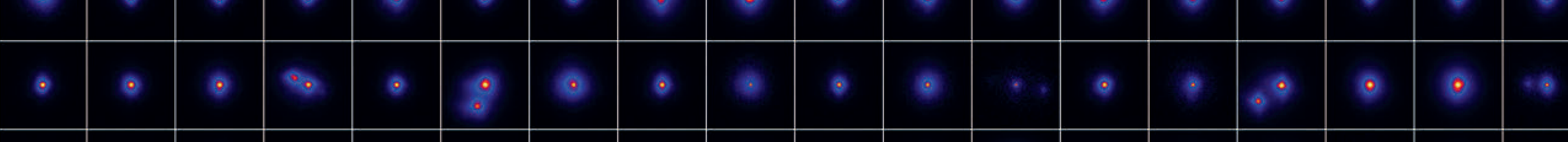

SEEING STARS WITH ROBOTS

On a typical night, pockets of hot and cold air swirl overhead, turning what would otherwise be pinpoints of starlight into twinkles. But twinkling stars also mean blurry stars, and for astronomers who want the sharpest images of the heavens, the turbulent atmosphere poses a problem.

Enter adaptive optics.

Using tiny, moving mirrors that bend the incoming light just enough to compensate for the atmosphere's blur, adaptive optics have revolutionized astronomy, bringing into focus everything from asteroids and planets to star-forming gas clouds and distant galaxies. Adaptive optics were first developed for astronomical use about two decades ago, and today they're an indispensable part of all large telescopes.

Now, Caltech astronomers are making adaptive optics even better—by turning the process robotic. Current adaptive-optics systems and the telescope's scientific instruments—such as its cameras and spectrometers—are separate, independent devices. To run the telescope, you often need several people to monitor and operate each component.

But the new system, dubbed Robo-AO, is an all-in-one instrument that attaches with just three bolts to the back of the telescope for which it was designed—the 60-inch telescope at Palomar Observatory. And you don't need a whole team on hand because it's entirely automated. All Robo-AO needs is a list of the astronomical objects you want to look at and it will open the observatory dome, point the telescope, switch on the adaptive-optics system, and take the data all on its own. That makes observing easier and cheaper—a big plus given today's tight budgets.

"Not only is the equipment cost low, but the capital to keep it going is also low," says Christoph Baranec (BS '01), the Caltech postdoc who's leading the project. With a price tag of only half a million dollars, Robo-AO is a bargain compared to conventional adaptive-optics systems, which tend to cost several to tens of millions. This is a potential boon for the older, smaller telescopes, which usually have to forego traditional adaptive optics for financial reasons.

In addition, Robo-AO can more easily correct distortions of visible light, which is more susceptible to atmospheric bending due to its shorter wavelength. "Other systems around the world, including Caltech's flagship 10-meter Keck AO system, can't do that yet," Baranec says.

The team put the Robo-AO system to use for the first time last summer, and so far it's working smoothly. In a current project, the team is using Robo-AO to determine which of the more than 2,000 candidate planets discovered by NASA's planet-hunting Kepler space telescope are indeed alien worlds and not false positives. While it would take a human almost a year to follow up on all of them, Robo-AO can do the job in just a couple of weeks.

A group of collaborators at Pomona College has successfully tested its own Robo-AO system on Table Mountain, northeast of Los Angeles. The team is also collaborating with astronomers at the Inter-University Centre for Astronomy and Astrophysics in Pune, India, to install such a system on their two-meter telescope.

With an adaptive-optics-enabled telescope that works on its own, astronomers can do more science for less money in less time. And, Baranec adds, Robo-AO offers one other benefit: "We can all get more sleep." *—MW* E&S

Above (and background): Robo-AO took these 414 images over the course of just three nights; the images are 10 times sharper than they would have been without this new system.

Below: The Robo-AO system at work as part of the 60-inch telescope at the Palomar Observatory. By projecting an ultraviolet laser onto the sky and measuring how the atmosphere distorts the beam, the system can shift tiny mirrors just enough to counteract the blurring effects of the swirling air.