtonian and tends to a limit of infinity. In classical physics there is no such distinction between these two velocities. This, we claim, is the root cause of the present confusion over relativistic time-delayed and quantum-instantaneous action-at-a-distance.

Now it needs to be stressed that these Einsteinian and Newtonian accounts of the motion of a body, although numerically different, are nevertheless no more than two different-dimensional aspects of *the same observed motion*. That is to say, they are both equally applicable. Unfortunately, the circumstances of the history of our academic science have made it seem that the two accounts are in some sense antagonistic, that they are contradictory and that the Einsteinian theory of motion has somehow replaced the Newtonian. This creates a false dichotomy. In truth, the two accounts are entirely complementary and inter-derivable, each with its own special application for the conduct of physics, the Einsteinian for the relativistic aspect of physics, and the Newtonian for the quantum aspect.

1.1. Natural relativity

For instance, on the evidence provided by Römer *et al.*, all *distances* of bodies in observer-space are *times* in the constant ratio of units c . This enables us logically to deduce the relativistic time-dilation of Einstein and Lorentz in the following unusual but very straightforward and conceptually economical way. Let s/c be the observational distance-time, measured in seconds travelled by an object, P, in the time (proper time) t_p , also in seconds, of that object itself over that distance as seen, say, in the telescope of the remote observer, O. These measures s/c and t_p are now axes of a graph whose units are fixed. That is to say, unlike an ordinary scalar graph, the axes of this time-graph of s/c by t_p are dependent variables, measured in the same units of seconds, which means that there is a geometrically

significant resultant, t_R , measured in seconds, of those two orthogonal time-components ^[1]. This resultant is, by Pythagoras:

$$t_R = \sqrt{t_P^2 + (s/c)^2}, \quad (1)$$

(See Fig. 1, below)

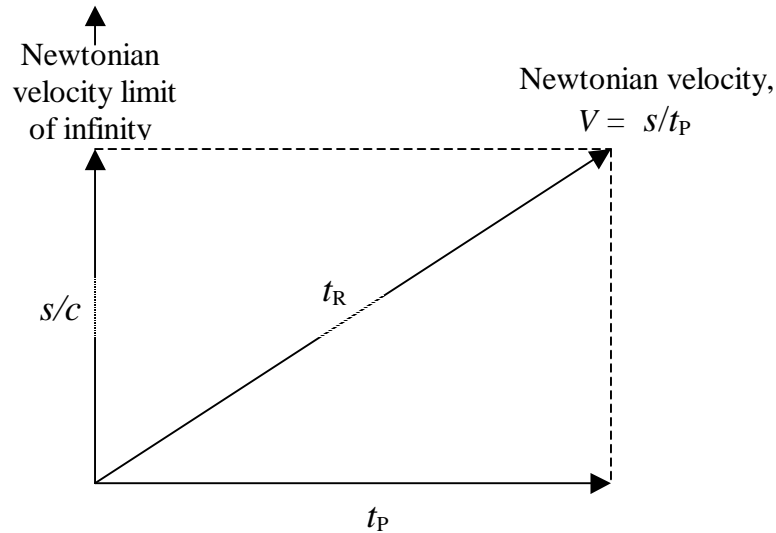


Fig. 1. The geometrical (geometro-temporal) resultant, t_R , of the rectangular time-components s/c and t_P .

This formula, (1), is easily recognisable as the time-dilation formula of Lorentz and Einstein. For instance, since the *relative* velocity v of the body is the observational distance s divided by the time t_P registered by the body as observed by O – that is, the relative time t_R – we have $v = s/t_R$, from which it follows that $s = vt_R$. Substituting for s in (1) this equivalent expression vt_R , yields:

$$t_r = \sqrt{t_p^2 + (vt_R/c)^2}, \quad (2)$$

which simplifies directly to the standard relativistic equation:

$$t_R/t_P = 1/\sqrt{1 - (v/c)^2} = \gamma. \quad (3)$$

1.2 The non-velocity (pure constant) interpretation of c

Now the first thing to notice about this very simple, ahistorical, neo-Newtonian derivation of relativistic time-dilation is that it requires no mention whatsoever of the Einsteinian "light speed in vacuo". That notoriously perplexing notion of light as something travelling invisibly with a speed that is constant relative to the vacuum and to everything else in that vacuum, whether moving or stationary, is made redundant ^[2]. Instead, the empirical constant c is taken simply as what Herman Bondi calls a conversion factor for converting Römer's distance-measure s in metres into a number s/c in seconds ^[3]. So we have the constant relation of units:

$$1 \text{ metre}/c \approx 3.3 \text{ nanoseconds} \quad (4)$$

In this neo-Newtonian depiction of motion, then, there is no question of the "Einstein separation" which makes a mystery of the seeming "clairvoyance" of particles in the Thomas Young two-slit experiment and other experiments dealing with the phenomenon of action-at-a-distance. In this new, non-standard account of the facts of modern physics, such mysteries simply don't arise. Nor, by implication, should they arise in the orthodox, Einsteinian

account, since the two accounts are no more than alternative aspects of *the same relative motion*, with the only difference being that in the Einsteinian account, c is a ‘velocity’, whereas in the Neo-Newtonian account c is no more than a constant for converting metres into seconds and vice versa. However, having said that, the implications of this merger of Newton and Einstein for the future conduct of theoretical physics and the understanding of nature generally, are hugely different

1.3 The Pythagorean space-time-cone

The Pythagorean formula (1), which is basic to both accounts, contains three variables. This means that the usual two-dimensional depiction of motion as a plot simply of the two variables, distance by time, is inadequate. For instance, if, instead of plotting a motion against the axes s/c and t_p as in Fig. 1, we plot it against s/c and t_R , then we obtain the typical relativistic or hyperbolic depiction of the same motion, shown in Fig. 2.

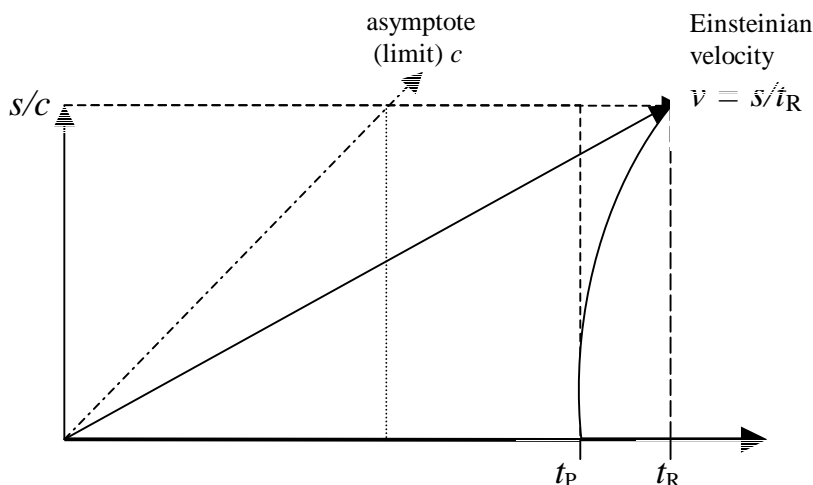


Fig. 2. The hyperbolic depiction of relative motion (plot of s/c by t_R)

A full depiction of motion in accordance with the Pythagorean equation (1) is therefore not just two-dimensional but *three-dimensional*. That is to say, it is not a chart or flat surface but a *model*. Nor does that model need to be fanciful, since mathematicians will recognise formula (1) as the equation for an equilateral conic surface, of which Figs. 1 and 2 are the end- and side-elevational projections, respectively. In Fig. 3 the motion vector s/c (the equilateral hyperbola of fig.2) is shown in the different views of a conic section (see inset)..

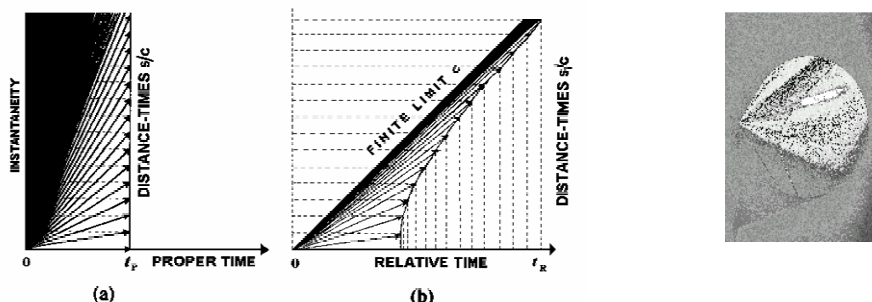


Fig. 3 The Two geometrical aspects of the time-formula $t_R^2 = t_p^2 + (s/c)^2$ showing the instantaneous and time-delayed aspects of c

On the left of the figure (end-elevation of the cone) we see a series of regularly increasing velocities plotted as the distance-times s/c travelled by bodies in some standard time t_p registered by those bodies themselves as viewed in the telescope of the observer. On the right (side-elevation of cone) we see those same motions as the same distance-times s/c travelled by the bodies but in the *relative* time t_R of the observer of the motion (*i.e.*, the observed time of the motion minus the distance-time s/c). In the first figure, the limit of the velocities s/t is infinity; in the second, the limit of the velocities (s/t_R) of those same motions is the asymptotic so-called ‘finite speed’ c .

The usual depiction of motion as a flat, two-dimensional surface or graph is therefore seen as an insufficient depiction of motion and is replaced, here, by a three-dimensional conic surface on which both the instantaneous and the time-delayed aspects of c are portrayed together. This Pythagorean time-cone should not be confused with the light-cone of Eddington. It is simply a graphic portrayal of the geometrical relations between the dimensions of motion, of which there are, altogether, five, comprising the three dimensions t_s , t_R and s/c , as well as the two other spatial dimensions of the latter which, in these diagrams, are suppressed for reasons of simplicity^[4]).

1.4 Natural force-free motion is not straight but orbital.

With the assurance that in dealing with the Newtonian aspect of motion we are also dealing, by implication, with the Einsteinian, let us take another look at Fig. 1. One reason why we refer to this depiction as neo-Newtonian is because it incorporates Bondi's distance-time conversion factor in a way which, due to circumstances of history, could never have occurred to Newton. Another reason is that although the motion depicted in that figure appears rectilinear, this is only when the figure is taken as a tiny section of a much larger depiction in which the tracks of all force-free-moving moving bodies, *in extensio*, are curved. This is because the Neo-Newtonian representation rejects Newton's dictum, as expressed in his notoriously unempirical First Law of motion, that all force-free (*i.e.* "inertial") motion takes place in straight lines. The new depiction takes account of the empirical fact that, in nature, the trajectories of freely moving bodies are never straight but curved. This avoids the Newtonian "rectilinear" assumption according to which a plethora of invisible *in vacuo* "forces", such as "Newtonian force", "Coulomb force", *etc.*, have to be assumed responsible for accelerating those bodies away from their supposedly straight-line trajectories. Without that "rectilinear" assumption there would be no need whatsoever for those *in vacuo* "forces".

The *Scheinproblem* this has bequeathed to physics, namely that of "unifying" these fictitious "forces" has enervated and defeated the very best of intellects – as how else would it be since those "forces" are unreal? Besides, as Aristotle argued, a force-free – *i.e.*, uninterrupted – motion cannot be rectilinear because a straight line, unless it is infinitely long, has a definite beginning and end and is thus interrupted. All *finite* force-free motion, Aristotle concluded, is therefore cyclic, or orbital, which is far more in direct agreement with the natural facts than Newton's eminently unempirical First Law. Newton's conception of rectilinear inertial motion as momentum mv is thus, from the Aristotelian point of view, the limiting case of an angular momentum mvr where r is always implicit and, in Newton's ideal case, infinite; which implies an infinite angular momentum. From this it follows that, in all *finite* measures of angular momentum, r is also finite and the motion, therefore, non-rectilinear. Indeed it transpires, as we shall see, that angular momentum is sufficient in itself, by its very nature, to account for orbital trajectories without involving postulates such as an *in vacuo* "force of gravity" or any similar "forces" of "electrostatic", "magnetostatic", nuclear or whatever.

1.3. Angular momentum is quantised.

Another advantage of this Neo-Newtonian, angular momentum interpretation of force-free motion is that not only does angular momentum automatically link everything together, but also, unlike Newton's truncated concept of continuous momentum, angular momentum is fundamentally *quantised* or *discretised*. This is in ultimate units of \hbar (h -bar), which is Planck's constant h , divided by 2π . This follows from Planck's (and Einstein's) discovery that the quantity *action* (the product of energy and time) is irreducible beyond the level of the quantum h , whence it follows that angular momentum, which is $action/2\pi$ is also quantised in that same way^[5]. Newton's Euclidean *continuum* of space (the so-called "inertial space") is thus replaced, in the neo-Newtonian account, by an angular momentum *discretum*. This obviates any need to suppose that the influences exerted by bodies on one another are due to "forces" exchanged between them *in vacuo*, as if those masses possessed, in themselves,

some static metaphysical *vis gravitata*, *vis electrica*, or whatever. By definition, angular momentum is sufficient in itself to explain those influences since, a), it signifies an automatically balanced, paired and therefore instantaneous relation between masses and, b), conservation demands that in a balanced angular momentum relation no mass can change its motion without immediately affecting the others, regardless of their distance r apart.

1.4. Instantaneous quantum action-at-a-distance

All distant actions of bodies on one another, therefore, due to these holistic shifts in angular momentum, have to be instantaneous. This, as we have seen, presents no problem from the neo-Newtonian standpoint depicted in Fig.1, in which no question of "Einstein separation" arises. In this ahistorical account, the motions of all masses are correlated automatically and instantaneously (*i.e.*, proper-time-instantaneously), with no question of fictitious "forces" being responsible for those correlations nor of those correlations being delayed or suspended for any length of time due to having to "travel through space". The different strengths of the *real* forces which are required, according to Newton's Third Law, to prevent masses from following their natural force-free orbital trajectories are sufficiently explained by the conservation of angular momentum, according to which the addition of spin angular momentum to the free orbital angular momentum of a body changes the value of G in the following equation:

$$J = mv_p r = 2\{K_O + K_S\}r^*/v_p = \bar{G}mM/v^* \quad (5)$$

In this equation, all the variables are Newtonian (non-relativistic), m being the mass of some atomic particle, or *ensemble* of particles, and $v_p = s/t_p$ being its proper orbital velocity when $K_S = 0$. (K_O is the orbital kinetic energy, while K_S is any additional kinetic energy such as, *e.g.*, spin), \bar{G} is a factor which is equal to the gravitational constant G when K_S is zero, while r^* and v_p^* are the changed values of s , r and v_p for \bar{G} not equal to G . M is the balancing counter-mass, taken for reasons of simplicity to be infinite, so that no account needs to be taken of wobble ^[6].

Since angular momentum is quantised in discrete units of \hbar , angular momentum can be lost or gained only in integer multiples, n , of that fundamental unit. Moreover, conservation demands that for an amount of angular momentum $n\hbar$ to be lost at one place, exactly the same amount of angular momentum must be gained somewhere else, and since the transfer is immediate (*i.e.*, proper-time-instantaneous), there is no distinction, at the quantum level, between cause and effect in that transfer. So far as the quantum is concerned it is present at both places at once, with no question of "velocity" being involved. The connection between the "emitter" and the "absorber" of that quantum action is therefore, as Gilbert Lewis once described it, a veritable physical "touching" ^[7]. This "touching" takes place in accordance with Newton's Third law of equal and opposite action/reaction which, since it is immediate, involves no question of mediation by any space-travelling "waves", "wave-particles", "photons", "gravitons" ... or whatever.

1.4. The holistic character of physical apparatuses

Every bit of mass that we observe is therefore, inextricably, part of an overall connected or correlated angular momentum system in which there can be no isolated, absolutely independent condition of "locality". All positions and motion trajectories are proper-time--instantaneously linked together, albeit not monolithically but sporadically in overall-conserved statistical numbers of these various overlapping quantum touchings. This is in the manner of a currency, where (barring the counterfeiting and destruction of coins), regardless of how irregularly or spasmodically the monetary transactions take place, economic stability overall is maintained.

Like that monetary currency, then, the angular momentum nexus as a whole, is a Heraclitan rather than a Parmenidean continuum. That is to say, it is not an absolute

continuum in which everything is instantly, simultaneously and permanently (*i.e.*, monolithically) connected. It is a *discretum*, whose permanence or continuity, to employ a simile of Heraclitus', is like that of a candle flame burning steadily in still air while everything within it is in a constant state of flux. Angular momentum is therefore the principle which, automatically, both separates bodies and keeps them together as a whole. This is the same for the constituent particles of physical bodies as for the bodies themselves, on all levels from microphysics to astronomy, including ordinary bits of furniture and scientific apparatuses such as that of the two-slit experiment.

1.5. The physical phenomenon of distance

But if everything is connected in this immediate, proper-time-instantaneous way, then of what does *distance* or *length* consist? The answer is as follows. There is, as we have seen, no distance nor time involved in a single quantum touching. Distance at the ordinary *macro-physical* level is an informational projection from patterns and intensities of these quantum events as they impinge (proper-time-instantly) on an object such as a pebble, a photographic plate or the eye of an observer. This is according to the equation:

$$s/s_0 = I_0/I \quad (6)$$

where s is the distance, I_0 some standard intensity (*e.g.* one candela) at some standard distance s_0 , and I is the actually measured intensity of the interaction ^[8]. These informationally projected distances s , since they are composed of instantaneous quantum touchings, are also instantaneous, and since that proper-time instantaneity is the same in all observational frames, the distance s is invariant and thus an absolute feature of the neo-Newtonian discretum. This optical principle applies, of course, not only to human vision but also, and essentially, to interactions between bodies such as sunshine on plants, planets, pebbles and so on. This same principle applies, of course, to the light-source and screen in the typical two-slit experiment.

It remains the case, however, that there can be no question of distance or causality in a single quantum event. Each quantum jump from A to B is a completely consummated and irreducible event in which the "emission" and "reception" of that quantum are co-determinate. That is to say, in quantum time, in observing the screen "image" of the quantum (that is, the quantum flash, or pixel) one is also, in that same instant, observing the "source". These instantaneous "images" are therefore comparable to the photographs called "stills" in cinematography, or the pixel events on a video screen which consist of informational patterns and distributions of photographic grains. In these quantum stills or pixel-events, there is no question of motion or causality between one still-frame or grain and another or between objects in the distance and those in the foreground. The phenomenon of physical motion is, in this sense, essentially *cinematographic*. With this comparison in mind, physical motion at the ordinary macroscopic level, including that of light-signals in experiments of the sort conducted by Thomas Young, Albert Michelson *et al.*, may be said to consist of cinematic sequences of such three-dimensional quantum projections or "stills", as in a movie or video scenario. This "flip-side" way of thinking about light puts a whole new complexion on alleged mysteries such as that of the two-slit experiment and paradoxes like that of "EPR" and the seeming irreconcilability of relativistic and quantum physics in general.

The only difficulty in all of this is the intellectual one which stems from the fact that we are accustomed to think of cinematography as an illusion, hence as a false or deceptive impression of reality. What stresses us is the need, if only for the sake of the exercise, to stand that custom on its head: that is, to contemplate what we customarily think of as 'reality' as the illusion and what we actually perceive, *i.e.*, kinematically in this instance, as the true reality. However, philosophers will be aware that this suggested radical alternative, this inverted way of thinking, is by no means new. As a *bona fide* observationist, or relativist approach to physical phenomena (in opposition to classical realism), it has an illustrious history all of its own. Called *Phenomenalism* it stems from the 17th-18th century philosophers,

Berkeley, Hume and Kant, up to its most famous modern exponent, the 20th century philosopher-physicist, Ernst Mach, whose relativism was the inspiration for Einstein. This philosophical alternative still continues, in the name of POAMS (the Pope-Osborne Angular Momentum Synthesis) as an ongoing Research Project in the Mathematics Department of Keele University, UK ^[9].

However, unlike a film sequence, in which the succession of "stills", as the viewer sees it, is predetermined by the film-maker, these quantum sequences are indeterminate, and in *observer-space* they propagate entropically, *i.e.*, causally, at speeds the upper limit of which is the asymptote c (the 45° slope of the cone shown in Figs. 2 and 3). For "cinematographic sequence", in these passages, therefore, now read "wave". A wave, in these terms is a temporal sequence *in observer-space* of elements which, ultimately, are instantaneous quantum jumps, or touchings. This wave is therefore *not* an underlying *precondition* of the observational scenario, as in the Standard Model interpretation of quantum mechanics – that is, as a mysterious “wave-continuum” which “collapses into reality” with the act of observation or detection. It is an integral part of *that very same phenomenological scenario* that contains the observer and everything else including the experimental apparatus. In other words, our *wave* is a cinematic sequence of events which takes place in *real space*, that is, the space of the actual *phenomena* not in some esoteric and inscrutable subspace, as in the standard orthodox interpretation of the “wave-function” as an underlying and continuous substratum.

2. THE TWO-SLIT EXPERIMENT OF THOMAS YOUNG

Like all other objects in the angular momentum system, the two-slit apparatus of Thomas Young exists and acts, in neo-Newtonian proper-time, as an instantaneous whole of the sort already described. In the experiment, the true *wave* is a succession, in delayed-time (observer-time) t_R , of proper-time-instantaneous quantum touchings, or direct inter-resonances between the source and the screen. This is in the dimensions of both s/c and t_P of *the object* and the adjacent dimensions s/c and t_R of *the observer*, as shown in the figures. The frequency of the wave sequence is, of course, that of its component quanta, $\nu = e/h$, where e is the energy of the quantum transition, and its amplitude is the probability amplitude ψ as in the Schrödinger wave-equation.

Our quantum-sequential “wave” is therefore, in effect, the wave-function of conventional quantum wave-dynamics (*i.e.*, the Schrödinger probabilistic “wave-function”) but with three essential differences. First is that there is now no question of any "Einstein separation" between the emitters and absorbers of the wave-energy (*i.e.*, between the atomic "boluses" which are the quantum accumulators of the angular momentum discretum). Second is that there is no need for the notoriously perplexing notion of the space-travelling wave-particle, or “photon”, far less any postulated “ether” to conduct the wave. Third is that there is no distinction between the space of the wave-function and ordinary observer-space. That is to say, there is no esoteric “sub-space”, or “nether-space” of component quantum events. The space of those quantum occurrences and the space of the actual physical *phenomena* are one and the same: that is, both equally *real* in our Neo-Machian, or Normal Realist sense ^[10].

In the two-slit experiment, then, the elements of the quantum sequential ‘wave’ are the discrete, instantaneous quantum jumps between atoms at the source and the atoms of the screen. And, quite obviously, there can be no such thing as a one-ended or open-ended quantum jump. A quantum, therefore, cannot be transacted between the emitting body and the absorbing body unless there is a prior mutual and reciprocal “agreement”, so to speak, between the two parties. That is to say, the action can take place only when the two atoms involved are in direct resonance. This means that, macroscopically speaking, those objects which are holistic *ensembles* of interacting atoms are in continual proper-time-instantaneous contact throughout the whole period of the wave's evolution in observer-time t_R . There is therefore no need to postulate "spooky superluminal" influences racing ahead of the light to

ensure consummation of the quantum interaction. So far as Normal Realism is concerned, the quantum instantaneity and the observational time-delay are inseparable *constituents of* the interaction as in cinematography. The only thing that makes this in any way puzzling is persistence of the false dichotomy created by classical physics between instantaneous and time-delayed distant interaction ^[11].

Like all true waves, then, these quantum-sequential waves are causally (entropically) propagated in observer-space (observational space-time) at speeds up to the limit c which is constant in each and every reference-frame of the sort depicted in Fig. 2. They are reflected, refracted, diffracted, attenuated, and so on, in all those ways familiar to students of optics and ordinary macrophenomenal wave-dynamics.

As is well known, the phenomenon of the two-slit experiment was first reported by Thomas Young, in 1801. He shone a beam of monochrome light on a screen through a pair of slits in an intervening diaphragm and noted the appearance on the screen of alternate light and dark bands, or fringes. This phenomenon is perfectly explicable in terms of standard wave theory as interference between the wavelengths due to the different distances the rays have to travel from the source to reach different parts of the screen. Yet this has since become one of the biggest mysteries of modern physics. Why is this? The reason is that it is inconceivable how this wave-type interference can be caused by "waves" whose ultimate constituents are little discrete light-particles, or *quanta*.

But why should this create a mystery? All waves are cinematic sequences of such discrete events. For instance, a water wave, is constituted of motions which are nothing like that of the wave itself but are small circular motions of the water molecules around relatively fixed points. The only thing that makes this light-interference seem such a mystery, then, is the idea that these energy packets $h\nu$ have been interpreted as "photons" travelling at the same speed as the wave. This is mystifying on two counts. First, a "wave" whose constituents are particles travelling at the same speed as the wave is not a wave, but a moving solid object. Second, particles cannot "interfere" with one another, far less with themselves, to exhibit the sort of interference which is typically observed in the two-slit experiment. Indeed, the two-slit experiment was originally regarded as providing decisive evidence for light being waves, and *not* particles. However, instead of accepting this phenomenon of wave-interference as plain evidence that the wave-quanta cannot be travelling particles, theoretical physicists have thrown all logic to the winds and taken the results as evidence of the existence of a conceptual chimera called a "wave-particle", thereby elevating an absurdity to the level of an esoteric discovery. Whoever subscribes to this "photon" interpretation of light quanta is therefore stuck forever with that chimera and all the mysticism associated with it, for, logically, in no way can waves behave like particles or particles like waves.

To dispense with the concept of the "photon" as a travelling particle (or wave-particle) is immediately to dissolve the 'problem' of the two-slit experiment, since there is no mystery whatsoever in regarding light waves as cinematic time-sequences of instantaneous transactions of energy in quantum packets $h\nu$. Obviously, then, if we refrain from interpreting light-quanta as travelling particles, the mystery of how those particles can cause patterns of wave-interference is automatically solved. Moreover, since the quantum light-wave as it develops remains connected at both ends throughout, any postulate of so-called "superluminal" influences acting ahead of it is, as already pointed out, redundant.

As relatively permanent forms, then, in the overall quantised angular momentum nexus the source and screen in the two-slit experiment are in continual (Heraclitan) proper-time-instantaneous contact *even when no actual light-waves are travelling between them*. Typically, therefore, in the two-slit apparatus, as designed and manufactured, even at the drawing-board stage there are as many whole geometrical lengths as a draughtsman may draw between the source and the screen via the two slits; and every one of these lengths is

potentially a free path for a quantum transaction between directly inter-resonating atoms at the two places.

Let us now, in our minds, send an imaginary wave through the apparatus. This divides the lengths of the paths theoretically into positive and negative half-units of the quantum length $\lambda = hc/\Delta E$, where λ is the wavelength of the imaginary wave, and ΔE is its energy. This means that in terms of those positive and negative half-lengths, the paths themselves, geometrically projected through the two slits, where they intersect at the screen are now either congruent or incongruent. That is to say, where two positive or two negative half lengths coincide, the sum of the potentials at that point is doubled (quadrupled in area terms), and where a positive half-length coincides with a negative one, the sum of the two potentials at that point is zero.

Now we recall that this purely imaginary "wave" is virtually the Schrödinger wave-function, which is cast in terms purely of probabilities, as are the imaginary interference-patterns projected from it. The only difference between our imaginary wave and the equally imaginary probability-wave of Schrödinger is that there are now no hidden variables, such as the underlying "wave-continuum" or "substratum" of current quantum wave-dynamics. Our wave-substratum, far from being a kind of preternatural nether-reality is no more nor less than *the apparatus itself* as a piece of ordinary hardware. That is to say, it is a distance-extended *proper-time-instantaneous whole*. The probabilities or potentialities it affords for interaction are provided by those paths that are geometrically projected through it. These probabilities, of course, are precisely in accordance with the pattern of interference that is actually observed when energy is transacted through the apparatus between the source and the screen.

The "interference" phenomenon, then, is not that of 'photons' travelling miraculously through both slits at once. It is a pure probability potential for that interference as defined by the Schrödinger equation, whose substratum in this case, far from being any metaphysical nether-continuum, is simply *the geometry of the paths themselves*, as neo-Newtonian, proper-time-instantaneous wholes. But, of course, while the geometrical potentiality of the apparatus for wave-interference is holistic and therefore instantaneous, any energies actually conducted through it are relativistically time-retarded. This is in the same way that in a movie, although objects in the space of a cinematographic still are connected instantaneously the sequential or cinematographic motion of those objects, as manifest to the viewer, is time-delayed.

Predictably, then, to place a detector at either of the slits is to terminate the path between the source and the screen at that point, leaving the only path available for that interaction another appropriate one through the opposite slit. This reduces the two-slit apparatus, in that instance, to a virtual one-slit apparatus, in which there can be no expectation of a fringe pattern of interference for that particular interaction. This is confirmed when the apparatus is switched on. With the detector interposed at one of the slits the fringe-pattern is seen to have disappeared, as should any mystery attaching to this result.

Predictable also is that these *path-potentials* will be the same, regardless of how many quantum transactions actually take place. With a probability amplitude so low that even if only one quantum is transferred per month, the cumulative effect is the same as for many transactions all at once – since, of course, *it is the paths in observer-space that interfere geometrically*, regardless of the actual transactions. No less predictable, on the same grounds, is the reputedly mysterious fact that electrons and other "slower-than-c" particles, either in beams or individually, distribute themselves in the final detection area in the same sorts of two-slit interference patterns as for light-quanta. This, once again, is because *it is not the particles that interfere with one another*, or with themselves by duplicating themselves and traversing the both slits, as if that were even remotely possible. What "interferes", as we say, are *the paths, as proper-time-instantaneous wholes*; that is, in congruent or incongruent

numbers of halves of the lengths $\lambda = h/mv$, where m is the mass of the particle and v ($v < c$) its velocity, according to the usual de Broglie relation.

3. PHILOSOPHICAL CONCLUSION

The two-slit experiment simply attests that things function as wholes rather than as collections of autonomous parts. In the same way that our solar system acts as a whole and that a spiral galaxy acts as a whole, with the motions of their parts correlated within the overall-conserved angular momentum nexus, so the two-slit apparatus behaves holistically: that is, in the same ordinary *observer-space* that contains those astronomical and ordinary everyday objects. In our Normal Realist paradigm, this phenomenon is therefore not a “mere observational image” created by atomic events in an underlying and inscrutable nether-reality. It is an item within the one and only reality that there is – or, at the very least, the only reality that can properly concern objective empirical science, namely, the world of the actual physical *phenomena*.

From the point of view of this alternative, Normal Realist paradigm, therefore, what both separates things and ‘cements’ them together as wholes is nothing like the traditional “electrostatic”, “magnetostatic”, *etc.*, “forces of attraction and repulsion”, or the fictitious “gravitation attraction” between masses opposed by an equally fictitious “centrifugal force”. It is simply and sufficiently, *angular momentum* which, according to its magnitude and direction, keeps bodies apart and holds them together. Like motion itself, angular momentum is up-front visible, as distinct from those vacuum-bridging “forces” of Newton, *et al.* which, eminently, are not.

Angular momentum, then, by its very definition, provides the only proper-time-instantaneous balance and interconnectedness of things that is everywhere observable, not least in the phenomenon of the two-slit experiment.

SUMMARY

Wave interference is a natural phenomenon to which, normally, no mystery whatsoever is attached. In every case, the wave is a longitudinal distance-time sequence of local movements taking place in directions more or less lateral to the longitudinal dimension of the wave. In no circumstances do the local wave-elements travel for more than relatively small distances in the direction of the wave, and in no instances whatsoever do they travel continually in the same direction and at the same speed as the wave from beginning to end.

To make a complete mystery, therefore, of wave interference would be to think of the elements of, say, a sound-wave in air, water or whatever, as travelling with the wave at the same speed and in the same direction as the wave. But that is precisely the mystery that is created by the interpretation of the quantum wave-element as a “photon”, hence of light as a stream of such “particles” travelling in a ballistic way at the same “velocity” c as the wave. But for that very strange conception, the results of the Thomas Young two-slit experiment would never have been in the least bit puzzling, and it is only since the introduction of that “travelling photon” concept that they have become so.

Stripped of that bogus “photon” concept, the results of the experiment make perfect sense, despite the fact that light is quantised in discrete elements of Planck’s action-quantum h . The wave-like nature of light is explained in the same natural way as any other wave phenomenon, that is, as an observational time-sequence of discrete events which, in this case, are proper-time instantaneous quantum contacts between the source and screen in the two-slit experiment – or between the source and the detector, as the case may be. These “quantum touchings” (*pace* Gilbert Lewis) are direct, intrinsically distanceless resonances between the interacting atoms at the respective places.

All this, but for Einstein's idiosyncratic concept of the "photon", is as logically consistent with Relativity as with Quantum Theory. Indeed, in this explanation of the two-slit experiment, those two theories naturally merge. But of course, ever since its inception, Relativity has encountered much hostility from physicists of the standard classical persuasion for whom physical "Reality" is an ubiquitous and unquestionable God's-eye-view' of the universe underlying all direct and instrumental observations. Trying to cram the practical results of observational relativism conceptually into that God's-eye-view "Realism" is to hammer the proverbial square peg into a round hole. The two concept-systems or paradigms can never fit together, and every attempt to combine them inevitable creates conceptual distortion, causing the sort of confusion which, in Modern Physics is now witnessed on all hands.

The philosophical slot, then, into which Relativity naturally fits is not the Platonic/Democritan "Realism" of classical physics but the observational relativism or *Phenomenalism* of Einstein's inspirer, Ernst Mach. To complete that philosophical flipover from classical absolutism into true relativism is clearly to distinguish and keep separate those two logically irreconcilable concept-systems, absolutism and empiricism, and sever Einstein's vestigial attachment, as a relativist, to God's-eye-view Realism. What helps to achieve the transition is to jettison the word "photon" in favour of the new word "*photum*" as the more appropriate descriptive term for the light-quantum. This change in nomenclature sheds all the unnecessary conceptual baggage carried by the concept of "light velocity" with which Physics is currently encumbered. In this way, not only is the mystery of the two-slit experiment naturally explained but so, also, are the many other associated mysteries. Among these are the notorious "EPR paradox" and the quantum *action-at-a-distance* of Bohr, Bell, Aspect, *et. al.*, all of which are created simply by presuming to "play God" instead of just using our eyes.

Notes and References

¹ The axes are orthogonal for the usual reason that only in that way, with the dimensions projected at right angles to each other are they prevented from encroaching on one another's domains. They can, of course, be shown other than orthogonally, but that would be an unnecessary complication, with the same results in any case.

² Physicists schooled in classical electrodynamics sometimes have great difficulty with this because "the vacuum" is historically conceived as a conveyor of dielectric displacement-currents propagating at the Maxwellian rate c . Philosophically speaking, however, all that can ever be measured is the effect of a material emitter on a material absorber. Any effect on a vacuum in between is purely theoretical, which means that the customary concept of electrodynamic propagation *in vacuo* is theoretically negotiable. We stress this against the tendency of some physicists to think that what they were taught about electrodynamics is not theory, but "plain demonstrable fact", and that anyone questioning it is necessarily a charlatan.

³ H. Bondi, 1965: Assumption and Myth in Physical Theory, CUP, p.28: "Any attempt to measure the velocity of light is not an attempt to measure the velocity of light but an attempt at ascertaining the length of the standard metre in Paris in terms of time-units".

⁴ It is plain that the other two (suppressed) dimensions of s are also time-measures ct because Römer's time-accompaniment of distance is independent of the point of observation.

⁵ Angular momentum is quantised because it occurs in cycles, which are limited, whereas Newtonian *momentum* without any such definite beginning and end, is unlimited (*pace* Aristotle).

⁶ Pope, N.V. & Osborne, A.D.,1995: "Instantaneous gravitational. and inertial action-at-a-distance", *Physics Essays* 8 (3) September, 384-397.

⁷ Lewis, G.N., 1926: "Light Waves and Corpuscles", *Nature* 117, p.256.

⁸ Pope, N.V., 1996: "Empiricism and the Quantum", 7th Newsletter of ANPA (Alternative Natural Philosophy Association), no. 16, p.12.

⁹ See Internet website: www.poams.org .

¹⁰ See search-engine Google under the title "Normal Realism".

¹¹ See the following publications on instantaneous action at a distance (IAAAD):

-
- i) *Instantaneous Action in Modern Physics: Pro and Contra* (a compilation of various international papers). Eds. A.E. Chubykalo, N. V. Pope, and Smirnov Rueda, Nova Science, NY, USA (1999);
 - ii) *Immediate Distant Action and Correlation in Modern Physics: the Balanced Universe*. Eds. N. V Pope, A. D. Osborne and A.F.T. Winfield, Edwin Mellen Press, USA, (2005). (a compilation of international papers contributed by pro-IAAAD authors);
 - iii) *The Eye of the Beholder: the Role of the Observer in Modern Physics*, Author V. Pope, Phi Philosophical Enterprises, UK, (2003).