Georges Sagnac's Rotating Interferometer

The Luminiferous Ether Demonstrated by the Effect of the Relative Motion of the Ether in an Interferometer in Uniform Rotation. Note of Monsieur G. Sagnac, presented by Monsieur E. Bouty.

Comptes Rendus . . . de l'Académie des Sciences (Paris) 157 (1913): 708–710, 1410–1413.

Session of 27 October 1913, pp. 708–710.

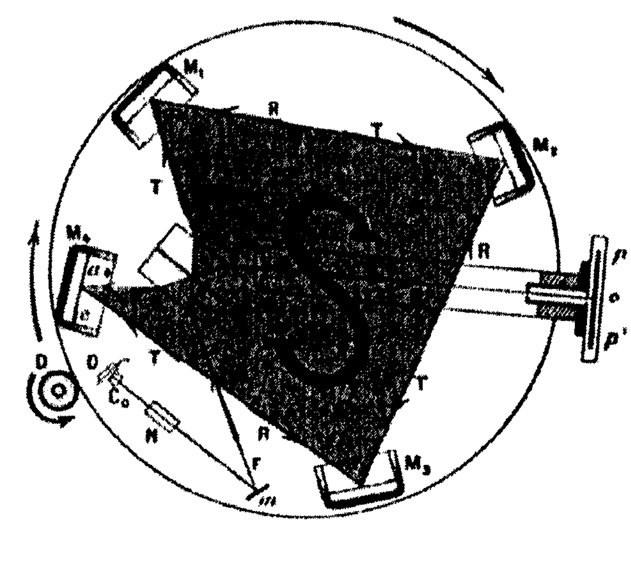
I. *Principle of the Method.* I cause to revolve uniformly, at one or two revolutions per second, around a vertical axis, a horizontal platform (50 centimeters in diameter) carrying, solidly screwed down, the various pieces of an interferometer similar to that which I have used in my previous researches and described in 1910.[1] The two interfering beams, reflected by four mirrors placed at the edge of the revolving platform, are superimposed in opposite directions upon one self-same horizontal *circuit encompassing a definite area* S. The rotating assemblage includes also the luminous source (a small electric lamp), and the receiver—a fine-grained photographic plate, which registers the interference fringes localized at the focus of a telescope.

Photographs designated *cw* are obtained during a clockwise rotation of the platform; photos designated *ccw* are obtained during a counter-clockwise rotation of the same frequency. In these two kinds of photos, the center of the central fringe presents two different positions. I measure this displacement of the center of interference.

First method. I locate on photo *cw*, then on the corresponding photo *ccw*, the position of the central fringe in relation to the images of vertical micrometric rods placed in the focal plane of the illuminating collimator.

Second method. I measure directly the distance from the central vertical fringe of a photo *cw* to the central fringe of a photo *ccw* which is exactly contiguous with the first photo and below a sharp horizontal line of separation on the same plate. I obtain these two contiguous photographs directly without touching the photographic plate holder, by positioning, before each of the two exposures *cw* and *ccw*, the two contiguous image positions corresponding to the illuminating slit, by means of sharp horizontal edges (razor blades) in the focal plane of the collimator.

II. *Effect of optical whirling.* Measured between fringes, the total displacement *z* of the center of interference that I have observed by the preceding method is a particular case of the optical whirling effect that I have defined before.[2]



Plan view of the Sagnac interferometer

In clear conception, it ought to be regarded as a direct manifestation of the luminiferous ether.

In a system moving as a whole with respect to

1. *Comptes Rendus . . . de l'Académie des Sciences* 150 (1910): 1676.

2. *Congrès de Bruxelles de Septembre 1910*, vol. 1, p. 217; *Comptes Rendus* 152 (1911): 310; *Le Radium* 8 (1911): 1.

the ether, the elapsed time of propagation between any two points of the system should be altered as though the system were immobile and subject to the action of an *ether wind* which would blow away the light waves in the manner of atmospheric wind blowing away sound waves. The observation of the optical effect of such a relative wind of ether would constitute *evidence for the ether*, just as the observation of the influence of the relative wind of the atmosphere on the speed of sound in a system in motion would (in the absence of a better explanation) constitute evidence of the existence of the atmosphere around the system in movement.

In this interferometer and others, it is necessary to use light vibrations diverging from one point, which we then reunite at another point, in order to make them interfere. This procedure reduces to zero the effect of interference of the first order which results from the movement as a whole of an optical system. At least, it does so if the matter, in entraining the ether, does not provoke (in one's optical circuit S) a circulation C of the ether—that is to say, a *whirling* ($b \cdot S$) *of the ether*.[3] I have demonstrated by interferometry with an optical circuit of 20 square meters of vertical extension, that the entrainment of ether adjacent to the ground does not itself produce a degree [*densité*] b of whirling of the ether of even 1/1000 radian per second.[4]

In a *horizontal* optical circuit, at latitude α, the diurnal rotation of the earth should, if the ether is immobile, produce a *relative* whirling of the ether of which the degree is $4\pi \sin \alpha/T$ radians per second, where T is the length of a sidereal day, 86,164 seconds. The result is notably less than the above limit of 1/1000 which I have established for a vertical circuit. I hope to be able to determine whether the slight corresponding optical whirling effect exists or not.

It has been very easy for me to find at the outset the evidence for the ether by causing a small optical circuit to rotate. A frequency N of 2 revolutions per second (successively in each direction) has furnished me a degree of relative whirling of the ether of $4\pi N$ or 25 radians per second. A uniform *clockwise* rotation of the interferograph produces, relatively, a *counter-clockwise* ether wind. It retards, by the fraction x of a ring, the phase of beam T which travels around the area S clockwise; and it advances by a like amount the phase of the inverse beam R which goes around the same area counter-clockwise. This simultaneous double effect displaces the fringes by $2x$ rings. The fraction of a ring z, which I observe in passing from a photo *ccw* to a photo *cw*, should amount to double again the preceding amount. Following the value of x already given,[5] one has $z = 4x = 4bS/\lambda V_0 = 16\pi NS/\lambda V_0$. Here, V_0 is the velocity of light in empty space; λ is the wavelength of light used.

The area S of the optical circuit is about 860 square centimeters. For a frequency N of 2 revolutions per second, the displacement z attains, with the indigo light used, the value 0.07, clearly visible on the photographs that I join per the previously described method of measurement. The distance between the fringes is here from 0.5 to 1 millimeter.

The total interferential displacement z is a constant fraction of the distance between fringes, for the same frequency N of rotation. The displacement becomes invisible on the photographs when the fringes have been adjusted to be narrow enough. Such a nullified result demonstrates that the normally observed displacement is clearly due to a difference of phase associated with the rotational movement of the system. Thanks to the backup screws which block the adjusting screws of the optical pieces, the displacement of the center of interference does not depend on accidental or elastic relative displacements of the optical pieces during rotation.

A whirling of air, produced above the interferometer by a fan with vertical axis and blowing downwards, does not displace the center of interference, thanks to the carefully adjusted superimposition of the two inverse beams. Accordingly, the less intense whirling of air generated by the turning of the interferometer does not disturb the results.

The observed interference effect is clearly the optical whirling effect due to the movement of the system in relation to the ether and directly manifests the existence of the ether, supporting necessarily the light waves of Huygens and of Fresnel.

3. *Comptes Rendus* 141 (1905): 1220; also see note 2.
4. See note 2.
5. See note 2.