3

The Structure of the Vacuum

Cosmic Radiation Anisotropy

Space devoid of matter provides a frame of reference for isotropic cosmic radiation. By measuring the local anisotropy of such radiation it is possible to determine motion relative to this cosmic frame. Radiometers carried by U-2 aircraft at altitudes of 20 km have detected a component of Earth motion through space of 390 ± 60 km/s. This was reported in October 1977* and its importance was rapidly recognized by the scientific press. 'Aether drift detected at last' was a headline in *Nature*, November 3, 1977, at p. 9. The May, 1978, issue of *Scientific American* featured an article on the same subject under the title: 'The Cosmic Background Radiation and the New Aether Drift'.

Meanwhile, conscious of previously reported data indicating anisotropy of cosmic background radiation, theoretical physicists have been examining ways of healing the wound inflicted on aether theories by the relativistic doctrine. Sciama, writing at p. 298 of the February 2, 1978, issue of *New Scientist*, gives cause for reviving aether theory. His title was 'The Ether Transmogrified' and his case for conciliation was founded upon the assertion:

> Of course if one is allowed to give the ether whatever properties are required to account for electromagnetic phenomena no difficulty with the (aether) concept need arise.

There is nothing new in this idea. Nobel prizewinner Dirac pointed out in the May, 1963, issue of *Scientific American* at p. 50 that one can overcome the difficulties of reconciling the idea of an aether and Einstein's theory. Einstein has said this too, but the fact remains that the need for an absolute universal frame of reference is denied

* G. F. Smoot, M. V. Gorenstein and R. A. Muller, *Phys. Rev. Lett.*, 39, 898 (1977).

by Einstein's Theory of Relativity and it now appears that such a reference frame has been discovered.

The doctrines of relativity have been exercised to suppress those who have advocated belief in the aether medium, with the result that interest in experiments of the kind now performed by NASA in the United States has been slow to develop. The renewed interest in the aether medium which should now follow these recent developments could herald other discoveries which may have great practical consequences. It is timely, therefore, to examine this mysterious vacuum through which we move at phenomenal speed and speculate a little on its properties in the light of modern experimental evidence. We have, it would seem, arrived at the crossroads in science of which we were alerted by Dingle in his famous book attacking relativity.*

The fundamental issue confronting us is that an experiment performed in the late nineteenth century showed that electromagnetic radiation in the laboratory vacuum was referenced on a frame moving with the Earth in its motion about the Sun. Such motion is at a speed of 30 km/s, compared with the speed of light of 300,000 km/s. This discovery thwarted the beliefs of scientists in the universal aether medium, supposedly providing the medium governing the speed of light anywhere in the universe. So perplexing was this problem that it paved the way for a new philosophical approach based upon the principle that the physics perceptible to any non-accelerated observer will never permit him to measure his speed without taking bearings upon a world external to his local system. Einstein's theory was built upon such a principle and has had amazing success. Yet Einstein's theory has not lived up to the expectations of many physicists. Einstein died having failed to accomplish a task he had struggled with for decades, that of unifying field theory to relate electromagnetic and gravitational interactions. Furthermore, in spite of the successes of Dirac, there has been insufficient connection established between quantum physics and relativity and it is difficult to see scope for any significant connections between relativity and the new particle physics.

Relativity may have passed its heyday and the case for reviving belief in the aether, now forced upon us by the cosmic radiation experiments, provides the stimulus for progress in physics along new non-relativistic tracks. The first task is to reconcile the detection of the background reference frame governing cosmic radiation with

* H. Dingle, *Science at the Crossroads*, Brian and O'Keefe, London, 1972.

the experiments on light propagation which helped to launch Einstein's theory. A clue is provided by the opening words of this chapter. 'Space devoid of matter' provides the cosmic frame of reference. What is different about the two experimental facts which we have just put in conflict? Simply that one involves the *speed* of radiation and the other the *intensity* of radiation. Speed is measured locally in the near presence of matter. Intensity based upon the assumption of the cosmic isotropy is measured locally too, but is a measure of radiation intensity in surrounding space undisturbed by matter. Here lies the key.

In empty space devoid of matter and not disturbed by nearby matter there is a universal cosmic reference frame relative to which electromagnetic waves travel at a constant and universal speed. Let us term this the 'C-frame'. In the laboratory environment even vacuous space might somehow be affected by the near presence of enveloping matter in motion relative to the surrounding C-frame. There could be disturbance affecting the properties of the space medium permeating the local vacuum. Here we know that the electromagnetic reference frame somehow adopts the observer's laboratory frame of reference so that the speed of light is independent of the linear motion of the laboratory and is constant in all directions. We may term this local electromagnetic reference frame the 'E-frame'. The E-frame and the C-frame become identical in the absence of matter.

In outer space it appears that the cosmic radiation is isotropic in the C-frame. Thus the intensity of this radiation traversing the Earthly laboratory will be isotropic relative to the surrounding C-frame. But the motion of the laboratory through space will mean that the energy detectors will sense an anisotropy in this radiation measured relative to the laboratory. This is so notwithstanding the fact that the speed of propagation of such radiation through the Earth system is rendered isotropic relative to the Earth's own E-frame.

Fig. 19 illustrates the hypothesis adopted. The Earth system moves through space at velocity V and causes disturbance of the permeating space medium by which the E-frame also travels at velocity V. Enveloping this there is undisturbed space in which the same medium provides a universal reference frame, the C-frame, which is similar in character to the E-frame but which is also the reference frame for motion such as V.

According to the old-fashioned aether hypothesis, the C-frame is the only frame of reference and would permeate the Earth as well. According to the Theory of Relativity, the only reference frames of relevance are those local to individual observers. In effect, with relativity there is a multiplicity of E-frames but no C-frame.

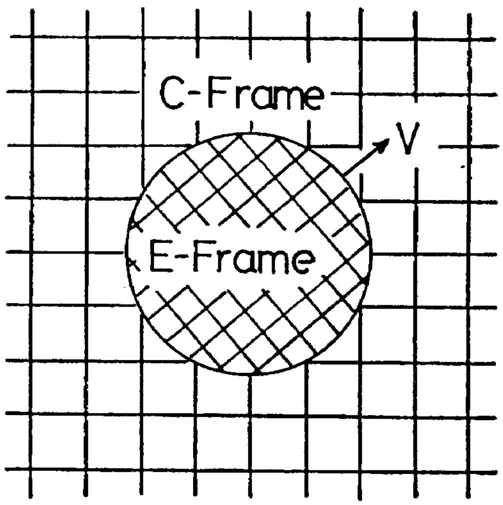

Fig. 19

It is true to say that much of physics can be described in relativistic terms without reference to the C-frame and the universal aether thereby implied, but it is wrong to deny the existence of such an aether in the light of the cosmic radiation experiments.

The discerning reader will recognize from Fig. 19 that what is proposed is a kind of 'aether drag' and will question the position of the boundary between the Earth's E-frame and the enveloping C-frame. Also there is the question of whether the E-frame rotates. Called to mind are problems of stellar aberration and Lodge's experiment* in which there was no evidence of drag on light propagation around a circuital path in the space between two rapidly rotating steel discs.

The boundary question will be left for a later chapter,† but we will deal here with Lodge's experiment and then come to the aberration issue. The null result of Lodge's experiment was taken as proving that there was no effect on the speed of light due to the motion of nearby matter. This is deemed to disprove aether drag.

* O. Lodge, *Phil. Trans. Roy. Soc.*, **184**, 727 (1893).
† See discussion on geomagnetism in Chapter 8.

But consider the consequences had a positive result been found. It would have meant that light speed was referenced on the frame rotating with the discs. Then an observer rotating with the discs would, in his frame, have been unable to detect his rotation by optical reference to the vacuum in his vicinity. Such a result would have been more in keeping with the relativistic hypothesis than with the idea of aether. In fact, the null result bears only upon aether drag in the sense of rotation and only then upon the drag of the electromagnetic reference frame. The word 'aether' conjures in our minds something more tangible than a mere frame of light reference and Lodge's experiment in no way proves that something tangible does not rotate with the discs.

The null result was consistent with the possibility of an observer rotating with the discs actually measuring his speed of rotation by optical tests based upon the non-rotational property of the vacuum. It became possible to measure speed of rotation in an absolute sense by interferometer techniques. The null result was a pointer that tests to detect rotary motion within a fixed aether medium should prove positive. The fixed aether concept need only stand refuted in respect of the failure to detect truly translational motion.

Reverting now to the E-frame theory, we see from Lodge's experiment that the E-frame cannot rotate, and yet, as will be shown, this does not deny rotation of structure constituting an aether and such rotation is important in defining the existence of separate E-frames.

Many optical experiments involving rotating apparatus and sensitive to the non-rotating vacuum frame have been performed. A modern development is found in the ring laser gyro. One of the earliest reported experiments was that of Sagnac* involving a ring interferometer on a rotating disc.

There is, in fact, a degree of conflict in certain experimental evidence involving speed of light measurements and bearing upon relativity. Simply stated, the experiments all give results in accord with the following statement:

> Light in vacuum is propagated at a speed which is independent of direction when measured relative to an inertial reference frame.

The problem is that our measurements require this inertial reference frame to be, in some cases, a frame located by the centre of the Earth

* G. Sagnac, *Comptes Rendus*, **157**, pp. 708 and 1410 (1913).

and, in other cases in which the test apparatus is rotating, a frame referenced by the structure of the apparatus itself. The consequences of this are very perplexing and the Theory of Relativity does not provide an adequate answer because it gives no basis for distinguishing the inertial frame to be used when applying the Principle of Relativity.

It has long been recognized that physical phenomena dependent upon rotation can highlight weaknesses in relativity theory. Philosopher Alfred North Whitehead in his work 'The Principle of Relativity with Applications to Physical Science' wrote:*

> The effects of rotation are among the most widespread phenomena of the apparent world. . . . Rotation is the stronghold of those who believe that in some sense there is an absolute space to provide a framework of dynamical axes. . . . The Einstein theory in explaining gravitation has made rotation an entire mystery.

In his work 'An Enquiry Concerning the Principles of Natural Knowledge', Whitehead† discusses the problem of the Earth's rotation and the centrifugal effect which develops the Earth's equatorial bulge. He poses the question: 'But rotating relatively to what?', and writes:

> It has been asserted that after all the fixed stars are essential, and that it is the rotation relatively to them which produces the bulge. But surely this ascription of the centrifugal force on the Earth's surface to the influence of Sirius is the last refuge of a theory in distress. . . . The more natural deduction is to look on the result as evidence that the theory of any empty space is an essential impossibility. Accordingly the absoluteness of direction is evidence for the existence of the material ether. . . Thus space expresses mutual relationships of parts of the ether, as well as the parts of the earth.

The Michelson–Morley experiment dates back to 1887 and is very well known. It is essentially a test involving a four-way propagation of light, two opposite ways in each of two orthogonal directions. The apparatus was calibrated by measuring the change in a light interference pattern resulting when the system is turned through

* This work appears in A. N. Whitehead's *An Anthology*, Cambridge University Press, 1953, p. 356.

† See p. 183 of Whitehead's *An Anthology*.

90° to interchange the effects of aether drift between the two measurement paths.

Assuming that light travels at a fixed speed in space, this experiment should have yielded at least an indication of the 30 km/s motion of the Earth about the Sun. No such effect was observed and, as Joos* demonstrated many years after the earliest experiments, no aether slip can be detected by this method, at least to within 1·5 km/s.

The experiment demonstrated that, within the limits of a few km/s, the speed of light measured in the laboratory is the same in all directions. The interesting question then is whether this speed depends upon the Earth's rotation. The laboratory is carried about 30,000 km every day in its motion about the Earth's axis for most of our experimental sites and a speed detection of 0·3 km/s is necessary to sense this rotation.

The Michelson–Gale–Pearson experiment is almost unknown. Shankland† has recently reminded us of its importance. Michelson gave an early account of the theory and argued the possibility of detecting the effects of the Earth's rotation through an aether‡ and finally came to perform the experiment§ in the years 1923–25. This involves the four-way propagation of light around a rectangular light path. Two opposite sides of the rectangle lie along different lines of the Earth's latitude. Since the Earth rotates light should travel at different speeds along different lines of latitude if the idea of an aether is tenable. In this experiment the apparatus remained fixed to the Earth. There was no independent rotation. A calibration reference for the measurement utilized a light beam travelling along the path in the opposite direction to that of the test beam.

The experiment gave exactly the result predicted on fixed aether theory. It was possible to detect the rotation of the Earth by measuring its effect on light speed within a vacuum enclosed by apparatus rotating with the Earth.

Here was a surprising conflict with the results of the earlier Michelson–Morley experiment. It seemed that aether theory suited rotation detection but could not account for the non-detection of linear motion, whereas relativity satisfied the latter and was not

* G. Joos, *Ann. der Physik*, 7, 385 (1930).

† R. S. Shankland, *Physics Today*, April, 1974, p. 37.

‡ A. A. Michelson, *Phil. Mag.*, **8**, 716 (1904).

§ A. A. Michelson, H. G. Gale and F. Pearson, *Astrophys. Jour.*, **61**, 140 (1925).

disturbed because it was generally silent on the former. These optical phenomena were the province of Einstein's Special Theory of Relativity and that concerns effects in non-rotating frames of reference.

A null result in the Michelson–Gale–Pearson experiment would have supported aether drag theory and could have helped the Theory of Relativity in dealing with the problem raised by Whitehead. It is one thing to look to distant stars as mediating between matter on Earth to help account for inertial properties in a way linked with gravitation. It is quite another matter to expect distant stars to affect the speed of propagation of light between two points on the Earth's surface, especially if this speed changes with latitude.

There is a tendency to dismiss this very important experiment as being a mere extension of the earlier Sagnac experiment, but it has far greater importance because the rotating reference frame for the experiment is the Earth itself.

Another very important experiment of this kind became possible once the maser was developed. It was no longer necessary to compare speed of light measurements at two latitudes. Instead of rotation being detected it became possible to test directly whether the east–west speed of light differs from the west–east speed. In the experiment reported in 1958 by Townes* working in collaboration with Cedarholm, Bland and Havens, the relative frequency of two beam-type maser oscillators with oppositely directed beams was used to test directly this speed difference. The test was a two-way test affording a first order measurement of v/c, where v is the speed of the apparatus through the aether and c denotes the speed of light. Calibration involves rotating the apparatus through 180° to interchange the beam directions. A measured 20 cps beat frequency would have indicated an aether drift of 30 km/s, assuming an appropriate thermal molecular velocity for the masers. In fact there was a consistent beat frequency measured of 1·08 cps which only varied about 0·05 cps during the day, that is during the full rotation of the Earth. This minimal variation throughout the 24 hour period gave affirmative evidence that the Earth's linear motion through space defies detection. The measured steady beat signal could indicate an aether drift about the Earth's axis of rotation of up to about 1·5 km/s. It was not so interpreted because the authors felt it to be due

* J. P. Cedarholm, G. F. Bland, B. L. Havens and C. H. Townes, ***Phys. Review Lett.***, **1**, 342 (1958).

to magnetic effects which they had not compensated. Their results were therefore inconclusive. However, guided by the Michelson–Gale–Pearson experiment, one must expect a drift of about 0·3 km/s to be in evidence. The technique of this maser-beam experiment if refined to overcome the magnetic disturbance should permit the measurement of this 0·3 km/s drift, bearing in mind the degree of accuracy reported for the variable component of the beat signal. Such a measurement would be a direct speed measurement and not a measure of speed of rotation.

An experiment of this kind would be very crucial to the validity of the Theory of Relativity. Suppose, for example, that the Earth's west–east motion could be measured as a direct speed quantity by these optical tests. Einstein's theory is then refuted because the speed of light is no longer constant relative to the observer. After all, the observer will have just measured his speed relative to the non-rotating reference frame centred in the Earth's axis by assuming that light speed is referenced in that frame and not one moving with him. It would really be no use arguing that the measurement of 0·3 km/s attributable to his motion about a remote axis does not count owing to it not being a non-accelerated linear motion. The failure to detect the Earth's 30 km/s motion about the remote Sun has been attributed to relativity. Yet this motion is circuital and therefore accelerated.

It is of interest to mention that lasers have been used in a four-way ring configuration to measure Fresnel drag, whether in solid, liquid or even gaseous media. In a paper* dated 1964 which described such apparatus it was stated:

> The effect of Earth rotation was significant, as could be demonstrated by velocity reversal of the moving media, and all data points were accordingly adjusted.

One may wonder, therefore, why the implicit effect of sensitivity to motion through the light reference frame has not been seized upon to demonstrate the invalidity of Einstein's theory.

An answer to this may come from the experiments which have shown that aether drift in the laboratory can be measured to a few metres per second and demonstrated as non-existent. However, these experiments either depend upon laser technology (discussed later)

* W. M. Macek, J. R. Schneider and R. M. Salamon, *Jour. Appl. Phys.*, **35**, 2557 (1964).

or require a rotation of the test apparatus about an axis within the confines of the laboratory. At this stage, it is noted that there is a difference between the two rotating systems depicted in Fig. 20.

Optical experiments by observer A spinning with a rotating platform at speed v_1 about its axis may detect this speed v_1 but not his speed v_2 about the Earth's axis. Nor, similarly, will observer B moving with the Earth about the Earth's axis be able to detect the Earth speed v_3 about the Sun, but observer B could well be able to

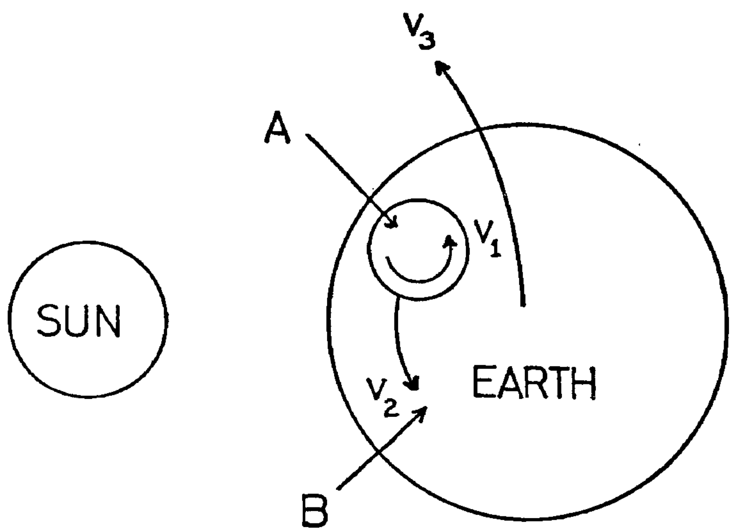

Fig. 20

detect his speed v_2 about this Earth axis. In the terminology developed earlier in this chapter we may say that rotating apparatus has developed in its own E-frame which moves within the larger E-frame of the Earth.

Thus a very important experiment on aether drift was proposed by Ruderfer* and performed by Champeney, Isaak and Khan.† It depends upon the Mossbauer effect and uses a gamma radiation source located at the central axis of a rapidly rotating table. The speed at which radiation is propagated from the source and measured relative to the axis is assumed to be subject to aether drifting past the apparatus. An absorber at the periphery of the table rotates at

* M. Ruderfer, *Phys. Review Lett.*, **5**, 191 (1960).

† D. C. Champeney, G. R. Isaak and A. M. Khan, *Proc. Phys. Soc.*, **85**, 583 (1965).

speed about the axis and senses the distorted wave radiation pattern emitted relative to the axis. The result should be a first-order one way sensing of aether drift. In fact none is detected in excess of a few metres per second. The experiment shows that the radiation travels at the same speed in different directions measured relative to the axis of the apparatus.

Although such experiments are deemed to have dispelled all credibility in the aether hypothesis and the scope for detecting motion through the reference medium for light propagation, the fact remains that Einstein's theory is on shaky foundation on the evidence of the optical detection of Earth rotation. More experiments involving apparatus sharing only the Earth's rotary motion are required.

A particularly relevant experiment, using laser interferometry is on record in 1976.* It gave such accurate null indications that the west–east motion of the laboratory due to Earth rotation was also nullified. This seems to refute the author's thesis, but it also seems anomalous having regard to the detection of rotation by using the ring laser gyro. Silvertooth, who performed this experiment, was led to interpret it as evidencing an aether interaction which implied an empirical reformulation of the Doppler Effect. However, it is submitted that the true answer to this anomaly lies in a basic deficiency in methods relying upon lasers as independent light sources when performing tests based upon interference effects.

In the ring laser gyro the optical interference path is intrinsic to the laser. The mirror system, which is essential to the laser, is the mirror system having an optical path sensitive to the speed of rotation. The laser frequency in this gyro device is therefore dependent upon the speed of rotation. Now, if the laser frequency depends upon the state of motion of the laser through the light-reference medium, we have to be very careful about using lasers in Michelson-type experiments. If the hypothetical basis for the experiment is that the apparatus is assumed somehow to be moving relative to the light-reference frame, then the effect of this same motion upon laser operation must be considered.

Since 1958, when the experiment by Cedarholm *et al.* was reported, the use of masers has given way to laser techniques. The above-mentioned 1976 experiment presented a refinement by superimposing the beams of two free-running lasers in oppositely-directed paths. Two semi-transparent photo-cathode detectors were placed some

* E. W. Silvertooth, *Applied Optics*, **15**, 1100 (1976).

50 cm apart along the axis of the interfering beams. These interrogated and compared the beat frequencies detected at the two locations. Theoretically, given stable laser frequencies, any motion through the light-reference frame would be directly related to a phase shift between the beat signals sensed. Silvertooth calculated a phase shift of some 79 complete cycles to correspond to the Earth's orbital velocity of 30 km/s. Thus a phase shift of this order was to be expected in rotating the apparatus through 90° at a certain time of day and given appropriate alignment of the apparatus. In spite of the very high sensitivity of this apparatus no phase shift was detected. The writer has questioned the author of this experiment and is assured that there was not the slightest trace of phase shift, meaning that even the 0·3 km/s west–east speed of Earth rotation was obscured.

Silvertooth's interpretation was that the frequencies of the interfering beams were themselves dependent upon velocity relative to a preferred frame. Hence he was led to propose an optical aether drift experiment which is currently under way at the University of Arizona Optical Sciences Center. Let us, instead, examine how motion could affect the laser directly. The amplification properties of the laser depend upon a resonance of reflected light waves and so depend upon the optical path within the laser. This must be an integral multiple of wave-lengths at the laser frequency. If the distance between the mirrors in the laser is fixed then it is only if the speed of light propagation over the return journey changes that we may expect the laser frequency to change.

For motion at velocity v along the laser axis, the speed of light is $c-v$ in one direction and $c+v$ in the other, c being the speed of light in the preferred frame. This makes an average speed of $1-(v/c)^2$ times the speed of light c. For a fixed wave-length this corresponds to a frequency proportional to $1-(v/c)^2$. The analysis is, indeed, analogous to that used as the basis for the Michelson–Morley experiment. It means that using a laser source moving in the direction of the laser axis we may expect the conventional Doppler equation for the frequency of a moving light source, as seen by a fixed observer, to be modified from a form proportional to $c/(c \pm v)$ to the inverse $(c \pm v)/c$. The ratio is the above parameter $1-(v/c)^2$.

The alternative is to recognize that if lasers are used for Michelson–Morley type experiments or direct interferometer tests of the kind outlined above, the frequency of the lasers will adjust to the reorientation of the apparatus exactly to cancel any effect due to motion through the light-reference frame. The null result becomes an inevitable consequence.

It may then be argued that any experiment purporting to use lasers in an interferometer to disprove the idea of motion through the aether is inconclusive. Note, however, that this conclusion might well be different if the speed of light for the many reflections of the light within the laser is very different from that associated with the primary apparatus. For example, if the light path of the apparatus is in air and that of the laser is in, say, a ruby, then c would not be the same for the main apparatus and the ruby laser. The cancellation of effects related to the speed v would only be partial and v might well be detected. It is accordingly suggested that the Silvertooth experiment should be repeated using ruby lasers in order to establish whether optical tests referenced on the vacuum medium can directly sense the 0·3 km/s speed of the Earth's rotation about the Earth's axis. In contrast with the Michelson–Gale–Pearson experiment of 1925, this would be a measurement of speed rather than rate of rotation. A positive result seems very likely and it might have rather dire consequences to the confidence we can place in one of the basic tenets of the Theory of Relativity.

It is submitted that the concept of the E-frame as providing a non-rotating reference frame adapting to the linear motion of local matter is viable. It remains, of course to explore the structure of this E-frame, but first it seems appropriate to examine other optical evidence supporting relativity.

The Transverse Doppler Effect

Historically the null result of the Michelson–Morley experiment was explained shortly after its discovery, by the contraction hypothesis of Fitzgerald and Lorentz. The apparatus was deemed to contract in proportion to the factor $(1-v^2/c^2)^{\frac{1}{2}}$ in its direction of motion at speed v. Lorentz modified his theory in 1904, reacting to the 1903 Trouton–Noble experiment (as discussed in Chapter 1) and the null detection of double diffraction by Rayleigh* and Brace.† He introduced time dilation in addition to contraction. These ideas also appear in Einstein's theory from 1905 onwards.

* Lord Rayleigh, *Phil Mag.*, **4**, 678 (1902).
† D. B. Brace, *Phil. Mag.*, **7**, 317 (1904).

In 1932 an experiment by Kennedy and Thorndike was reported.* It was similar to the Michelson–Morley experiment but required the optical arms of the interferometer to be of different length. It gave a null result and thereby indicated that if contraction was to be relied upon to explain the null Michelson–Morley result then there must also be a modification of the frequencies emitted by atoms producing the light source. The frequency had to be proportional to $(1 - v^2/c^2)^{\frac{1}{2}}$. The paper by Kennedy and Thorndike was deemed to verify the concept of time dilation and so one of the basic tenets of Einstein's theory.

Dingle, in discussing the Kennedy and Thorndike experiment in his 1940 book *The Special Theory of Relativity*,† declares that it is possible to interpret its null result as a Fitzgerald contraction plus a modification of the frequency emitted by atoms 'produced by their motion through the ether'. But he says this would involve ad hoc assumptions as there is no other evidence that such a phenomenon exists at all. In fact, Ives and Stilwell (1938, 1941) provided the experimental evidence that motion affects the optical frequencies emitted by atoms.‡ This has been taken as direct evidence of time dilation and as support for Einstein's theory. Thus, although the introduction of the E-frame concepts makes contraction and time dilation irrelevant as an explanation of the Kennedy and Thorndike null observation, the experiments of Ives and Stilwell in demonstrating what is termed the transverse Doppler effect are regarded as proof supporting the Theory of Relativity.

Now it is the concept of time dilation which is so difficult for many sceptics to accept. Yet this concept appears to have direct experimental support from three different aspects. Firstly, there are the direct optical measurements of transverse Doppler effect on atoms moving at high speeds. Secondly, there is the so-called 'thermal red shift', a transverse Doppler effect appearing in the emission of gamma rays by atomic nuclei and detected in Mossbauer experiments. Thirdly, there are experiments showing that the lifetime of mu-mesons increases with their speed.

In the face of such evidence it is hardly surprising that physicists can turn a blind eye to the open question left from the inconclusive

* R. J. Kennedy and E. M. Thorndike, *Physical Review*, **42**, 400 (1932).

† Published by Methuen. See p. 20.

‡ H. E. Ives and G. R. Stilwell, *Jour. Opt. Soc. Am.*, **28**, 215 (1938) and **31**, 369 (1941).

maser-beam experiments discussed above. It seems so improbable that relativity could fail such a basic test. Yet, it only needs one such failure for the whole theory to collapse. In this event, how can we deal with the evidence giving independent support for time dilation?

One of the tests above has a ready answer. It is to be found in a book by Wertheim.* He first shows how the relativistic formulation for the transverse Doppler effect is verified by affording an explanation for an extraneous effect which appeared in a Mossbauer experiment. It appears as a red shift of the gamma quantum emitted by the source and manifested in dependence upon temperature. Then Wertheim goes on to give an entirely separate explanation based solely upon use of the energy-mass relation $E=Mc^2$. The same result is obtained without any use of the time dilation theory. Wertheim concludes his account in favour of time dilation by discussing the 'twin paradox', one of the perplexing consequences of time dilation, but in this connection relies essentially upon the experimental evidence provided by meson decay.

Encouraged by this, let us ask whether the spectral emission by atoms can be expected to be modified by motion. We need then to examine the nature of the Rydberg constant R. Is this a speed-dependent constant? Rc has the dimensions of frequency and R is formulated as:

$$R=2\pi^2 me^4/h^3 c \tag{55}$$

where m is electron mass, e is electron charge, h is Planck's constant and c is the speed of light in vacuo.

It is conventional to regard e, h and c as invariant, whereas m is known to increase with speed in proportion to $(1-v^2/c^2)^{-\frac{1}{2}}$. On this account we would expect the value of R to increase with speed v, whereas, for frequency subject to relativistic time dilation, R should decrease in proportion to $(1-v^2/c^2)^{\frac{1}{2}}$. Here then is an interesting problem.

The answer emerges as soon as we remember how R is derived. Rhc is an energy and, theoretically, it is the difference between an electric interaction energy $4\pi^2 me^4/h^2$ and a kinetic energy $2\pi^2 me^4/h^2$. If only this kinetic energy term is affected by the change of speed whilst the interaction energy term remains unaffected then the mass

* G. K. Wertheim, *Mossbauer Effect: Principles and Applications*, Academic Press, New York, 1964, p. 32.

increase only applies to the latter formulation. The Rydberg constant would then increase with speed v in proportion to:

$$2-(1-v^2/c^2)^{-\frac{1}{2}} \tag{56}$$

For small v/c this factor given by (56) is very close to the expression corresponding to time dilation $(1-v^2/c^2)^{\frac{1}{2}}$.

But why should we suppose that the electric interaction energy does not exhibit mass increase with speed? Surely all energy has mass which is augmented by the mass attributable to its kinetic energy. Curiously, this is by no means certain. Although it is well established that inertial mass and gravitational mass are equivalent to a very high order of accuracy, there is no certain equivalence between mass and energy. The formula $E=Mc^2$ is a statement that a mass M has association with an energy E but its derivation is by no means an assurance that all energy exhibits mass. In discussing the experimental evidence favouring equivalence, Dicke* stresses that his conclusions depend upon the *assumption* of the equivalence of inertial mass and energy. This is a very important point, particularly as energy has different forms.

For example, kinetic energy and the rest mass energy of a particle are intimately associated with the inertial property and the derivation of $E=Mc^2$. Here the mass-energy equivalence must be rigorously valid. However, the mutual energy of interaction between the proton and the electron in the hydrogen atom is less evidently connected with its own inertial property. This two body system has its proton and electron in motion about their common centre of gravity and the electric interaction energy shares this same centre of gravity. If the mass property is somehow nucleated by electric charge it may only be the self energy of such charges that constitutes mass-energy. Indeed, collectively all the interaction energy present locally may be the determining influence which provides the local inertial frame. This is speculation, just as the supposition that interaction energy may have mass is mere assumption. It is, however, speculation encouraged by Brillouin.† He discusses the location of the mass ascribed to the interaction energy between an electron in a box and a charge on the box. He argues that none of this interacting energy

* R. H. Dicke, *The Theoretical Significance of Experimental Relativity*, p. 7. Blackie, London, 1964.

† L. Brillouin, *Relativity Reexamined*, Academic Press, New York, 1970, pp. 14 and 24.

can affect the mass of the electron in the box. In the same work he shows that it is conventional to disregard the movement of the 'external potential energy', the interaction energy of our argument, when considering inertial properties. He may well refer to this as a 'strange situation'. However, it is less strange when we see the result deduced above. It has led us to the time dilation formula without there being any need for time to dilate. When an atom is moving at high speed its spectral emission shifts simply because the energy quanta released are reduced. This is not time dilation in the sense intended by Einstein.

We have, however, a proposal which may yet be tested to distinguish between the relativistic theory and that just proposed. When v/c approaches unity it becomes possible to distinguish between (56) and the relativistic formula. Note the difference between the two expressions:

$$2-(1-v^2/c^2)^{-\frac{1}{2}} = 1-\tfrac{1}{2}(v/c)^2-0{\cdot}375(v/c)^4\ldots\ldots$$
$$(1-v^2/c^2)^{0\cdot5+k} = 1-\tfrac{1}{2}(v/c)^2-k(v/c)^2-0{\cdot}125(v/c)^4\ldots\ldots$$

An experiment is needed to measure k to check whether it is zero as required by relativity or whether it has a positive value of approximately $0{\cdot}25(v/c)^2$, as indicated by the theory just developed.

Mandelberg and Witten* in their experiments with hydrogen atoms used a value of v/c of less than 0·01 and found that $0{\cdot}5+k$ was $0{\cdot}498 \pm 0{\cdot}025$. Snyder and Hall,† working with neon atoms, aim for much higher accuracy and have already reported $0{\cdot}5+k$ as $0{\cdot}502 \pm 0{\cdot}003$. Snyder and Hall seek to detect the existence of a 'preferred frame' by a speed-of-light anisotropy measurement which could also account for a finite value of the factor k, but which, if detected, would nevertheless disturb the basis for relativity.

It is submitted that the spectral frequency shifts found when atoms move at high speed are not convincing evidence of time dilation. It then remains to consider the third support, that provided by the meson lifetime.

Here it is observed that Einstein's theory does not explain the reason by meson decay. Meson lifetime is not calculated by applying relativity. Given that a meson at rest has a definite mean lifetime, the observation that this increases with speed v in proportion to

* H. I. Mandelberg and L. Witten, *Jour. Opt. Soc. Am.*, **52**, 529 (1962).

† J. J. Snyder and J. L. Hall's researches are discussed in an editorial section in *New Scientist*, April 22, 1976, p. 184.

$(1-v^2/{}^2c)^{-\frac{1}{2}}$ was taken by those interested in relativity as endorsement for the proposition that time is dilated. It is also true to say that the energy of the meson increases owing to its speed in exactly this same proportion. Then, as Cullwick writes in his paper 'The Riddle of Relativity',*

> The reason for the decay of a meson is not known, but it is not unreasonable to suppose that its endurance in some way depends on its energy.

Meson lifetime should not be taken as proof of time dilation in these circumstances. Rather the evidence should be regarded as support for the so-called relativistic mass increase. Indeed, all the experiments which purport to support time dilation have ready explanation if one can accept the aether hypothesis plus the two facts which can be justified independently without recourse to the Theory of Relativity, namely the formula $E=Mc^2$ and the formula for increase of mass with speed. Cullwick in the above paper explains how these two formulae follow from a combination of Maxwell's theory and Newton's Third Law of Motion. We will consider a different justification in the next chapter.

Aberration

Stellar aberration, as discovered by Bradley, was understood in pre-Einstein times in terms of the motion of an Earthly observer through the fixed aether medium. The failure to detect the Earth's motion by the Michelson–Morley experiment then cast doubt on the aether explanation of aberration. Einstein† has asserted that the explanation of aberration as a result of relative motion is 'exceedingly simple'. But there are aspects of aberration which need special consideration as we progress towards more refined methods of optical measurement.

Born,‡ in his book *Einstein's Theory of Relativity*, demonstrates the difficulty of using wave theory to account for a phenomenon as simple as aberration. He explains the need to consider motion of light energy as corpuscular in character. Born argued that light was not at all deflected by an aether wind, which then leaves open the

* E. G. Cullwick, *Bull. Inst. Phys.*, March, 1959, p. 55.
† A. Einstein, *Relativity*, Crown, New York, 1961, p. 49.
‡ M. Born, *Einstein's Theory of Relativity*, Dover, 1962, p. 140.

question of whether there is an aether drag associated with the Earth. He also pointed out that Fresnel's theory gave very good account of experimental facts.

Curiously, however, light is deflected by the lateral motion, or rather the rotary lateral motion, of matter. Jones* has verified the lateral drag given by the Fresnel formula. He obtained very accurate confirmation. The lateral displacement δ of a ray of light traversing a rotating glass disc of thickness d and refractive index n was found to be:

$$\delta = dn(1 - 1/n^2)(v/c) \tag{57}$$

where v is the lateral speed of the disc and c is the speed of light in vacuo.

It is noted that in the classical electromagnetic theory of light propagation:

$$n^2 = 1 + \varphi \tag{58}$$

where φ is an expression representing the oscillating electrons within the refractive medium. φ will move with the medium. The unity term in (57) is a vacuum property and if this remains at rest we can regard the quantity $1 + \varphi$ as having an overall motion which is $\varphi/(1 + \varphi)$ that of φ. From (58) this is $(1 - 1/n^2)$, the factor used in (57). By supposing that as light traverses the medium laterally at speed c/n it is deflected in the direction of rotation of the medium at a rate equal to the Fresnel drag coefficient, we obtain the formula (57).

Yet it is not at all obvious why Fresnel drag should affect the *direction* of a light beam when, historically, it is only concerned with a change in the *speed* of light travelling in the line of motion of the refractive medium. Bearing in mind that the E-frame does not rotate, we can interpret this experiment by Jones as indicating that the motion of a refractive medium relative to the E-frame can cause lateral drag. The logic for this is that φ in (58) represents an electromagnetic disturbance and so must be referenced on an electromagnetic reference frame.

A question then of interest is what happens for a linear lateral motion? We know that the Earth carries its E-frame with it in its linear motion through space. If a refractive medium moves linearly with this E-frame there is no relative motion and we should not expect the presence of the refractive medium to cause any lateral drag deflecting a light beam. This is verified by an experiment

* R. V. Jones, *Proc. Roy. Soc. Lond.*, **A328**, 337 (1972).

performed by Airy, who found that a telescope filled with water and moving with the Earth about the Sun will give the same aberration observations as those of Bradley.

In accord with Born, we must interpret Bradley's aberration measurements as implying no lateral drag owing to the 'aether wind', or rather the lateral motion of the E-frame. Here is a very important clue to the content of the vacuum medium. The E-frame may have some tangible structure but, for some reason, its motion does not drag a light beam. We would expect the beam to be transported laterally by the E-frame. So what is happening? The answer appears to be that it is being transported forward by the E-frame and backwards by something moving in a counter-motion to the E-frame, with the result that it remains undeflected. Whereas the refractive medium had, in the Jones experiment, a unidirectional motion and could thereby impart momentum, the linear motion of the E-frame appears not to be able to communicate momentum, because there is a balance of linear momentum owing to the reverse flow of that 'something' associated with the E-frame.

The model we come to, in terms of the q charge system, is that the E-frame comprises a structured lattice of q charges which may move bodily through space. However, to avoid any build-up of q charge at the forward boundaries of such a system, when moving linearly, there is a migrant population of q charges in reverse flow through the lattice. The latter is like a gaseous medium flowing through the interstices within a moving solid, but assuring that the net linear momentum is zero. It seems then that the frame of reference for electromagnetic disturbance is set by the lattice system, and so the speed of light is referenced on this E-frame lattice, but the linear motion of the lattice cannot drag a light beam laterally.

It is rather perplexing that the rotation of the lattice appears not to result in a rotation of the E-frame and yet the linear motion of the lattice carries the E-frame with it. It would seem more consistent to look to the lattice properties to provide a structure having a degree of rigidity and capable of generating displacements which propagate at a fixed speed in a universal frame of reference. The rigidity could stem from the powerful electric interaction forces between the q charges and apply even though there may be a translation or rotation of a body of q charge having its own lattice structure.

Such rigidity might then permit us to make an analogy with solid materials by imparting to the vacuum medium a pressure modulus or energy density modulus P, which relates to the propagation speed c_1 by the formula:

$$c_1 = (P/\rho)^{\frac{1}{2}} \tag{59}$$

where ρ is the mass density of the lattice. Here c_1 is referenced on the universal frame.

In undisturbed space remote from matter c_1 will equal c, but, where we have a body of the lattice in linear motion at velocity v, some of the lattice substance will be shed to establish the counterflow at velocity u and ρ in (59) will thereby be reduced, making c_1 larger than c. Write:

$$n = c/c_1 \tag{60}$$

where n is the refractive index in this region. Then, from (59) and (60) we see that n^2 is proportional to the mass density of the lattice.

We expect linear momentum of the vacuum medium to be zero and this means that if the proportion k of the lattice is shed to provide the balancing flow the following relation holds:

$$uk + v(1-k) = 0 \tag{61}$$

Also:

$$n^2 = 1 - k \tag{62}$$

Combining (61) and (62), we have:

$$u(1 - 1/n^2) = v \tag{63}$$

Now the expression given by (63) is the Fresnel drag coefficient and, as applied to the vacuum medium, it tells us that the speed of light within a linearly-moving lattice is augmented by the velocity v, that is by the velocity of the lattice. In other words, relative to the moving lattice the speed of light is the same in all directions, as we know it should be from the Michelson–Morley experiment. Hence, we are correct in saying that the E-frame can move linearly. On the other hand, for rotation there is no counterflow and no Fresnel drag, meaning that the E-frame does not rotate.

On this interpretation, we also find that the light from a star will not undergo any lateral deflection owing to the motion of the E-frame with the Earth. Hence we can apply the classical explanation to the problem of aberration.

It may seem to be highly speculative to devise a dual aether, in the sense that the vacuum has a structured particle form which can move within surrounding structure by dissolving at its forward boundaries and flowing back through the structure in a kind of gaseous form to reestablish structure at the rear. Yet, given that Nature's forces favour structure and that Nature insists on motion of structure within structure, there is very little alternative to the model presented. With this two-part aether we have a system able to develop a frame of electromagnetic reference which adapts to the linear motion of matter, and does this without demanding any linear momentum. The model is so simple that one wonders why it was not discovered in earlier times. Perhaps the answer lies in the fixed idea that the word 'aether' had conveyed in the period before the Michelson–Morley discovery. In the words of Campbell,* writing in 1913:

> This is the simple way out of the difficulties raised by the Michelson–Morley experiment. If from the beginning we had used a plural instead of a singular word to denote the system in which radiant energy is localised (or even a word which, like 'sheep', might be either single or plural), those difficulties would never have appeared. There has never been a better example of the danger of being deceived by arbitrary choice of terminology. However, physicists, not recognising the gratuitous assumption made in the use of the words 'the aether', adopted the second alternative; they introduced new assumptions.

Campbell meant here that they turned to relativity. Instead, and in some accord with Campbell's view, we have seen that the aether hypothesis can survive the experimental tests without recourse to the rather abstract concepts of relativity. The hypothesis of a structured vacuum component capable of motion to endow an observer's own system with its own electromagnetic reference frame overcomes the difficulties.

Happily, we have been led into other problems, which cause us to address issues beyond the scope of Einstein's theories. The most important of these is that, whereas we have argued that the linear motion of the E-frame with a structured lattice has no net linear momentum, there is the case to consider for which the lattice rotates, albeit without causing the E-frame to rotate. For lattice rotation the vacuum medium should exhibit angular momentum.

* N. R. Campbell, *Modern Electrical Theory*, Cambridge University Press, 2nd ed., 1913, p. 388.

We will come back to this in Chapters 8 and 9, particularly in relation to the lattice rotation with the Earth. Suffice it here to say that, whereas the Earth appears to share its rotation with the q charge lattice of the space medium, the mere rotation of apparatus such as that used by Champeney *et al.* for their Mossbauer tests does not mean that the coextensive charge lattice will rotate at the same speed as the apparatus. The lattice rotation is governed by an electrical inductive action and this imposes certain constraints, which nevertheless have interesting consequences and merit experimental exploration.