Interferometer and estimation of variations in the position of the interference picture

Experiments were carried out using he two-beams interferometer, the main element of the interferometer was a rotating optical disk in which light propagated in two opposite directions (Fig. 1).

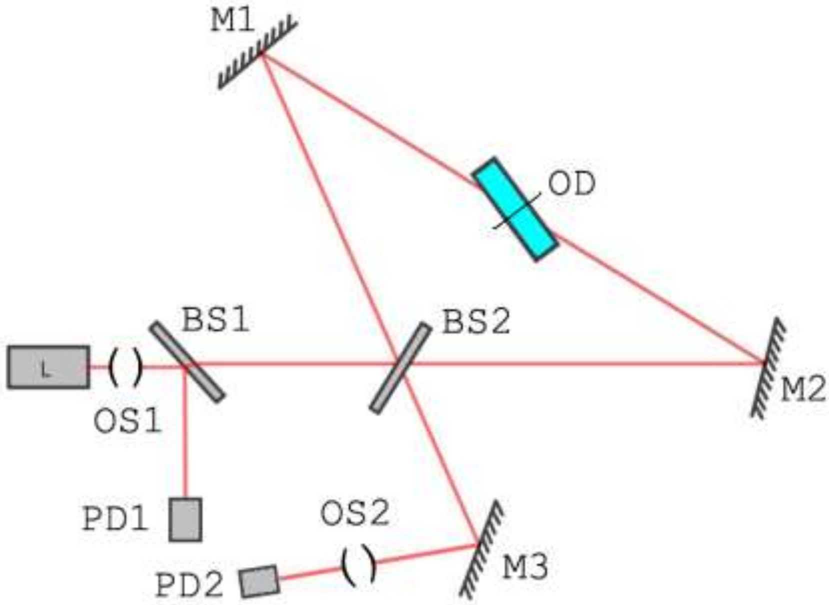

Fig.1. In the interferometer a beam from laser L is divided by $BS2$ on two beams, which propagate in the rotating optical disk OD in two opposite directions. Because of OD rotation, one of the beams has positive phase shift, and another has negative that.

In the work the interferometer scheme (fig. 1) equivalent in the first approximation to the Fizeau-type interferometer with the one-passage scheme was suggested. In the interferometer a beam from laser L after propagate in the optical system $OS1$ is divided by $BS2$ on two beams, which propagate in the rotating optical disk OD in two opposite directions after the mirrors $M1$ and $M2$. Because of OD rotation, one of the beams has positive phase shift, and another has negative that. After beams mix in $BS2$, reflect from the mirror $M3$, and propagate in the optical system $OS2$, they get onto the photodetector $PD2$. Changing the direction of ОД rotation leads to altering the direction of fringes shift on $PD2$.

In the interferometer the light from a laser with wave length $\lambda = 0,632991\ \mu km$ was incident onto the flat surface of an optical disk with a diameter $D = 62\ mm$. Projection of path length of a beam in the medium on the flat surface of the disk $l = 41\ mm$, the index of refraction for the glass material was $n = 1,7125$ and disk thickness was $d = 10\ mm$. Incident beam angle to the flat surface of the disk was $\vartheta_0 = 60^\circ$. Rate of disk revolutions per a second ν had variations within $250 \ldots 350\ s^{-1}$.

Interference pattern shift due to the longitudinal Fizeau's effect is calculated

$$\Delta_0 \approx \frac{2l}{\lambda}\frac{\beta'_{2n}(n^2-1)}{(1+\beta)},\ \beta'_{2n} = V_{2n}/c = 2\pi\nu r/c. \qquad (1)$$

Interference pattern shift with accounting the transversal dragging effect

$$\Delta_\Sigma^\pm = (1 \pm \rho)\Delta_0. \qquad (2)$$

Here the parameter is

$$\rho(n_2, \vartheta_0) = \frac{n_2 - 1}{n_2} tg\,\vartheta_2 = \frac{n_2 - 1}{n_2}\frac{\sin^2\vartheta_0}{\sqrt{n_2^2 - \sin^2\vartheta_0}}$$

Sign in the formula (2) is defined with the scheme of the interferometer. For the interferometer in the fig.1 the longitudinal and transversal dragging effects have different directions, so we need to select the sign «-» and obtain the result $\Delta_\Sigma^- = 0,017 \ldots 0,024$ for rates of OD $\nu = 250 \ldots 350\,Hz$.

Estimation for fringes shift variations in the interferometer when it rotates in space with $\beta \cong 2{,}3 \times 10^{-3}$ gives the magnitude order $d\Delta = 2\beta\Delta_{\Sigma}^{-} = (0{,}78\ldots1{,}10) \times 10^{-4}$ (of a fringe) without accounting influence of dispersion in a moving medium [3]. Therefore, the needed level of sensibility is $d\Delta \approx 3 \times 10^{-5}$.

The interferometer was constructed on two optical platforms with a passive vibroprotected system. A motor with optical disk was situated on the first platform and another optical part of the interferometer was based on the second that. Both platforms of the interferometer was mounted on a rotary platform.

Light is reflected on plane surfaces of the optical disk. The interferential reflecting cover of the optical disk plane surfaces was calculated on the laser wavelength.

The initial transformation of signals was performed by an National Instruments analog-digital converter, then the numerical sequence of signals order was introduced in the personal computer and further processed.

The interferometer was located into a casing with an active thermo-stabilization system. The interferometer was in thermo-stabilized cavity with accuracy 0,1ºC. Temperature was controlled inside and outside the interferometer by three independent channels.

The rotation of the interferometer was produced by a step engine and was computer-controlled with accuracy $0,2^{\circ}$.

As a measuring photo detector it was chosen a high-speed Hamamatsu phototransistor.

Interference pattern shift was measured according to time of fringes motion along a FD aperture. A measuring method is presented in works [5], [6].

The method, allowing to recalculate from time interval to IP shift, is realized with elliptical integrals of second genus and is presented in [5]. Hence, as an interferometer was adjusted for one working point of the phase curve during measurements was carried out, so the IP shift is proportional to time of fringes motion along a FD aperture in the first approximation.

Increasing or decreasing a time interval with the fixed direction of OD rotation depends on adjustments of an interferometer. Thus, if we calibrate the interferometer, we will be able to define IP shift by altering time of interference fringes motion. Then we can solve the reverse task – to define velocity of medium motion by using time of interference fringes motion. If velocity of medium motion is given, but anisotropy appears in the experiment, so we will be able to find magnitude and direction of interferometer motion velocity in space by means of an anisotropy component, which is measured with different orientations of the interferometer in space.

To obtain possible dependence of a signal on spatial orientation of the interferometer we carried out an experiment for measuring a signal when the interferometer was turning within 360 degrees in two opposite directions. The experiment was repeated with different orientations of the platform in 5° interval in a laboratory reference system.

Time of signal recording was 15 seconds. Thus, for example, when rotation frequency was 200 Hz it was made 3000 measurements for one point of the diagram. To reduce low-frequency mechanical noises and high-frequency electromagnetic influence, we used filtration.

In the case space-time optical anisotropy exists, we will have variations of interference pattern position when the interferometer is turned in space. The variations can be selected from time signal when interference fringes are moved on a photodetector aperture.

References

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