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Manufacturing and Testing of Unimorph Deformable Mirrors for Space Telescopes

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Abstract content
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Future concepts of large space telescopes are based on lightweight primary mirrors. These primaries cannot meet the required optical surface figure due to their floppy structure, misalignment of the mirror segments, and gravity release and are likely to generate several microns of wave-front error. One potential solution to correct for these errors could be the integration of a space-compatible deformable mirror. Such a mirror is a prerequisite for a diffraction-limited space telescope with an aperture that is significantly larger than that of the James Webb Space Telescope. A temperature insensitive mirror with suitable diameter, stroke and surface fidelity embodied in the optical train would relax the specifications and improve the optical performance of a space telescope.

The harsh environmental conditions in space impose special challenges on the instruments. A deformable mirror would be exposed to a broad vibration spectrum, as well as to accelerations of several tens of g. Cosmic irradiation may degrade the optical coating, exposure to vacuum could lead to contamination and further degradation of the mirror's surface. Cryogenic temperatures down to 100 K demand a thermally insensitive design of the mechanical support and careful selection of the used materials.

We have scaled our small-sized laser mirror which was originally developed for high power laser applications towards an aperture diameter of 50 mm to take into account the Lagrange invariant of large aperture telescopes. To cope with the cryogenic temperatures, an athermal design was achieved via both CTE matching and stress relieve by implementing an isostatic mounting. The optomechanical layout of the mirror has been investigated by extensive finite element calculations, which allowed for an optimization of the design. The use of low outgassing materials ensures vacuum compatibility.

A tailored test-bed has been designed to experimentally characterize the mirror's performance. To confirm space compatibility, performance tests in a cryogenic environment have been conducted. Further tests were carried out to validate the mirrors ability to withstand vibration, acceleration and irradiation levels typically occurring during space missions.

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