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ONEWAY SAGNAC DEVICE TO MEASURE ABSOLUTE VELOCITY

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The difference in the intensity of light produced by two independent beams passing in opposite directions through a oneway Sagnac device may be used to measure the absolute velocity of the device and, thus, the solar system.

Key words: oneway Sagnac device, absolute velocity measurement.

1. THEORY AND THE ONEWAY SAGNAC DEVICE

The positive results of the original Sagnac [1] and Michelson-Gale [2] experiments are trivially explained if the oneway velocity of light is rectilinear and uniform with the magnitude c with respect to absolute space (or with respect to the fixed "lumeniferous ether" as originally stated by Sagnac [1]). The fact that the absolute velocity of light is c is further established by the observations of Roemer [3], Bradley [4], and Conklin [5] and by the experiments of Marinov [6]. Moreover, there is no presently known experiment (including the Michelson-Morley experiment) or observation (as reviewed by Wesley [7]) that is in conflict with this conclusion.

The rotation of the Sagnac [1] device does not affect the rectilinear propagation of light with the absolute velocity c in anyway; the rotation merely serves to promote the mirrors into appropriate positions at appropriate times. To make this abundantly clear and to indicate that a *closed* light path is not necessary and that no *centrifugal effect on light* can possibly be involved Wesley [8] proposed the oneway Sagnac device diagrammed in Fig. 1. Light from

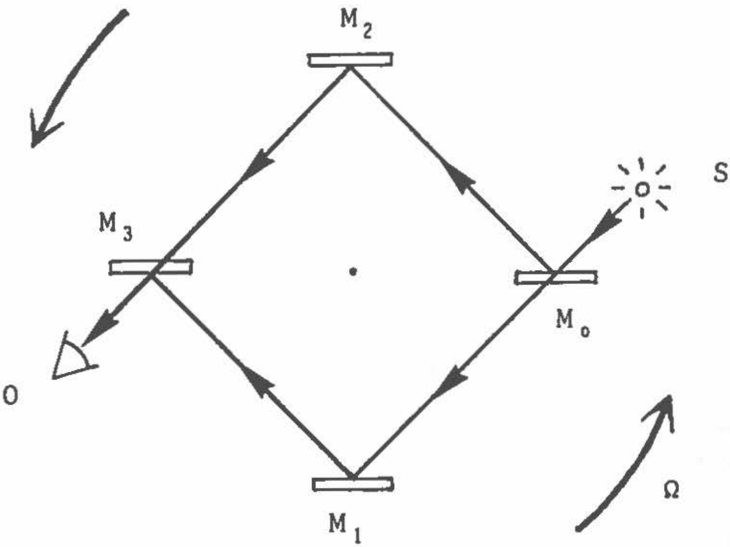

Fig. 1. The oneway Sagnac device where light travels essentially in one direction only (from right to left for the orientation shown).

a coherent (laser) source S is split into two beams at the semitransparent mirror M_0. One beam (the upper) travels in the direction of rotation, being reflected at mirror M_2 and transmitted through the semitransparent mirror M_3 to arrive at the photodetector O. The other beam (the lower) travels counter to the direction of rotation, being reflected at the mirror M_1 and the semitranspatent mirror M_3 to also arrive at the photodetector O.

In the time Δt it takes light to travel from mirror M_0 to M_2 the mirror M_2 moves through the tangential distance

$$L\Omega\Delta t/\sqrt{2}, \tag{1}$$

where L is the distance between mirrors, Ω is the angular velocity of the device, and the time Δt to first order in $L\Omega/c$ is

$$\Delta t = L/c. \tag{2}$$

Considering the geometry in detail it may seen that to first order in $L\Omega/c$ light travels the distance

$$L + L\Omega\Delta t/2 = L + L^2\Omega/2c, \tag{3}$$

in going from mirror M_0 to mirror M_2. Similarly, the light path from mirror M_0 to mirror M_1 is correspondingly shorter and is

$$L - L^2\Omega/2c. \tag{4}$$

The difference in the light paths D for the two beams upon arriving at the photodetector O is then seen to be

$$D = 2L^2\Omega/c = 2A\Omega/c, \tag{5}$$

where A is the area of the square. (This result (5) is seen to be 1/2 the result for the usual Sagnac setup; since here the beams travel only halfway around the device.)

2. THE EFFECT OF THE ABSOLUTE VELOCITY

The effect of the absolute velocity of the device (or laboratory or, thus, the solar system) on this oneway Sagnac device can be obtained by considering the effective light velocities relative to the apparatus for the beams in the various branches of the apparatus. Considering the component of the absolute velocity in the plane of the device, $\mathbf{v}$, at a particular instant t, it makes the angle

$$\alpha = \varphi_0 - \Omega t, \tag{6}$$

with respect to the angular position of the mirror M_0, where M_0 makes the angle Ωt with respect to a fixed direction in the laboratory and φ_0 is the direction of $\mathbf{v}$ with respect to this fixed direction. Considering the geometry, the apparent speed of light relative to the apparatus along the path from mirror M_0 to M_2 is found to be

$$c - v\sin(\pi/4 - \alpha) = c - v\sin(\Omega t - \varphi_0 + \pi/4). \tag{7}$$

Including the time delay to reach the receding mirror M_2 the net effective velocity from mirror M_0 to M_2 is

$$c_{02} = c - L\Omega/2 - v\sin(\Omega t - \varphi_0 + \pi/4). \tag{8}$$

Similarly, along the path from mirror M_2 to M_3 the apparent speed is

$$c - v\cos(\pi/4 - \alpha) = c - v\cos(\Omega t - \varphi_0 + \pi/4); \tag{9}$$

and including the time delay, the net effective velocity from mirror M_2 to M_3 is

$$c_{23} = c - L\Omega/2 - v\cos(\Omega t - \varphi + \pi/4). \tag{10}$$

Considering the other beam the speed along the path from M_0 to M_1 is given by Eq.(9); and the speed along the path from M_1 to M_3 is given by Eq.(7). Considering the shortened times the effective velocities become:

$$\begin{aligned} c_{01} &= c + L\Omega/2 - v\cos(\Omega t - \varphi_0 + \pi/4), \\ c_{13} &= c + L\Omega/2 - v\sin(\Omega t - \varphi_0 + \pi/4). \end{aligned} \tag{11}$$

From Eqs.(8), (10), and (11) the light path difference D' now becomes

$$\begin{aligned} D' = cL(1/c_{02} &+ 1/c_{23} - 1/c_{01} - 1/c_{13}) \\ &= D\left[1 + \sqrt{2}(v/c)\cos(\Omega t - \varphi_0)\right], \end{aligned} \tag{12}$$

to first power in v/c, where D is given by Eq.(5).

3. INTENSITY DIFFERENCE FOR LIGHT PASSED THROUGH IN OPPOSITE DIRECTIONS

In order to extract the information about the absolute velocity v an independent, but otherwise identical, setup may be introduced, where coherent (laser) light is sent through the oneway Sagnac device, shown in Fig. 1, in the opposite direction. The light from the new source above mirror M_3 is split at the semitransparent mirror M_3 and the two new beams are then finally detected at a new photodetector below the semitransparent mirror M_0. The same mirrors may be used as before; but the new beams must not overlap the original beams; the two setups must remain optically independent of each other. The path difference D" between the two new beams produced by the new setup is readily seen to be given by Eq.(12) by simply replacing v by - v; thus,

$$D'' = D\left[1 - \sqrt{2}(v/c)\cos(\Omega t - \varphi_0)\right]. \tag{13}$$

From Eqs.(12) and (13) the fractional difference in the output of the two independent photodetectors I'' and I' is given by

$$\begin{aligned}\Delta I/I_0 &= (I'' - I')/I_0 = 2\cos^2(\pi D''/\lambda) - 2\cos^2(\pi D'/\lambda) \\ &= 8\sqrt{2}(\pi D/\lambda)\sin(\pi D/\lambda)(v/c)\sin(\Omega t - \varphi_0),\end{aligned} \tag{14}$$

to first power in v/c where λ is the wavelength of light used, I_0 is the maximum output of either one of the identical detectors, and D is defined by Eq.(5). If the angular velocity of rotation Ω is chosen so that $\pi D/\lambda = \pi/2$, then the intensity difference $|\Delta I|$ is a maximum and

$$\Delta I_{max}/I_0 = 4\sqrt{2}\pi(v/c)\cos(\Omega t - \varphi_0). \tag{15}$$

If now the root mean square value of this maximum oscillating signal is measured and the result is indicated as ΔI_{rms}, then from Eq.(15) the magnitude of the component of the absolute velocity in the plane of the oneway Sagnac device becomes

$$v = c\,\Delta I_{rms}/4\pi I_0. \tag{16}$$

4. SOME EXPERIMENTAL CONSIDERATIONS

From the above discussion it is clear that in principle the oneway Sagnac device can be used to measure the absolute velocity of the device and, thus, the absolute velocity of the solar system. Now it is necessary to see if the method indicated is practicable.

Apart from the absolute velocity of the device the oneway Sagnac device should permit a path difference D that can attain at least a half wavelength, $D = \lambda/2$, so that $I = I_0\cos^2(\pi D/\lambda) = 0$. For this value of D Eq.(5) yields the condition

$$c = 4L^2\Omega = 8\pi L^2 f, \tag{17}$$

where f is the frequency of rotation. Since the light can pass only once through the device; the value L should be chosen large. If, for example, L = 1 m and λ = 6000 Å, the frequency of rotation needed is f = 7.2 rev/sec or .430 revolutions per minute. Thus, the setup can be easily made to function as a oneway Sagnac device. This means that the condition $D = \lambda/2$ leading to Eqs.(15) and (16) from (14) can be readily attained.

Since the magnitude of the absolute velocity of the solar system is about 300 km/sec; $v/c \sim 10^{-3}$. This means from Eq.(16) that it is necessary to measure the quantity $\Delta I_{rms}/I_o = 4\pi v/c$ to within an accuracy of 10^{-2}. Since fractional differences in intensities can be readily determined to about 10^{-5}, using sensitive bridge networks; it would seem that the absolute velocity of the solar system could be determined by this method to three places with an error in the third. If larger path differences can be achieved, where $D = (2n + 1)\lambda/2$, where n is an integer, then still greater accuracy can be achieved; since from Eqs.(14) and (15) $\Delta I_{rms}/I_o = 4\pi(2n + 1)v/c$.

The discussion above is for the magnitude of the component of the absolute velocity of the laboratory lying in the plane of the device. At a northern (or southern) latitude the absolute orientation of the plane of the device (if kept level in the laboratory) will change in the course of a day. Moreover, one need only make observations of ΔI for limited portions of a cycle of the rotating device. Thus in the neighborhood of a particular fixed angle θ, one might, for example, examine values of ΔI for Ωt lying in the range $\theta - \pi/8 \leq \Omega t \leq \theta + \pi/8$. From Eq.(14) a maximum positive difference ΔI could then be expected when $\theta = \phi_0$, the direction of the component of the absolute velocity v in the plane of the device. It is clear that a variety of modes are available for making observations to determine the direction as well as the magnitude of the absolute velocity of the laboratory and, thus, of the solar system.

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