Method of an Assessment of Reliability of High-Precision Measurements

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***Abstract* – Authors offer a new principle of comparison of characteristics and calibration of optical interferential measuring systems with various lengths of waves of laser radiation. Results of measurements of exemplary and certified measuring systems are represented in the form of the decision of system of comparisons which is displayed on a complex phase plane. The offered approach allows receiving with split-hair accuracy an estimation of casual and regular errors of measurements without use of specially prepared standards.**

***Index Terms* – Nanomeasurement, laser, standard.**

I. INTRODUCTION

Optical interferential measuring systems are widely used at measurements of geometry of nanoobjects [1,2]. Geometrical parameters are connected with a measured optical phase the relation: $\delta=(\Lambda/2\pi)\varphi$ – optical difference of a course.

Accuracy of measurement of geometrical parameters optical interferential measuring systems comes nearer to accuracy of methods of atomic–force and scanning probe microscopy. Therefore the problem of checking and calibration of optical interferential measuring systems is very actual [3]. Complexity of definition of true errors in such systems is caused by lack of authentic means of checking as their accuracy should exceed accuracy of measurement of systems calibrated by them [4]. For the solution of this problem authors offer a new approach to metrology of optical interferential systems which is based on use as a standard of fundamental constants which such sizes as ratios of lengths of waves of laser radiation concern.

II. PROBLEM DEFINITION

Let's present results of measurement of exemplary and certified measuring systems with different lengths of waves of laser radiation in the form of the decision of set

4. $$\delta_1 \equiv \Lambda \bmod \lambda_1,$$
$$\delta_2 \equiv \Lambda \bmod \lambda_2.$$

For descriptive reasons we will display results of the decision in the form of a trajectory of a point on the complex plane with coordinates δ_1 and δ_2.

At change of a measured optical phase Λ the point will move on a certain trajectory in space (δ_1,δ_2). It is obvious that if in the measured phases δ_1 and δ_2 there are mistakes; it will lead to shift of a point of rather initial trajectory.

III. EXPERIMENTAL RESULTS

For check of an offered approach two interferential laser systems with the lasers, having lengths of waves of λ_1 =633 and λ_2=488 nanometers respectively were taken. For example, we will make comparison of accuracy of measurements of these systems. Change of a phase was made by shift of a basic mirror of the external interferometer of laser system. Results of measurements are shown on Fig. 1.

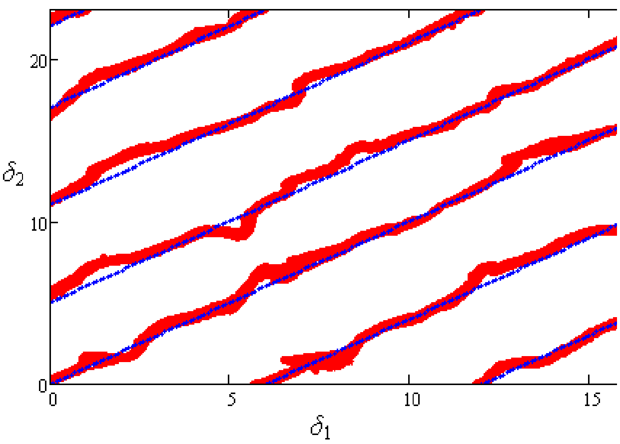

Fig. 1. A trajectory of interferential signals δ_1 and δ_2.

From the analysis of a trajectory of interferential signals δ_1 and δ_2 (see Fig.1) follows that both systems have approximately identical accuracy of measurements. This conclusion proves to be true that the trajectory of interferential signals fluctuates along diagonals and has no preferable arrangement, and the sizes of these fluctuations are approximately identical both across, and down.

III. CONCLUSION

The considered new approach of comparison of characteristics and calibration of optical interferential measuring systems with various lengths of waves of laser radiation as a standard uses fundamental constants – the relations of lengths of waves of the laser and doesn't demand application of additional reference measures therefore the most important principle of metrological providing – self-calibration of measuring systems in the course of measurement is easily realized. The analysis of a trajectory of measured signals also allows receiving with high precision an assessment of random and systematic errors, both reference, and calibrated measuring system.

REFERENCES

[1] Bulygin F.V.// Optical and electronic measurements. Collection of articles/ Edited by V.S. Ivanova. – Moscow: Publishing office “University book”, 2005. – p. 420.

[2] F. Chen, G. M. Brown, and M. Song, “Overview of three-dimensional shape measurement using optical methods,” Opt. Eng. 39, 10–22 (2000).

[3] B.I. Guzhov, S. P. Ilyinykh. Computer interferometry. - Novosibirsk. NGTU publishing house, 2004, 252p. (in Rissian).

[4] Todua P.A., Bulls of V-A., Wolf of Ch.P., Gornev E.S., Zhelkobayev Zh., Zykin L.M., Ishanov A.B., Kalendin V. V., Novikov Yu.A., Ozerin Yu.V., Carpenters of Yu.I., Prokhorov A.M., Crayfish of A.V., Saunin S. A., Chernyakov V. N. “Metrological ensuring measurements of length in micrometer and nanometer ranges and their introduction in microelectronics and a nanotechnology”. Microsystem equipment. 2004. No. 1,.38-44,. No. 2, 24-39, No. 3, 25-32. (in Rissian).

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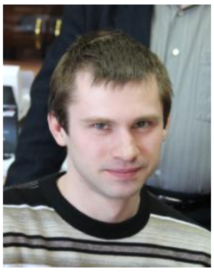

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