

APPLICATIONS OF LAU PHASE INTERFEROMETRY IN OPTICAL METROLOGY

by

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This is to certify that the thesis entitled, “APPLICATION OF LAU PHASE INTERFEROMETRY IN OPTICAL METROLOGY”, being submitted by Ms. **Madhuri Thakur**, to the Indian Institute of Technology, Delhi, for the award of the degree of “DOCTOR OF PHILOSOPHY” is a record of the bonafide research work carried out by her under our supervision and guidance. She has fulfilled the requirements for submission of this thesis, which to the best of our knowledge has reached the required standard.

The material contained in this thesis has not been submitted in part or full to any other University or Institute for the award of any degree or diploma.



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ABSTRACT

Optics pertains to the generation, amplification, propagation, reception, modification and modulation of light. In short, *Optics* is science, technology and engineering with light. Measurement techniques based on light come under the heading of Optical Metrology. The optical techniques are non-contact type, non-invasive and fast. In recent years use of optical techniques for measurement has dramatically increased. These techniques are used to determine the topography of landscapes to the checking the roughness of polished surfaces. By using optical measurement techniques the information about the whole object can be obtained simultaneously, thereby giving a capability of whole field measurement. Optical methods such as interferometry, holographic interferometry moiré deflectometry, laser speckle photography, laser speckle shearing interferometry, and Talbot interferometry have been investigated in great details for measurement of length, strain, deformations, vibrations, refractive index, focal length of optical components and systems, temperature and temperature profile of gaseous flames and current and voltage etc. All these techniques, by and large, require a spatially coherent illumination. In the present thesis, we have investigated the application of Lau phase interferometry with linear and circular grating to determine the full-field temperature profile of the axisymmetric gaseous flame as well as two-dimensional gaseous flame obtained from slot burner used in atomic absorption spectrophotometer. We have also investigated the application of Lau phase interferometry with linear gratings to determine the focal length of the lenses and the refractive index of the plane parallel plates. White-light Lau phase interferometry reduces coherent noise in the interferogram and leads to high signal-to-noise ratio. White-light interference bands also have high stability.

The thesis is organized in five chapters:

Chapter I provides a brief introduction of the flame, optics of flame and most of optical techniques used for the investigation of the flame. Further this chapter presents brief introduction to moiré deflectometry, laser speckle techniques, Talbot interferometry and Lau phase interferometry.

Chapter II deals with application of Lau phase interferometry for the measurement of temperature and temperature profile of the gaseous flames. It presents detailed experimental investigations and theoretical analysis to measure temperature and temperature profile of an axisymmetric flame using Lau phase interferometry with linear gratings and white-light source. The optimization of the experimental parameters to obtain high-contrast fringes and to enhance the sensitivity are discussed. The angle of refraction ' ϕ ' is calculated experimentally from the number of the fringe, pitch of the grating and the distance between the flame and the detection grating. Once the angle of refraction ' ϕ ' is known, the refractive index and the temperature at different points are calculated.

Chapter III deals with the application of Lau phase interferometry with linear gratings to measure temperature and temperature profile of a 2-dimensional flame, obtained from the slot burner used in atomic absorption spectrophotometer. This chapter also presents detailed analysis of experimental investigations and the effect of aspirating water through the nebulizer on the temperature profile. A program was developed in Lab view environment to draw the line profile of the Lau phase interferometric fringes. This

chapter discusses the procedure for the calculation of angle of refraction ' ϕ ' and temperature.

Chapter IV presents measurement of the temperature and temperature profile of the axisymmetric flame and two-dimensional flame obtained from the slot burner by using Lau phase interferometry with circular gratings. This chapter also presents the advantages/disadvantages of using circular gratings in Lau phase interferometry over to the use of linear gratings.

Chapter V presents a technique for evaluating the focal length of lenses by using white-light Lau phase interferometry. This chapter also provides the analysis of errors in the measurement of focal length using Lau phase interferometry.

THE WORK HAS RESULTED IN THE FOLLOWING PUBLICATIONS

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1. **Madhuri Thakur**, S. K. Angra and Chandra Shakher, "Measurement of temperature profile of 2 - Dimensional slot burner using Lau phase interferometer with linear gratings," *Opt. Engg.* (Appearing in 2003).
2. **Madhuri Thakur**, A. L. Vyas, Chandra Shakher, "Measurement of temperature profile of a gaseous flame with a Lau phase interferometer that has circular gratings," *Appl. Opt.* **41**, 654-657 (2002).
3. **Madhuri Thakur**, Chandra Shakher, "Evaluation of the focal distance of lenses by white-light Lau phase interferometry," *Appl. Opt.* **41**, 1841-1845 (2002).
4. **Madhuri Thakur**, A. L. Vyas, Chandra Shakher, "Measurement of temperature and temperature profile of an axisymmetric gaseous flames using Lau phase interferometer with linear gratings," *Opt. Laser and Engg.* **36**, 373-380 (2001).

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5. **Madhuri Thakur**, R. Kumar, S. Singh, Chandra Shakher, "Measurement of the temperature and temperature profile of a gaseous flame using Lau phase interferometer and Image processing technique," Proceedings of International Conference on FRINGE'01, held at Bremen (Germany), pp. 654-659, Elsevier, 17-19 September (2001).

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