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# APPLICATIONS OF ACTIVE OPTICS IN LARGE SPACE MIRRORS

**Abstract**

Development of space telescopes, such as Hubble Space Telescope (HST) and James Webb Telescope, has been very challenging in terms of cost, schedule, and performance. Initial poor wavefront quality for HST was corrected by enormously costly in-orbit astronaut servicing. If HST had deformable mirror, the surface error of the primary mirror could be easily compensated by the deformable mirror. HST also had very high jitter due to solar array and control interactions. This problem was also solved by astronaut servicing by replacing solar array with high stiffness. This problem also could have been solved without astronaut servicing if HST had fast steering mirror for jitter control. For future imaging spacecraft to provide higher resolution imaging capability, larger mirrors, in the range of 10-20 meters, achieving surface accuracy requirements in nanometer range for high resolution imaging with large aperture light weight mirrors becomes a very challenging task. . Application of Active Optics on future spacecraft has the potential to reduce cost and schedule for future space telescopes and to provide higher confidence in meeting on-orbit optical performance. Active optics will relax fabrication tolerances - allowing assembly to mechanical tolerance instead of optical tolerances – and result in significant reduction in time and cost for testing. The Actuated Hybrid Mirrors (AHM) is such a system. It is a hybrid structure integrating a precision Nanolaminate foil facesheet and Silicon Carbide (SiC) substrate embedded with electroactive ceramic actuators. Wavefront sensors are used to determine wavefront errors created by mirror surface errors. A control system is used to determine voltage for actuators based on the wavefront errors. The Naval Postgraduate School (NPS) recently received a 3-meter diameter space telescope testbed with six segments that uses and AHM technology. Putting a MEMS deformable mirror in back optics can further correct the residual error not corrected by AHMs actuators.

Naval Postgraduate School has active research program in active optics. The control for active optics system has been a challenging problem to avoid structural control interactions and provide high performance. The system has hundreds of sensor outputs and hundreds of actuator inputs. Therefore, it becomes a complex multi-input-multi-output control problem. Modern control techniques such as H-infinity can be used for further performance enhancement. However, it will require significant model reduction. Several model reduction techniques have been developed and compared. In some techniques, higher order wave front errors are neglected. This paper will present some of these results.