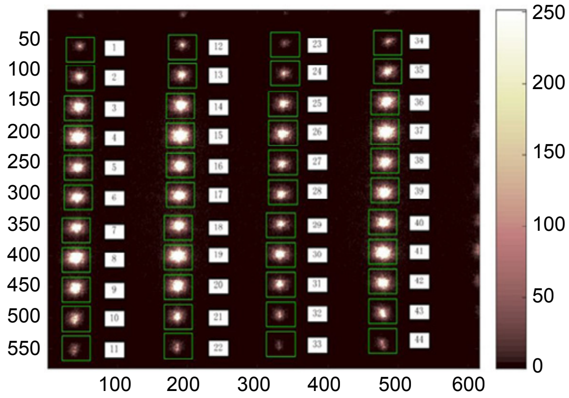
DOI: 10.3969/j.issn.1003-501X.2017.09.008

A high-precision centroid detecting method based on two-dimension orthogonal gratings

Lin Chen[1,2,3], Linhai Huang[1,2] and Xinyang Li[1,2]*

[1]The Key Laboratory on Adaptive Optics, Chinese Academy of Sciences, Chengdu 610209, China;
[2]Instituteic of Optics and Electronics, Chinese Academy of Sciences, Chengdu 610209, China;
[3]University of Chinese Academy of Sciences, Beijing 100049, China



One frame of spots array captured by CCD.

Abstract: In order to improve the detection accuracy of far-field spots centroid, a new optical path structure on the basis of a two-dimension orthogonal diffraction grating is proposed. Using two orthogonal one-dimension diffraction gratings, a single spot on the far-field focal plane is developed into a multiple spots array. A corresponding experimental setup was built to compare the centroid detection accuracy of the new method and the conventional method under the same experiment conditions. The experimental results show that by increasing the input information of the far-field detected spots, the centroid detection accuracy can be improved. First, the far-field imaging principle of the two-dimension orthogonal diffraction gratings is introduced. In this paper, the beam splitting characteristic of the two-dimensional diffraction grating is used to improve the detection accuracy of the incidence optical axis. The two-dimensional diffraction grating is composed of two orthogonal one-dimensional diffraction gratings. The incidence beam is divided into number of beams with the same phase and different intensity. A set of diffraction spots, which has different intensities but has the same ranks distance and distribution, are formed. These images are captured by the CCD camera. Second, the spot centroid detecting error is analyzed in theory and results show that the centroid random error is one of the main errors source. Third, the formula to decrease the centroid detecting random error based on far-field multiple spots is established. By increasing the input information of the far-field detected spots, the centroid detection accuracy can be improved. Finally, the experiments of centroid detecting are carried out. The experimental results show that the centroid detecting accuracy of multiple spots is 4 times larger than that of single spot. The root mean square of single spot centroid detecting error is 0.0385 pixels and the RMS of 16 spots centroid detecting error is 0.0099 pixels. In conclusion, a modified method with a two-dimensional orthogonal diffraction grating is proposed to improve the detection accuracy of far-field spots centroid. The basic principle of proposed method and the processing of the new method are described. The experimental setup with the diffraction grating is also illustrated in detail. It is only necessary to place the diffraction grating in the front of image lens, and the structure is simple. Under the same condition, the experiments are done to validate the high-precision centroid detection. Compared with the far-field single spot centroid detecting method, the far-field multiple spots centroid detecting method proposed is simpler and more convenient, especially for the optical axis alignment with bigger axis offset. It can be used as optical axis detection in an adaptive optics system.

Keywords: optical test; diffraction grating; centroid detection; far-field spot; random noise
Citation: Chen Lin, Huang Linhai, Li Xinyang. A high-precision far-field spot centroid detecting method based on two-dimension orthogonal diffraction gratings[J]. *Opto-Electronic Engineering*, 2017, **44**(9): 912–918.

See page 912 for full paper.