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The "twins" paradox of relativity

"What is long overdue is a general summing up of the whole matter, so that the source of the scandal can be located and removed without futile polemic."

by the late Herbert Dingle

In *Nature*, volume 269, page 284 (22 September 1977) I put a question to Dr Tom Wilkie concerning an often advanced suggestion he had repeated for disposing of the twin paradox of relativity. He did not reply, but added a note stating that he would be writing me "privately" on the matter. It was, of course, entirely proper that misunderstandings should be removed before the reply appeared, but although after considerable correspondence this seems to have been achieved, Dr Wilkie has not accepted my invitation to him now to publish his reply. It does not accord with recognised scientific practice that questions considered worthy of publication should remain without published answer, and it therefore become my duty to comment publicly myself on the implications of this incident.

But far more is involved here than the incident itself. The so-called "twin paradox" has been the centre of more or less continuous controversy for more than half a century, and still remains unsettled. Because of its peculiar — I believe unique — character it is no exaggeration, but a considered temperate statement, to call this a scandal, for reasons which I shall show, and what is long overdue is a general summing-up of the whole matter so that the source of the scandal may be located and removed without further futile polemic. This is attempted here and the uniqueness of the problem in scientific discussions made clear, but first it is desirable, notwithstanding its familiarity, to state what the "paradox" is in its simplest form. For brevity and clarity a particular extreme example — that given in my letter in *Nature* of 31 August 1973 — is chosen. There is no disagreement about the legitimacy and typicality of this example, and therefore no begging of the question in selecting it.

Peter and Paul are twins, of whom Paul travels at birth with uniform velocity v to a distant planet stationary with respect to the Earth, and immediately returns at the same velocity having aged by three days, to find his Earthbound twin, Peter, 30 years old. In the general case, any two identical forms of standard clock may be substituted for the twins, and if t is "Peter's" age when "Paul" returns, "Paul's" age at that event is $t\sqrt{1-v^2/c^2}$, where c is the velocity of light. It is evident that in this example v must be very slightly less than c.

Now the peculiar nature of this "paradox" lies in the fact that this has never been observed in any form: the result is wholly a deduction from a theory. In all the traditional controversies or paradoxes of science — the Ptolemaic and Copernican theories of celestial motions, the wave or particle nature of light, etc. — the problem has arisen from *observations*, and what has called for decision has been the correct theory for explaining them. Here the reverse is the case. The dispute is not about what theory best explains the observations (which do not exist), but about what observation — equal or unequal ages of the twins on reunion — is required by an independently accepted theory. And indeed there is an allied peculiarity in that if the observation were made, its result, whatever it might be, would still leave the problem unsolved: the question would still remain, what is wrong with the deduction from the theory of the opposite result? The problem, therefore, lies within the theory itself. Failure to understand the course of nature is excusable and observation of nature might be expected to bring enlightenment: failure to agree on the implications of our own constructed and accepted theories is not excusable. That is what makes the endless persistence of this controversy a scandal.

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Let us assume that the theory is true, and give the net results of the arguments for its requirement of symmetrical and asymmetrical ageing, respectively. The first can be stated very simply. The relativity theories, both special and general, require that it is equally true to regard Paul as moving with respect to a stationary Peter and planet, and Peter and planet as moving with respect to a stationary Paul. Therefore if, as the theories also require, the moving twin ages more slowly than

Herbert Dingle

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Herbert Dingle was a distinguished scientist and philosopher who was Professor of History and Philosophy of Science at University College, London, from 1946 to 1955. Before that he was Professor of Natural Philosophy at Imperial College, from which he had graduated in 1918. His numerous scientific distinctions included the presidency of the Royal Astronomical Society (1951-53) and of the British Society for the History of Science (1955-57); he wrote several well-known books and an enormous number of scientific papers.

The early part of Professor Dingle's scientific career was a period of intense interest in relativity, and he became an expert on the subject. Although an admirer of the theory, he was sceptical about the well-known clock paradox or twin paradox, and did not agree with its generally-accepted resolution. After a prominent but inconclusive debate on the paradox, during the 1950s, he became convinced that the special theory, though mathematically impeccable, was physically impossible, and he spent much of his time and energy during the last 20 years of his life trying to persuade the scientific world that the theory was untenable. His criticisms of the theory, and his Socratic ability to ask questions that nobody else could answer, were not always well received, I have suggested elsewhere (*Canadian Electrical Engineering Journal*, April 1980) that his thesis has not been satisfactorily answered.

The accompanying paper is Professor Dingle's final summing-up of his views on the twin paradox. He sent me the manuscript a few months before his death, in the hope that I would be able to have it published, and I commend it to scientists in the hope that they will give it the serious attention that it deserves.

I am grateful to Mrs Pamela Dingle for giving her permission for this paper to be published, and to *Wireless World* for publishing it.

Ian McCausland
University of Toronto

the stationary one, a difference of ages on reunion would require Peter and Paul each to be the older at that event. This is impossible, so asymmetrical ageing cannot occur, and it is up to those who claim that it can to discover their error. (Though not among them I once thought I had done this[1], but later found that my argument failed, though not for the reasons alleged by my critics at the time[2]. That left me with no alternative to rejection of the theory. However, we are for the present regarding it as true.)

The arguments for asymmetrical ageing — by far the most favoured alternative – are legion but only one calls for serious attention, namely that given first by Einstein himself[3] and supported by Born[4], Tolman[5], Pauli[6], among others, and elaborated in detail by Moller[7] and Born & Biem[8]. No other has a weight of authority behind it comparable with this, or indeed when examined carries any conviction at all, while, granting the validity of the theories, every step in this argument is irresistible. I shall therefore consider it alone.

The essence of this argument is that, indeed, during the main part of the whole journey – that at constant velocity in both directions – the moving twin, whether he be regarded as Paul or Peter must be held to age more slowly than the stationary one, but if Paul is regarded as stationary, then the field of force* must be assumed to exist everywhere during the period of reversal of motion to keep Paul at rest, despite the impulse given him by the working of the engine of his vehicle, and also to bring Peter back to him although no such impulse is given to Peter. The effect of this force-field is to make Peter, during the period of reversal of motion, gain so much in age, and Paul to lose so much, as to far outweigh Paul's more rapid ageing during the uniform motions, and ultimately to give the same ages of the twins on reunion as those following from the assumption that Paul, and not Peter, is the one who moves. The calculation in this last case is simple. No force-field is required, since the engine suffices to reverse Paul's motion and Peter does not move, so Peter's gain during the periods of uniform motion is the sole effect. (Incidentally, when Peter moves similar force-fields are needed to accelerate him initially from rest to velocity v and to bring him to rest again at the end, and at these events Peter and Paul are virtually at the same place, and the general theory requires that in such circumstances the difference in the effects on ageing is negligible.)

Now let us apply this to our example. If Paul is the traveller he ages by 1.5 days during each of his outward and return journeys and by a negligible

*It is called a gravitational field, but this is misleading because it must be granted properties not found in natural gravitational fields.

Why *not* discuss relativity?

After the accompanying article by Herbert Dingle had been submitted for publication, there appeared an article in *New Scientist*[1], by Paul Davies, bearing the title "Why pick on Einstein?". This article defends relativity from its critics by presenting some of the evidence that is claimed to support the theory. As the only critic mentioned by name is Herbert Dingle, who is not able to answer back, I am briefly replying on his behalf. Because Professor Dingle has already presented the arguments in question himself, I shall not re-state them, but merely indicate the general nature of the arguments and cite appropriate references. I think the fact that Professor Davies does not even mention these arguments is evidence that they have not received enough attention from the scientific community.

Professor Davies mentions the Michelson-Morley experiment, stating that it consisted of comparing the times that light pulses travelling in perpendicular directions took to cross the same distance. But, as Dingle pointed out on various occasions[2, 3, 4], the experiment did *not* involve a direct measurement of time; the time comparison has been inferred from interference patterns. Of the possible interpretations of the experiment, one is that Newton's laws of motion are wrong, another is that Maxwell's electromagnetic theory is wrong; the usual interpretation of the experiment, in which the time difference is deduced using Maxwell's theory, eliminates in advance the interpretation that that theory is wrong. This illegitimate elimination of one of the possible interpretations of the experiment rules out that experiment as evidence in support of the special theory.

Dingle has also pointed out[3, 4] that, in experiments that involve elementary particles moving at very high speeds, the speeds of the particles are not measured directly but are inferred from certain observations by a process that involves the use of Maxwell's electromagnetic theory; this fact also rules out experiments of this kind as evidence in support of special relativity.

Professor Dingle[4] has also questioned observations of double stars as evidence supporting the special theory. Although one of his hypotheses – that light travels at constant velocity with respect to its own source, however the source may move – may seem rather difficult to accept, it is surely no more difficult to accept than some of the other phenomena that many physicists appear to believe in. The hypothesis is based on a suggestion already made by Faraday, and if it were true it would also, according to Moon and Spencer[5], allow clocks to be synchronised regardless of their state of motion. Dingle has also suggested that more attention should be devoted to the work of Ritz, whom he mentions in his article and whose work has recently been discussed by Waldron[6].

Furthermore, according to Dingle[4], all the experimental evidence that is taken to support the special theory could with equal validity be taken to support Lorentz's quite different theory if Einstein's special theory had never been conceived. In another *New Scientist* article, Roxburgh[7] appeared to agree with this when he stated that Einstein's theory and Lorentz's were "observationally indistinguishable."

In his book *Space and time in the modern universe*, Professor Davies[8] makes the following statement in connection with two clock-carrying observers in uniform relative motion: "It is not that each observer merely *sees* the other clock running slow, it actually *is* running slow – a real physical effect." [Emphasis in the original]. This statement seems to me to provide strong support for Dingle's claim that, if there are two clocks in uniform relative motion, the special theory requires *each* clock to run (not merely *seem* to run) faster than the other.

The heading of the *New Scientist* article[1] uses the term "scientific malcontents" to refer to those who attack relativity. If being a relativist entails acceptance of all the mutually-contradictory arguments (some of which I have recently documented[9]) that have been published in defending special relativity against the criticism of Herbert Dingle, then I prefer to be a scientific malcontent, and I accept that designation with pride. I think every scientist should be a malcontent; after all, what is the value of trying to contribute new knowledge unless one is dissatisfied with the present state of knowledge?

I could write at length about my encounters with what Davies calls the "special provision" that most editors of science journals make for coping with papers of the type he describes, but this is not the time or the place. In any case, Dingle has described his own experiences so eloquently[4] that it is scarcely necessary to augment his description, but it is noteworthy that a supporter of relativity has now stated openly that most editors of scientific journals do make such special provision; it is not merely a figment of the critics' imaginations. Others who have encountered the "special provision" may tend to agree with me in thinking that the question in the heading of the *New Scientist* article should be amended to read: Why is criticism of relativity so resented?

Ian McCausland

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amount during the three periods of acceleration, while Peter ages regularly by 30 years during the complete process: hence, when they meet again, Peter's age is 30 years and Paul's three days. On the other hand, if Peter is the traveller he ages by 1.5 days during each of his outward and return journeys, and by almost 30 years during the change from recession to approach with respect to Paul, while the stationary Paul ages by 15 years during Peter's outward journey, changes during Peter's reversal to a state nearly 15 years before birth, and then ages by 15 years during Peter's return, somehow getting born shortly before Peter arrives. Consequently, when they meet, Peter's age is 30 years and Paul's three days – exactly as in the former case.

We can hardly suppose that Einstein, Born and the others believed that these processes were both actual occurrances, the one entitled to claim reality depending on our preference in choosing to whom to assign the motion, nor did they. What they supposed was that the only *observable* events in the whole process were the separation of Peter and Paul at the beginning and their reunion at the end. Everything that happened in between was regarded as being beyond possibility of observation and therefore demanding compatibility only with theory, not with experience, with which it had nothing to do. This is obviously so important that it is necessary to confirm it by quoting Einstein's own words (in translation), all that needs explanation being that the clock U_1 is Peter and U_2 Paul and that "the right and left hand columns" give the descriptions of the process, as I have described them, when Peter and Paul, respectively, are regarded as moving. Einstein writes[3]:

> "You must bear in mind that exactly the same process is described in the right and in the left hand columns, but the description on the left refers to the coordinate system K while that on the right refers to K'. According to both descriptions, at the end of the process the clock U_2 is retarded by a definite amount compared with U_1. With reference to K' this is explained as follows: it is true that during the stages 2 and 4, the clock U_1, moving with velocity v, works more slowly than U_2, which is at rest. But this retardation is over-compensated by the quicker working of U_1 during stage 3. For, according to the general theory of relativity, the clock works the faster the higher the gravitational potential at the place where it is situated, and during stage 3 U_1 is indeed situated in a region of higher gravitational potential than U_2. Calculation shows that the consequent advancement amounts to exactly twice as much as the retardation during stages 2 and 4. This completely clears up the paradox."

What Einstein means here by "the same process" is, of course, everything that is *observable*, while "the description", which differs in the two cases, is wholly a mental construction. The first is unique, for it must be the one thing that would actually occur; the last owes allegiance only to theory, not observation, and can vary within the limits allowed by the theory.

But it is clear, beyond possibility of question, that Einstein's "descriptions" relate to what is observable, and cannot therefore both be permissible; and furthermore, as the credentials of both are exactly the same, it is impossible to decide which must be rejected. Paul could be accompanied by a nurse, of such an age as to become 30 years younger without losing her power of intelligent observation, and she would report on return whether it was a baby or a teenage boy who arrived at the planet, and whether or not a baby was born during the return journey, even if she were unable to confirm the antenatal age of the being whom the planet left. The question I asked Dr Wilkie was, in effect, whether what the nurse would observe would admit of both of Einstein's "descriptions", or whether a theory that required it to do so must be abandoned. I am not surprised at his reluctance to commit himself to a choice; nevertheless, it is imperative that scientists shall make a choice if the ethical demands of science are not to be jettisoned.

"... Mathematical consistency, though a necessary condition, is not a sufficient one for the truth of a physical theory."

What is the net result of all this? As I have said, it throws no light at all on what would happen if the experiment were made, for it is an analysis, not of a physical process that has never occurred, but of the requirements of a theory that purports to accord with physical processes, and I think it shows beyond doubt that the special relativity theory at least must be wrong. If the motion can be ascribed equally rightly to either twin, it cannot make them age at different rates; if it makes them age at different rates, there must be an absolute standard of rest to provide a criterion for distinguishing the faster from the slower developer. The special relativity theory requires different rates of ageing to result from motion which belongs no more to one twin than to the other: that is impossible.

It is impossible to exaggerate the importance of this result, for this theory is, by common consent, "taken for granted" in Max Born's words, in all modern atomic research, and it determines the course of practically all current developments in physical science, theoretical and experimental, whether concerned with the laboratory or with the universe. To continue to use the theory without discrimination, therefore, is not only to follow a false trail in the investigation of nature, but also to risk physical disaster on the unforeseeable scale, modern atomic experiments being what they are. It should therefore be a point of honour with those on whose authority atomic research is now being conducted to acknowledge at once the untenability of the theory, and to take without delay the necessary steps to discover where the theory falls.

That does not necessarily mean complete abandoning of its use, but it does demand the determination of the limits of its usefulness. It has already proved its effectiveness in many respects, and this has been mistaken by physicists for evidence of its truth. What the many successes of the Lorentz transformation equations have shown is that those equations are an effectual corrective of the imperfect classical electromagnetic equations within a limited range of experience. But it is now clear that the interpretation of those equations as constituting a basis for a new kinematics, displacing that of Galileo and Newton, which is the essence of the special relativity theory, leads inevitably to impossibilities and therefore cannot be true. Either there is an absolute standard of rest – call it the ether as with Maxwell, or the universe as with Mach, or absolute space as with Newton, or what you will — or else *all* motion, including that with the speed of light, is relative, as with Ritz. It remains to be determined, by a valid experimental determination of the true relation of the velocity of light to that of its source, which of these alternatives is the true one. In the meantime, the fiction of "space-time" as an objective element of nature, and the associated pseudo-concepts such as "time-dilation", that violate "saving common sense", should be discharged from physics and philosophy, and the fact realised that mathematical consistency, though a necessary condition, is not a sufficient one for the truth of a physical theory. Only thus can the scandal of more than half a century of confusion about the meaning of our own creations be ended.

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