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THE EFFECT OF THE EARTH'S ROTATION ON THE VELOCITY OF LIGHT

PART I

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ABSTRACT

Theory of the effect of the rotation of the earth on the velocity of light as derived on the hypothesis of a fixed ether.

Historical Remarks.—The theory was given originally in 1904. The experiment was undertaken at the urgent instance of Dr. L. Silberstein. A preliminary experiment at Mount Wilson in 1923 showed that it was necessary to resort to an exhausted pipe-line.

In the *Philosophical Magazine*, (6) **8**, 716, 1904, a plan was proposed for testing the effect of the earth's rotation on the velocity of light. The expression for the difference in path between two interfering pencils, one of which travels in a clockwise, and the other in a counterclockwise direction, may be deduced on the hypothesis of a fixed ether as follows:

If l_1 is the length of path at latitude ϕ_1 and l_2 that at latitude ϕ_2, v_1 and v_2 the corresponding linear velocities of the earth's rotation, and V the velocity of light, the difference in time required for the two pencils to return to the starting-point will be

$$T=\frac{2\,l_2v_2}{V^2-v_2^2}-\frac{2\,l_1v_1}{V^2-v_1^2}$$

or with sufficient approximation

$$T=2\left(\frac{l_2v_2-l_1v_1}{V^2}\right)$$

or if

$$l_1=l_0 \cos\phi_1 \qquad \text{and} \qquad v_1=v_0 \cos\phi_1$$
$$l_2=l_0 \cos\phi_2 \qquad \qquad v_2=v_0 \cos\phi_2$$

and

$$\phi_1-\phi_2=\frac{h}{R}$$

(R=earth's radius),

the resulting difference in phase of the two pencils will be

$$\Delta=\frac{4\,lh}{V\lambda}\,\omega \sin\phi,$$[1]

in which ω is the earth's angular velocity, and λ the effective wave-length of the light employed.

The experiment remained in abeyance for many years, until, at the urgent instance of Dr. L. Silberstein, the writer was convinced of the importance of the work, notwithstanding serious difficulties which were anticipated in the way of raising the necessary funds. The greatest expense would be in arranging a pipe line a mile long and a foot in diameter, such as would be required for the work. In the hope that this device might not be necessary, however, it was decided to attempt the experiment in the open air at Mount Wilson.

The work was undertaken at Mount Wilson during the summer of 1923, with a circuit over one mile in length. The interference fringes between the two pencils, one of which traversed the circuit clockwise, and the other counterclockwise, were observed most clearly during the half-hour before and after sunset. But even under the best conditions, the interference fringes were so unsteady that it was found impossible to make any reliable measurements.

A doubt had been raised concerning the possibility of referring

[1] In the original article, Δ was erroneously given as half of this value. Dr. L. Silberstein (*Journal of the Optical Society*, **5**, 291, 1921) deduced the expression equivalent to the above, which was confirmed by Dr. A. C. Lunn, *ibid.*, **6**, 112, 1922, except that the area inclosed is substituted for the product lh.

any expected displacement to a fiducial zero with which to compare the results. Such a fiducial zero was furnished by providing a double circuit, in one of which the area, on which the expected displacement depends, was much greater than in the other. The impossibility of obtaining accurate results in the open-air experiments on Mount Wilson showed that it was clearly necessary to resort to a pipe line about one mile long and one foot in diameter which could be exhausted of air.

Funds for this experiment, amounting to about $17,000, were furnished by the University of Chicago, with an additional contribution of $491.55 made through the efforts of Dr. L. Silberstein. With this support it was decided to perform the experiments at Clearing, Illinois; and in this work, which is to be discussed in the next article, Dr. Gale was invited to join.