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Lecture Demonstration

(DEMONSTRATION OF MICHELSON INTERFEROMETER OPERATING WITH 3-cm ELECTROMAGNETIC WAVES)

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THE Michelson optic interferometer is quite complicated, and its details are not easily observable. Yet the operating principle of the Michelson interferometer can be easily demonstrated with the aid of 3-cm electromagnetic waves using the classical scheme shown in the figure.

In the demonstration, the emitter E is a 3-cm oscillator with a horn-waveguide output that produces linearly polarized radiation. The radiated 3-cm electromagnetic waves were modulated in amplitude at a low frequency on the order of 400 Hz. The receiver R was a dipole antenna tuned to resonance.

The detected low-frequency signal was fed through an amplifier (U2-4) to the vertical input of an EO-7 oscilloscope.

The semitransparent plate P used in the demonstration was a Plexiglas plate measuring 42 × 42 × 0.5 cm. To be sure, this plate is not strictly semitransparent, but exact satisfaction of this requirement is not essential. Indeed, let the effective reflection coefficient of the plate (with allowance for the multiple reflections in it) be equal to α; the effective transmission coefficient of the plate is $(1-\alpha)$, and the mirrors have an effective reflection coefficient β.

If the intensity of the wave incident on the plate P is I, then the intensity delivered to the receiver by each of the separated waves is $I_1 = I\alpha\beta(1-\alpha)$.

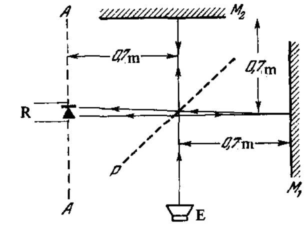
Introduction of a compensating plate in the interferometer arm is not obligatory, since the effective thickness of the plate P is small compared with the wavelength.

The reflecting mirrors M_1 and M_2 were dielectric plates with sufficiently high dielectric constant ϵ, measuring 27 × 27 cm. The RT7 dielectric, with $\epsilon \approx 5$, was used in the experiment. The use of a dielectric excluded partial depolarization of the electromagnetic waves, as is the case when reflection takes place from the metal. This depolarization was particularly noticeable when attempts were made to replace the plate P by a Hertz array with wires making an angle 45° to the electric field of the incident wave.

The demonstration of the experiment is performed in the following sequence:

1. The interference pattern is observed as the receiver is moved in the plane AA. The alternation of the maxima and minima of the intensity of the received signal corresponds to passage of the receiver through the positions of the maxima and minima of the interference pattern.

2. The experimental conditions (inexact perpendicularity of the mirrors) allow us to draw the conclusion that interference fringes of equal thickness were observed. Indeed, let us place the receiver in a position corresponding to a certain reception maximum. By



varying the angle between the mirrors, it is possible to reduce the intensity of the signal at the reception point to zero. On the other hand, if the receiver is displaced in the AA plane, then it is easy to verify that the position of the maximum shifts in space when the angle between the mirrors changes.

3. The shift of the interference fringes can be observed by moving one of the mirrors parallel to itself.

Let us locate the receiver at a point in the AA plane corresponding to the maximum reception. We shift one of the mirrors parallel to itself by 0.8 cm. This corresponds to a change of the path difference by half a wavelength. The receiver, which previously registered maximum reception at a given point of the plane AA, will now register a minimum of intensity. By shifting the receiver in the AA plane, we verify that at the new position of the mirrors the maximum of the intensity has shifted in space, and the overall interference pattern is the same as before.

4. To illustrate the influence of the refractive index of the medium on the conditions of the interference, it is possible to introduce into one of the arms of the interferometer a plane-parallel dielectric plate oriented parallel to the plane of the mirror. Generally speaking, the position of the maximum (or minimum) in the AA plane will be somewhat changed thereby, but this position can be restored by shifting the corresponding mirror. Of course, an estimate of ϵ of the plate is impossible in this case, since the interference pattern is influenced also by reflection from the faces of the plate; in addition, it is impossible to determine the number of half-waves by which the path difference has changed, but the fact that the interference pattern is displaced serves as proof of the change of the path difference of the interfering waves.

If plane-parallel plates made of the same material but of different thicknesses are introduced in each arm of the interferometer (e.g., glass plates with a thickness difference on the order of 1 cm), then an analogous effect is observed.

This experiment illustrates the methods used in optics to measure ϵ, but the measurement itself cannot be performed in our case, since it is impossible to separate the zeroth interference fringe in the lecture experiment.

5. It should be noted that the receiving dipole can be

replaced by a horn; in this case it is possible to observe the same effects, but since the horn sums the radiation contained within several interference maxima (in the AA plane), the explanation of its operation is more complicated. On the other hand, the sensitivity is increased by several times.

The entire installation operates very reliably, can be easily tuned, and its functions are very clear.

Translated by J. G. Adashko