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On the Phenomena of Optodynamics

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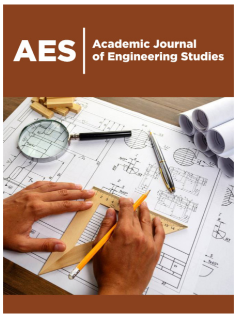
Abstract

Precise optical devices for full measurement of the accelerated motion are presented. The proposed devices are implemented on the basis of the linear semiconductor laser, without moving or tensioned parts and without ring resonators, and could be arranged on the belt fastened around the object to be measured. Presented method consists in the using of standing wave of the coherent radiation in the resonator as the sensitive element of the accelerated movement measurement.

Keywords: Accelerometer, Control, Navigation, Linear laser resonator, Optodynamics



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Introduction

Known phenomena of Optodynamics in moving resonators

We consider the dynamic action of external forces on a rigid resonator with an invariable geometry, with resonator elements and a photodetector stationary relative to each other during the interaction time, which leads to an accelerated motion of the resonator with radiation. We also consider the radiation medium to be stationery and uniform in the intrinsic frame of reference of the moving resonator, when the dielectric ε and the magnetic μ permeability are constant. At the same time, the movement of the source and the receiver of radiation relative to each other under the action of external forces, or the movement of the active medium [1,2] in the cavity, additionally lead to the Doppler, Fresnel-Fizeau effects, etc. [3,4]. Today, the term "Optodynamics" corresponds to the processes of motion of particles of a medium under the influence of light, including laser cutting and drilling. In our case, the term "phenomena of Optodynamics in moving resonators" is used to refer to phenomena in the case of uneven motion of a rigid resonator with radiation.

Prior to our work in rigid moving resonators, there were only two "phenomena of Optodynamics in moving resonators" independent of the medium: The first is the invariability of the radiation parameters of the source in the form of a cross-shaped interferograph moving with the Earth's orbital velocity; it was discovered by Albert Abraham Michelson [5-7]. Second is the appearance of a frequency shift proportional to the angular velocity of rotation of the ring resonator for each component of its radiation; it was most fully investigated by Georges Marc Marie Sagnac [8-12]. Both of these phenomena were investigated in order to test the hypothesis of "ether dragging" [13].

Cross-shaped Michelson interferograph

Michelson and his co-workers had created a new optical setup to measure "ether vortices". A cruciform interferograph was assembled in a wine cellar, on a stone slab (1.5 x 1.5 x 0.3) m3, floating on a "pillow" of mercury [13]. Moreover, the measuring "shoulder" of the cross-shaped beam contour of the linear interferograph was directed either along the motion of the Earth, then perpendicular to it. But the displacement of the interference fringes on the screen, expected by the "ether" model, was not found either during the first experiment in 1881, or after. It shouldn't have been, but for different reasons. By other we mean reasons not related to the presence or absence of "ether". In Figure 1 shows a diagram of an interferograph for measuring the assumed "ether vortices" during the translational movement of the installation together with the Earth in its orbit. Its elements remained motionless when measured relative to each other. The interference picture on the screen of the new setup turned out to be very sensitive to the shift of any of its elements. The "wrong" interferograph with a moving element, or with a moving optically dense medium, has become an interferometer - a precision instrument of wide application. Until recently, the Michelson interferometer was widely used in the rotation stabilization system in CD-ROM devices for personal computers and was produced in millions of copies.

Interpretation of the first experiments of Michelson

Before our works, the negative result of Michelson's first experiments, or the invariability of radiation parameters in a cruciform interferograph, was explained by the fact that the ether, as a special physical medium, does not exist, which of course is true. On the other hand, a stable effect was found in a Sagnac ring interferograph on the same plate - the appearance of a frequency shifts proportional to the angular velocity of rotation of the ring resonator. SRT (to explain Michelson's experiment) and GRT (including, to explain the Sagnac experiment) were created. The absence of the observed change in the interference pattern at the output of the setup according to Figure 1 allows for a different (without creating SRT) explanation based on a general physical approach [14-17]. The absence of interference fringes shifting on the screen of a linear (cross-shaped) interferograph does not contradict the laws of classical physics and is in no way connected with the presence / absence of "ether". After all, what were the researchers doing? On a freely floating slab, they fixed: a light source, a light receiver and framing elements (mirrors and beam splitter).

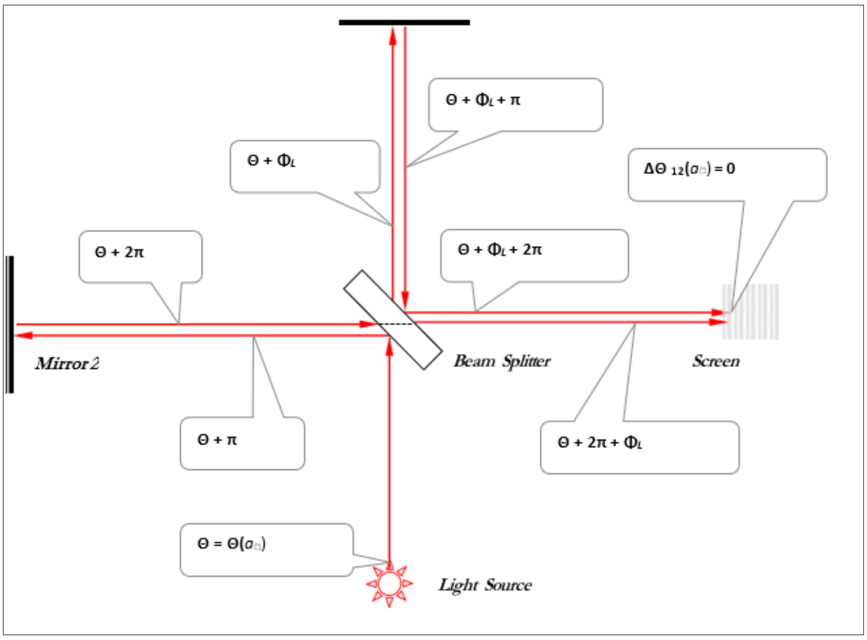

Figure 1: Optical scheme of Michelson's interferograph (1881-1886).

The system was closed, and, left to itself, moved uniformly and rectilinear during their measurements. The orbital motion of the Earth around the Sun is the best available example of uniform rectilinear motion for small terrestrial objects in a short experiment time. According to Galileo (Galileo Galilei, 1564-1642), a physical system is able to detect only a change in its speed (state) with uneven motion (external influence).

In addition, it can be shown that at the output of the cross-shaped interferograph, a "zero path difference" was observed between two components of the same beam (see Figure 1). This design compensates for any change in beam phase due to uneven movement of the entire system. In the first Michelson interferograph, the initial beam from the source is split into two (opposite in phase), each of which undergoes same number of reflections, on its way to the screen. It is also impossible to expect that electromagnetic radiation without mass in kg, but with its eigenvalues of energy, momentum, or angular momentum, changes its space-time characteristics in the same way as a material point. Michelson did not measure the orbital velocity of the Earth's motion in the first relevant works, since:

1. the absence of a shift of the fringes of the interference pattern on the Screen of Michelson's "interferograph" does not contradict general physical laws; the system was closed, left to itself, and moved with the Earth almost uniformly and rectilinearly during the entire experiment in orbit around the Sun;

2. according to Maxwell's theory, the radiation from the Light Source is divided by the Beam Splitter plate into 2 sleeves from the Beam Splitter to Mirror 1 and to Mirror 2; the beams pass back and forth and meet on the Screen after an equal number of reflections, with equal phases and with zero phase difference;

3. the light in the resonator does not have to be sensitive to the movement of the common plate along the standing radiation wave; this will be the case only if the beam of light consists of

massive balls; for example, the axis of sensitivity of the "autonomous resonatory device" (ARD) to acceleration is directed almost at right angles to the standing wave of light in the resonator, which is determined by the direction of the "vector of radiation" [14-17];

4. according to the theory of ARD, the interferograph circuit compensates for any possible change in the phase of the radiation, including with the uneven motion of the entire system. It can be assumed that when installation moves, phase of radiation from the "Light Source" changes, depending on the acceleration of the entire installation plate, by the value $\Theta(\boldsymbol{a}_{\square})$, where $a_{\square}$ - is the acceleration of the common plate ($\square$) of the installation. Further, the phase of light in the arms of the interferometer changes by π after each reflection and by phase ΦL after each pass of the "Beam Splitter" dividing plate, where L is the length of the optical path traveled in the plate. As a result, from Figure 1, we get zero phase difference at the output.

Related works by others

Ring resonator-based devices: The main difference between our device and G. Sagnac effect-based laser gyro is the shape of the sensitive element: the linear light standing wave instead the ring one of laser gyro. But ring laser itself as the sensitive element of laser gyro has the dead zone and nonlinear part on the characteristics. The laser gyro includes necessarily added mechanic or electromagnetic alternating bias devices attached to the active or passive ring resonator. Linear resonator-based devices with an alteration of the dimensions of light pathlength. These devices are based on Doppler effect and resonator dimension changing. They are characterized with an element of measurement system additionally disposed on the moving object. At the same time other parts of the measurement system are disposed on a motionless environment. This group of devices has common generic subject matter such that altering of dimension of the sensitive pathlength as dynamic response.

Linear resonator based devices with an alteration of the media parameters: These devices are based on the alteration of some parameters of the media in the resonator, as density or birefringence in tensioned fiber, caused by the forced movement due to its specific properties, e.g. inertia. This group of devices has common generic subject matter such that altering of the material parameters of the sensitive pathlength as dynamic response. All devices of mentioned above groups include necessarily added mechanic or electromagnetic subsystems and non-controlled nonlinear parts on the output characteristics.

Presented works: The presented devices of the same type, depending on a method of measurement and processing of output signal, are single-axis accelerometers or vibrometers. A couple of the devices, fixed on definite distance from each other, will be laser gyro without dead zone. Presented devices measure acceleration of actual motion, including constant acceleration as against to piezo effect based sensors, which are reacting only with changing of acceleration of the object. Our devices measure acceleration of actual motion at free falling of object as against to all other accelerometers. In Figure 2 shows the optical scheme of the semiconductor laser based ARD. In total, the sensor (without a preamplifier, power supplies and control units) contains three parts, including: a frameless semiconductor laser, a return mirror and a frameless silicon photodiode. The weight of the sensor together with the housing and the preamplifier is 20 grams. In Figure 2 denotes: 1 - uncased semiconductor laser; 2 return mirrors; 3 - photodetector with an output photocurrent. Here, solid red arrows present the radiation with uneven motion of the ARD, dashed arrows present the radiation of a resting ARD. The basic features of the ARDs: «B-1AC» & «B-1AM» are listed in the Table 1:

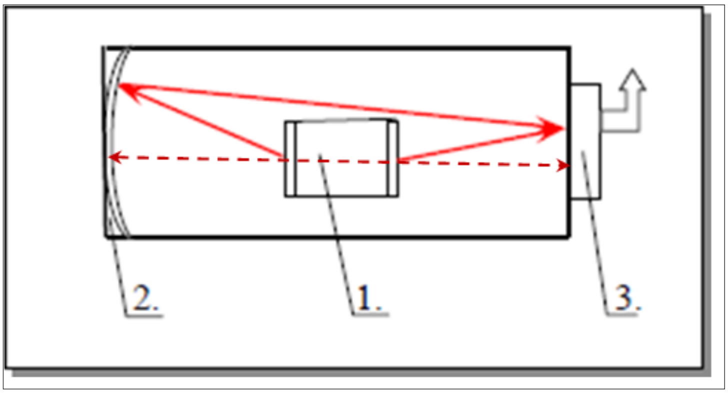

Figure 2: Optical scheme of ARD based on a semiconductor laser, BAGRON Co. (1999).

Table 1:

Parameters	«B-1AC» (Ceramic Fulfillment)	«B-1AM» (Metal Fulfillment)	Analogue on Accuracy «A-4» Quartz Accelerometer
Mass	< 0,015 Kg	< 0,020 Kg	0,050 Kg
Dimensions with preamplifier	12 x 12 x 32 mm	Ø12 mm x 32 mm	Ø38 mm x 21 mm

Working range	±12 **g**	±12 **g**	±7 **g**
DC power supply	±5 V; +2 V; 0,1 W	±5 V; +2 V; 0,1 W	±15 V, +9 V; 100 mA
Frequency band of operation	(0÷100) KHz Determined by preamplifier	(0÷100) KHz Determined by preamplifier	(0÷100) Hz
Output signal	Analogue	Analogue	Analogue
Sensitivity	<10^{-6}**g** Determined by photoreceiver	< 10^{-5}**g** Determined by photoreceiver	$5 \cdot 10^{-7}$**g** in case of stable **g**, acting on the accelerometer
Instability of «zero» signal during the movement of object	Does not depend from **g** and is determined by electronic units	Does not depend from **g** and is determined by electronic units	Not worse than $5 \cdot 10^{-5} \cdot$**g** in case of stable **g** acting on the accelerometer

Conclusion

1. The first experiments of Michelson admit of a different interpretation.
2. The prototypes of "autonomous resonator sensor" - a new type of linear laser accelerometer without straining and moving relative to each other parts are developed.
3. Depending on the magnitude of the impact and the parameters of the resonator, the response function of the ARD ceases to notice a strong constant external impact of (1÷0.1)g after (1÷100)ms, respectively. The rise time of the first maximum of the ARD response at an acceleration of ~ 10-6g is up to hundreds of seconds at a low amplitude.
4. Proposed ARD can be used in transport and tool control systems, for analyzing destruction from high-frequency vibrations and in 3D computer mice without a pad.

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