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Initial Results from the Lick Observatory Laser Guide Star Adaptive Optics System

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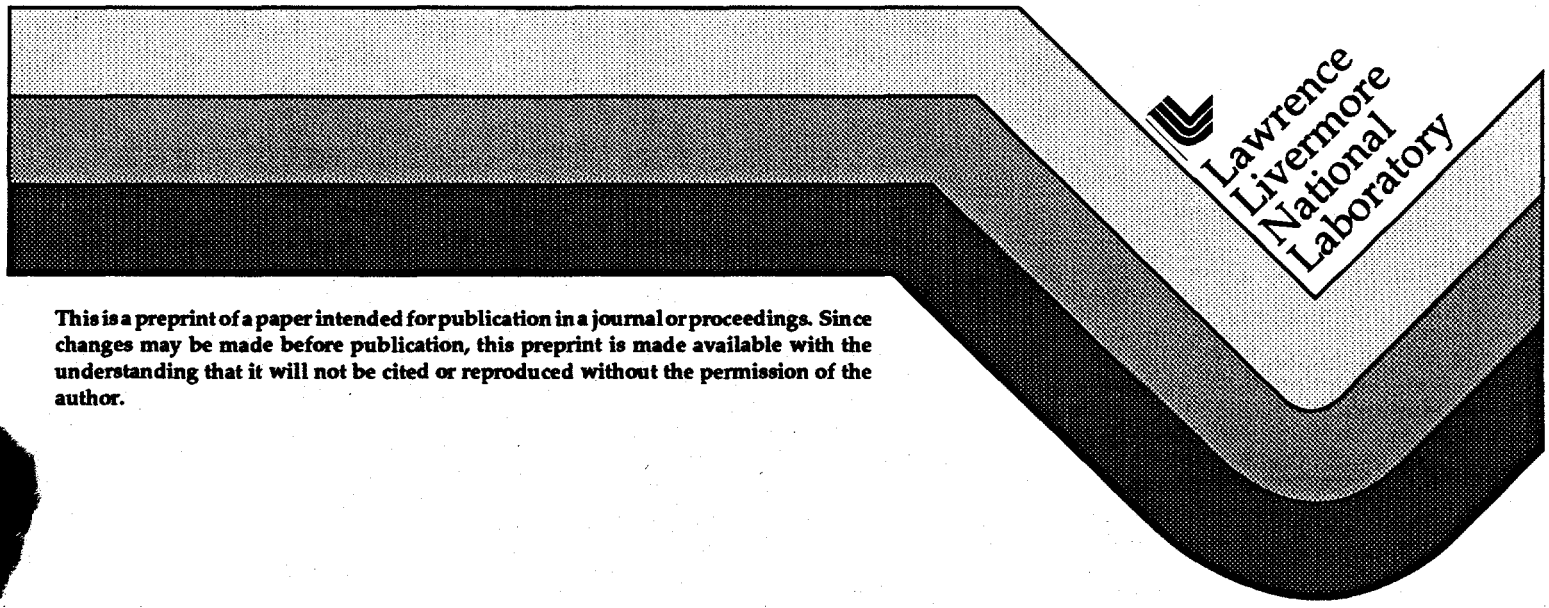

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Abstract

We present initial results from the sodium-layer laser guide star adaptive optics system developed for the 3-m Shane telescope at Lick Observatory.

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Summary

A prototype adaptive optics system has been developed at Lawrence Livermore National Laboratory (LLNL) for use on the 3-m Shane telescope at Lick Observatory. This system is currently based on a 127-actuator continuous-surface deformable mirror developed at LLNL, a high-quantum-efficiency low-noise fast CCD camera built for LLNL by Adaptive Optics Associates using a chip developed by Lincoln Laboratory, and a Mercury VME board containing four Intel i860 processors.

An earlier version of this system based on an ITEK 69-actuator continuous-surface deformable mirror, and a Kodak fast-framing intensified CCD camera was tested using natural reference stars on the 1-m Nickel telescope at Lick Observatory yielding up to a factor of 10 increase in image peak intensity and a factor of 6 reduction in image full width at half maximum (FWHM) at an observing wavelength of 0.85 μm (Olivier et al. 1994).

In order to improve performance, the intensified CCD camera was replaced by a high-quantum-efficiency low-noise fast CCD camera built for LLNL by Adaptive Optics Associates using a chip developed by Lincoln Laboratory and the system was tested was tested using natural reference stars on the 3-m Shane telescope at Lick Observatory yielding up to a factor of 13 increase in image peak intensity and a factor of 7 reduction in image FWHM at an observing wavelength of 1.0 μm (Figure 1).

This system was also tested with the Lick Observatory near-IR facility camera, LIRC II, and images were produced at 2.2 μm with a factor of 12 improvement in the peak intensity. These results are consistent with having about 30% of the light from the star in a diffraction-limited core.

The main factor limiting the performance in these tests appeared to be the limited dynamic range of the deformable mirror coupled with fairly large static aberrations in the telescope optics. The upgrade to the 127-actuator LLNL mirror is expected to alleviate this problem since it has a much larger dynamic range than the 69-actuator ITEK mirror. Tests with this mirror will be performed this Summer, and the results will be presented.

A sodium-layer laser guide star system has also been developed at LLNL to serve as a beacon for the adaptive optics system on the 3-m Shane telescope. This system is based on frequency-doubled Nd-YAG pump lasers that are fiber-optically coupled to a dye laser tuned to the D_2 Na resonance at 589 nm. This is propogated out of a 30 cm refractive launch telescope attached to the side of the 3-m Shane telescope. This sytem has been operated at the telescope and has produced a beam with up to 17 W average power.

Integrated tests with the laser guide star and adaptive optics systems will be perfromed during the Summer, and the results will be presented.

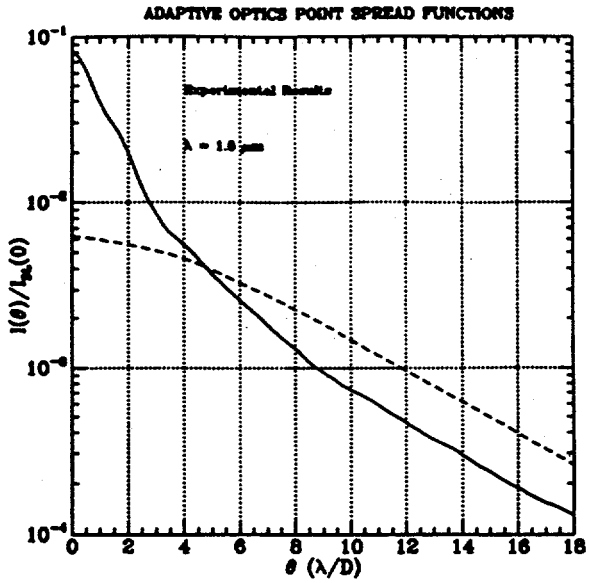

Figure 1 – Radially averaged image data from Alpha Perseus with and without adaptive optics compensation.

In addition, four astronomy programs using the laser guide star system will be begun this Summer: infrared adaptive optics imaging of active galactic nuclei and their host galaxies, a search for companions to faint Hyades main-sequence stars, a survey of nearby bright stars for faint stellar/sub-stellar companions, and a survey of stellar duplicity in the alpha Perseus cluster. A status report and some intial results from these astonomy projects will also be presented.

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References:

Olivier, S. S., J. An, K. Avicola, H. D. Bissinger, J. M. Brase, H. W. Friedman, D. T. Gavel, E. M. Johannson, C. E. Max, K. E. Waltjen, W. A. Fisher, W. Bradford, 1994, "Performance of adaptive optics at Lick Observatory", SPIE Proceedings 2201, 1110-1120.