Compact interferometer for precise shape testing of large-size convex aspherical mirrors

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Abstract. A model of an interferometer for testing of convex aspherical mirrors up to 250 mm in diameter based on the scheme of orthogonal rays is presented. An algorithm for interferogram processing has been developed. The results of measurements of the profile of a convex spherical mirror on the presented interferometer are presented.

1. Introduction

The development of testing methods for convex aspherical and spherical mirrors of large diameter is an urgent task today because when testing convex mirrors by traditional methods, it is necessary to use precision optical elements with a diameter larger than the diameter of the test surface [1-3].

Professor D.T. Purjaev proposed the basic scheme of orthogonal rays for testing convex aspherical and spherical optical surfaces in 1982 (figure 1). The scheme of orthogonal rays is a scheme of illumination by a collimating beam of a testing surface, which is directed along the normal to its axis of symmetry. An interference method for testing convex optical surfaces based on an orthogonal ray scheme was also proposed by D.T. Puryaev [4]. Therefore, the proposed test method is applicable for small mirrors only.

We offer an improved interference method for testing convex spherical and aspherical optical parts, which is suitable for testing parts, both small and large diameters [5-7]. We analyze the entire tangential section of the interference pattern, which makes it possible to test the shape of the tangential profile of the surface, in contrast to the method proposed by D.T. Puryaev. The dimensions of the analyzed tangential cross section of the interference pattern are smaller than the diameter of the test mirrors; therefore, the method is applicable for testing mirrors of large diameter.
2. The experimental setup

The scheme of orthogonal rays has been implemented for the first time in practice in the STC UI RAS. The optical scheme of the interferometer is shown in the figure 1. The collimated beam formed by a collimator (1) directed onto tested mirror (2). The reference and object beams interfere in the plane of the object of the micro-objectives (4a), (5a). The images of the interferogram are projected onto video cameras (4b), (5b). To register the entire interference pattern, we move the microscopes (4) and (5) consisting of a micro-objective and a video camera along the registration plane using a linear translator (6). The information contained in the registered interference pattern (7) contains information about the profile of the test surface in the tangential section. To check the entire surface, we rotate it around the axis of symmetry 0z of the testing mirror 0z using the turntable (3).

The width of the interference fringes decreases with increasing coordinate in the registration plane. The most frequent interference bands are formed on the edge of the interference pattern. For this reason, the layout for testing convex mirrors contains two micro-objectives with different magnifications.

Figure 1 shows the plot 8 of the width of the interference band (b) versus the coordinates of the centers of maximum of the interference band (h). The applications of micro-objects (4a) and (5a) are also shown in figure 8. Micro-objective (4a) with high magnification \( \beta = 40 \) and numerical aperture \( A = 0.6 \) is used at the field I for registration the most frequent interference bands. Micro-objective (5a) with magnification \( \beta = 10 \) is used at the field II.

The created interferometer for testing convex aspherical mirrors is included in the setup of the Fizeau interferometer [8-9] located at the All-Russian research institute of metrological service. The
interferometer forms a reference collimated beam of 300 mm diameter. Figures 2 shows: Fizeau interferometer (1), testing spherical mirror (2) and the system of interferogram registration (4)-(6).

3. Data processing
The plot of the width of the interference band versus the coordinates of the centers of maximum of the interference band \(b(h)\) contains information about test mirror profile \(z(y)\) in the tangential section. The coordinate system of the test surface is shown in figure 1.

![Figure 3](image-url)

Figure 3. The data prossecing of the obtained interference pattern.

Thus, the test procedure is reduced to measuring the coordinates of the interference bands maxima, building the dependence \(b(h)\), based on experimental data. The experimental plot is compared with the theoretical one.

Figure 3 shows an example of a registered fragment of the interference pattern (a), an image of the same fragment (b) filtered using a spatial Fourier transform and an intensity distribution in the filtered image with the coordinates of the centers of interference maxima superimposed on it depending on the coordinates of the pixel (c).

![Figure 4](image-url)

Figure 4. The mirror profile test result in the tangential section.
The figure 4 shows the profile test result in the tangential section obtained with the created interferometer. The maximum shape deviation of the test mirror ($\Delta z$) is 0.0036 mm.

4. Conclusion
An interferometer has been designed and manufactured for testing convex aspherical mirrors, which does not require precision large optical components in their work. The experimental data obtained using an interferometer are presented.

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