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Change of the Weight of Optical Fiber under the Impact of Laser Radiation

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Abstract: *Authors present results of high-precision weighing of sealed containers holding coils of fiber optics bundles (plaits) while stimulating these fibers by radiation of helium-neon and semiconductor lasers. Weight decrease of fiber has been observed during dissemination of laser light. The weight reduction remains for a few seconds after the laser is turned off. The article offers qualitative physical explanation of this effect.*

Keywords: *weight, optical fiber, laser radiation*

Contemporary physical theories exclude noticeable impact of radiation disseminating in the optical fiber on its weight [1]. With energy E of the current of photons, for example with the value of 1 J, increase $\Delta m = E/c^2$ of gravitational mass of the fiber equals about 10^{-8} mcg which is practically impossible to measure. Light might implicitly impact the weight of the fiber, i.e. as a result of heating of optical fiber during absorption of radiation which causes the change of the dimensions of the fiber and therefore the change of buoyancy of weighed sample (during laboratory weighing in the atmosphere). Experimental data of high-precision measurements of the weight of optical fiber stimulated by laser radiation are highly important both in physics and mass metrology. The article presents the results of weighing of sealed containers holding coils of optical fiber (plaits) during input of helium-neon (wavelength 633 nm) and semiconductor (wavelength 650 nm) lasers into fiber.

Appearance of container №1 is presented on Fig. 1.

Fig1. *Container №1*

Input tip of fiber optic bundle 2m long with light diameter of 4mm (produced by Lytkarinskiy Factory of Optical Glass – LZOS) is attached to the wall of cylindrical container. Output tip is covered by the end mirror which enhanced concentration of radiation in the fiber. Container with diameter of 60mm and height of 100mm is placed in comparator CC1000SL SARTORIUS. Laser radiation was introduced to the end of the fiber optic bundle through transparent wall of comparator which was located in the tight area with atmospheric pressure of 1007 hPa and relative humidity of 38%. During weighing the temperature inside comparator was 22.38^{0}C - 22.16^{0}C. Power of radiation of helium-neon laser introduced to the fiber optics bundle was 16 mW. Weight of appointed container was about 350 g.

Measurements of comparator were taken every 5 sec., discontinuity of measurements of the weight was 1 mcg.

Example of experimental time dependence of the change of weight measurements of container №1 is shown on Fig. 2. Vertical lines on Fig. 2 and further down on Fig. 3 and 4 indicate moments when the laser was turned on (cross-hatching line) and turned off (solid line).

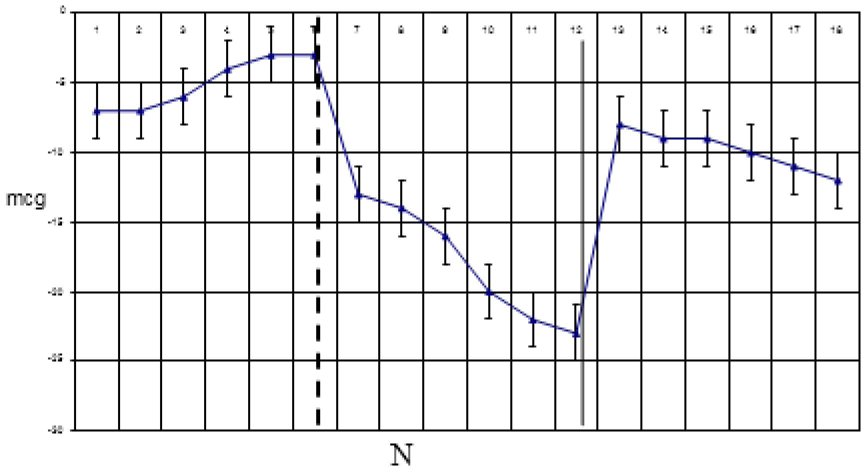

Fig2. *Temporary change of the weight of container №1. N – number of measurement.*

As shown on Fig.2, reduction of the weight of container caused by the laser reaches 15-20 mcg with drifting of weight measurements less than 1 mcg/sec.

Results of weighing of container №2 holding the coil consisting of three successively connected fibers (also produced by LZOS) with light diameter of 1.5mm and length of 4.6m [2] are presented on Fig. 3. Measurements were taken on comparator CC50 SARTORIUS. Power of semiconductor laser with the wavelength of 650 nm introduced to a optic fiber was 55 mW. Input and output tips of fiber optic bundle are attached to the wall of cylindrical container with the weight of 37.4 g, the diameter of 33mm, and the height of 49mm.

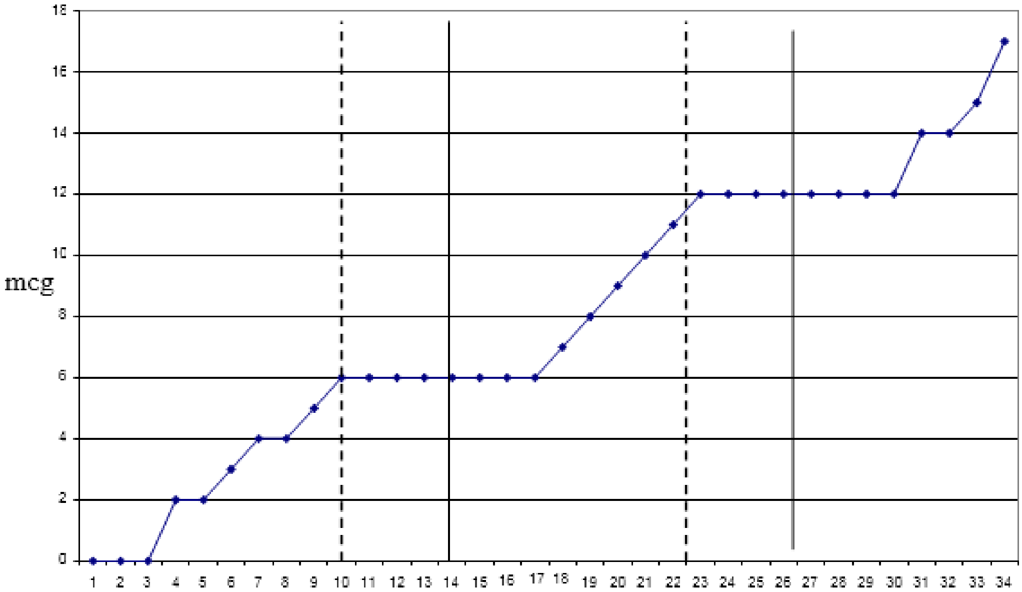

Fig3. *Temporary change of the weight of container №2. Horizontal scale - number of measurement.*

On Fig.3 decrease of the weight of container affected by the laser corresponds to the horizontal parts of presented correlation which represents compensation of positive drift of measurements of comparator with the value of 0.2 mcg/sec. It is interesting to emphasize the inertia of observed effect: decrease of the weight of container happens not only during exposure, but also for the duration of 20 sec after the laser was turned off. As seen on the graph, reduction of the weight of the container affected by laser is 6 mcg with the error of 1 mcg.

On Fig. 4 we showed results of the measurements of the weight of container №2, taken on comparator CC1000SL SARTORIUS. Here, radiation of semiconductor laser with the wavelength of 650nm and power of about 50 mW was introduced into the fiber optic bundle with the help of focusing lens, which made input of radiation more effective.

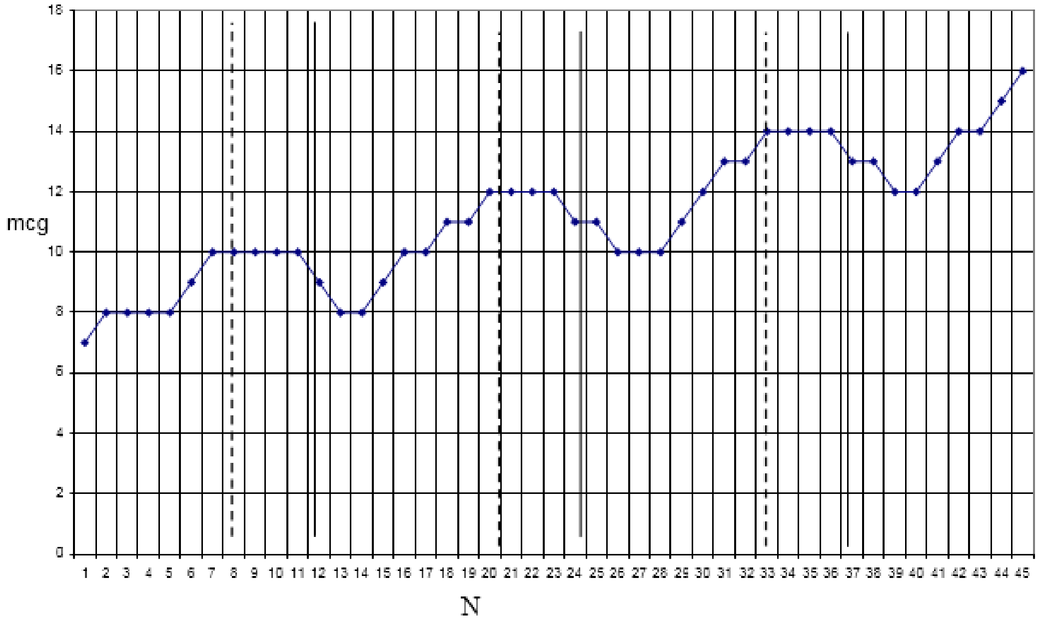

Fig4. *Changes in the weight of container №2 during input of focused radiation of semiconductor laser into the optical fiber bundle. N – number of measurement.*

Fig. 2, 3, and 4 demonstrate general, well recreated tendency of weight decrease of fiber optic bundle during input of laser radiation into them. Questions about why the decrease of weight of the optic fiber continues for a few seconds after turning off of the semiconductor laser and how this effect is being affected by coherency of the source of the light, are still open. Possible causes of the temporary dependency of the weight on Fig. 3 and 4 are particular qualities of processes of distribution of the heat inside optical fiber, analogous to qualities earlier observed during precise weighing of nonmagnetic metal samples heated by ultrasound [3].

Structure of the container and thermal insulation of the center of the optical fiber bundle made heating of the container itself almost impossible, especially during the first seconds after the laser was turned on. Therefore, the cause of the changing of the weight of containers is not related to the impact of the forces of buoyance on them, but probably is related to the heating of fiber optic bundle placed in the containers due to absorption of laser radiation in them. Such decrease in weight of the fiber optic bundle is consistent with negative temperature dependency of their weight [3] observed during precise measurement of non-magnetic samples.

Presented “thermal” interpretation of produced dependencies is not an only explanation of the effect of decrease of weight of optical fiber. Optical radiation even in ideally transparent mediums affects high frequency, with optical frequency of 10^{14} Hz, change of polarization of the medium, therefore vibration and accelerated movement of its particles. Presented in [3-5] a simple phenomenological theory shows that such vibrations may be accompanied by the change of medium weight of a sample.

Experimental and theoretical research of the effect of radiation spreading in the optical fiber on its weight, are forward-looking both in physical optics and metrology of the weight.

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