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APPLICATIONS OF TUNED MASS DAMPERS TO IMPROVE PERFORMANCE OF LARGE SPACE MIRRORS

Abstract

In order for future imaging spacecraft to meet higher resolution imaging capability, it will be necessary to build large space telescopes with primary mirror diameters that range from 10 to 20 meters and do so with nanometer surface accuracy. Due to launch vehicle mass and volume constraints, these mirrors have to be deployable and lightweight; such as segmented mirrors using active optics to correct mirror surfaces with closed loop control. The Naval Postgraduate has received a 3-meter diameter Segmented Mirror Telescope (SMT) that uses Active Hybrid Mirror (AHM) technology for the active control of segmented mirrors.

Before the system can be used operationally, the mirrors must be aligned to within very tight tolerances. These mirrors are very lightweight and have low damping. As such, the relative motions between segments are more than a wavelength when exposed to the ambient conditions of a clean room. This is due to the dynamic excitation of segments caused by low level air pressure perturbations. The Phase Diversity (PD) sensor used for segment alignment is unable to perform under such high magnitude perturbations as the relative motion is beyond the dynamic range of the sensor. It is desirable to have the WaveFront Error (WFE) less than one-quarter waves for this sensor. The system has several structural modes; however, the critical modes creating WFE are between 27 Hz and 40 Hz. These are the modes creating relative motion between the segments.

Research was performed at the Naval Postgraduate School to evaluate different techniques to increase damping of these structural modes. Based on this work Tuned Mass Dampers (TMDs) were selected because of their simplicity in implementation and effectiveness in targeting specific modes. The selected damping mechanism was an eddy current damper where the damping and frequency of the damper could be easily changed. System identification of segments was performed to derive TMD specifications. Several configurations of the damper were evaluated; including the amount and placement of TMDs, damping constant, and targeted structural modes. The final configuration consisted of two dampers located at the edge of each segment and resulted in 30 dB reduction in dynamic motion. The WFE for the system without dampers was 1.5 waves, with one TMD, the WFE was 0.9 waves, and with two TMDs the WFE was 0.25 waves. This paper will provide details of some of the work done in this area.