Modified Fizeau interferometer with the fringes polynomial smoothing algorithm

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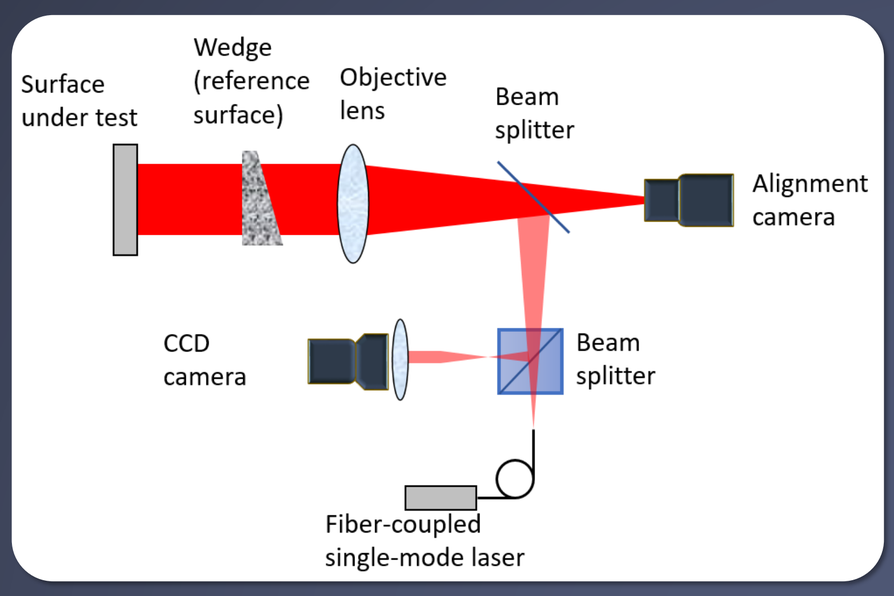
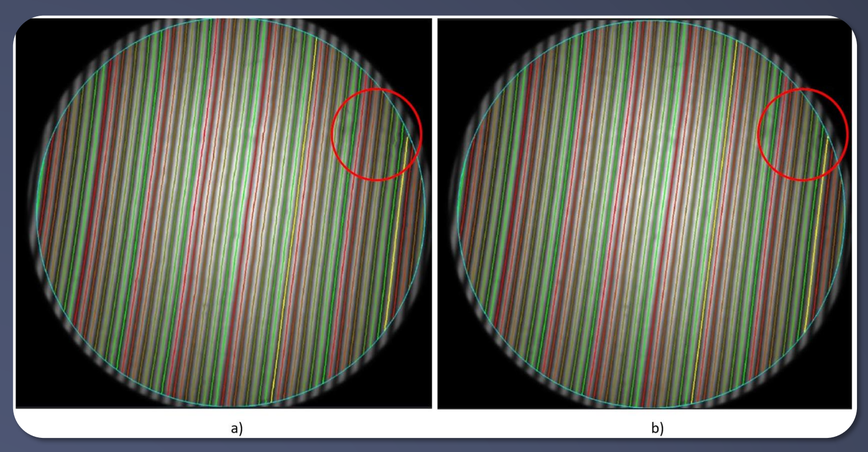
Fizeau interferometer

- The modified Fizeau interferometer that allows to diagnose plane and spherical optical elements with the diameter ranging from 10 to 100 mm is discussed.
- The method of interference patterns reconstruction based on reference lines is modified, the algorithm of 4th order polynomial smoothing is implemented.
- The modified method increases the reliability and accuracy of interferometric pattern reconstruction and suppress the influence of incoming noise.



Principal scheme of the Fizeau interferometer



Wrong determination of interference pattern extremuma — color line within the single fringe changes its color; yellow circles show the regions where this error appears (a). Correct determination of extremuma — each fringe marked with single color line (b).

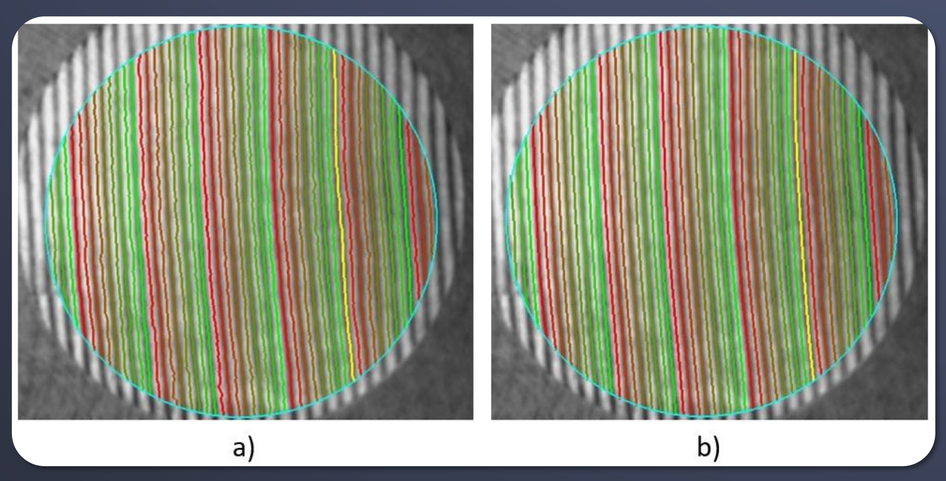
Polynomial smoothing algorithm

4th order polynomial smoothing algorithm takes the X and Y coordinates of each point of the determined interference patterns and approximates it using the polynomials of 4th order. By solving the least squares problem, the approximation coefficients Ci are obtained. The resultant Ynew coordinates of each point of the determined interference patterns are recalculated (based on the old Yold values) using the formula

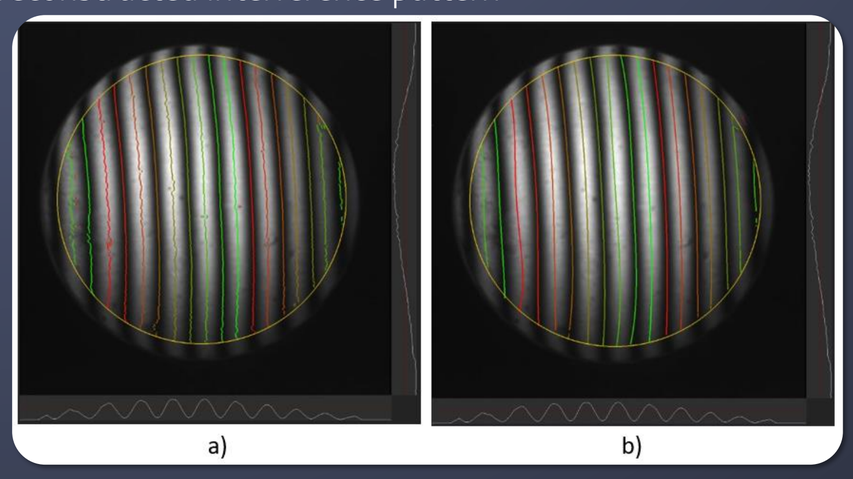
$$Y_{new} = C_0 + C_1 \cdot Y_{old} + C_2 \cdot (Y_{old})^2 + C_3 \cdot (Y_{old})^3 + C_4 \cdot (Y_{old})^4$$

Results

Interference pattern reconstructed with error — red circle shows the dislocation of the color lines that have small bends (a). Correctly reconstructed interference pattern (b)



The result of algorithm application for the case when the interference pattern coming from the CCD camera is rather noisy: a) interference pattern of noisy image reconstructed with error, b) correctly reconstructed interference pattern



The peak-to-valley value of the reconstructed phase surface (without tip and tilt aberrations) was decreased from 0.3λ to 0.13λ after turning on the polynomial smoothing algorithm. Table 1 contains the resultant Zernike coefficients obtained after interference fringes pattern reconstruction before (row #1) and after (row #2) applying 4th order polynomial smoothing algorithm

	PV	RMS	Z3	Z4	Z5	Z6	Z7	Z8
Before	0.3	0.046	0.069	0.032	-0.014	0.005	-0.01	0.01
After	0.13	0.038	0.061	0.025	-0.004	-0.002	-0.001	0.003

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