The Luminiferous Ether is Detected as a Wind Effect Relative to the Ether Using a Uniformly Rotating Interferometer

Georges Sagnac

Abstract: This is English translation of Georges Sagnac's paper, where he gives a presentation for his "rotating interferometer experiment" which manifested the phenomenon called later the *Sagnac effect*. This paper was originally published, in French, as: L'éther lumineux démontré par l'effet du vent relatif d'éther dans un interféromètre en rotation uniforme. Note de G. Sagnac, présentée par E. Bouty. *Comptes rendus*, tome 157, 1913, pages 708–710. Translated from the French in 2008 by William Lonc, Canada. The Editor of *The Abraham Zelmanov Journal* thanks William Lonc for this effort, and also Ioannis Haranas, Canada, for assistance. Special thank go to the *National Library of France* and Nadège Danet in person for the permission to reproduce the originally Sagnac paper in English.

§1. The Method. — I uniformly *rotated*, at a speed of one or two turns per second around a vertical axis, a horizontal plate (50 cm in diameter) on which the various components of an interferometer were firmly anchored, analogous to the one I used in previous research and described in 1910 (*Comptes rendus*, tome 150, page 1676). The two interfering beams, after reflection from 4 mirrors placed at the edges of the rotating platform, were superimposed and travelled in opposite directions around exactly the same horizontal *circuit circumscribing the area* S. The rotating system also contained the light source: a small electric lamp, and the detector L, a fine-grained photographic plate that registered the interference fringes at the focal point of a lens.

In the images d and s, obtained successively during a *right-hand* rotation of the platform and then a *left-hand* rotation, both at the same rotation frequency, the central fringe was observed to occur at two different positions. I measure the difference between the centres of the fringes.

First method. — I mark on image d, and then on image s, the position of the central fringe relative to the image of a micrometer's vertical graduations placed in the focal plane of a collimator.

Second method. — I measure directly the distance from the vertical central fringe of the image d to the central fringe in image s precisely contiguous to the first but below a thin horizontal line separating the two. I obtain these two contiguous images without touching the photographic plate-holder, by opening-prior to obtaining the images d and s — the two contiguous positions corresponding to the illuminated slit on the edges of the horizontal edges (razor blades) in the collimator's focal plane.

§2. Optical rotation effect. — Measured from the fring-spacing, the displacement z from the interference centre that I observed with the preceding method is a particular case of the optical rotation effect that I have defined earlier (*Congrès de Bruxelles de septembre*, 1910, tome 1, page 217; *Comptes rendus*, tome 152, 1911, page 310; *Le Radium*, tome VIII, 1911, page 1), and which, in the context of current ideas, should be construed as a direct observation of the luminiferous ether.

In a system moving as a whole relative to the ether, the propagation time between any two points of the system should change in a way similar to a stationary system subjected to an ether wind, the relative speed of which at each point of the system will be the same and directly opposite to the speed of any point, and would contain light waves in a manner similar to atmospheric wind carrying sound waves. The observation of the optical effect of such an *ether wind relative to the* [stationary] *ether* will constitute a proof of the ether's existence, just as the observation of a wind relative to the atmosphere on the speed of sound in a moving system would constitute — everything else being equal — a proof of the existence of a stationary atmosphere enveloping the moving system.

The need to bring to one *common luminous point* oscillations that are combined at *another point* and to thereby produce interference, reduces to zero the first-order interference effect of the linear translation of the entire optical system, if the matter constituting the ether does not produce a *circular motion* C of the ether within the optical circuit of area S; that is to say, a *rotation* or *circulation* bS in the ether (*Comptes rendus*, tome 141, 1905, page 1220; 1910 and 1911, *loc. cit.*). I have shown interferometrically (1910 and 1911, *loc. cit.*) with an optical path enclosing $20\,\mathrm{m}^2$ in *vertical* projection, that ether drag in the Sun's neighbourhood does not produce a *rotational density* b of more than $1/1000$ rad. per second in the ether.

In a *horizontally mounted* optical circuit, at Latitude a, the diurnal rotation of Earth should, if the ether is stationary, produce a rotation relative to the ether with a density of $\frac{4\pi\sin\alpha}{T}$ or $\frac{4\pi\sin\alpha}{86164}$ rad. per sec, where T is the duration of the sidereal day; a very small quantity compared with $1/1000$, the upper limit that I established for a vertically mounted optical circuit. I hope to be able to determine whether a corresponding small optical rotation exists or not.

It was easier for me to first find a proof for the ether's existence by rotating a small optical circuit. A rotational frequency N of two turns per second gave me a rotational density of $4\pi N$ relative to the ether for a rotation of 25 rad. per second. A uniform *left-hand rotation* of the interferometer produces a *left-handed ether wind*; and delays by x the phase of the beam (T) whose motion around the area S is *right-handed*, and advances by the other beam R by the same amount, thus displacing the fringes by $2x$ units. The displacement z that I observe between images s and d should be twice that of the former*. On the basis of the value of x observed earlier (*loc. cit.*, 1910 and 1911), we have

$$z = 4x = 4\,\frac{bS}{\lambda V_0} = \frac{16\pi NS}{\lambda V_0}\,;$$

where V_0 is the speed of light in vacuum, and λ is the operating wavelength.

For a rotational frequency of $N = 2$ per sec., and the path area S being $860\,\mathrm{cm}^2$, the observed value of z is 0.07 when using indigo light, and is easily visible in the photographs I attach to this Note and where the fringe-spacing is between 0.5 and 1.0 mm.

The interference displacement z, a constant fringe-spacing for the same value of rotation frequency N, disappears on the photographs when the fringes were made sufficiently narrow; this shows that the observed effect is very much due to a *phase difference* related to the rotational motion of the system and that (thanks to counter-screws that prevent movement of the mounting screws of the optical components) the displacement of the interferogram, observed in the comparison of image s with image d, does not arise from accidental relative displacements or elastic effects in the optical components during rotation.

Turbulent air produced above the interferometer by a fan rotating about a vertical axis and blowing downwards does not produce any displacement of the interferogram's centre, given a careful superposition of the two opposite beams. Any turbulent air, analogous and less intense, produced during rotation of the system does not affect the experiment.

The observed interference effect is very much the effect of optical rotation due to the motion of the system relative to the ether, and directly shows the existence of the ether, a necessary condition for the luminiferous waves proposed by Huygens and Fresnel.

*That is, twice that of $2x$. — Translator's comment. W. L.

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