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A prototype experiment of the adaptive deformable mirror based on voice coil and Eddy Current Sensor

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ABSTRACT

Large adaptive deformable mirror is becoming a trend for ground base telescope, at present almost all the large adaptive deformable mirrors in use are driven by voice coil, simultaneously the capacitive sensor is used as a feedback component. While the Eddy Current Sensor could have a lot of advantages over the capacitive one in large deformable mirror. In this research a prototype of 150mm deformable mirror is built, which is driven by 7 voice coil actuators, the ECSs are used in this prototype instead of capacitive ones. In the prototype experiment some standard low-order aberrations applied on the mirror could be corrected as expected, so it could be proved that the ECS could be used in large adaptive deformable mirror to take place of the capacitive one

Keywords: adaptive optics, deformable mirror, Eddy Current Sensor, voice coil, actuator, LOT

1. INTRODUCTION

The concept of adaptive secondary is proposed by Arcetri Astrophysical Obseratory in 1990s^[1], this kind of adaptive optical system takes telescope's secondary as the deformable mirror of AO system, This kind of AO system gets more and more attention these years, and the adaptive secondary mirror is popularly used in the large aperture telescope, such as MMT, LBT and Magellan Telescope, in addition the adaptive secondary of VLT, GMT is under development. Moreover the Chinese Large Optical/ Infra-red Telescope could use this type of secondary to achieve the GLAO system. At present almost all the large adaptive deformable mirrors in use are driven by voice coil, simultaneously the capacitive sensor is used as a feedback component. While the Eddy Current Sensor could have a lot of advantages over the capacitive one in large deformable mirror, such as the eddy current sensors have stronger environmental adaptability; the back of the mirror surface does not need to be coated, which reduces the processing difficulty; the sensor units are independent of each other, which is favorable for maintenance; and the sensor's installation does not require high accuracy, so the cost could be reduced significantly. Then this type of sensors' disadvantage on thermal stability could be overcame by the wavefront sensor's calibration.

2. VOICE COIL

In this research a prototype of 150mm deformable mirror was built, which is driven by 7 voice coil actuators, the voice coil 's structure is optimized firstly to get the best efficiency. Firstly the gap between the coil and magnet was set to certain distance such as 0.1mm, and then the voice coil's output force would increase along with increase of the input current.



Figure 1. voice coil experiment structure

Figure 2. voice coil's output force sensitivity

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The experiment result shows that the voice coil's force sensitivity is about 2.17N/A, which is in good agreement with the simulation result. In addition output force could have very good linearity.

3. EDDY CURRENT SENSOR

The output voltage range of the ECS which is designed for deformable mirror is from -10V to 10V, corresponding to -25 μ m to 25 μ m, in addition the measurement frequency is set to 5kHz in order to test the circuit's noise level, the output signal could be catch using an oscilloscope, the result shows that the final noise level is below than 2mV, which means the ECS's measurement resolution within 50 μ m range could get to 6nm at 5kHz measurement frequency



Figure 3. Eddy Current Sensor Figure 4. the ECS's sensitivity

4. 7 ELEMENTS PROTOTYPE

A prototype which consists of 7 voice coil actuators was built, meanwhile 7 ECSs are used in this prototype instead of capacitive ones to provide feedback for the voice coils.



Figure 5. the voice coil actuators' base plate for the 7 elements prototype

In the prototype experiment the standard defocus and astigmatism would be applied on the mirror in high frequency, and the actuator should work to correct the introduced aberration at the same frequency. So this prototype could be used to verify whether the designed ECS could be used in the deformable mirror cooperating with the voice coil. Further experiment would be completed in this summer. This type of deformable mirror could be used in the GLAO system of Chinese Large Optical/Infra-red Telescope in the future

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