INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **Development of a Zonal Wavefront Sensor with Enhanced Performance Using a Reconfigurable Array of Binary Diffraction Gratings**

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Thesis Submitted to the Department/ Center	:	**Physics**
Date of completion of Thesis Viva-Voce Exam	:	**13-10-2017**
Key words for description of Thesis Work	:	Shack-Hartmann Wavefront Sensors, Wavefront Sensing, Wavefront Estimation, Grating Array, Computer Generated Holography, Liquid Crystal Spatial Light Modulator, Wavefront Estimation Errors, Spatial Resolution, Centroid Accuracy, Polyester Film.

SHORT ABSTRACT

The Shack Hartmann wavefront sensor (SHWS) is a widely used zonal wavefront sensor, named after Johannes Franz Hartmann and Roland Shack. It consists of a 2D array of micro-lenses called lenslets along with a detector placed at the common focal plane of these micro-lenses. The SHWS comprises two essential processes, namely, the wavefront sensing and the wavefront estimation. However, it has been observed that a conventional SHWS encounters a number of issues in each of these processes that puts serious limitations in the performance of the sensor. In view of the above issues, the present thesis aims to develop a grating array based zonal wavefront sensor where some of such issues are addressed. The sensor in the thesis work uses a two dimensional array of plane diffraction gratings and a single focusing lens. This arrangement thus replaces the lenslets array of the SHWS, thereby overcoming some important limitations associated with the lenslets array. We call such an arrangement as grating array based zonal wavefront sensor (GAWS). The proposed sensor is implemented using a liquid crystal spatial light modulator (LCSLM), employing a computer generated holography technique. In this thesis we also introduce an improved wavefront estimation algorithm, applicable for Shack-Hartmann type wavefront sensors that shows significant improvement in the wavefront estimation. We theoretically analyze the performance of the proposed wavefront estimation algorithm in a comprehensive manner by quantifying the important sources of errors associated with it. Further, we introduce a scheme to enhance the spatial resolution of the GAWS by using a sequence of laterally shifted binary grating array patterns, realised with the help of the 24 bit-planes display of a ferroelectric LCSLM. We also propose a scheme to improve the accuracy of centroid detection and to enhance the dynamic range of the sensor or to reduce the possibility of crosstalk in the GAWS by using multiple detector planes via a mirror and beam splitting mechanism. Finally, we describe the use of a print of an array of binary diffraction gratings on a transparent polyester sheet as a cost effective means to implement the GAWS. Each of the proposed schemes is demonstrated with the help of proof-of-principle experiments.