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Mende Interferometer with the Mechanical Division of the Ray

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Abstract The new type of interferometer with the mechanical division of ray is developed. In contrast to the Michelson interferometer this interferometer does not contain the dividing and reflecting mirrors, which gives the possibility to carry out the experiments, which cannot be conducted with the aid of the Michelson interferometer.

Keywords: *Michelson interferometer, Snel law, interference, laser, special theory of relativity, Doppler effect*

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1. Introduction

The Michelson interferometer was invented by the American physicist Albert Abraham Michelson at the beginning of the last century. With the help of this interferometer, a number of important scientific and applied problems were solved, in particular, the speed of light was measured with high accuracy. However, in the experiments conducted by Michelson, there were significant errors. These mistakes he made when he tried to prove that the speed of the electromagnetic (EM) wave is added at the speed of its source. Until the end of his life, Michelson believed that there is an elastic medium in which EM waves propagate. Therefore, the results of the experiments he conducted with Morley [1] on the discovery of such an environment were a big surprise for him. Trying to improve the experiment, he tried to use the light of the star as the source of radiation, but here he was even more unfortunate. Studies have shown that the measured speed of light does not depend on the speed of the star and is equal to its previously measured value, which corresponded to the special theory of relativity, which he did not recognize until the end of his life.

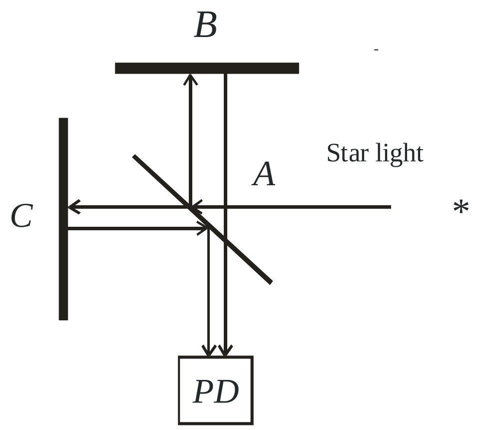

Figure 1. Schematic of Michelson interferometer

In order to understand, in than consisted Michelson's error, let us examine the principle of the work of its interferometer [2], diagram of whom it is given in Figure 1.

The electromagnetic (EM) wave, which arrived from the star and reflected from the dividing mirror A falls on the reflecting mirror B and, being reflected from it, it falls on photodetector. The special feature of this process is the fact that the mirror B is located in the same inertial reference system (IRS), in which is located interferometer itself. This means that, whatever there was the speed EM of the wave, which arrived from the star, its speed, after reflection from the mirror B, will be equal to the speed of light in IRS of interferometer.

The second part EM of the wave, which arrived from the star, penetrating the dividing mirror A, also falls on reflective mirror C. After reflection from this mirror the wave will also have a speed equal to the speed of light in the system of interferometer. But a question consists in what speed will have the electromagnetic wave after the passage of dividing mirror indicated. The reflecting coating, with the aid of which occurs the division of ray, is substituted to the transparent glass plate.

Let us examine the flow chart of the ray through the dividing mirror, taking into account that the fact that the reflecting layer on it is substituted to the transparent of the glass- specific thickness. Since glass- is the dielectric, which possesses the dielectric constant, different from air, the trajectory of the motion of ray will depend on the refractive index of glass. This trajectory is shown in Figure 2.

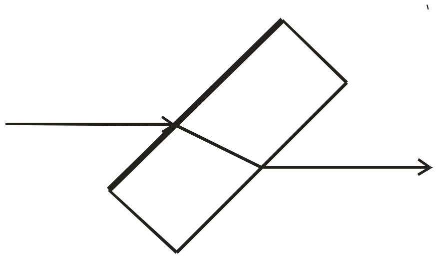

Figure 2. Propagation of light beam through the glass plate

Light beam falls on the glass plate and, refracting twice, it leaves from it in the same direction. During the reverse motion of ray its trajectory remains constant, changes only direction of its motion. In this case the ray moves in accordance with the Snel law [2] and sharply changes its direction after entrance and output from the plate. But this refraction is connected with the fact that the electric fields of the wave, passing through the plate, make it necessary to hesitate the bound charges in the dielectric, which re-emit these fields. And if prior to the entrance into the plate wave had a speed different from the speed of light in the frame of reference of interferometer, then after the passage of the wave through the plate its speed will be equal to the speed of light in the system of its counting. These special features of the work of Michelson interferometer indicate that with his aid it is not possible to measure the speed EM of wave to its contact with dividing mirror. Michelson did not consider these circumstance, of than consisted its error.

Subsequently, various modifications of the Michelson interferometer [2] were invented, such as the Rozhdestvensky interferometer, Fabry-Perot interferometer and other instruments with repeatedly separated light beams. But in all these devices, for the division and separation of light rays, semitransparent layers of metals applied to glass plates or interfaces between dielectrics with different dielectric constant are used. Therefore, all these interferometers suffer from the same drawbacks as the Michelson interferometer.

After the creation of the theory of relativity many researchers attempted to carry out testing the second postulate of this theory about the invariance of the speed of light. Most characteristic these works present in the publications [3-11], but in all these experiments they were used different modifications of Michelson interferometer; therefore could not be obtained reliable results in these experiments.

In the article is proposed the new type of the interferometer of that deprived of such deficiencies, the operating principle of which is based on the mechanical division of laser beam. The use of this interferometer significantly expands the circle of the tasks, decided with the aid of the interferometers. With its aid the experiments on checking of the second postulate can be correctly set. The application of this interferometer opens the way of the new scientific and technical direction – of passive radar.

2. Interferometer with the Mechanical Division of Laser Beam

The schematic of interferometer with the mechanical division of laser beam is shown in Figure 3.

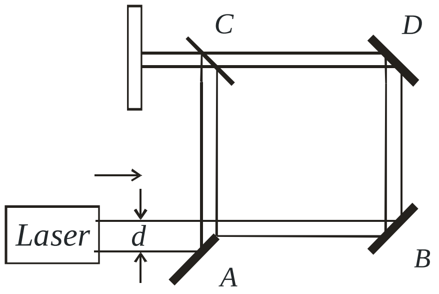

Figure 3. Schematic of interferometer with the mechanical division of laser beam

Laser beam, whose diameter is equal d, it partially overlaps the reflecting mirror A. This mirror the part of the ray it located so that reflects in the normal direction with respect to the primary direction of the motion of ray. The second part of the ray continues to move in the same direction with the previous speed and, falling on the reflecting mirror B, it is reflected in the normal direction with respect to the initial direction of motion. Further rays, after passing ways indicated in the diagram, where D - the reflecting mirror, and C – dividing mirror, fall on the screen, where is reproduced the picture of their interference. In the diagram examined the laser, which is radiation source, can be fixed or move with the given speed. On the spot laser also can be located the mirror, which reflects the ray of fixed laser, in this case the mirror also can be fixed or move according to the assigned law. This case is equivalent to the case examined with the only difference that it is used the ray, reflected from the moving reflective mirror. The advantage of interferometer with the mechanical division of ray is the fact that in it for the separation of ray are not used the dividing mirrors, but splitting ray it is produced by the method of its overlap. In this interferometer are not used also the reflecting mirrors, as in the Michelson interferometer. This method allows to split ray in any proportions with the way of the mechanical displacement of the first mirror, without requiring in this case the replacement of dividing mirror.

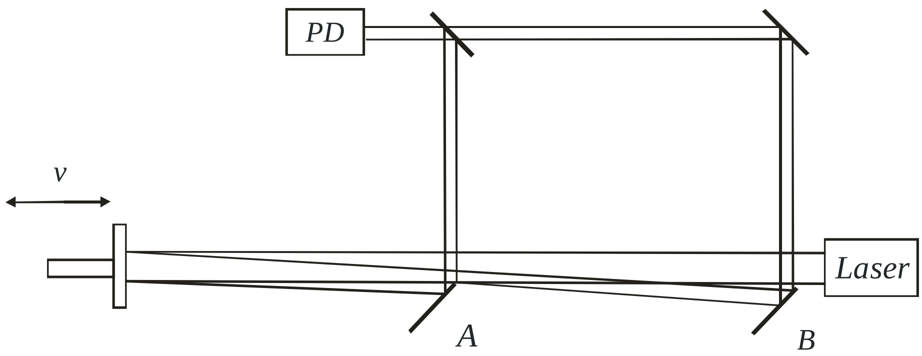

Figure 4. Schematic of interferometer with the reflective mirror

The schematic of interferometer with the mechanical division of the ray, in which is used the fixed laser, whose ray is reflected from the fixed or moving mirror, it is depicted in Figure 4. On this diagram the laser beam has the assigned diameter, which is equal to the distance between the lines, which emerge from the laser.

Let us describe the parameters of the interferometer being investigated and the method of its tuning.

The interferometer is installed on a mounting plate measuring 75x300x1200 mm and has the following parameters: the distance between the laser and the mirror B is 200 mm, the distance between the mirrors A and B, and between the mirrors D and C is 500 mm, the distance between the mirrors A and C, and between mirrors B and D - 200 mm. The distance from the laser to the reflecting mirror is 1400 mm.

In the interferometer as the laser the laser with the green flash with Green Laser Pointer the wavelength 532 nm with a power of 5 mW is used. The diameter of its ray is 1.1 mm. Laser beam leaves from the tip. To this tip from the outer side is dressed the sheet reflector, in which there is an opening for the passage of the ray with a diameter of about 2 mm. At first reflecting mirrors A also in are established in such a way that they would not interfere with the passage of the straight and reflected beam.

Tuning interferometer is produced in the following order. Laser beam is directed at the fixed reflecting mirror, and this mirror is established in such a way that the reflected beam would fall on screen on the tip of laser at a distance 2-3 mm from the opening. Then mirrors A also in are established at the angle 45 of degrees with respect to the direction of the reflected beam. Further mirror v is advanced towards to ray in such a way that it would completely overlap the reflected beam, but it did not overlap straight line. After this, it is advanced mirror A. It is advanced until to ray intensity, reflected from the mirrors A and D it is equal. Further, turning mirrors D and C, they attain the information of rays on the screen, located on the motion of the svodimykh rays. For an increase in the interference picture the objective, established on the course of ray (in the diagram it is not shown) is used.

The interference pattern obtained on the screen is shown in Figure 5.

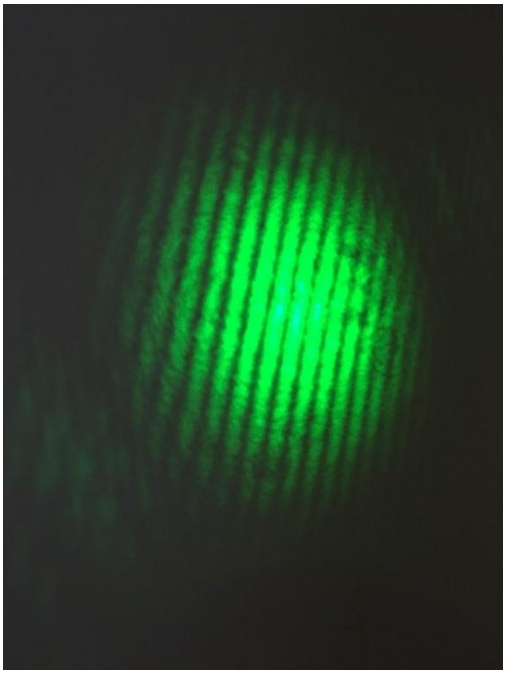

Figure 5. The interference pattern obtained on the screen

Let us examine the work of interferometer based on example of band saw (Figure 6).

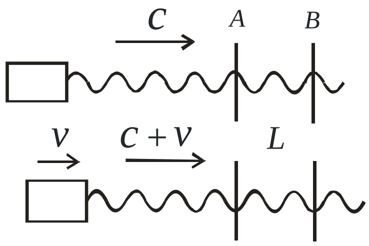

Figure 6. Work of the band saw

From the machine tool, designated by square, with speed c leaves the band saw, whose teeth are cut in the form sinusoid. If the distance between the teeth is equal λ_0, that the frequency of the output of teeth from the machine tool is equal $f_0 = c/\lambda_0$, where c - the speed of the motion of the tape of saw. A quantity of teeth is placed between two lines of observation L, located at a distance in this case, equal $N = L/\lambda_0$, and the speed of the motion of the teeth through the lines of observation is equal c. Let us assume that machine tool begins to move to the side of the lines of observation with the speed v. Together with it will move the moving saw. In this case the speed of the motion of teeth relative to the lines of observation will increase and will become equal $c+v$, but a quantity of saw teeth between the lines in this case it will remain before. The frequency of the passage of the teeth through the lines of observation also will increase and it will become equal

$$f_v = (c+v)/\lambda_0 .$$

Doppler additive to the frequency of the passage of the teeth through the lines of observation in this case will comprise $f_v - f_0 = v/\lambda_0$. It is possible to examine another case, when machine tool remains fixed, and the lines of observation move to the side of machine tool with the speed v. Situation will be the same as during the motion of machine tool to the side of lines. Consequently, a quantity of teeth, which are been located between the lines of observation does not depend on the rate of machine tool or lines of observation.

A similar situation occurs in the section AB in the interferometer, only instead of the saw teeth we deal concerning the electromagnetic wave.

3. Use of an Interferometer with the Mechanical Division of the Ray for Purposes of the Passive Radar

The proposed interferometer can be used for purposes passive radar. For determining the speed of the moving generator should be determined the wavelength λ_0 in the section AB. For this one of the mirrors must be made mobile and its displacement compared with a quantity of strips, which correspond to this displacement. According to the measured value of wavelength should be determined the frequency of the moving oscillator $f_0 = c/\lambda_0$. Then it is necessary to measure the frequency f_v in one of the observation points. In this case the speed of the moving generator will be determined from the relationship

$$v = (f_v - f_0)\lambda_0 .$$

The moving generator thus to easily distinguish of the fixed, whose frequency changes. For the fixed generator wavelength λ, measured between the observation points, and frequency f, measured at the observation points, they will be connected with the relationship

$$\lambda f = c .$$

The general view of the interferometer is shown in Figure 7.

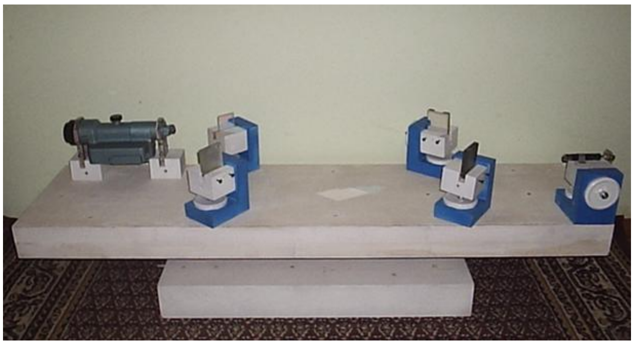

Figure 7. General view of the interferometer

4. Conclusion

Is developed and tested the new type of the interferometer, in which the division of ray is accomplished by a mechanical method. In this interferometer are not used the dividing and reflecting mirrors, as it takes place in the Michelson interferometer. This feature of the interferometer in question significantly expands the range of solved scientific and technical problems in comparison with the Michelson interferometer. In particular, experiments on checking of the second postulate of the special theory of relativity about the invariance of the speed of light can be correctly set. The described interferometer can be used for purposes passive radar.

In accessible publications, the author did not find analogues of the interferometer considered, so he was given the name of the author.

The Appreciation

The author express large appreciation Valery Alexandrovich Nevolnichenko for help in the production of interferometer.

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