The Clock Paradox And Its Space Counterpart In Special Relativity Theory

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Section 1

The contention in this paper is that Special Theory of Relativity gives rise to results which are physically impossible, and therefore, there is a need either for the abandonment of the theory or for its drastic restructuring.

One result concerns the well-known 'clock paradox' which has been under discussion since 1911 onwards and the second result concerns the space counterpart of the clock paradox. This latter result has missed so far the attention of the supporters as well as the critics of the special theory.

THE CLOCK PARADOX

Section 2

Of the two synchronized clocks M and R, if clock M goes to a distant destination at constant, high velocity and later returns to the clock R with the same velocity, will it show the same or less or more elapsed time than clock R? Or, in terms of the twin brothers Paul and Peter, if Peter goes in a rocket on space travels with high, uniform velocity, on his return, will Peter have aged the same or less or more than his earth-bound twin brother Paul?

Three answers have been given to this question:

1. Clock M will show less elapsed time than clock R.

2. The two clocks will show the same time.
3. Clock M will show less elapsed time than clock R and clock R will show less elapsed time than clock M — a result which is physically impossible.

The first result was predicted by Einstein himself in his original paper on special theory of relativity in 1905. He wrote,[84] "If one of the two synchronous clocks at A is moved in a closed curve with constant velocity until it returns to A, the journey lasting t seconds, then by the clock which has remained at rest, the travelled clock on its arrival at A will be ½ t V^2 /C^2 second slow".

Six years later he put it in a more graphic form. He said,[85] "If we placed a living organism in a box — one could arrange that the organism after an arbitrarily lengthy flight could be returned to its original spot in a scarcely altered condition while corresponding organisms which had remained in their original position had long since given way to new generations. In the moving organism the lengthy time of the journey was a mere instant, provided the motion took place with approximately the speed of light".

The first result is today upheld by almost all the conventional supporters of the theory.

This result is, however, in conflict with the time aspect of the Holy Prophet's (may peace be upon him). In less time passed on earth, whereas the Holy Prophet met events and gained experiences which could be spread over a considerable stretch of time. But in the case of Peter, the astronaut who goes on space-travel, more time will pass on earth and less for the astronaut. Although the two episodes, viz., the astronaut's space travel and the Holy Prophet's ascension, are not strictly on the same plane and as such do not require analogous considerations, yet this contention of the supporters of the special theory, in the name of science, can have highly misleading

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[84] Electrodynamics by A. Einstein, page 49 of the Principle of Relativity, Dover Publications.
[85] Quoted from 'What is Time?' by G. J. Whitrow, Thames and Hudson, London, page 112.

consequences for young Muslim science students, if they chance to imagine together and compare and contrast the time aspects of the two episodes. Hence the need for a strict examination and a close look at this aspect of the theory.

The second answer is by Prof. H. Dingle, former President of the Royal Astronomical Society and a few others.

The third result was first deduced by P. Langevin[86] in 1911 who substituted twin brothers for the two synchronised clocks. Ever since then, the problem has been termed the 'clock paradox' or the 'twin-paradox' in relativity literature.

The paradox has two aspects, one based on a certain misconception and, therefore, trivial and unimportant, the other serious and fatally damaging to the theory.

The paper argues on the basis of a few well-known results of the special theory of relativity. These results are as below:

Of the two systems K and K' in uniform relative motion, observers in each consider their own system to be at rest and the other in motion with the same velocity.

When either of the system K and K' is considered to be in motion,

i. lengths inn it, in the line of motion, are judged from the other system to be contracted by the factor
$\sqrt{1-\frac{C^2}{V^2}}$ which in our example below is 3/5,

ii. clocks in it are judged from the other system to run

[86] Quoted from 'The Logic of Special Relativity' by J. Prokhovnik, page 17.

slow by the factor $\sqrt{1-\frac{C^2}{V^2}}$ (or 3/5 of ourexample.)

iii. clocks at different places in it are judged from the other system to be out of synchronism by the factor

$\frac{V}{C^2}.X$ or $\frac{V}{C^2}.X$ as the case may be, clocks ahead of the origin being behind in time and those behind the origin being ahead in time by the same factor.

iv. two events at a distance, which are simultaneous in it, are judged from the other system, not to be simultaneous.

Section 3

The Unimportant Aspect

This arises as under:

The twin brother Peter with his clock M makes a journey to a distant star at constant high velocity V. If the time taken for the journey is t years as measured on the clock R of the earth-bound twin brother Paul, according to Einstein's prediction and the usual formula for time dilatation, the elapsed $t\sqrt{1-\frac{C^2}{V^2}}$ years which is less than t and, thus, he will be found younger than his stay-at-home twin brother Paul on reunion. This asymmetrical behavior of the clocks or of physiological aging processes (which constitute a clock by their regular, periodic functioning) puzzled some critics, particularly Prof. H. Dingle. He thought that the 'length contraction' and 'time retardation' results of the theory are reciprocal and symmetrical results. If Paul judges that during the period of uniform motion, the clock carried by Peter runs slow by the factor and his $\sqrt{1-\frac{C^2}{V^2}}$ meter-stick is shortened by the same factor, Peter has as good a right to judge, by virtue of the motion being relative, that the

clock of Paul runs slow and his meter-stick is shortened by the same factor. How can, then, only the clock of Peter be retarded or only he can be considered to have aged less number of years? Dingle's position was that the principle of relativity required symmetrical behaviour of clocks and measuring rods and hence, if the principle was true.[87]

"the clocks must be retarded equally or not at all: in either case, their readings will agree on reunion if they agreed on separation".

From 1940 to 1967, Prof. Dingle contributed over two[88] dozer articles in discussion of the subject in the various international journals and as a result of his long sustained examination of the theory, he came to repudiate it in the end as inconsistent,[89] though he had started earlier as an admirer and supporter of the theory.

Dingle has been opposed by a large number of the ardent admirers of the theory. They are unanimous that Dingle is wrong, but there is no unanimity among them as to the nature of his error. To uphold the asymmetrical aging or the asymmetrical time on the 1 two clocks, they find out some asymmetry in the situation of the clocks or the twins, but there is no agreement as to what exactly the asymmetry is. Some[90] consider that the different times on the two clocks are due to the fact that the clock M undergoes accelerations at the start and at the turn round. Others[91] think that it is the acceleration or change of inertial system by clock M at the turn

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[87] The Clock Paradox of Relativity by H. Dingle, Nature., June 1 957 pages 1242-1 243.

[88] Listed on pages 187-189 of Time and the Space Traveller by L. Marder, University of Pennsylvania Press, 1974.

[89] The Case against Special Relativity by H. Dingle, Nature 216, 119, 1967, quoted from page 188 of Time and the Space Traveller by L. Marder, University of, Pennsylvania Press, 1974.

[90] (i) Space Traveller's Youth by H. Bondy, Discovery, December 1957, pages 505-510.
(ii) The Resolution of the Clock Paradox by Geoffray Builder, Philosophy of Science, April 1959, Pages 135-144.

[91] (i) Experimental Verification of the Clock Paradox of Relativity by Franks S. Crawford Jun., Nature, January 1957, pages 35-36:

(ii) Time and Relativity — Part I by O. R. Frisch. Con-

temporary Physics. October 1961 pages 16—27.

round alone which produces asymmetrical times. A few[92] believe that it is the accelerations of the two clocks separately with respect to the rest of the matter in the universe, which are responsible for their asymmetrical behaviour. Others[93] satisfy themselves by drawing a Minkowsky space-time diagram.

Such difference of opinion is a symptom that the matter is not being properly understood.

Section 4

The contention in this paper is that the asymmetrical intervals of time are due to the distance of travel which has to be initially fixed in one inertial system in order to set up the problem. To substantiate this contention, it will be helpful to study the matter in the context of a simple numerical example.

Suppose that K and K' are two inertial systems in uniform relative motion along their common X-axis with clocks R and M at their respective origins O and 0' which coincide at zero hour. Their relative velocity is 4 legs per second, the velocity of light being 5 legs per second. There is an object D, 600 legs from O in the system K towards the positive side of the X-axis. Clock M is to coincide with the object D and then the relative velocity is to be reversed so that clock M rejoins clock R.

According to the system K, clock M will coincide with D after (600/4) 150 seconds, but due to its motion, it will run slow by the factor $\sqrt{1-\frac{C^2}{V^2}}$ the example 3/5, and time on it will be [150 x 3/51 90 seconds on coincidence with the object D. It will take another 90 seconds for its return

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92 (i) The Clock Paradox of Relativity by Frank S. Crawford Jun, Nature, May, 1957 pages 1071-1072.
Special Relativity by A. P. French pages 155-156.

93 On Solutions of the Clock Paradox by G. David Scott, American Journal of Physics, November 1959, Pages 580—584.

journey and when it rejoins clock R, time on it will be (90+ 90) 180 seconds and on the clock R (150 + 150) 300 seconds.

Let us contemplate the situation from the point of view of each system K and K' when their respective clocks R and M show 45 seconds each.

According to the System K

Observers in the system K will consider themselves to be at rest and the system K' to be in motion at 4 legs per second towards the right. According to the accepted results of length contraction and time retardation in the moving system, the picture as viewed from the system K after 45 seconds will be as under: [Fig. 1(a)]

(a) (i) The distance between the two clocks R and M willbe (45 x 4) 180 legs measured in K.

(ii) The same distance will be (180 x 5/3) 300 legs of K's measure as judged from K (length in K being contracted).

(iii) The clock R will show 45 seconds.

(iv) The clock M will show (45 x 3/5) 27 seconds (time in K' being retarded.)

(v) The clocks in the system K' will be out of synchronism by the factor $\frac{V}{C^2}.X$ as judged from the system K (relativity of synchronism). The clocks in front of the origin O' being behind in time by the factor ($\frac{V}{C^2}.X$) and those in the back of the origin 0' being ahead in time by the same factor.

(vi) The clock of the system K' at the location of clock R will, therefore, show $(300x\frac{4}{5}+27)$ 75 seconds.

According to the System K'

Observers in the system K' will consider themselves to be at rest and the system K to be in motion at 4 legs per second towards the left. The picture as viewed from the system K' after 45 seconds will be as under: [Fig. 1(b)] .

(b) (i) The distance between the two clocks M and R will be (45 x 4) 180 legs measured in K'.

(ii) The same distance will be (180 x 5/3) 300 legs of K's measure as judged from the system K' (length now in the system K being contracted).

(iii) The clock M will show 45 seconds.

(iv) The clock R will show (45 x 3/5) 27 seconds (time in K being retarded).

(v) The clocks in the system K will be out of synchronism by the factor ($\frac{V}{C^2}.X$) as judged from K' (relativity of synchronism). The clocks in front of the origin O being behind in time by the factor $\frac{V}{C^2}.X$ and those in the back of the origin O being ahead in time by the same factor.

(vi) The clock of the system K at the location of clock M will, therefore, show $(300x\frac{4}{5}+27)$75 seconds.

The two pictures are exactly symmetrical as regards the times and the distances covered.

After 45 seconds as judged from K:

$$K \quad R\frac{O}{45Second}\frac{180legs.}{45\sec.}\frac{D}{600legs.}$$

K 75sec. 27sec.

[Fig.1(a)]_____'O'

1000 legs. 75sec. M.

After 45 seconds as judged from K':

OR 300 legs. D

K_____ _____

27 sec. 75 sec. 600 legs

K 180 legs. M

Fig.1(b)]_____'O'

1000 legs. 45sec. 45sec.

This symmetry will prevail till the clocks R and M show 90 seconds each. The two pictures will, then, be as under: Fig. 2(c)]

According to the System K

(c) (i) The distance between the two clocks R and M will be (90 x 4) 360 legs measured in K.

(ii) The same distance will be (360 x 5/3) 600 legs of K's measure as judged from K (length in K' being contracted).

(iii) The clock R will show 90 seconds.

(iv) The clock M will show (90 x 3/5) 54 seconds (time in K' being retarded).

(v) The clocks in the system K' will be out of synchronism by the factor $(\frac{V}{C^2}.X)$ as judged from K (relativity of synchronism).

(vi) The clock of the system K' at the location of clock R will, therefore, show (600 x 4/25 + 54) 150 seconds.

According to the System K'

[Fig. 2(d)]

(d) (i) The distance between the two clocks M and R will be (90 x 4) 360 legs measured in K'.

(ii) The same distance will be (360 x 5/3) 600 legs of K's measure as judged from K' (length in K being contracted).

(iii) The clock M will show 90 seconds.

(iv) The clock R will show (90 x 3/5) 54 seconds (time in K being retarded)

(v) The clocks in the system K will be out of synchronism by the factor ($\frac{V}{C^2}.X$) as judged from K' (relativity of synchronism).

(vi) The clock of the system K at the location of clock M, that is the clock at D will, therefore, show (600 x 4/25 + 54) 150 seconds.

After 90 seconds as judged from K:

R 360 legs. 600 legs.

K O_____ D

90 sec. 90 sec.

159 sec. 54 sec.

[Fig. 2(c)] K'_____ O'

1000 legs. 600 legs.

M

After 90 seconds as judged from K'

K'_____O R 600 legs.

_____ D

54 sec. 150 sec.

90 sec. 90 sec.

[Fig. 2(d)] K'_____ O'

1000 legs. 360 legs. M

From now on the symmetry will no longer prevail. The distance of 600 legs of the system K between O and D will stand covered (d-ii above). The event of coincidence of the clock M and the destination D will have occurred according to the system K', but it will not have occurred yet according to the system K. According to this latter system, the event of coincidence of the clock M and the destination D will occur when the clock R records 150 seconds. The picture according to this latter system K will be as under: [Fig. 3(e)]

According to the System K

(e) (i) The distance between the clocks R and M will be (150 x 4) 600 legs measured in K.

(ii) The same distance will be (600 x 5/3) 1000 legs of K',s measure as judged from K (length in K' being contracted.)

(iii) The clock R will show 150 seconds.

(iv) The clock M will show (150 x 3/5) 90 seconds (time in K' being retarded.)

(v) The clocks in the system K' will be out of synchronism by the factor ($\frac{V}{C^2}.X$) as judged from the system K (relativity of synchronism).

(vi) The clock of the system K' at the location of clock R, that is, at 1000 legs towards the left of the system K' will, therefore, show (1000 x 4/25 + 90) 250 seconds.

The time value of 90 seconds on the clock M as judged from the system K in (e)-iv above is not the same quantity as that of 90 seconds on the clock

M in (d)-iii above. Here as judged from the system K, the distance associated with 90 seconds in (e)-iv is 1000 legs of K',s measure as judged from K, vide (e)-ii above, but there, the distance associated with 90 seconds in (d)-iii above is 360 legs of K',s measure as judged from K', vide (d)-i above.

After 150 seconds as judged from K:

$$K \quad O \frac{R}{150\text{sec}} \frac{600\ \text{legs.}}{150\ \text{sec.}} D$$

[Fig. 3(e)] K'------- $O \frac{250\ \text{sec.}}{1000\ \text{legs}} \frac{90\ \text{sec.}}{M} O$

After 90 seconds as judged from K':

$$O \frac{R}{5\,4\text{sec}} \frac{600\ \text{legs.}}{150\ \text{sec.}} D \text{———} K$$

[Fig. 3(d)] $O \frac{90\ \text{sec.}}{1000\ \text{legs.}} \frac{}{360\ \text{legs.}} \frac{90\text{sec}}{M} O'$

Section 5

It is obvious from the above that the initial fixation of the distance O D in the system K prevents the emergence of exactly symmetrical time values. This fixed distance is a physical restriction in the problem of which account must be taken and to which the length contraction and time retardation results of the theory must conform. We cannot, therefore, get the second result as demanded by Dingle. He was in error to demand exactly symmetrical time values. *But* those *who* blamed *the asymmetry on* accelerations *or* change of inertial system, etc., were also in error. It seems Dingle understated his case. Instead of exact symmetry, he should have demanded reciprocity which can be conceded as will appear in the sequel., With this, we get leave of Dingle and the unimportant aspect of the paradox. There will be no paradox in different times if it were true that the theory predicted only one-

sided time retardation. The claim in this paper is that the theory predicts two-sided, reciprocal time retardation as in the third result mentioned in Section 2.

THE SERIOUS ASPECT OF THE CLOCK PARADOX

Section 6

It has been stated earlier that according to the system K, clock M will be in uniform motion at 4 legs per second towards the object D, fixed 600 legs away from O in the inertial system K and that it will take (600/4) 150 seconds of the system K to reach the destination D. But due to its motion, it will be judged to run slow by the factor $\sqrt{1-V^2/C^2}$ in our example 3/5, and time on it will be (150 x 3/5) 90 seconds when it coincides with D. But the system K' can be considered to be at rest and the system K to be in uniform motion at 4 legs per second towards the negative side of the X-axis. Accordingly, the distance of 600 legs between O and D in the system K will be shortened by the factor $\sqrt{1-V^2/C^2}$ and will be (600 x 3/5) 360 legs measured in K'. This distance will be covered in (360/4) be seconds of the clock M. But now the clock R will appear working slow by the factor $\sqrt{1-V^2/C^2}$ and when clock M coincides with the object D, time on clock R will be (90 x 3/5) 54 seconds. This is in conflict with the previous result of 150 seconds on the clock R. Therefore, when clocks M and R reunite, the clock R will be both ahead in time of the clock M and behind in time of the same clock. In terms of the twins, Paul and Paul. on reunion, Peter will be both younger than Paul and older than This is physically impossible.

Section 7

There are four time values here for the interval between the events of separation and reunion of the clocks M and R.

As judged from the system K.

1. 300 seconds an the clock R.
2. 180 seconds on the clock M.

As judged from the system K'.

3. 1 80 seconds on the clock M.
4. 108 seconds on the clock R.

The upholders of the theory consider that the values in 2 and 3 above are the same quantity. They also tend to ignore the value of 108 seconds in 4 and assimilating 2 and 3, accept the values 300 seconds on clock R and 180 seconds on clock M and then believe that there is no paradox. But, as indicated at the end of section 4 above, the time value of 180 seconds in 2 arises from association with 600 legs (unshortened) of the System K and 1000 legs (shortened) of the system K', whereas the value of 180 seconds in 3 arises from association with 360 legs (unshortened) of the system K' and 600 legs (shortened) of the system K. As such the two values are not one and the same quantity. Though hundreds of papers have been published to date in efforts to justify one-sided time retardation, quite a number of these betray no awareness of the real nature of the paradox. They even do not concern

with the derivation of the time value in 4 above, such as 108 seconds on the clock R. The authors of some of these papers employ an ingenious method, such as that involving doppler[94] shifts or exchange of Iight[95] signals or K[96] calculus, etc., to arrive at the values 300 seconds on the clock R and 180 seconds on the clock M and, perhaps, getting impressed with the novelty, originality and ingenuity of their method, they are misled into believing that by their unusual derivation of these values they have solved the paradox. These values are very easily deriveable by the simple operation of the length contraction and time retardation factor $\sqrt{1-V^2/C^2}$ and as pointed out earlier, there would be no contradiction in 300 seconds on the clock R and 180 seconds on the clock M, provided that these alone were predicted by the theory. The crucial fact is that the value 108 seconds on the clock R in the system K is also predicted by the theory with the same validity with which the 'length contraction' and time retardation' results in this system are predictable. The important question which has got to be faced squarely by the admirers of the theory is why the result of 108 seconds on the clock R is to be ignored.

Section 8

The correct answer to this question is that the time values of 300 seconds and 108 seconds on clock R at one and the same time are physically impossible. Suppose for a moment that a far off region, in our universe has been discovered in which one person is actually, both younger and older than another person or in which one person is two persons at one and the same time so that he or she can be both younger and older than another,. what a delight it would be to proclaim that the special theory of relativity already

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[94] Time and Relativity, Part I by O. R. Frisch. Contemporary Physics, October, 1961, pages 16—27.

[95] The Clock Paradox in Relativity by C. G. Darwin, Nature, November 1 957, pages 976-977.

[96] Space Travellers Youth by H. Bondi Discovery, December 1 957, pages 505—510.

predicted such a phenomena. Apart from this physical impossibility, no genuinely satisfactory reason has been produced to ignore this time value.

Section 9

The real question is whether or not the third result mentioned in section 2 above is a valid deduction or in terms of our numerical example, whether or not the time value of 108 seconds on the clock R is a valid result from the theory. If this value is a valid result, efforts to refute it are efforts, in effect, to refute the theory. If it is not a valid deduction from the theory, all that you require is to pin-point the. logico-mathematical error which is being committed in deducing it. No such error has been discovered, even though the matter has been under debate now for almost three quarters of a century. If no such error has been spot-lighted so far, it is reasonable to assume that there is no such error. It is no error to judge from the system K, the length to be contracted and the time to be retarded in the system K' and there is no error to judge from the system K', the length to be contracted and the time to be retarded in the system K, while the two systems are in uniform relative motion. This is accepted by all and sundry. But the value of 108 seconds on the clock R arises from the operation of these two standard results and hence it is a valid and unavoidable consequence of the theory.

Section 10

It is remarkable that the conventional adherers[97] of the theory allow the length of 600 legs between O and D in the system K to be contracted when judged from the system K' to (600 x 3/5) 360 legs: of the system K', so that (360/4) + (360/4) 180 seconds should elapse on the clock M for the object D to approach it and to return to its original position. Also, when the experimental result of the flight of p-mesons from a height of about 10 kilometres above sea level is being explained, the admirers[98] of the theory feel

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[97] (i) Relativity (ii) Relativity and Space Travel by J. R. Pierce, Proceeding of the IRE, June 1959, pages 1053-1061.
and Space Travel by J. H. Fremlin, Nature 180, 499, 1957.

[98] (i) Elementary Modern Physics by Richard T. Weidner and Robert L. Sells, pages 409-411, Allyn and Bacon In. Boston.

no inhibition against asserting that from the point of view of an hypothetical observer travelling with the μ-mesons, the earth will appear to be approaching and the distance between the p-mesons and the earth will be contracted by the factor $\sqrt{1-V^2/C^2}$ and will, thus, be traversable in the short, half-life time of the p-mesons. These admirers of the theory, thus, see no reason, not to judge from the system K', the length of 600 legs in the system K between O and D to be contracted, but they stop short of taking the further step of judging the clock R in the same system to be retarded.

Section 11

The clock problem involves four distinct steps.

(i) Time on clock R in the system K will be (600/4) 150 seconds when clock M reaches the destination D.

(ii) Clock M will be judged from the system K to work slow by the factor, $\sqrt{1-V^2/C^2}$ and the time on" it will be (150 x 3/5) 90 seconds when it reaches D.

(iii) System K' can be judged to be at rest and the system K to be in motion towards the opposite direction. The distance of 600 legs in the system K will, therefore, be contracted to (600 x 3/5) 360 legs of the system K'. Clock M will, therefore, take (360/4) 90 seconds to bridge this distance.

(iv) Clock R will now be judged from the system K' to work slow by the factor $\sqrt{1-V^2/C^2}$ and time on it will be (90 x 3/5) 54 seconds when it coincides with leg 360 of the system K' on the left.

While predicting the first result in 1905 in his original paper, Einstein confined his thought to the first two steps only. His followers have since made some progress. It is apparent from the above section that they can now take the third step also without inhibition when it suits their purpose and when they try to explain the flight of mesons or when they desire to get the result of 90 seconds on the clock M. They are, however, averse to the fourth step. This is because, if they take this further step, they are face to face with

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(ii) Time and the Space Traveller by L. Marder, page 63, University of Pennsylvania Press, 1974.

the paradox which is destructive to the theory. They, therefore, have to employ all sorts of manoeuvres to evade this unpleasant step. Many of them even fail to draw a line of distinction between the trivial and the serious aspects of the paradox and treat the problem as if it involved only the question of justification of the time 300 seconds on the clock R and 180 seconds on the clock M. Some[99] of the others who are aware of the serious nature of the paradox plead that the standard of simultaneity in the original system K should be accepted and the time value of 108 seconds on the clock R should, thus, be avoided. A few[100] believe that the concept that 'all motion is relative' is not true. Some[101] consider (including Einstein in 1918) that the matter requires to be dealt with under general theory as accelerations are involved. Others[102] believe that the general theory adds nothing of significance to the problem and succeeds only in evading the paradox rather than solving it. Such ad hoc and arbitrary reasons are satisfactory to their authors alone, otherwise, why should the discussion of the paradox be an ongoing process. As late as June, 1981, one finds Prof. W. G. Unruh[103] producing in the American Journal of Physics an extremely far-fetched solution of the paradox based on the abberation formula of the special theory.

Section 1 2

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[99] (i) The Clock Paradox and Space Travel by Edwin M. McMillan, Science, August 1957, pages 381—384.

(ii) Space-time Physics by Edwin F. Taylor and John Archilbald Wheeler, pages 95-96.

[100] (i) Relativistic Observations and the Clock Problem, by J. Terrell, Nuovo Cimento, May 1960, pages 457—468.

The Theory of Space, Time and Gravitation by V. Fock, page 62.

[101] (i) Die Naturwiss 6, 697, 1918 by A. Einstein.

(ii) Relativity, Thermodynamics and Cosmology by R. C. Tolman, Oxford University Press, 1934.

[102] (i) The Resolution of the Clock Paradox by Geoffray Builder, Philosophy of Science, April 1959, pages 135—144.

On Solutions of the Clock Paradox by G. David Scott, American Journal of Physics, November 1959, pages 580—584.

[103] Parallax, distance, time and the twin "paradox" by W. G. Unruh American Journal of Physics, June 1981, pages 589—592.

It has been remarked earlier that if Prof. Dingle had demanded the reciprocal results of time dilatation rather than exactly symmetrical time values, he would have been on the right track. A cursory look at the time and distance values mentioned in (d) and (e) of Section 4 above, will establish that these values are reciprocal as demanded by the basic principles of the theory. [Fig. 4(d) and (e)] . The reciprocal of 1000 legs of K in (e)-ii, contracted to 600 legs of K in (e)-i are 600 legs of K in (d)-ii contracted 360 legs of K' in (d)-i.

The reciprocal of 150 seconds on the clock R in (e)-iii retarded to 90 seconds on the clock M in (e)-iv, are 90 seconds on the clock M in (d)-iii retarded to 54 seconds on the dock R in (d)-iv. The reciprocal of 250 seconds in (e)-vi on the clock opposite Rat leg 1000 towards the left in the system K', which is out of synchronism from 90 seconds on the clock M in (e)-iv by (1000 x 4/25) 160 seconds, are 150 seconds in (d)-vi on the clock opposite clock M at 600 legs to-wards the right in the system K, that is on the clock at D, which is out of synchronism from 54 seconds on the clock R in (d)-iv by (600 x 4/25) 96 seconds. Reciprocity, therefore, prevails, exactly symmetrical values not obtaining for the simple reason that the initial distance of travel of 600 legs in the system K has been fixed unilaterally.

As judged from K after 150 seconds:

$$\text{K O}\ \frac{\text{R}}{150\text{sec}}\ \frac{600\ \text{legs.}}{150\ \text{sec.}}\ D$$

$$\text{[Fig. 4(d)]}\ \frac{K'}{}\ \frac{1000\ \text{legs}}{250\text{sec}}\ \frac{\text{M.}}{90\ \text{sec.}}\ O'$$

As judged from K' after 90 seconds:

$$\text{O}\ \frac{\text{R}}{54\text{sec}}\ \frac{150\ \text{sec.}}{600\ \text{legs.}}\ D---K$$

[Fig. 4(d)] $\frac{\text{1000 legs}}{\text{360 legs}} \frac{\text{90 sec}}{\text{M}} \frac{\text{90 sec.}}{O'\ \text{K}}$

Reciprocals as judged from K in[Fig. 4(e)]	Conversion factor	Reciprocals as judged from K' in [Fig. 4(d)]
1. 1000 legs of K' in (1) contracted to 600 legs of K in (4).	3/5	600 legs of K in {1) contracted to 360 legs of K' in (4).
2. 150 seconds on R in (2) retarded to 90 seconds on M in (5).	3/5	90 seconds on M in (2) retarded to 54 seconds on R in (5).
3. 250 seconds at leg 1000 of K' in (3) retarded to 150 seconds at leg 600 of K in (6).	3/5	150 seconds at leg 600 of K in (3) retarded to 90 seconds at leg 360 of K' in (6).

Section 13

The two values of 300 seconds and 108 seconds at one and the same time on the clock R at the end of the journey as judged from the two systems K and K', respectively, are, accordingly, in line with what the theory demands. It is, therefore, the third result mentioned in section 2 above, viz, clock M will be both behind in time and ahead in time of the clock R, to which the theory gives rise and which displays reciprocity as demanded by the basic principles of the theory. The first result, mentioned in Section 2, involving only the first two of the four steps mentioned in Section 11 above, will be only a half-way house between what the theory demands and what its

conventional admirers are willing to concede to it. Little do they realize that by upholding the first result only, they are truncating the logical corpus of the theory. Result one depicts the picture only from the point of view of observers in the system K and totally neglects the second picture depicting the point of view of observers in the system K'

The first result of one-sided time retardation is, therefore, only a partial and incomplete deduction from the concept of relativity of motion, taken together with the concepts of length contraction and time retardation, the full and complete deduction from these concepts being that of two-sided, reciprocal time retardation embodied in the third answer mentioned in Section 2 above.

THE SPACE COUNTERPART OF THE CLOCK PARADOX

Section 14

Even if we agree with the upholders of the theory and accept the values 300 seconds on the clock R and 180 seconds on the clock M, we land into the space counterpart of the clock paradox. Very strangely, this aspect of the problem has persistently been overlooked so far.

This paradox arises as follows:

According to the system K, the system K' will be moving towards the right at 4 legs per second. So a distance of (150 x 4) 600 legs of K's measure of the system K' will pass in front of R. As the length in the system K' will be contracted, there will be (600 x 5/3) 1000 legs of the system K' in this distance. If there should be a target shooting device at the location of clock R and one target at each leg of the system K' on the negative side of the X-axis, one thousand targets will be shot down at the location of clock R.

According to the system K', the system K will be moving towards the left at 4 legs per second. Therefore, the clock R will pass in front of (90 x 4) 360 legs of the system K' and only 360 tar-gets will be shot down at the location of clock R.

According to the system K:

$$K \ \frac{R}{150\text{sec}} \qquad \frac{600\ \text{legs.}}{150\ \text{sec.}}\ D$$

$$[\text{Fig. 5(e)}]\ \frac{K'\ 1000\ \text{legs}}{250\text{sec}} \qquad \frac{M.}{90\ \text{sec.}}$$

According to the system K:

$$[\text{Fig. 5(d)}]\ \frac{360\ \text{legs}}{1000\ \text{legs}} \qquad \frac{M}{90\ \text{sec}} \qquad \frac{}{90\ \text{sec.}}\ O'\ K$$

On reunion the targets 361 to 1000 (or targets 601 to 1000) will be found to have been shot down and not to have shot down at the location of clock R.

This again is physically impossible.

Thus by whatever method we try to extricate ourselves from the clock paradox and accept the values 150-seconds on the clock R and 90 seconds on the clock M for the one way travel, *we* land *into* its space counterpart.

Section 15

Einstein hazarded his special theory on the requirement that mankind abandon the concept of simultaneity as an absolute concept and accept it as a relative one. Thus two[104] events at a distance in one inertial system which are simultaneous in that system, will not be simultaneous in another inertial system. Now, suppose we ask the question, "where is clock R in the system K' when clock M *and the* destination D coincide and what is the time on it?" There will be two answers to this question, depending upon the standard of simultaneity in each system. According to the system K, when M coincides with the destination D, clock R is opposite leg 1000 in the system K' towards the left and time on it is 150 seconds. Time on the clock opposite clock R at 1000 legs in the system K' will be 250 seconds, but this clock will have been set (1000 x 4/25) 160 seconds ahead of the clock M and thus correct time on this clock should also be (250 - 160) 90 seconds as on the clock M. According to the system K', when clock M and the destination D coincide, clock R is opposite leg 360 in the system K' towards the left and time on it is 54 seconds. Time on the clock opposite clock M in the system K, that is on the clock at the destination D, will be 150 seconds, but this clock will have been set (600 x 4/25) 96 seconds ahead of the clock R and, thus, correct time on this clock should also be (150 96) 54 seconds as on the clock R. There is nothing in the corpus of the special theory to remove these differences of judgement of the observers in the system K and K'

Section 16

Rather, the basic principles of the theory confirm these differences. The fundamental requirement which the Lorentz transformation is meant to fulfil is to answer the question, 'What are the coordinates of the event of

[104] Electrodynamics by A. Einstein, The Principle of Relativity, Dover Publications Inc. page 42.

coincidence of clock M with the destination D in the system K' if these coordinates in the system K are already known?' Clock M is in the system K' and the destination D is fixed in the inertial system K. As two systems are involved in the problem, there must of necessity by two pictures of the manner in which this event ingresses into each system. In the system K, it is simultaneously associated with the event of coincidence of clock R with leg 1000 of the system K' on the left when clock R shows 150 seconds and the clock at leg 1000 in the system K' shows 250 seconds. In the system K', it is simultaneously associated with the event of coincidence of clock R with the leg 360 of the system K' on the left when clock R shows 54 seconds and the clock at leg 360 of the system K'

shows 90 seconds. The two pictures [Fig. 6(e) and (d)] are reciprocal as demanded by the basic principles of the, theory, the second picture arising from the first by the operation of the length contraction and time retardation factor $\sqrt{1-V^2/C^2}$ 3/5 in our example. In the first picture, [Fig. 6(e)] there are two distances, 600 legs of K and 1000 legs of K'. They give rise to (600 x 3/5) 360 legs of K' and (1000 x 3/5) 600 legs of K in the second picture. In the first picture there are four time values, 150 seconds and 150 seconds of K and 90 seconds and 250 seconds of K'. These give rise to (150 x 3/5) 90 seconds and (150 x 3/5) 90 seconds of K' and (90 x 3/5) 54 seconds and (250 x 3/5) 150 seconds of K in the second picture, [Fig. 6(d)]

As judged from K:

$$\text{K}\ \frac{\text{R}}{150\text{sec}}\qquad\frac{600\ \text{legs.}}{150\ \text{sec.}}\ D$$

$$\text{[Fig. 6(e)]}\ \frac{K'}{}\ \frac{1000\ \text{legs}}{250\text{sec}}\qquad\frac{\text{M.}}{90\ \text{sec.}}$$

As Judged from K:

$$\frac{\text{1000 legs}}{\text{360 legs}} \quad \frac{\text{M}}{\text{90 sec}} \quad \frac{}{\text{90 sec.}} \; O' \; \text{K}$$

[Fig. 6(d)] $\frac{\text{R}}{\text{54sec}} \quad \frac{\text{600 legs.}}{\text{150 sec.}} \; D$ ____K

The second picture is a miniature of the first, arising from the operation of the factor $\sqrt{1-V^2/C^2}$ If you take away the event of coincidence of clock R with leg 360 of the system K' on its !eft when clock R shows 54 seconds and the clock at leg 360 shows 90 seconds, you mutilate the second picture and destroy reciprocity which is a necessary consequence of the logic of the special theory of relativity.

Nor is there anything in the theory to allow preference to the standard of simultaneity of one system over that of another.

These paradoxes, accordingly, are irremoveable in principle and as such are destructive to the theory.

ACCELERATIONS

Section 17

We may now take up the question of accelerations. The obvious purpose which accelerations serve is to give the separating clock a specific, uniform velocity and when it has reached the destination, to turn it round towards the origin with the same velocity and finally to bring it to halt at the origin. When an object moves at a particular, uniform velocity in a straight line, it is conceived to be associated with a particular inertial system in which it is thought to be at rest and the inertial system or better the inertial[105] space to be in motion with that particular, uniform velocity. If the object changes its direction or adopts another uniform velocity, it is said to have changed its inertial system. Accelerations can, therefore, be imagined to put an object in specific inertial systems or inertial spaces, by giving it a particular state of uniform motion or rest.

Accelerations were implicit in Einstein's thought from the very start, but he did not take explicit account of them. In his original paper in 1905, he first imagines a stationary rigid rod[106] and then requires that a uniform velocity V be imparted to it. Without accelerations a velocity cannot be given to the rod. In the same paper he imagines[107] a clock to move from A to B in any polygonal line. Without accelerations, the clock cannot move on a polygonal path as it has to change its direction off and on. But, unfortunately, he did not give explicit consideration to the fact of accelerations and developed his special theory assuming objects to be in a continued uniform motion without conceiving how they were to be put in that state. As pointed out above in Section 11, he came to the conclusion in 1918, when the clock paradox had already been ?n the arena for over half a

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[105] Relativity, the Special and the General Theory by A. Einstein page 148, Methuen, London, 1960.

[106] Electrodynamics by A. Einstein, The Principle of Relativity, Dover Publications Inc. page 41.

[107] *Ibid.,* page 49.

dozen years, that as accelerations were involved in the problem, the paradox could be handled only under general relativity which he had propounded 3 years earlier. He, however, produced no detailed calculations and indicated only the general lines on which the problem could be tackled. Apart from this, he seems to have stopped discussing the clock question subsequent to 1911. Thus, in his book, 'Relativity, the Special and the General Theory', published in 1916 and in his book, 'The Meaning of Relativity', published in 1922, he discussed other aspects of the theory but made no mention of the clock problem. Einstein's followers have produced prodigious literature[108] on the clock paradox, but have given scant consideration in the context of special relativity to the question of accelerations which according to some of them, served the sole purpose of bringing about an asymmetry in the status of the two clocks.

Section 18

Accelerations give rise to rather unfamiliar consequences, some of which are highly unfortunate for the special theory.

Imagine two rods A B and P Q, each of 2000 legs lying side by side at rest so that their end points A and P on the left, middle points O and 0' and the end points B and Q on the right coincide, respectively. The legs are numbered from their middle points, so that A and P will be at the thousandth leg on the left and B and Q on the thousandth leg on the right of each rod.

A				**O**				**B**
1000 legs	… 3	2	1	1	2	3	…	1000 legs
1000 legs	… 3	2	1	1	2	3	…	1000 legs
P				O'				Q

[Fig. 7]

[108] Selected bibliography of 241 items given on pages 184—199 of Time and the Space Traveller by L. Marder, University of Pennsylvania Press, 1974.

Let suitable accelerators be fixed on the rod PQ at appropriate distances and let there be synchronised clocks at each leg of the two rods. When all these clocks show zero hour, that is to, let the accelerators start functioning, so that they give the rod PQ a tremendous push simultaneously and put it at a uniform velocity of 4 legs per second in the shortest possible time. Let the instant at which the rod PQ has attained this velocity be termed $t1_1$, so that the interval between to and t_0, on the clocks on the rod AB is as small- as possible.

We stand at the middle point O of the stationary rod A B and ask 'where is the middle point 0' of the rod PQ at the instant t, ?' It will be very unreasonable to suppose that it has shifted very far away from O in this short interval. If there are recording devices on the rod A B, they will record it close to, almost opposite the middle point O at the instant t1 By the same reasoning, the end point P will be recorded opposite A at this very instant and the end point Q opposite B. But the rod PQ has been said to have attained the uniform velocity of 4 legs per second by this instant t_1, and it is no longer in the system K, but has been transferred to the system K' in which length will be contracted when judged from the system K. If the middle point 0' of the rod PQ is judged to be in the vicinity of the middle point of O of the rod A B at the instant t1, the end point P of the rod PQ will not be opposite A but will be opposite (1000 x 3/5) leg 600 of the rod A B on the left because the rod PQ will be contracted from both ends towards O'

A		**O**	**B**
1000 legs	600 legs	600 legs	1000 legs
	1000 legs	1000 legs	
P	P	O'	Q

[Fig. 8]

This will involve a contradiction. The end point P will be at two places opposite A and opposite leg 600 of the rod AB on the left at one and the

same instant t_1, in other words it will be opposite A and not be opposite A simultaneously.

If we take our stand at the point A of the rod AB, the point P will be opposite A at the instant t_1, but the middle point 0' of the rod will not now be opposite O of the rod AB, but will be opposite leg 400 of the rod AB towards the left at the instant t_1, because the rod will now be contracted towards P

A		**O**	**B**
1000 legs	400 legs		100 legs
1000 legs		100 legs	
P	**O**	**Q**	

[Fig. 9]

Similarly, if we judge the situation from the end point B of the rod AB, the end point Q of the rod PQ will be opposite B, but the end point P and the middle point 0' of the rod PQ will not be where they happened to be previously, but P will be opposite leg 200 of the rod AB on the left of O and 0' will be opposite leg 400 of the rod AB on the right of O, the rod PQ being contracted towards Q.

A		**O**	**B**
1000 legs	200 legs	400 legs	1000 legs
	1000 legs		1000 legs
	P	O'	Q

Fig. 101

This shows that it is purely an arbitrary matter in this context where we fix our origin for the purpose of calculations and our calculated values of times and distances of the natural phenomena will depend upon and will vary with the whim and fancy with which we decide to fix the origin of our coordinate system. If so, this will hardly by physics because the quantities involved in natural phenomena are not subordinate to our fancy.

Section 19

Further, if we stipulate that a light ray starts from A or P at the instant the accelerators are started, with P carrying a message, P will reach O and deliver its message when the clock at O shows (1000x 3/5/4) 150 seconds, because as judged from 0, it was opposite (1000 x 3/5) legs 600 at the instant t1 . But the ray of light will reach there when the same clock show (1000/5) 200 seconds, that is, P will reach 50 seconds earlier than the ray of light, though according to observers at A and P, both started together when the clock at A showed zero hour, this clock being synchronised with the clock at O. Here, from one point of view, the light ray and the material point P start moving at the same instant to of the rod AB, but the ray of light covers the same distance. in 200 seconds and the material point P in 150 seconds. In other words, the material point P arrives at the destination earlier than light, the turtle beating the hare in a race.

Section 20

Notwithstanding these anamolies, we may proceed with the question as to how the clock paradox and/or its space counterpart may be affected by acclerations. We suppose that our clocks Rand M are located at the origins O and $0'$ respectively of the rods and the destination D is situated at a distance of 600 legs from R towards the right on the rod AB and immediately after accelerations, the(clock M on the rod PQ is opposite clock R. Clock M will reach when all the clocks on the rod PQ show 90 seconds each. Accelerations are, then, again given to this rod simultaneously to reverse velocity. This is now a physical restriction in the problem and our treatment of it must take this restriction into account. According observers on the rod PQ when its clocks show 90 seconds, its leg360 on the left will be opposite clock R which will show 54 seconds the clock at leg 360 will show 90 seconds.

$$\frac{A}{100legs}\ \frac{R}{54\sec.}\ \frac{600legs.}{150\sec}\ \frac{}{1000legs}\ B \text{ —— } ROD\ \underline{AB}$$

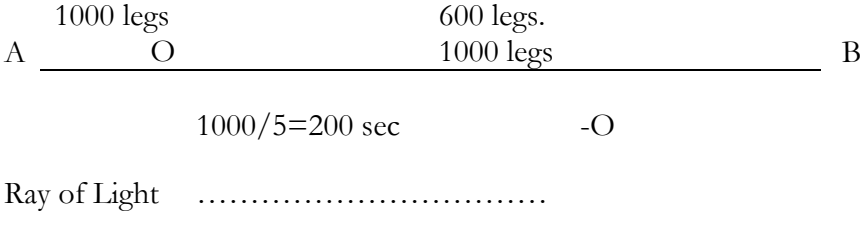
$$\frac{1000legs.}{P}\ \frac{90\sec.}{360legs.}\ \frac{90\sec..}{O}\ \frac{1000legs}{Q}\ ROD\ \underline{PQ}$$

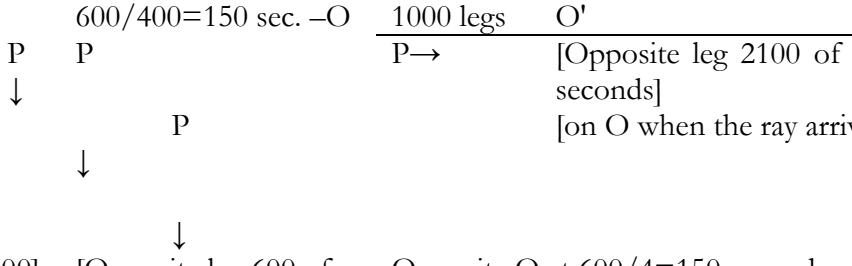
[Fig. 12]

As judged from rod PQ reversion of the direction of movement takes place when leg 360 of the rod PQ is opposite clock R. On clock R time is

54 seconds and at leg 360 it is 90 seconds. Clock M is opposite the destination D. Time at D is 150 seconds and on clock M it is 90 seconds.

If the acceleration occurs according to observers on the rod AB also, when the clock R shows 54 seconds and when leg 360 is opposite clock R, so that leg 360 reverses its direction of movement at this instant, only 360 targets of the rod PQ will be shot down at the location of clock R for observers at the rod AB also and as such there will be no space counterpart of the clock paradox.





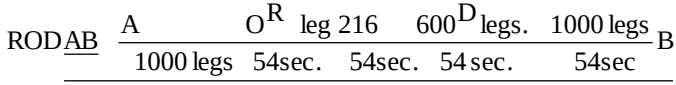
[Opposite leg 1000] of AB at zero hour of O when accelerators start.]

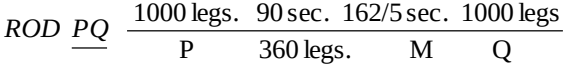
[Opposite leg 600 of the rod AB at t_1 of O. The interval between zero of O & t_1 of O for which the accelerators worked being as small as

Opposite O at 600/4=150 seconds o

possible]

[Figure. 11]





[Fig. 13]

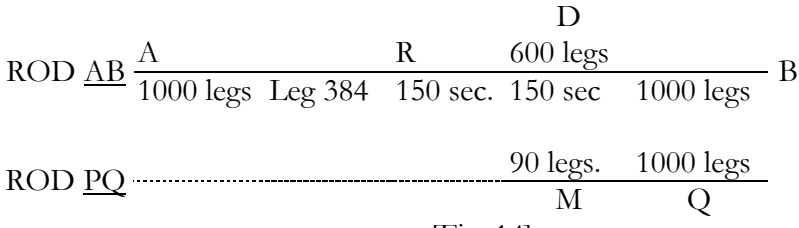
As judged from rod AB reversion of the direction of movement takes place when leg 360 of the rod PQ (contracted) is opposite clock R On clock R time is 54 seconds and at leg 360 it is 90 seconds. Clock M is opposite leg 216 of the rod AB. Time at leg 216 is 54 seconds and on clock M it is 162/5 seconds. Clock M has not yet reached the destination D.

Section 21

But another paradoxical consequence of the point of view of these observers will arise in the following manner:

An observer situated at the location of clock R on the rod AB will agree that when clock R showed 54 seconds, leg 360 of the rod PQ was opposite clock R. This is because in his judgement, length on the rod PQ will he contracted, 360 legs of this rod being equal to (360 x 3/5) 216 legs of the rod AB and these will pass in front of the clock R in (216/4) 54 seconds of that clock. He will also agree that time on the clock at leg 360 of the rod PQ was 90 seconds. This is because this clock would have been set (360 x 4/25) $\frac{288}{5}$

seconds ahead of the clock M which had not yet reached the destination D and was opposite (54 x 4) leg 216 of the rod AB on its right and time on it was (54 x 3/5) 162/5 seconds which when added to 288/5 seconds would make up (288/5 + 162/5) 90 seconds of the clock at leg 360. If the leg 360 of the rod PQ reverses its velocity when the clock at it shows 90 seconds, the rod PQ will not be rigid for the observers situated at the location of the clock R on the rod AB. The portion behind leg 360 on the left of the rod PQ will be going backwards and that in front will be going forward, because acceleration of the rod PQ will not be simultaneous to this observer. The acceleration will occur at the location of clock R when this clock shows 54 seconds and at the destination D when the clock at D shows 150 seconds. Therefore, for (150 — 54) 96 seconds, one end of the rod PQ will be going in one direction and the other in the opposite direction at 4 legs (of the rod AB) per second, so that when clock M reaches D, the leg 360 of the rod PQ will have traversed (96 x 4) 384 legs of the rod A B and will be 384 legs to the left of clock R. If leg 360 of the rod PQ is opposite leg 384 of the rod A B on its left and clock M is opposite the destination D which is at a distance of 600 legs of the rod AB on its right, according to observers on the rod AB, lengths on the rod PQ will have stretched, 360 legs of the rod PQ becoming equal to 984 legs of the rod AB.

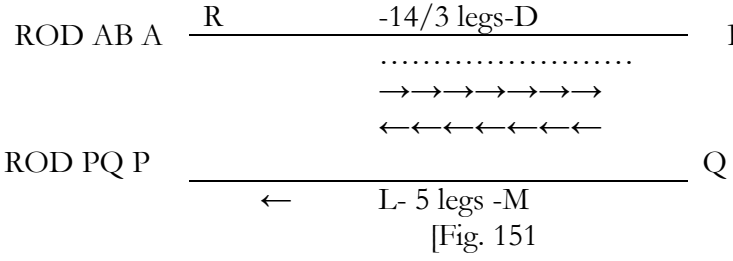


[Fig. 14]

As judged from the rod AB, when clock M reverses the direction of its movement, leg 360 of the rod PQ has already reached leg 384 of the rod AB on the left of clock R. Rod PQ has expanded, 360 legs of this rod becoming equal to (600 + 384) 984 legs of the rod AB, even though the rod PQ is moving towards the left.

Time on the expanded rod will now pass more slowly. This can be illustrated by means of the Einstein — Langevin ideal clock in which a ray of light travels to and fro between two mirrors fixed at a specified distance from each other. The velocity of light over an outward and return journey is considered to be the most satisfactory theoretical time standard in relativity. Let us suppose, one mirror is mounted at M and the other at L towards the left of M at a k distance of 5 legs measured on the rod PQ. The light ray will take one second of the rod PQ (system K') to travel from M to L and one second to travel back from L to M, thus covering a total distance of 10 legs in 2 seconds of PQ. The behaviour of this clock will be judged from the rod AB (system K) as under:

On the return journey from D to R, the rod PQ will be moving towards the left and 360 legs of it will measure the same distance as' 984 legs of the rod AB. Thus, one leg of it will be equal to 984/360 or 41/15 legs the rod AB and 5 legs of it between the mirrors M and L will be equal to (5 x 41/15) 41/3 legs of the rod AB.



[Fig. 151

The light will start from M at 5 legs of the rod AB towards L and L will move away from it at 4 legs of the rod AB in one second of AB. Thus, the ray will gain on the rod PQ a distance of (5—4) one leg of the rod AB in one second of AB. It has to cover a distance of 41/3 legs of the rod AB between the mirrors M and L. It will, therefore, take (1 x 41/3) 41/3 seconds of the rod AB to arrive at L. On its return journey towards M, it will move at 5 legs of the rod AB and M will move towards it at 4 legs of the rod AB in one second of AB. Thus it will cover a distance of (5 + 4) 9 legs of the rod AB in

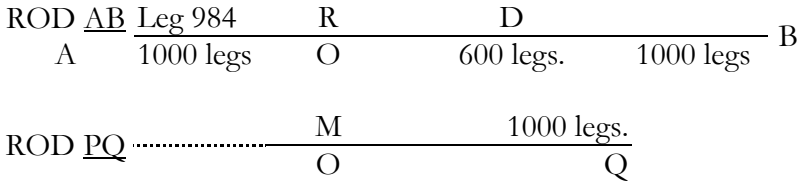
one second of AB, or one leg of the rod AB in 1 /9 second of AB and 41/3 legs of the rod AB in (1/9 x 41/3) 41/27 seconds of the rod AB. So the total time for the ray to start from M, get reflected at L and arrive back at M will be (5/5 + 5/5) 2 seconds of the rod PQ and (41/3 + 41/27) 410/27 seconds of the rod AB. Or one second of the rod AB will be equal to (2 x 27/410) 27/205 seconds of the rod PQ. But according to the observers on the rod AB, M will take (600/4) 150 seconds of the rod AB to return from D to R and these 150 seconds will measure the same time interval as (150 x 27/205) 810/41 seconds of the rod PQ.

The inquisitive reader, if so desired, may calculate on these lines the time of the clock M for its outward journey from R to D. The distances on the rod PQ, in this case will be contracted by the factor $\sqrt{1-\frac{V^2}{C^2}}$ or 3/5 in our example and 5 legs of the rod PQ between the mirrors M and L will be equal to (5 x 3/5) 3 legs of the rod AB. The calculated time will turn out to be 90 seconds of the rod PQ, the same as given by the time retardation formula. An essential feature of the theory, so little known or so little paid attention to, is the fact that observers in each system consider the velocity of one and the same ray of light to be C in their own system, but equal to (C + V) or (C — V) in the other system, depending upon the direction of the latter's movement.

Therefore, as judged by the observers on the rod AB, the total time of M to depart from R, arrive at D and return to R will be (90 + 810/41) 109.75 seconds of the rod PQ. But as judged by the observers on the rod PQ, the total time of the journey will be (360/4+ 360/4) 180 seconds on this rod. Thus, on return, clock M will be found to have added, uptil a single moment, two times to its life, 180 seconds and 109.75 seconds. Or, if M could be substituted by Peter, the astronaut, Peter on return, will be found to be 180 seconds old and 109.75 seconds old at one and the same time.

As judged from rod PQ when clock M again coincides with clock R, leg 360 of the rod PQ has reached opposite leg 600 of the rod AB on its left and 600 targets have been shot down at leg 360 of the rod PQ.

But according to observers on the rod AB, 984 targets will be shot down at leg 360 of the rod PQ.



[Fig. 16]

As judged from the rod AB, when clock M again coincides with clock R, leg 360 of the rod PQ has reached opposite leg 984 of the rod AB on its left and 984 targets have been shot down at leg 360 of the rod PQ.

Targets from leg 601 to leg 984 of the rod AB will, therefore, need to be treated to have been shot down and not to have been shot down at the location of leg 360 of the rod PQ.

This again is physically impossible.

We have brought out this paradoxical aspect of the problem in order to forestall the suggestion that the space counterpart of the clock paradox can be avoided by accepting the view that only 360 legs of the rod PQ will confront the clock R when acceleration occurs at this leg and it begins to move backwards. In our opinion, by virtue of the two separate systems K and K' and the separate standards of simultaneity in each, two separate phenomena are involved in the problem. According to the system K the system K' will reverse its direction when all the clocks in the system K show 150 seconds simultaneously, but according to the system K', it or the system K will reverse the direction of its movement when all the clocks in the system K' show 90 seconds simultaneously. Even if, for the sake of

argument, we concede that acceleration occurs according to the system K also at leg 360 of the rod PQ when the clock of the system K opposite this leg shows 54 seconds, a space distance of further 640 legs will still pass in front of the clock R, because the co-moving inertial system or inertial space in which clock M is at rest will keep on moving as long as clock M does not reach the destination D. Therefore (360 + 640) 1000 legs of the inertial space associated with clock M will still pass in front of clock R even though the material atoms constituting the rod PQ from leg 361 backwards may have left this inertial space and landed into another one.

Section 22

The upholders of the theory claim that considerable experimental evidence now exists which confirms the special theory of relativity. Doubts seem to have been expressed by scientists[109] themselves about the validity of the alleged confirmatory evidence. The contention in this paper is that even if there exists experiment-al evidence, it needs to be explained on the basis - of some other theory, special relativity theory being inconsistent with physical fact.

Further, the experimental evidence of one-sided time retardation, such as on clock M alone, will falsify the reciprocity aspect and will, thus, destroy the validity of the special theory which predicts what we have been arguing, two-sided, reciprocal time retardation, such as mentioned in the third answer in section 2 above, of which, in the very nature of things, there can be no experimental evidence.

Section 23

There are a number of solutions of the clock paradox[110] in relativity literature. These can, perhaps, be criticized destructively and the fallacy lying in each can be exposed, but this is not possible here. Many of these solutions are in the context of the Dingle aspect of the paradox. As the Dingle paradox arises from the initial fixation of the distance of travel and, in fact, is not a paradox at all, these solutions are irrelevant. As regards the solutions of the

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[109] The Logic of Special Relativity, J. Prokhovnik, pages 18—21.

[110] Items at 4, 7, 9, 9-i, 10, 11, 12 13, 14-ii, 16-i, 17-i, and 19 reprinted in Special Relativity Theory, Selected Reprints, American Institute of Physics, New York.

serious aspect of the paradox, these suffer, one and all, from a remarkable fallacious, procedure The requirement is to show convincingly that the paradox cannot arise. These solutions, on the other hand, concede first, implicitly or explicitly that the paradox does arise from the concept of relativity of motion and then ignore, unwittingly or deliberately, some essential feature of the theory, or step clean outside the theory and bring forth ad hoc, extraneous and arbitrary reasons for the acceptance of one-sided time retardation. If the paradox arises from the principles of the theory, then it does arise and the requirement is to accept it and face the consequences.

Section 24

It is interesting to note that Einstein began to construct his special relativity theory with almost the same definition of time as that formulated by the Muslim Ashrite Mutakallimun. According to the Ashrites:[111]

> "time is a specified occurrence with which is correlated another unspecified occurrence in order to. remove the ambiguity in the latter. — For example, if it is asked, "when did Zaid come?", the reply may be, "when the sun rose", if the questioner witnessed the event of sun-rising but did not witness the event of Zaid's arrival",

خامس المذهب فی حقیقة الزمان مذهب الاشعرة وهوا نہ متجد و معلوم یقدر بہ متجدد سبهم ازالة لا مبهامة... فاذا قیل متی جا ذید یقال عند طلوع الشمس ان کان المخاطب الذی هوالسائل مستحفرالطلوع الشمس ولم یکن مستحقوا لمجئی زید کم دل علیہ سوالہ0

Obviously the rising of the sun and the arrival of Zaid are here simultaneous events.

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111 Sharah-al-Mawaqif by al-Jurjani al-Sayyid al-Sharif, Ali Ibn Muhammad, Newal Kishore, Lucknow, page 268.

شرح المواقف از سید الشریف علی الجرجانی. مطبوعہ منشی نولکشور. لکھنو، صفحہ 268

In his first paper on relativity in 1905 Einstein wrote[112]… all our judgements in which time plays a part are always judgements of simultaneous events. If, for instance, I say, "That train arrives here at 7 O'clock", I mean something like this, "The pointing of the small hand of my watch to 7 and the arrival of the train are simultaneous events.

It might appear possible to overcome all the difficulties attending the definition of "time" by substituting "the position of the small hand of my watch" for "time".

Both the definitions are the same in substance and provide the procedure for dating or clocking an event.

The Mutakallimun were primarily concerned with the nature of time and with the question of its objective existence. They did not believe that time was something existing in its own right[113]; it was, according to them, a sort of abstraction by imagination from the occurrence of events.

Einstein seems to adopt a similar view. He writes:[114]

……We have attempted to describe how the concepts of space, time and event can be put psychologically into relation with experiences. Considered logically, they are free creations of human intelligence, tools of thought, which are to serve the purpose of bringing experiences into relation with each other ……".

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112 A. Einstein, 'On the Electrodynamics of Moving Bodies in the Principle of Relativity, Dover Publications, Inc. page 39.

113 Sharah-al-Mawaqif by al-Jurjani al-Sayyid al-Sharif, Ali Ibn Muhammad, Newal Kishore, Lucknow, page 257. "The Mutakallimun denied [the existence of] time… a changing continuous quantity just as they denied [the existence of] number and the unchanging continuous quantity".
المتکلمین کم انکر والعدو والمقدار الذی هوا لکم المتصل القار انکروایض الزمان الذی هوا لکم المتصل الغیرالقار
(شرح المواقف از سید الشریف علی الجرجانی، صفحہ 257)

114 Relativity, The Special and General Theory. A. Einstein, Methuen, London, 1960, page 141.

Though Einstein does not directly question the objective existence of time, he seems to fall in line with the position of the Mutakallimun by calling the concepts of space and time 'free creations of human intelligence' and 'tools of thought'.

In not very distant past the position of the Mutakallimun was upheld by Behr-ul-Ulum, Abdul Ali and Syed Barkat Ahmed of Khairabadi school of thought. According to these thinkers, it is the things themselve which are qualified with the concepts 'before' and 'after' and time as a quantity is an intellectual abstraction there-from[115]

قبلیت و بعدیت کے ساتھ بالذات وہ اشیا موصوف ہیں جو متقدم و متاخر ہوتی ہیں اور زماں نام ہے

اس امتداد موہوم کا جو وہ اشیا کے تقدمات و تاخرات سے منتزع ہوتا ہے.

Very recently, Dr. G. J. Whitrow, Senior Research Fellow of the Imperial College of Science and Technology, London, surveyed the problem of time in its various aspects in his book, 'The Natural Philosophy of Time',

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[115] Iqbal Review, July 1968, page 37, The Iqbal Academy Pakistan, Karachi, Urdu translation of Itteqan-ul-Irfan fi Mahiat-uz-Zaman by Syed Barkat Ahmed, translation by Hakim Mehmood Ahmed Barkati.

اقبال ریویو جولائی 1968. صفحہ 37. اقبال اکادمی، پاکستان کراچی، اردو ترجمہ رسالہ اتقان العرفان فی ماہیۃ الزمان از سید برکات احمد. ترجمہ از حکیم محمود احمد برکاتی.

1980 edition, and wrote in conclusion[116], "I maintain, however, that our conscious awareness of time is neither a necessary condition of our experience, in the sense intended by Kant, nor a simple sensation, as Mach believed, but an intellectual construction that depends not only on our physical surroundings, but also on the particular type of culture in which we happen to live".

A little further on he writes:[117]

> "……without activity there can be no time. Consequently, time does not exist independently of events, but is an aspect of the nature of the universe and all that comprises it".

By calling time 'an intellectual construction' which 'does not exist independently of events', Whitrow would seem to fall in line with Abdul Ali and Barkat Ahmed and thereby vindicate the insight of the Mutakallimun who, like Einstein, had considered that the important thing about the concept 'time' was the practical requirement of determining the date, that is, the time of occurrence of events.

Section 25

Another instance of insight of the Mutakallimun in the problem of time, which is being upheld today concerns the question of the origin of the universe. The Mutakallimun believed that the universe was *not* eternal and

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[116] The Natural Philosophy of Time by G. J. Whitrow, second edition, 1980, Clarendon Press, Oxford, pp 370-371.
[117] *Ibid., p. 372.*

had begun to exist. They based their proof for the existence of God on the beginning of the universe. Imam Ghazzali's version of the proof is as under:[118]

1. Every being which begins has a cause for its beginning.
2. The world is a being which begins.
3. Therefore, it possesses a cause for its beginning.

The proof is known in the West as the Kalam Cosmological Argument. Dr. William Lane Craig wrote a book in 1979, titled 'Kalam Cosmological Argument', in which he assessed 'the worth of the argument in light of modern developments in philosophy, theology, mathematics and science,[119] and came to the conclusion that the argument 'is most likely to be a sound and persuasive proof for the existence of God.[120] He devotes one chapter of the book to al-Kindi and another to al-Ghazzali. They, both, had argued, not only for the beginning of the world, but also for the beginning of time itself. The central issue of their arguments was, 'whether the temporal series of past events could be actually infinite.[121] They argued that it could not. The summary form of one of the arguments of al-Kindi for the finitude of time as given by Craig is as under:[122]

> "……any given moment can not be reached until a time before it has been reached, and that time cannot be reached until a time before it has been reached, and so on, ad infinitum. But it is impossible to traverse the infinite; therefore, if time were infinite, the given moment would never have arrived. But clearly a given moment has arrived; therefore, time must be finite".

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[118] AI-Ghazzali, Kitabul-Iqtisad fil Ihtiqad, with a foreword by Ibrahim Agah Cubukou and Huseyin Atay, University of Ankara Press, Ankara, pp 15-16. Quoted from p. 44 and p. 59 of The Kalam Cosmological Argument, William Lane Craig., 1979, Library of Philosophy and Religion, University of Birmingham.

[119] The Kalam Cosmological Argument, William Lane Craig, 1979, Library of Philosophy and Religion, University of .Birmingham, pp 1-2, Preface.

[120] *Ibid,* p. 63.

[121] *Ibid.,* p. 1, Preface.

[122] *Ibid.,* pp. 22 and 56, Al-Kindi, On First Philosophy, pp. 74-75.

The Muslim philosophers such as Farabi and Ibn-i-Sina considered that the universe was eternal but was finite in spatial extent. To the commonsense question 'what was beyond the world', they replied that the question was not meaningful; nothing was beyond it, neither empty space nor occupied one. A similar question arises today in connection with one particular cosmological model of a finite but expanding universe; as to what it is expanding in and this question is being met in a similar answer applied to the question what was 'before' the creation of the world. He wrote,[123] "There is no difference between temporal extension . . . . which is described in terms of its relations, as 'before' and 'after' . . . . and spatial extension .. which is described in terms of its relation as 'above' and 'below'. If it is possible to have an above-less 'above', it should also be possible to have a before-less 'before'."

As regards the beginning of time and the world, the Imam wrote[124]

"Time did have a beginning; and it was created. And before time, there was no time whatsoever. When we say: "God is prior to the world and time ', we mean that He was and the world was not; and that, afterwards, He was and the world was together with Him .... In order to understand this statement, it will not be necessary to suppose any third thing". The third thing, viz., time, obviously comes into being with creation of the world.

[123] Tahafut Al-Falasifah, Al-Ghazzali, English translation by Sabih Ahmad Kamali, Pakistan Philosophical Congress, Lahore, 1958, pp 38-39.
[124] *Ibid.,* p. 36.

According to the present-day cosmology, the universe began with a great explosion (termed big bang) from a state of infinite density about 15 billion years ago. Four prominent scientists describe that event in these words:[125]

> "……the universe began from a state of infinite density about one Hubble time ago. Space and time were created in that event and so was all the matter in the universe. It is not meaningful to ask what happened before the big bang: it is somewhat like asking what is north of the North pole".

Professor Whitrow writes:[126]

> "……the concept of a first moment of time is not a self-contradictory concept, for it may be defined as the first event that happened . . . . for example, the initial 'explosion' of an expanding universe .... There was no time before that".

The position of the Mutakallimun, al-Kindi and al-Ghazzali, therefore, seems to have been well-founded.

The age of the universe is determined according to the scale of cosmic time[127] which Einstein introduced in his general theory of relativity in 1917 and which is a sort of universal time. If the relativistic time which is, now, considered to be a local phenomenon can be abandoned altogether, universal time or some variant of it, is again likely to prevail in science.

Section 26

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[125] J. Richard Gott III, James E. Gunn, David N. Schramm and Beatrice M. Tinsley, 'Will the Universe Expand Forever?', Scientific American, March, 1979, quoted from pp. 116 & 162 of the Kalam Cosmological Argument by William Lane Craig, 1979, Library of Philosophy and Religion, Birmingham University.

[126] The Natural Philosophy of Time, G. J. Whitrow, second edition 1980, Clarendon Press, Oxford, p. 33.

[127] *Ibid,* p. 283.

From an early time in their history, Muslims-displayed a keen interest in the problems of space and time. According to Iqbal:[128]

> " ... both in the realm of pure intellect and . . . . higher Sufi-ism, the ideal revealed is the possession and enjoyment of the infinite. In a culture, with such an attitude, the problem of space and time becomes a question of life and death".

A little after the middle of the sixth century Hijra, a sufi thinker conceived of different orders of space and different orders of time for different types of entities. His views have been summarized by Iqbal in his *Reconstruction of Religious Thought in Islam* in the name of Iraqi[129] and Dr. Razi-ud-Din Siddiqi has also referred to them in his book on IqbaI[130]. It has since transpired through the researches of Nazar Sabri[131] that the worthy sufi in question was not Iraqi, but Shaikh Taj-ud-Din Mehmood Ashnawi. There seems to have been a Muslim tradition not to mention ones name in ones own publication lest one be projecting oneself. Hence, probably, the misapprehension in this case.

Though Einstein had postulated a plurality of inertial spaces and the resultant plurality of time systems, the approaches of Einstein and Shaikh Ashnawi were vastly different and, therefore, the parallel in their views does not go beyond the plurality of space orders and plurality of time orders. Even

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128 The Reconstruction of Religious Thought in Islam, Sir Mohammad Iqbal, Shaikh Muhammad Ashraf, Lahore, 1954, p. 132.

129 *Ibid.,* p. 75 and pp. 135-137.

130 Iqbal Ka Tassawar-i-Zaman-o-Makan, .Razi-ud-Din Siddiqi, Majlis-e-Taraqi-e-Adab, Lahore, 1973, pp. 95-96.

اقبال کا تصور زمان و مکان اور دوسرے مضامین از ڈاکٹر رضی الدین صدیقی، مجلس ترقی ادب لاہور. 73. ص95-96

131 Ghayat-ul-Amkan-fi-Mabrifat-uz-Zaman-wal-Makan, Shaikh Tajud-Din Mehmood bin Khuda Dad Ashnawi, Majlis Nawadraat-e-Ilmya, Attock, Campbellpur, 1401 Hijra with a Preface and a prolegomena by Nazr Sabri, p. Meem, Ya.

غایۃ الامکان فی معرفۃ الزمان والمکان از شیخ تاج الدین محمود بن خداداد اشنوی. مجلس نوادرات علمیہ، اٹک کیمپلپور، 12 ربیع الاول 1401ھ پیش لفظ و مقدمہ از نذر صابری. ص م ی

then, to have anticipated a development in human thought by some eight centuries is no small matter.

The special theory of relativity radically modified the existing ideas about space and time. The reaction to it in Muslim circles does not seem to be what it need have been. The working Muslim scientists show a trend to accept its teachings uncritically and on authority, yet the voices of criticism and dissent were not altogether lacking. The late Justice Sir Shah Mohammad Sulaiman, an important jurist and scientist, disagreed with the theory. The late Dr. Iqbal who was much intrigued with the philosophical implications of the theory, was dissatisfied with the manner in which the theory regarded 'the future as something already given, as indubitably fixed as the past' wherein 'events do not happen; we simply meet them.'[132] As pointed out by Razi-ud-Din, this was a rather distorted view of the theory[133], which was in vogue then, but it must have exercised Iqbal's mind considerably, according to whom time was 'a free creative movement'.[134] But for his untimely death, he was to lecture at Oxford[135] on the subject of space and time, a subject in which he was deeply

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[132] The Reconstruction of Religious Thought in Islam, Sir Mohammad Iqbal, Shaikh Muhammad Ashraf, Lahore, 1954, pp: 38-39.

[133] Iqbal Ka Tassawar-i-Zaman-o-Makan, Razi-du-Din Siddiqi, Majlis-e-Taraqi-e-Adab, Lahore, 1973, p. 119.

اقبال کا تصور زمان و مکان اور دوسرے مضامین از ڈاکٹر رضی الدین صدیقی. مجلس ترقی ادب لاہور 1973. ص 119

[134] The Reconstruction of Religious Thought in Islam, Sir Mohammad Iqbal, Shaikh Muhammad Ashraf, Lahore,1954, p. 38.

[135] Dr. Javed Iqbal, Lahore, in a letter to the author.

Dr. Sir Mohammed Iqbal
BAR-AT-LAW

MAYO ROAD
Lahore 193

Your Highness,

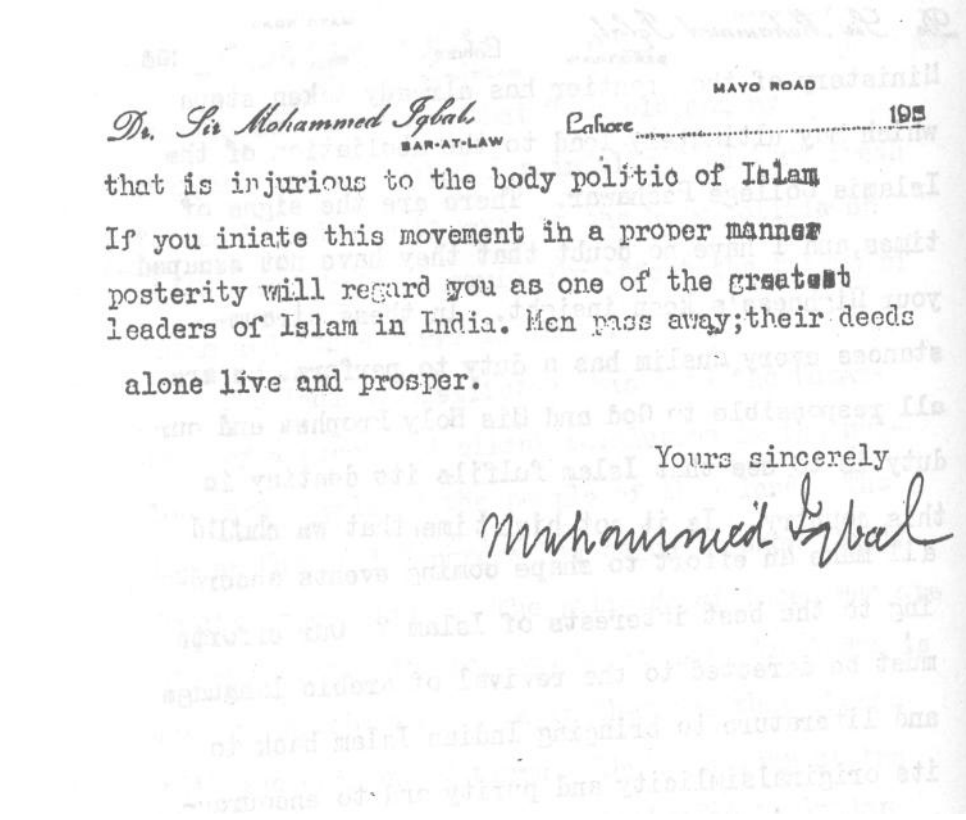
I have been long intending to write to your Highness; but unfortunately I have been prevented from doing so on account of ill-health, which has now extended over 3 years. I feel, however, a little better than before and have made up my mind to address you in the hope that in the multiplicity of state affairs which must be engaging your attention, you will find time to reflect over the contents of this letter even though it is bit long. Briefly I want to interest your Highness in the future of Islam and Islamic culture in India. I have every hope that my letter may help your highness in clearly seeing your duties as a Muslim ruler and as a lineal descendent of those from the foutain of whose religious consciousness flowed the stream of this religion and culture.

Since I know that your Highness is deeply concerned in the matter-far more deeply than any body else in India-to you alone can I disclose my mind and its apprehensions with regard to the problem which is now confronting the Muslims of India. I suppose your Highness knows that I have devoted the last 30 years of my life to a clear exposition of the underlying principles of Islam

and its culture. Now that I am old, and my energies are exhausted I painfully find that fresh forces have begun to work in the body politic of India which are likely to seriously affect the future of Islam and its culture in India.

The Indian Constitution has laid the foundation of a great and silent revolution in the outlook and ideals of the people of this land. The Indian National Congress has begun to show itself in its true colours. The policies of those who are at helm of affairs can not be trusted, for there is nothing of abiding value in them and they change with the changes of times. The behaviour of the Ulemas of Islam who have participated in Indian politics have shown that they have absolutely no grasp of the Muslim situation in India. Indeed the most learned of the Ulema have shown themselves to be the most stupid of them. It was reported the other day in the papers that a Muslim student of the Lucknow University openly declared that he was not a Muslim. I have reasons to believe that modern conditions are producing a type of Muslim youth who privately if not publicly ridicule religion. In the shape of a political song-Bandematram the Muslim-Congress-man is perhaps unconsciously learning to invoke the idol of ancient India. The Congress

Ministery of the Frontier has already taken steps which may ultimately lead to the aboliation of the Islamia College Peshawar. There are the signs of times,and I have no doubt that they have not escaped your Highness's keen insight. In these circumstances every Muslim has a duty to perform. We are all responsible to God and His Holy Prophet and our duty is to see that Islam fulfils its destiny in this country. Is it not high time, that we should all make an effort to shape coming events according to the best interests of Islam ? Our efforts must be directed to the revival of Arabic language and literature to bringing Indian Islam back to its original simlicity and purity and to encouraging the publication of literature which may illuminate the way to our destination. In this enterprise your Highness alone can give the lead to the Muslims of atleast North-West India. I have only briefly indicated the general problem which confronts Indian Islam; Details may be worked out later. For the present my only object is to interest your Highness in this serious situation. in the hope that you may give anxious thought to the subject of my letter,and start cultural movemen which may help the Muslim to assimilate all that is good and noble in our times and reject all



MAYO ROAD

Dr. Sir Mohammed Iqbal
BAR-AT-LAW

Lahore 193

that is injurious to the body politic of Islam
If you iniate this movement in a proper manner
posterity will regard you as one of the greatest
leaders of Islam in India. Men pass away;their deeds
alone live and prosper.

Yours sincerely

Muhammed Iqbal

Iqbal's letter to Nawab Sadiq Muhammad 'Abbasi' of Bahawalpur, written in 1937.

9th October, 1937.

My dear Sir Iqbal

Assalamu alaikum wa rahmat ullah wa barkatuh!

I was extremely delighted to get your letter for which I thank you very much.

You have indeed touched on a problem which has, for quite a long time been causing me much concern and anxiety. I am indeed greatly honoured and deeply touched by all the kind references you have made about myself and my State.

The situation as it stands is indeed well deserving of a united effort by those who like yourself are deeply verst in all questions pertaining to the most noble and uprighteous of faiths, our Islam. At times such as these through which we are passing, when we daily come to learn of incidents that are in every respect most derogatory to the interests of our faith, and shamless in the eyes of selfrespecting people, and are in themselves of a nature that apart from laying down undesirable precedences and bad examples are indeed very much detrimental to the interest of our much cherished cause. It is indeed most heartrending and disappointing that we can do nothing but have to silently witness the passing of time without correction or remedy.

of matters of which I would like to know more, I keenly feel my ignorance and also realise my helplessness by not having, worthy lieutenants near me who could correctly understand the true sense of what all of us owe to our Creator and to Him Whom He hath sent to guide us. I find myself surrounded by a world full of people eager only for their own betterment forgetting Him Who giveth all which we seek. All my endeavours for better and more desirable salutions to the many most intricate and mighty problems, which most rightfully deserve my time and consideration, thus remain unaccomplished and I feel that many a good opportunity has sliped by when I could have done some duty in the service of my Master and Creator.

I can assure you that during the last 14 years that I have looked after my State and people I have through the bounty of Allah had occasions to come into contact with, and know and learn from so many types, creeds and classes of His people, my fellow creatures, that I feel I am now in a position to serve His Cause if only it should be His wish and command, of course, all of us cannot or do not get every desire fulfilled but as long as there is faith,

reason why He who has the power to create and dispose of mighty things, cannot bestow His bounty on those of us who are in constant need of His goodness and blessings.

In as humble way I have for a long time given much thought to the very questions that you have made references to, but I find that with the present state of affairs when alas! we all stand not as one but devided, what is then to be done ? What should be the remedy that we should seek?

Of course, so much can be done, and certainly much is being done, but the way that the different individuals, bodies and missions scattered throughout the length and breadth of the world are working, even these if correctly judged and given their full value with their numerous individual interests so very far apart one from the other that I shudder to see how much injury, (even if the intention or the enterprise be with the best of intentions for the betterment of Islam), are doing with their different methods of carrying out their missionery propaganda. They are indeed giving sufficient food for thought to those who eagerly await an opportunity to adopt, if not the religion, the principles and doctrines of Islam. The various activities of the different missions, each vieing with the other for supremacy

and influence causes much anxiety and hesitation on the part of those eager to adopt our Faith.

Needless to add there is so much one could write about, but sincerely hoping that Insha-allah in the very near future I shall have the pleasure of meeting you, I see no necessity in lengthening this letter in which I feel I have already allowed my feelings to run riot ,' so please excuse me if you find all I have said, not too interesting.

I do hope that you are much better in health. It is indeed a very long time since we last met.

With sincere good wishes for your health and every happiness and with my best wishes and kind regards.

Yours ever Sincerely

(Sd) S. M. Abbasi

Dr. Sir Mohammed Iqbal,
Kt: M.A., Ph.D.,
Bar-at-Law,
Jawid Munzil,
Mayo Road,
Lahore.

Nawab Sadiq Muhammad Abbasi's reply to Iqbal's Letter. Reprinted with the courtesy of Sahibzada Qamaruzzaman Abbasi, grandson of the Nawab of Bahawalpur

interested. With the drawn of 'space age' this subject has. taken vastly increased importance. Let the Muslim theoretical thinkers pick up the thread where Iqbal left.