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A subfringe integration method for multiple-beam Fizeau fringe analysis

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Abstract

Some aspects concerning the subfringe integration method in interferogram analysis have been investigated and modified. The modified algorithm, introduced in this paper, is capable of reconstructing the phase in the presence of noise or errors in carrier frequency. The subfringe integration method was applied to analyze two computer simulated patterns of equispaced Fizeau fringes using N bucket integration. Also, it is used to analyze the multiple-beam Fizeau fringe. The refractive index profile of polyethylene fiber is obtained by using two methods, subfringe integration method, and Fourier transform method. A comparison between the obtained results using the maintained methods is presented.

Keywords: Automatic fringe analysis; Subfringe integration; Fourier transform; Phase measurement; Multiple beam Fizeau fringes; Refractive index profile; Polyethylene fiber

1. Introduction

Because of the determination of the phase difference in interferometry is directed to the physical quantity to be measured, the last three decades have seen an upsurge of interest in optical interferometric measurement. Phase measurement interferometry is the most widely used technique to directly measure wavefront phase in an interferometer corresponding to the relative difference between the test and reference optical paths. The direct measurement of phase information has many advantages over simply recording interferogram and digitizing the position of the fringe maxima and minima. The main advantages of optical interferometric measurement are the two-dimensional phase that can be measured with high precision and automated by fast measurement using computer-aid.

The phase-shifting method is an effective technique for fringe analysis to obtain the phase distribution. In this case the phase difference between the two interfering beams mutate in a known manner [1]. We acquire the phase value by calculating the intensity change of an investigated point corresponding to at least three different phase shifts.

There are many different methods to introduce phase shift or modulation in an interferometer [2,3], for example moving a mirror, tilting a glass plate, moving a grating and rotating a half-wave plate or analyzer. A simple and a common straightforward way to introduce phase shifting technique is to mount one of the mirrors of the interferometer on a piezoelectric transducer (PZT) and apply a suitable voltage to the PZT. Many brands of PZT are available to linearly move a mirror over many micrometers. Accurate calibration of the PZT is then very important to obtain the desired phase shifts between data frames.

The fringe pattern analysis techniques provide a powerful tool in optical interferometric measurement for accurate determination of phase. Numerous authors used interferometric pattern to determine the phase of an unknown wavefront. Each has proposed a phase extraction algorithm appropriate for his particular data-acquisition scheme [4].

There are many different techniques for quantitative phase measurement from fringe patterns. These techniques can be classified into two categories: temporal [5] and spatial [6] techniques. Temporal technique takes the phase data sequentially while spatial technique takes the phase data simultaneously. Each of the techniques has its own fundamental advantages and disadvantages in accuracy, range of measurement, and type of object that can be measured.

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