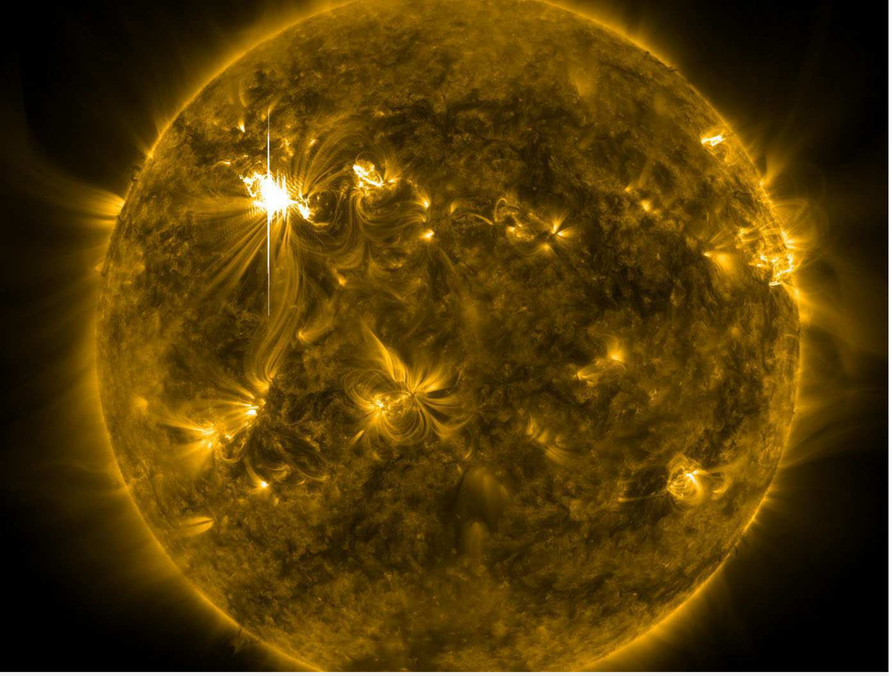

National Aeronautics and
Space Administration

Optics

Flight Mirror Mount and Flight Mounting Procedure

For an Ultra-Lightweight High-Precision Glass Mirror

The use of larger, lighter, and more precise space optics requires not only a means of manufacture, but also a means of spacecraft integration and performance verification. Engineers at NASA Goddard Space Flight Center (GSFC) have demonstrated a process capable of producing a high precision mounted lightweight mirror, and have validated its on-orbit figure. This effort included the design of a mount capable of surviving the launch environment of a sounding rocket, as well as a mounting process that did not introduce performance degrading figure distortion. Additionally, analysis techniques were developed and adapted to address the challenges in measuring an optic that exceeds its figure specification under the strain of its own weight.

BENEFITS

- Enables the in-situ measurement of small nanometer sized zero-g mirror figure distortions in the presence of large gravity induced mirror distortions
- Hardware and test results allow for the iterative analysis, isolation, and correction of any induced mirror distortions due to the mounting process before the mount is irreversibly locked

technology solution

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THE TECHNOLOGY

NASA GSFC Engineers have designed a mirror mount and an associated mirror mounting process that enables ultra-lightweight high-precision mirrors to be mounted without distortions exceeding length scales of several nanometers (root-mean-squared, over the optical aperture), provides an on-orbit, or zero-gravity mirror surface figure verification capability in the presence of much larger self-weight gravity distortions, and is proven to both mechanically survive a launch environment and optically maintain mirror surface figure.

This hardware design and mounting method are particularly innovative because they enable the in-situ measurement of small nanometer sized zero-g mirror figure distortions in the presence of large gravity induced mirror distortions. Furthermore, the hardware and test results allow for the iterative analysis, isolation, and correction of any induced mirror distortions due to the mounting process before the mount is irreversibly locked. The core of this innovation is the means of integrating mount design, support hardware capabilities, modeling and analysis, and in-situ optical testing.

A high-precision ultra-lightweight 0.5m mirror with ultraviolet grade tolerances on surface figure quality has been measured through the coating and mounting process, and shown to survive component vibration testing. This 4.5kg, 0.5m paraboloid mirror is the prime optic of two sounding-rocket telescopes: SHARPI (solar high angular resolution photometric imager) and PICTURE (planet imaging concept testbed using a rocket experiment). By integrating the analysis of interferometer data with finite element models, the ability to isolate surface figure effects comparable to UV diffraction limited tolerances from much larger gravity and mount distortions was demonstrated. The ability to measure such features paired with in situ monitoring of mirror figure through the mirror mounting process has allowed for a diagnosis of perturbations and the remediation of process errors. Nanometer scale measurement accuracy was achieved, and the final mounted surface figure was 12.5 nm RMS, maintaining UV diffraction-limited performance with an aggressively lightweight mirror.

APPLICATIONS

The technology has several potential applications:

- The in-situ test approach, mount concept, and methodology enables the verifiable distortion-free mounting of lightweight optics in a manner compatible with spaceflight. This is particularly applicable to the production of any system that employs precision lightweight optics that must withstand a harsh launch environment then operate in a zero gravity environment. This includes, but is not limited to: earth-observing systems, optics used in space exploration, and space-borne astronomical observatories

PUBLICATIONS

Patent No: 8092031

Antonille, S., Content, D., Rabin, D., Wake, S., & Wallace, T. (2008). Figure verification of a precision ultra-lightweight mirror: Techniques and results from the SHARPI/PICTURE mirror at NASA/GSFC. Space Telescopes and Instrumentation 2008: Ultraviolet to Gamma Ray.

More Information

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