OPTICAL GEOMETRY OF MOTION: A NEW VIEW OF THE THEORY OF RELATIVITY

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BY

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PREFACE.

In placing before his readers the following brief outline of a point of view, the writer is well aware that it is far from complete in many respects. He however believes that, in the first presentment of a theory, there are considerable advantages in stating explicitly only its principal features.

To cover up a general standpoint under a mass of detail is to run the risk of obscuring it altogether. There is always the danger that the reader may "not be able to see the wood for the trees"—a danger which is becoming very real in much modern mathematics.

The substance of the following essay was originally intended by the writer to form a chapter of a book of semi-philosophical character upon which he is engaged.

In view, however, of the amount of attention which the subject of Relativity is at present attracting, it seemed to him that this portion might prove of sufficient interest to warrant its separate publication.

From the standpoint of the pure mathematician *Geometry* is a branch of *formal logic*, but there are more aspects of things than one, and the geometrician has but to look at the name of his science to be reminded that it had its origin in a definite *physical* problem.

That problem in an extended form still retains its interest.

A. A. Robb.

Cambridge,
May 13th, 1911.

"But deepest of all illusory Appearances, for hiding Wonder, as for many other ends, are your two grand fundamental world-enveloping Appearances, SPACE and TIME. These, as spun and woven for us from before Birth itself to clothe our celestial ME for dwelling here, and yet to blind it,—lie all-embracing, as the universal canvas, or warp and woof, whereby all minor Illusions in this Phantasm Existence weave and paint themselves. In vain, while here on Earth shall you endeavour to strip them off; you can, at best, but rend them asunder for moments, and look through."

CARLYLE, "*Sartor Resartus.*"

OPTICAL GEOMETRY OF MOTION.

Introduction.

THE foundations of Geometry have been carefully investigated, especially of late years, by many eminent mathematicians. These investigations have (with the notable exception of those of Helmholtz) been almost all directed towards the Logical aspects of the subject, while the Physical standpoint has received comparatively little attention.

Speaking of the different "Geometries" which have been devised, Poincaré has gone so far as to say that: "one Geometry cannot be more true than another; it can only be more convenient." In order to support this view it is pointed out that it is possible to construct a sort of dictionary by means of which we may pass from theorems in Euclidian Geometry to corresponding theorems in the Geometries of Lobatschefskij or Riemann.

In reply to this; it must be remembered that the language of Geometry has a certain fairly well defined physical signification which *in its essential features* must be preserved if we are to avoid confusion.

As regards the "dictionary," we would venture to add that it would also be possible to construct one in which the ordinary uses of the words *black* and *white* were interchanged, but, in spite of this, the substitution of the word *white* for the word *black* is frequently taken as the very type of a falsehood.

It is the contention of the writer that the axioms of Geometry, with a few exceptions, may be regarded as the formal expression of certain Optical facts. The exceptions are a few axioms whose basis appears to be Logical rather than Physical.

It is proposed in the following pages to refer briefly, in the first place, to certain Optical phenomena which occur in free space, upon which we might suppose some of the chief axioms to have their foundations; and then to employ these to establish on a new basis some of the groundwork of the theory of "Relativity."

The writer does not propose, in the present paper, to go into the more minute Logical details of the foundations of Geometry; as it seems to him that these would tend to obscure the general standpoint which he desires to emphasize. For this reason he prefers to reserve them for a future occasion.

Optical Geometry of Rest.

In the application of ordinary Geometry as distinguished from Kinematics, we are concerned with systems which preserve their configuration unchanged. We shall first consider briefly such systems. Our sense of vision supplies us with a direct means by which we can tell that a particle in free space lies in the same straight line as two other particles. If three particles A, B, and C do not all lie in the same straight line, we may also make use of our sense of vision to determine when a fourth particle D lies in the same plane as A, B, and C. The test is as follows:

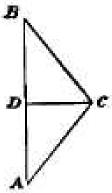
We take a fifth particle E, and then, if D lies in the plane of A, B, C, we may place E so that it is in the same straight line as D and one of the three particles, say A, and is also in the same straight line as the remaining particles B and C. (In case AD and BC are parallel, we must interchange either A and B or A and C in order to carry out the test.)

Simple Optical interpretations of like nature may be devised for various other Geometrical conceptions. As regards the notions and axioms of congruence these may be given a very simple interpretation by means of the properties of plane mirrors, but from a theoretical standpoint it appears better to regard congruence as based on the finite propagation of light.

We shall regard it as an experimental fact that light takes a finite interval of time in travelling from a particle A to a particle B and back again.

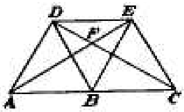
Let us suppose that we have a particle A which is so situated with respect to other particles B, C, D, &c., that a flash of light being sent out simultaneously to B, C, D, &c., and reflected from these back to A, returns to the latter simultaneously from all the particles. We shall then define the stretches AB, AC, AD, &c., as *congruent* or *equal*.

We shall define a right angle as follows:



Let D be a particle which lies in the same straight line as two others A and B, and so that the stretches DA and DB are equal. Let C be another particle not lying in the line AB, but such that the stretches CA and CB are equal. Then we shall define the angles CDA and CDB as right angles. As regards other angles we shall define them as congruent when their trigonometrical ratios are equal. The method of determining these will be obvious hereafter.

Since we have ascribed a meaning to the equality of stretches, we know the meaning of an equilateral triangle.



Suppose now we have five particles A, B, C, D, E, of which A, B, and C lie in a straight line and so that the stretches BA and BC are equal. Let the other two particles be so situated that ADB and BEC are equilateral triangles, and, further, let them lie in one plane and on the same side of the line AB.

The test for this is that we should be able to place a sixth particle F so as to lie both in the line AE and in the line CD.

We shall suppose then that observation shows our system to be such that DBE is also an equilateral triangle.

This excludes the Geometries of Lobatschefskij and Riemann, since in these the angle of an equilateral triangle is either less or more than one-third of two right angles. We shall find an interpretation of Lobatschefskij's Geometry when we come to deal with motion.

It will be shown that a system of three particles diverging uniformly, with equal relative rapidities, from simultaneous contact may be regarded as the corners of a Lobatschefskij triangle.

It thus appears that the fulfilment of our criterion of a Euclidian system excludes the possibility of our system of particles diverging from one another in this way—a possibility which at first sight might appear to lie open.

Since we are not yet in a position to prove this, we must ignore the seeming possibility until we have shown that the set of diverging particles has this property, and it may then be shown (by a process of *reductio ad absurdum*) that the seeming possibility has already actually been excluded.

There is another important restriction which we must suppose placed on our system of permanent configuration before we can go on to consider the motion of particles.

Let us consider any three particles A, B, C of our system, which are not all in the same straight line, and suppose a flash of light, starting out from one of the particles, say A, goes thence to B, thence to C, and thence back to A. Imagine a second flash, starting simultaneously with the first, and going round in the opposite direction, namely, from A to C, from C to B, and from B back to A.

Now, from the *purely logical standpoint*, three possibilities are open:

(1) The first flash may arrive before the second.
(2) The second flash may arrive before the first.
(3) The two flashes may arrive simultaneously.

If, starting from any of the three particles, both flashes return simultaneously, we regard the system as not rotating in its own plane.

Thus "*absolute rotation*" acquires a definite meaning in our system of Optical Geometry. We shall suppose this test to be applied to the various sets of three particles which may be selected from a group of four particles which do not all lie in one plane. By doing this we ensure the absence of rotation about *any* axis of our system of permanent configuration.

Let us now suppose that any selected two of the particles of the system are at one-half the unit distance apart. As we have not yet properly defined distance, it would perhaps be better to say that, having selected a suitable pair of particles of the system, we define them to be at one-half the unit distance apart. Having got such a system of particles, we now proceed to make use of it.

"Index" of Fundamental Particle at any Instant.

We propose to introduce a conception which we shall call *the index of a particle at any instant. This is a number which we shall define in a certain physical way as associated with a particle at an instant.* We shall at first define it only for one of our fundamental particles, leaving the general definition till later.

Let us take then the particle A, and at a selected instant suppose a flash of light sent out to B, which is at one-half the unit distance from it, and reflected from B back to A. We shall say that the *index* of A at the instant of departure is 0, while at the instant of return it is 1. We shall suppose the flash returned once more at B and then back to A,