ADAPTIVE OPTICS: ADDITIONAL ADVANCES AND APPLICATIONS

Graham Collins's Search and Discovery story "Making Stars to See Stars: DOD Adaptive Optics Work Is Declassified" (February, page 17) mentions only two of the three laser guide-star adaptive optics experiments sponsored by the Department of Defense. The third, sponsored by the Office of Naval Research and funded by the Innovative Science and Technology Directorate of the Strategic Defense Initiative Organization, was performed during 1989–90 by my research group in San Diego. We used an ultraviolet laser star at a distance of 8 km to compensate for the effects of turbulence at 353-nm wavelength over a 0.5-meter telescope. The turbulence was corrected using a deformable mirror composed of an array of 500 flat mirror segments, each controlled in piston, tip and tilt. Our tests consisted of comparing 3-msec images of the star Vega before and after correction. An average of several short exposures indicates that after adaptive correction, the full width at half-maximum of the star decreased by a factor of 4, from 2 arcsec to less than 0.5 arcsec. Thus there is further evidence that laser-star adaptive optics can substantially sharpen images, even in the ultraviolet, where the effects of turbulence are quite strong. We are now beginning experiments on a 1-meter telescope, aimed at achieving nearly diffraction-limited images at optical wavelengths using a commercial visible laser to project the artificial star.

In the section entitled "Synthetic constellations," Collins accurately points out that correcting large telescopes may require several laser stars. He implies that only one experiment has been performed: a proof of principle using two laser stars. In fact, last year we performed experiments for the Air Force using a lattice of 20 laser stars over a 1-meter telescope. These experiments showed that if the lattice has a special geometry, the wavefront distortion can be measured as if the light emanated from a single point, thus removing many of the complications that arise if one tries to keep track of the light from each star.

Manuscripts describing these experiments are being completed for publication. This should surely be an exciting period for ground-based astronomy as the DOD adaptive optics methods and technology are applied to astronomy in the near term. In the longer term, a challenge for the adaptive optics community is to innovatively extend the DOD research and technology to better fit the resources and needs of astronomers.

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The discussion of adaptive optics and synthetic "guide star" beacons was extremely interesting. In addition to the astronomy applications discussed, another emerging application for lasers with adaptive optics is now receiving considerable attention: the possibility of providing power in space using laser beams.[1] Lasers with high average power are beginning to become available. Using the technology of adaptive optics, such lasers can be used to produce nearly diffraction-limited illumination on space photovoltaic arrays. Lasers and photovoltaic arrays are a natural match: Solar cells can be twice as efficient under optimally chosen monochromatic light as under solar illumination.

Using ground-based lasers for power-beaming has several advantages over other space power systems, including the ability to power systems during the local eclipse period[2] and the possibility of high power density. Possible applications include providing eclipse power for satellites, power for electrically propelled space transfer vehicles and power for a Moon base during the 14-day-long lunar night. At the distance of geosynchronous orbit, an 800-nanometer laser with a 10-meter beam director would illuminate an 8-meter-diameter spot; at the Moon, the same laser would illuminate an 80-meter spot. As the technology becomes better understood, more applications are likely to become evident. This interesting topic has been made technologically possible by the advent of adaptive optics and is now under investigation by several researchers.[3]

References

1. G. A. Landis, IEEE Aerospace Electron. Systems **6**(6), 3 (1991).
2. G. A. Landis, Acta Astronautica **25**, 229 (1991).
3. E. E. Montgomery, ed., *Proc. Review of SELENE FY91 Program Results and FY92 Program Kickoff*, NASA Marshall Space Flight Center, Huntsville, Ala. (December 1991).

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Has Defense Research Held Science Back?

I read the news stories in the February Search and Discovery section with a mixture of pleasure and dismay. The reports describe the use of artificial guide stars for adaptive optics, and the discovery and further study of gamma-ray bursters. What wonderful, exciting stuff! The potential for future telescopes offered by adaptive optics is matched by the fascination of the puzzles presented by bursters, and I imagine that both subjects will make more appearances in PHYSICS TODAY.

But as exciting as these developments are, it is disturbing to realize that both subjects began behind the closed doors of the defense industry and were shared with the rest of the scientific community only after a decade or more. How much more might we know by now about adaptive optics or gamma-ray bursters if the early discoveries had been published in the open literature when they were