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ON A DISPLACEMENT OF FRINGES RECORDED ON A PLATFORM IN UNIFORM ROTATION

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Synopsis. — In a first series of experiments, here detailed, it is necessary to realize, that we used an entire optical circuit attached to the revolving platform, as in former work of Sagnac. Under these conditions we noted that displacements of fringes observed are the same ones with a margin of 6%, whether the source of light and the photographic receiver are entrained as part of the rotation of the platform, as in the experiments of Sagnac, or when they remain fixed in the laboratory.

The purpose of the second series of experiments described here was to study the displacement of the fringes of to rotation, under entirely new conditions characterized by the fact that the optical circuit of the two superimposed interfering beams is made of two parts in series, of which one remains fixed compared to the laboratory while the other is attached to the platform in rotation. The displacement of the fringes, obtained under these new conditions, was used to predict the classical theory.

In the discussion where the optical circuit is in entirety attached to the revolving disc, as in the experiments of Sagnac, the observer has no means of making a choice between interpretations of D placement of the fringes obtained and S given respectively by the classical theory and the relativistic theorists. But in the discussions where there is a part of the circuit which remains fixed relative to the laboratory, the relativistic theory cannot remain in agreement with the classical theorist, nor with observed results, assuming, as he had done until here, that the center, where he must assume the position to calculate the experience can be chosen arbitrarily on the revolving platform. The center must be with the center of rotation of the platform.

I. — Experiments in which the optical circuit is entirely attached to the revolving platform.

1. Preliminary experiments. — To familiarize ourselves with the experimental difficulties, we initially repeated the experiment of Sagnac [1] in which all the optical apparatus is, as one knows, entrained by the disc in uniform rotation.

We employed, for this purpose, the same mirrors which had been used by Sagnac in his memorable experiments, but the platform we used was twice as large as his. It had a 1 m diameter and could turn at a measured speed, not exceeding however 5 turns/sec., in one direction, then in the other, around its axis of revolution laid out vertically. This axis was defined by the line passing through the endpoints of the rigid shaft supporting the disc, pivot points where in greasing cup devices carried by a solid frame sealed with the wall of the laboratory. This assembly removed any slack in the rotation of the apparatus and allowed however the easy maintenance of its movement without harmful vibrations. The engine torque was provided by a small dynamo attached to the same wall; the transmission of this torque was obtained via a belt operating a pulley attached to the shaft of the platform. This material remained the same for all the experiments of which will be the subject here.

Figure 1 gives the schematic diagram of the optical device carried by the entire disc and used in these preliminary tests. It is more or less identical to that of Sagnac and does not present anything original. The separator of Sagnac which could not have been found was replaced here by the glass R, separating and receiving, not silver plated, receiving the rays under a large angle of incidence.

The light resulting from the source S crosses the formed collimator of the whole of the lens L and from the diaphragm *o* in their holders, then, after reflection at auxiliary *m*, comes to give the two interfering beams which are separated by C, at the center of the disc, to traverse in opposite directions, one way CMM'M"M'''C and the other way CM'''M"M'MC.

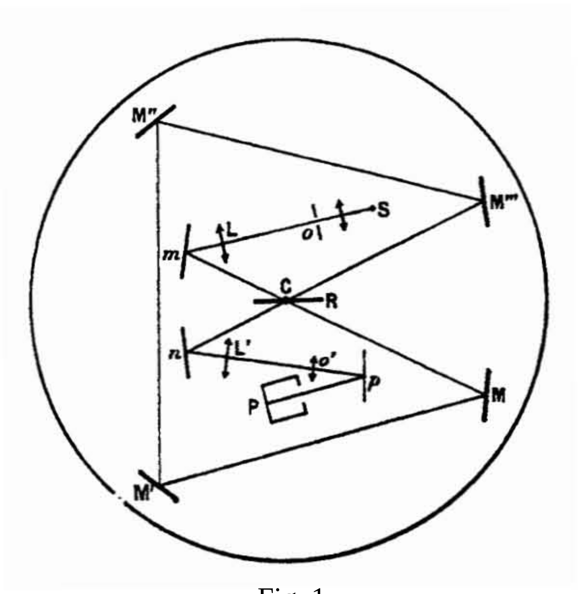

Fig. 1

After their meeting at C, these beams are returned by auxiliary mirror *n* to the eyepiece at L'*o*' which make it possible to obtain, after a last auxiliary reflection off of *p*, real fringes on the photographic plate P.

As a result of the low intensity available on the photographic plate, we almost always had to operate in white light with *Agfa* panchromatic plates of great sensitivity. It follows that measurements of displacements of fringes made on all our shots are obviously affected by small and variable errors related to spectral composition of the light used and the selective sensitivity of the emulsions of the various sets of plates for the different wavelengths. In spite of this imperfection, the significance of the results obtained remains whole here from the qualitative point of view, the extreme variations of the numerical results of the same series of recordings never exceeded 12 per 100 of the median value, the order of magnitude of this thus remains valid and endowed with significance.

The experiments made with the device of Figure 1 were used to precisely calibrate the indications of the photographic recordings according to the value of Sagnac reflection in white light for the particular plates which we used. For each direction of rotation, the duration of exposure was of a fraction of a second. Knowledge of the number of revolutions during the exposure was obtained by measuring the number of turns carried out by the platform during 2 minutes, converted to meters per second. We recorded on the same plate the fringes obtained, initially for one direction of rotation, then for the other direction. The magnetic regulation of two small shutters, remotely, made it possible successively to protect each half of the plate against the action from the light. We thus obtained for the two systems of fringes corresponding to the two directions of rotation separated from each other by a fine line facilitating their comparison. The measurement of the distances between interference rings and the shift of the fringes was checked by a division machine.

The average of nine recordings of the ordinary Sagnac effect gave us, for value of this effect, 0.082 of the distance between interference rings at an angular velocity of 1 turn/sec. for the two directions of rotation, the source of light being the filament of an averagely pushed incandescent lamp.

The order of magnitude thus observed for the ordinary Sagnac effect appears well in agreement with what one could expect by taking account of the position of the approximate center of gravity in the spectrum, of the action of the light on the panchromatic plates used; besides this center of gravity defines the effective wavelength for the calculation of the phenomenon. In the formula of Sagnac, which gives in fractions of the distance between interference rings, the value δ of the total shift of the fringes for the two directions of rotation $\delta = \dfrac{16\pi NA}{c\lambda}$, N is the number of revolutions/sec. of the platform, A is the value of the interior surface to which the course is enclosed by CMM'M"M'''C of Figure 1, c is the speed of light and λ the wavelength used. In our experiments, surface A was approximately 2840 cm^2. The experimental results obtained thus allowed us to deduce from it for the effective wavelength λ a value from approximately $0.57\,\mu$ when the source is consisted a fairly pushed incandescent filament, $0.54\,\mu$ if it is more brilliant, $0.45\,\mu$ if this white light crossed a Schott screen out of blue glass, letting pass only the area of the going spectrum from 0.5 to $0.36\,\mu$.

2. Experiments made with a source of light fixed in the laboratory. — The first question that we considered was to seek if the entraining of the source that creates the light was essential to the production of the phenomenon.

We then devised the device of which is diagramed by Figure 2. The characteristics of this assembly are to use the light of a fixed source in the laboratory and to send this light on the optical courses attached to the platform in rotation, in the shape of flashes repeating itself with each turn of the disc when it passes in the same position.

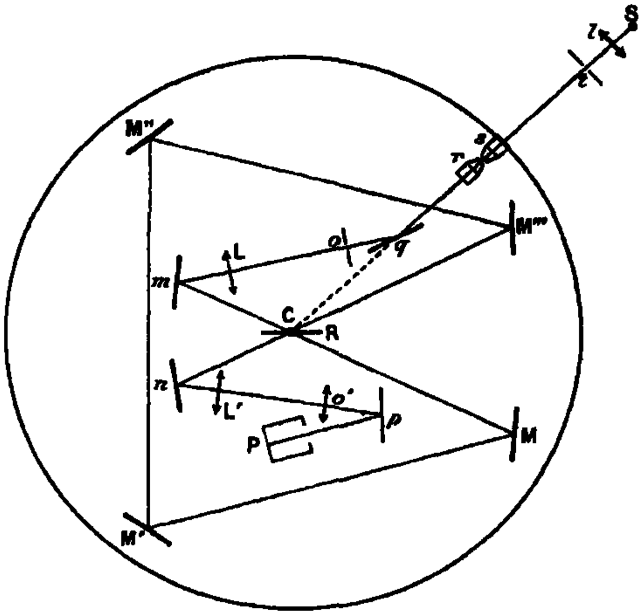

Fig. 2

For this purpose, the light resulting from the source S crosses the lens *l*, the diaphragm *t* and the objective of a microscope at *s*; all of these components are kept fixed in the laboratory. Another microscope objective, *r*, identical to the precedent, is attached to the revolving platform and gives out to *o*, thanks to the auxiliary reflection at *q*, an image of the diaphragm *t* equalizes with this one, when the platform precisely has the position indicated in the figure. The *Ssrq* line is directed so that its prolongation passes by the center of rotation C, so that the objective lens *r* and *s* work together at the time of the flash.

If *v* are the linear velocity of the objective *r* and *g* its growth, the linear velocity of the image of the diaphragm *t* on the diaphragm *o* will have as approximate value *vg*. The duration τ of the flash will be thus about $\tau = \frac{vg}{d}$ if *d* is the diameter, here common, of the diaphragms *o* and *t*.

In our experiments, C*r* = 45 cm; *g* == 10; *d* = 1.5 mm, which gives, for an angular velocity of about 4 turns/sec.; $\tau = 1.3\ 10^{-5}$ sec., approximately.

Thus, even at this speed, with each flash, the duration τ of the useful light beam is well above the travel time of light along the optical circuit. This one has, in fact, approximately 3 m of length, and is consequently traversed by the light in 10^{-8} sec. Each beam thus makes at least 1300 times around the optical circuit during a flash. The fringes thus have ample time to be formed on the photographic plate. However, to obtain a sufficient photographic exposure under these experimental conditions, the exposure time will have to be longer than in the case of the entrained source. Approximately 5 min. where used here for each direction of rotation, using the same white source of light as above.

The recordings which we carried out thus show a net shift of the fringes and were completely comparable to that provided by the conventional mounting of Sagnac. The average of the results of the measurements made on a series of nine shots led to value 0.088 of the distance between interference rings for the shift of the fringes corresponding to the two directions of rotation and a platform angular velocity of 1 turn/sec. The deviations of the individual results are at most 15 per 100 of the average. We see only 5 or 6 per 100; the average shift observed here is of the same value as that obtained above with the ordinary assembly of Sagnac.

The specimens of recordings reproduced here in Figure 3 represent, increased four times, two of the original stereotypes. The directions of rotation relative respectively to the upper and lower parts of the same stereotype are opposite. Stereotype 57 (number of revolutions 4.13 turns/sec.) shows the Sagnac effect obtained with the traditional device where the source is entrained by the disc. Stereotype 45 (number of revolutions 4.39 turns/sec.) is a recording obtained under the current conditions, i.e. when the source is fixed in the laboratory. We see that the fringe shift is appreciably the same one in these two tests.

Fig. 3

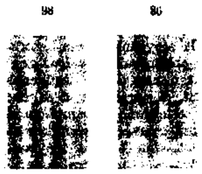

Fig. 4

In short, these last experiments show that it is allowed to practically use the light emitted by a source not belonging to the system of the mobile disc, at the time of the study of the light propagation on this disc for an observer entrained in rotation of the platform, notable though rather slow; but the experimental results are modified for him in an appreciable way.

3. Experiments made by using a source and a photographic recorder remaining fixed in the laboratory. — One might even wonder whether the interference phenomenon was the same one as for the observer entrained in rotation and for an observer maintained fixed in the laboratory.

To carry out this study, the device represented schematically in Figure 2 underwent the following modifications: the mirror *p* was removed, the formed glasses of the objective lens L' and the eyepiece *o*' as well as the photographic scope *P* were removed from the platform and were fixed at a motionless support sealed to the wall of the laboratory, so as to be placed on straight line at a suitable location in the path of reflected light from mirror *n* at the time of the flash. In this provision, the source of light and the observer operating the photography of the fringes with photographic glasses and eyepiece are both fixed, compared to the laboratory.

But throughout the flash, very short though non-null, the platform turned a small angle and the fringes obtained on the photographic plate underwent a slight modification because eyepiece and plate are motionless, while the interferometer turns. To, as far as possible, eliminate the effect this error causes, we used the known change of sign of the Sagnac effect when one makes a swivel of a small angle ε around a vertical axis; the separating glass *R* being in an average position when the central fringe extends across the interference field. For the stereotypes obtained when angle ε is positive, the shift of the fringes due to the rotation of the interferometer during the flash will be added, for example, with the Sagnac effect. On the contrary, for the stereotypes obtained when angle ε is negative, the shift of the fringes due to rotation will be removed from the Sagnac effect. By taking the average of these two sets of recordings, we obtain a value of the Sagnac effect corresponding to one negligible duration of the flash. Naturally, the precision of the results suffers a little because of this additional difficulty. In spite of that, we found values remain similar to the preceding ones. Thus the average of the shift of the fringes given by about ten stereotypes in each series for the two directions of rotation and an angular of 1 turn/sec. velocity is equal to 0.098 of the distance between interference rings for a certain sign of ε, and to 0.084 of the distance between interference rings for the other sign of ε. The average of these two values is 0.091 of the distance between interference rings, differing only from 3 to 4 per 100 of the number obtained previously if the source of light were fixed in the laboratory.

Specimens 98 and 86 (angular velocity of approximately 3.7 turns/sec.), given in Figure 4, increased four times, represent two of the original stereotypes obtained under these conditions, and for which the direction of rotation of the platform is the same one with regard to the higher areas of the recordings; for the lower parts of these specimens the direction of rotation is opposed to the precedent. The angle ε was of a certain sign for Stereotype 86, of the contrary sign for Stereotype 98. One realizes, at first glance, that the average of the absolute values of the shifts of fringes on Stereotypes 86 and 98 is of the same order of magnitude as the shift of the fringes detected by Stereotype 45 of Figure 3.

This result is related to the fact that the platform turns a very small angle throughout flash.

II. — Experiments in which the optical circuit comprises, in series, a fixed in the laboratory and a part entrained by the platform in rotation.

1. Preliminary tests. — Figure 5 is a perspective, diagram of the next device design to be tested.

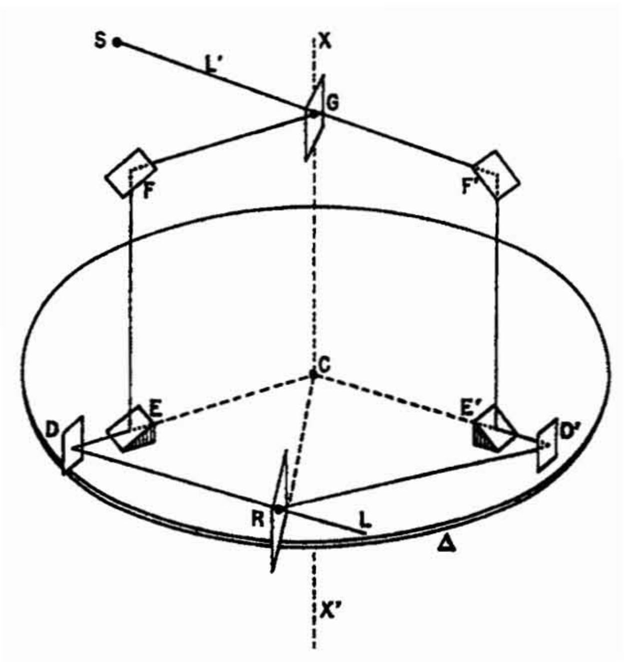

Fig. 5

The light resulting from the source S crosses the collimator L', not entrained, and comes to provide, by the action of the separating glass G, the two interfering beams with separate trips, one GFEDR and the other GF'E'D'R. The fringes are observed in the eyepiece at L.

The source S, the collimator L' and the mirrors G, F, and F' are fixed in the laboratory. The other mirrors, as well as the glasses L and the photographic plate are carried by the platform and turn with it. Consequently, only portions EDR and E'D'R pathways of the light are entrained by the disc in rotation. Lastly, the arrangement of the mirrors is assumed perfectly symmetrical compared to the plane in GCR in which line CG is congruent with the axis of rotation XX' of the disc.

The experiment carried out in accordance with this assembly could not lead to effective recordings, because it was necessary to operate in monochromatic light whose intensity would have been insufficient to expose the plate without excessive durations of exposure, and especially because low vibrations of the ground blurred the system of fringes, which would have removed any significance with the discussion of the results.

2. Device actually used. — The preceding disadvantages resulted owing to the fact that the two interfering beams follow separate paths. They disappeared when we forced the two beams to follow the same course in opposite directions.

Figure 6 shows, in prospective, the diagram of the layout of our experimental construction. The collimator L' and the eyepiece at L are not entrained, the glass S (separating and receiving) where the observer O is supposed to be, plane mirrors K, J, D, E, and F are all attached to the platform and turn with it.

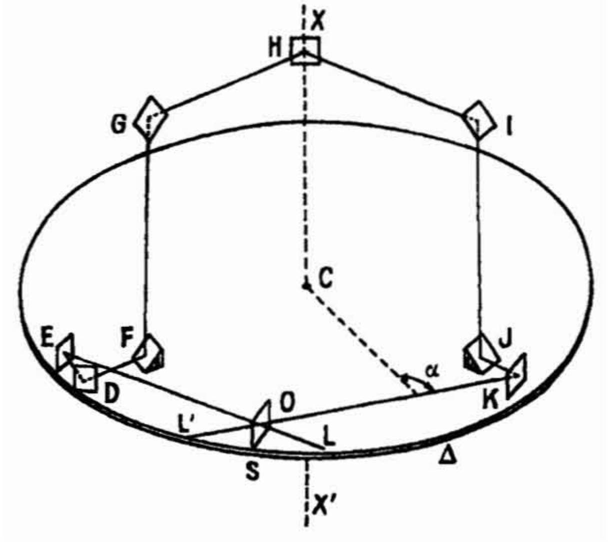

Fig. 6

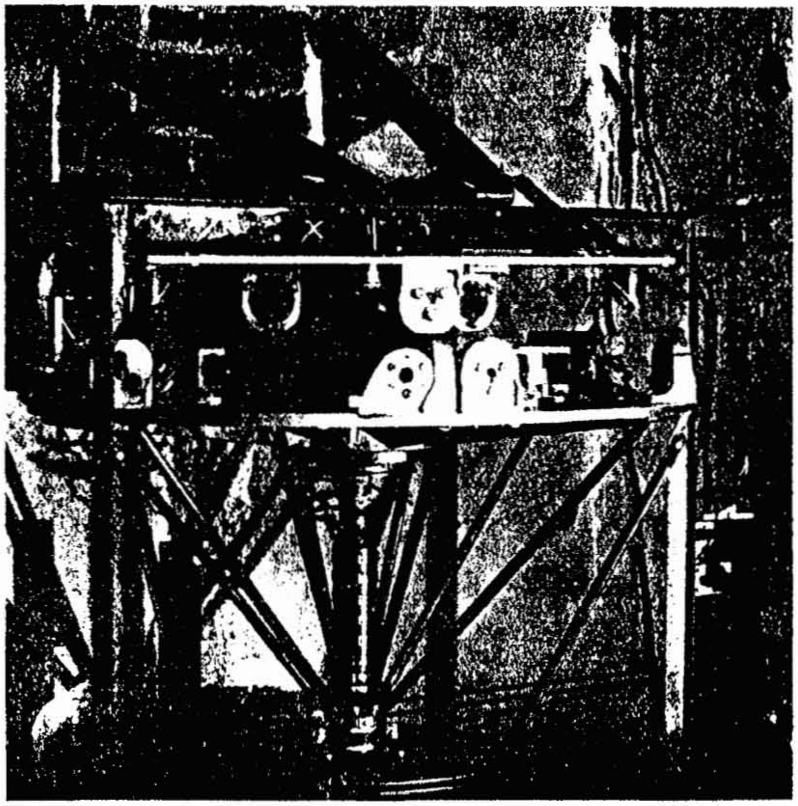

Fig. 7

The glass plane S is about at equal distance from mirrors F and J. In addition, the radial lengths CF and CJ are equal. The plane mirrors G, H, and I remain fixed in the laboratory. For all the mirrors other than F, G, I, and J, the plans of incidence are horizontal, parallel to the platform. Only the planes of incidence of the mirrors F, G, I, and J are vertical and contain the axis of rotation XCX'. These last mirrors are tilted with 45° on the vertical, the mirror F being parallel with the mirror G, and mirror J parallel with mirror I at the time of the flash in white light provided by a source not entrained, fixed in the laboratory, and consisting of a (positive crater) carbon arc. Lastly, lengths FG and IJ are parallel to the axis of rotation, equal to each and of a value of 10 cm.

One of the interfering beams follows way SKJ on the disc, then JIHGF (course remaining fixed in the laboratory), and returns by way FDES carried out on the disc. The other beam goes in opposite direction of the precedent on the same course. The fringes are recorded on a photographic plate attached to platform Δ and located in the focal plane of the eyepiece at L.

Figure 7 is a photograph of the experimental device we used. The source of light is not visible there, being too far on the left, outside the field. The turning disc, by its vertical axis, is surmounted by one second platform fixed to the frame sealed to the wall of the laboratory and which carries the mirrors of the upper floor. There are, actually, five and not three as shown schematically in Figure 6. Indeed it is an obvious impossibility to place a mirror fixed according to plan at H on the axis of rotation of the revolving platform; this single mirror H was replaced in fact, by three plane mirrors which one sees in Figure 7 and which make it possible for the interfering beams to circumvent the shaft of the mobile platform, and not to be intercepted by it. But as the higher course of the beams is fixed in the laboratory, and the azimuths of the planes of incidence of the mirrors G and I remain unchanged, it is more convenient to use in this reasoning (and it is what we will do), the plane mirror fictitious H of Figure 6, to be replaced by three fixed real mirrors of Figure 7 which are equivalent for it in the experiment.

One can wonder, however, if it is reasonable to hope to obtain fringes usable with such an interferometer already rather complicated and of which the two parts are in relative motion. It is thus necessary, very required, to manage to obtain sufficiently definite fringes, remaining unchanged throughout flash, and this in spite of the movement of the revolving platform.

These two conditions could be satisfied by constituting the upper floor with the device by an odd number of plane mirrors and by equipping the apparatus with an additional plane mirror, D. Here are the reasons which justified such provisions:

1° For the length of time, short, but non-null, of the flash during the rotation of the platform, the direction of the incident beam of light hardly changes, but the mirrors F and J attached to the rotating disc moved a little compared to the beams which they respectively receive from the upper floor. However, the fringes used are localized to infinity and each one of them is provided by a whole group of rays. So that these fringes do not undergo modifications, it is necessary that the whole of the rays of each interfering beam remains in the same positions relative compared to the mirrors that they meet, a condition which particularly relates to the 45° mirrors F and J, attached to the turntable. However, if one observes in J the luminous spot provided by the beam traveling in the direction of F to G towards J, and the luminous spot out of F provided by the beam going in contrary direction of J to I towards F, one notes that these luminous spots move a little in consequence of the rotation of the mobile platform Δ, and in opposite directions when the fictitious mirror H is replaced by an even number of plane mirrors, two for example, to transmit the light of G to I and I to G. Under such conditions, one can obtain fringes well (the mirror D being then supposed non-existent), but these fringes narrow or widen according to the direction of the rotation, even very slow, transmitted with the mobile platform. These modifications of fringes result owing to the fact that the group of the luminous rays does not meet each the mirrors F and J always in the same relative positions during the rotation of the platform.

But if the optical course of G to I and I to G is carried out this time in the upper floor by an odd number of plane mirrors, there is change of direction of displacement out of F or J for one of the beams, so that during the flash, the regions of arrival of the beams on the mirrors F and J accompanies them during their rotation. And the fringes which one obtains then (the mirror D being supposed positioned back, one will see why below) remain unchanged for the duration of the flash if the number of revolutions is negligible, as shown in Stereotype 142 (here enlarged approximately four times) in Figure 9.

2° If the plane mirror D did not exist, the number of the mirrors located on the light path would be odd, here equal to 9; and it is known that in this kind of interferometer, the number of the mirrors must be even so that the corresponding rays are found on the separating glass. The presence of this mirror is thus necessary so that the rays which are separated at the various points from the separating blade do not provide on their return to this blade, two turned-over beams, one compared to the other.

3° But the existence of the additional mirror D is made compulsory for another reason: its role is also to compensate for the modification of the points of impact of the rays on the 45°mirrors F and J, modification due to the displacement of these mirrors throughout course of the light above the mobile platform Δ, in the upper floor carried by another fixed platform in the laboratory.

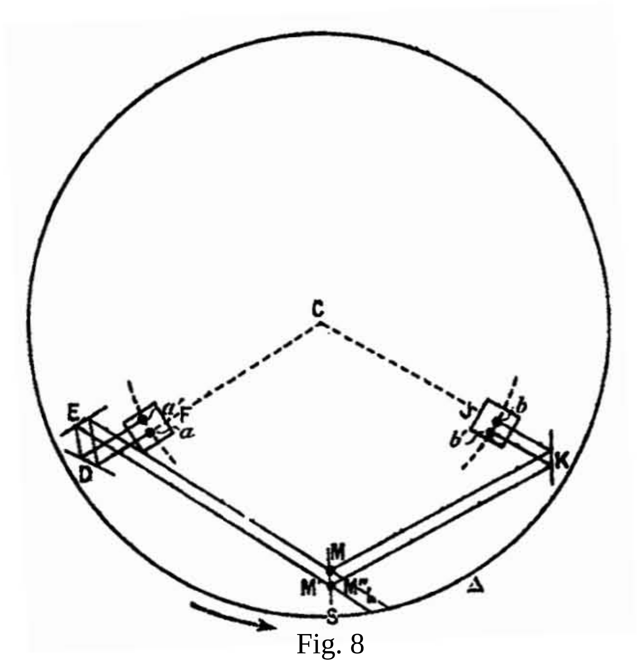

Fig. 8

Figure 8 represents, for this purpose, the revolving platform plan view. Points *a* and *b* mark the respective starting and arrival points of the interfering beams, reduced here to a single ray; the platform is assumed immobile, and the adjustment is such that the rays of return coming from an incidental ray come to be cut on the separating glass. Under these conditions, the ray circulating in the direction which starts from M, arrives in *a* on the mirror F, goes up on the upper floor, goes down again out of *b* on the mirror J and returns to M. The ray circulating in the opposite direction arrives out of *b* on the mirror J, goes up on the upper floor, goes down again in *a* on the mirror F and returns to M. The corresponding fringe is seen in direction ML.

Let us suppose now that the disc Δ is now animated with angular velocity ω in the direction indicated by the arrow. Are still *a* and *b*, under these new conditions, the respective points of offset of the interfering rays moving towards the upper floor?

Let us ignore this for the moment in what follows, of what can happen in the higher journey of the rays.

During the journey time of the light apart from disc Δ, it has turned a certain angle. The ray left *a* will not return any more to *b*, but to *b*' on the mirror J and will follow then the way *b*'KM' seemingly traced on the platform Δ itself. The ray left *b* towards the upper floor will not return any more to *a*, but to *a*' on the mirror F, and will follow then way *a*'DEM" seemingly traced on the platform Δ itself. If the separating glass is at equal distance from the mirrors F and J, then *aa*' = *bb*'.

It should be noted that the returning rays keep the same direction, provided the assumed lines are traced on platform Δ, whether this one turns or does not turn.

From this parallelism and condition *aa*' = *bb*', one deduces that the rays of return *b*'KM' and *a*'DEM" cut the separating glass at the same point, so that M' and M" are matching. It also results from it that the fringe corresponding to infinity remains, on disc Δ, in same direction ML as when the platform was motionless. But the question which arises immediately is to know if the appearance of the fringe remained unchanged.

Two hypotheses are considered:

First Hypothesis. – The speed of light on the platform remains constant and equal to *c*, whether this platform is motionless or moving. The frequency of light on the disc preserving a constant value, one deduces, in this case, of the parallel noted above, that the rays of return arriving in M'M" are, opposite one of the other, under the same relative phases as if the platform did not turn. It follows that the fringes recorded by the photographic plate are modified neither in aspect, nor in position by the only fact of the rotation of the platform Δ.

Second Hypothesis. -- The speed of light propagation on the revolving platform depends on the direction in which it travels. In this case, the motion of the rays, traced on the platform, does not change admittedly but a new factor intervenes: it is the delay brought between the luminous rays by the inequality of the speed of light propagation, delay which modifies the order of interference of the fringe laid in the direction remained however constant, ML. It follows, therefore, equivalent from it an effective displacement of the fringes on the photographic plate.

But, ultimately, one sees that, on these two hypotheses, modification of the positions of the points of return *a*' and *b*' of the rays, resulting from rotation, cannot, *alone,* determine an unspecified variation of the aspect or position of the fringes on the photographic plate attached to the mobile platform.

In the more general case where the two interfering rays would leave one after the other the points *a* and *b*, a reasoning similar to the precedent would show that the points M' and M" would not be confused any more, but the conclusion given above would be always valid.

Lastly, it is advisable to announce the possible existence of an aberration effect along vertical ways FG and JI of Figure 6. But the linear velocity of the entrained mirrors F and J do not exceed in our experiments, 9 m/sec., which could skew the result for rays FG or JI only by 6 thousandths of a second of arc, and is considered completely negligible.

In short, the device thus supplemented does not determine any modification in the aspect and the position of the fringes when the angular velocity of the platform Δ in a direction or the other, is extremely small. It results from it that so experiments, made when the angular velocity is notable, give a variation of the fringes on the photographic plate attached to the mobile disc, it will be necessary to seek of it the cause in the influence of the factor relative speed of the disc compared to the laboratory in which it turns.

3. Experimental results. — We carried out under the preceding conditions, two series of recordings; angle FCJ being equal to 120°.

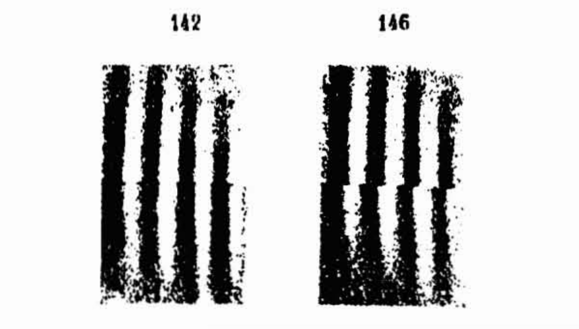

Fig. 9

The second series differs from the first only by the positions of the vertical mirrors of the upper floor. The number of revolutions varied from 1.43 to 4 turns/sec. The successive exposures in the opposite directions of rotation were cross so as to eliminate as much as possible the accidental variations from the fringes during the 5 min. which lasted in all each installation for a direction of rotation. The source of light was like previously the (positive crater) carbon arc. The plates were same as above, of *Agfa* panchromatic sensitive.

Stereotype 146 of Figure 9 represents, increased four times, one of the recordings carried out; the number of revolutions being approximately 3.6 turns/sec. The fringes of the top and those of the bottom of this test correspond respectively to opposite directions of rotation of the mobile platform Δ. The discrepancy of the two systems of fringes, one for Stereotype 142 obtained as one mentioned above when the number of revolutions is negligible, is on the contrary very apparent for Stereotype 146 correspondent at a significant angular velocity.

Measurements of the various stereotypes used, made with the division machine, provided the following results expressing in distances between interference rings the mutual shift δ of the two systems of fringes for the two directions of rotation and an angular velocity of 1 turn/sec. for the mobile platform. The first series of experiments gave for δ, like average of measurements of 15 recordings, the value $\delta = 0.058$. The second series, made up of 7 recordings, provided the value $\delta = 0.054$. In the first series, the individual values of δ has spread out between $\delta = 0.052$ minimum value and $\delta = 0.071$ maximum value. Those of the second series, less good than the first, remain between $\delta = 0.046$ minimum value and $\delta = 0.078$ maximum value.

These experiments thus highlight the existence, under these conditions, of a shift of the fringes of approximately 0.056 of the distance between interference rings in white light, for the two directions rotation and an angular velocity of 1 turn/sec. Although the precision of the operations does not make it possible to exceed the approximation of a few percent on the median value, the phenomenon is of no doubt and its cause must be required in the influence number of revolutions of the platform on the light propagation, by calling upon various possible interpretations. It is what we will consider now.

III. — Interpretation of the experimental results

Let us point out initially the elements of the theories that should apply here.

The classical theory supposes, as one knows, that for the observer bound to the disc, the speed of light from a point on the revolving disc differs the speed c of the light in the laboratory, of a quantity which equalizes with $\pm v$, if v represents the absolute projection the linear velocity of drive item on the platform on the test route considered.

We will use as relativistic theory of these phenomena, that given by Mr. Langevin [2] in 1921 and recalled by him more recently [3]. In this form of interpretation, the observer pulled by the disc movement is supposed to adopt a central time t which is that of the Galilean observers against which the center O is chosen on the platform as stationary. (Let us note in passing that this selected center O is not necessarily the center C of rotation of the platform, but that it is an unspecified point, arbitrarily selected on the disc.) The form which takes the fundamental invariant ds^2 implies anisotropy in the light propagation of which speed varies with the direction between $c+\omega r$ and $c-\omega r$ with the first order of approximation in ω. In these expressions, ω is the angular velocity of rotation of the platform, r is the distance from the center O arbitrarily chosen, at the point of passage, on the disc, of the luminous ray considered. Mr. Langevin finds thus that the duration dt of luminous course length dl is given for a direction of circulation of the light by the expression $\mathrm{d}t = \frac{\mathrm{d}l}{c} + \frac{2\omega}{c^2}\mathrm{d}A$, where d$A$ is the surface of the triangle of base dl and the peak center O, arbitrary selected. While integrating along the finished light path attached to the revolving disc, and by taking account of the direction of propagation, one can deduce the value of the fringe displacement ascribable to the journey in question.

Ultimately, the two leading theories, as one knows, make the following predictions concerning the finished way attached to the revolving disc: the awaited shift of this chiefly for the fringes is, all things being equal, proportional to a surface having for base the way traversed by the light on the mobile platform, but whose top is not the same one for these two theories: in classical theory, this top is the point C center of rotation of the platform, and is independent of the position of the point O, where the traditional observer attached to this mobile platform is supposed to be; according to the relativistic theory reported above, this top is arbitrary; we choose it just like on the glass S at the same point O, which is also the supposed to put the relativistic observer attached to the mobile platform.

We have then to make the application of these considerations to the two following cases:

1° *The Optical circuit, closed, is in full solidarity with the revolving disc.* - It is the well-known case of the experiments of Sagnac.

The two theories are here of agreement between them and agreement with the experiment, with regard to the total shift of the fringes recorded on the revolving disc. However, the traditional theorist and the relativistic theorist are not agreement between them on the allocation which they make, of the cause of the phenomenon, among the various components of the total course. But so that the operator physicist who makes the experiment has the possibility of making a choice between these two theoretical interpretations, what would be needed is to take a direct experimental measurement of the speed of light on the platform in rotation; an operation which is impossible to realize with the precision necessary, in the current state of the art.

2° *Part of optical circuit, closed, is attached to the rotating disc; the other part of the optical circuit is fixed relative to the laboratory.* -- Under these conditions, which are those of our experiments, the shift of the fringes is due obviously to the optical course attached to the revolving disc. We will calculate the values which are returned to him according to the two theories.

In the experiments made in accordance with the assembly of Figure 6, the area included in the sector based upon the light path caused by FDEOKJ and for top the center C of rotation of the platform has an algebraic value (because the surface of the small basic triangle ED in this figure must be counted like negative), A' == 1777 cm^2 approximately, while the area of the sector and the base line of light FDEOKJ and whose top is the point O where the observer is pulled by the disc is, has an algebraic full value

A = 168 cm^2 approximately,

By introducing these numerical values into the expression of the shift δ of the fringes, one finds with λ =0.56 μ, for the two directions of rotation and an angular velocity of 1 turn/sec.,

$$\delta = \frac{16\pi A'}{c\lambda} = 0.053 \text{ of a fringe}$$

according to the classical theory,

$$\delta = \frac{16\pi A}{c\lambda} = 0.005 \text{ of a fringe}$$

according to the relativistic theory; that is to say a value of δ approximately ten times smaller, according to this last theory, than according to the preceding one.

The relativistic theory thus seems to be in complete disagreement with the classical theory and also with the result provided by the experiment. But it is that, as the notes of Langevin reported above appeared to allow it, we had considered that the center where must be presumably placed by the relativistic theorist can be arbitrarily selected. The relativistic theory is found contrary to agreement with the classical theory and the experiment if this center must obligatorily be confused with the center of rotation of the disc, the only point of the disc which can be the permanent origin of Galilean axes not subjected to the rotation movement of the unit. It is besides the conclusion at which Mr. Langevin said to us to be arrived after having been informed of the result of our experiments.

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(See Note following page.)

NOTE.

Mr. Langevin points out to us that, to observers related to an unspecified point O of the revolving disc can be regarded as motionless when they are first order experiments according to the angular velocity of rotation ω, and it is the point of view at which he placed himself in his Notes of 1921 and of 1937; they must on the contrary, in classical theory as in relativity, to take account of their distance r from the axis of rotation C when they are experiments of the second order, or when as in the experiments in question here, the experimental device is only partly related to the revolving disc. If one wants, in relativistic theory, to place oneself from the point of view of the observer O, it is necessary to consider the part of the device external with the disc, as, with the first order, being animated of a movement of translational speed ωr. The reasoning which supposes this motionless part requires that the observer be related to the center C.