ASTRONOMY

NASA Encourages Researchers To Map Search for Alien Earths

BOULDER, COLORADO—The search for other worlds that might be hospitable to life has traditionally been one of astronomy's more quixotic endeavors. "There's been a bit of a giggle factor" about it, acknowledges astronomer Alan Stern of the Southwest Research Institute. "But it's gone now," he insists; "we're in the vanguard of an emerging field." Stern isn't alone in that belief. At the University of Colorado from 15 to 17 May, in a symposium that Stern helped organize, some 120 astronomers discussed new technologies for seeking Earthlike planets around other stars and basked in a new burst of attention from an old patron: the National Aeronautics and Space Administration (NASA).

Their goal has at least rhetorical support from NASA Administrator Dan Goldin, who has spoken of transforming humanity's view of itself by snapping a Landsat-style picture of another Earth. "What a revelation that would be," Goldin said in a speech to the American Geophysical Union last year. "No human endeavor or human thought would be untouched." The agency hasn't promised any new funds beyond the $7 million a year its Astronomical Search for Extrasolar Planets (ASEPS) program now contributes to the construction of a second 10-meter Keck telescope on Mauna Kea in Hawaii. But just before the symposium, NASA convened three study groups, led by Roger Angel of the University of Arizona, Robert Reasenberg of the Harvard-Smithsonian Center for Astrophysics, and Charles Beichman of Caltech and the Jet Propulsion Laboratory, for a friendly competition to develop the best "road map" toward finding and imaging an alien world.

Such efforts have yielded little in the past—just a handful of "detections" that turned out to be errors in observation. The only planets detected beyond the solar system are hardly what Goldin has in mind for inspiring snapshots: three presumably inhospitable chunks of matter that turned up in an unexpected place—orbiting a pulsar, the cinder of an exploded star. But at the Boulder meeting, astronomers argued that improvements in telescopes and detectors have brought the discovery of alien planets the size of Jupiter—if not Earth—within reach. "I think we'll find Jupiters by indirect techniques within 3 to 5 years," says Beichman. Although such gas giant planets would fall far short of Goldin's vision, they could reveal clues to planet-forming processes and to the prospects for more hospitable worlds.

Even that more modest goal presents formidable obstacles, however. In a telescope image of even the sun's closest neighbors, any planet would be practically inseparable from its parent star and lost in its glare. The star, after all, would outshine the planet by a factor of a billion in visible light and several million in infrared. "It's a firefly next to a searchlight," Beichman says.

ROGER RESSMEYER/STARLIGHT

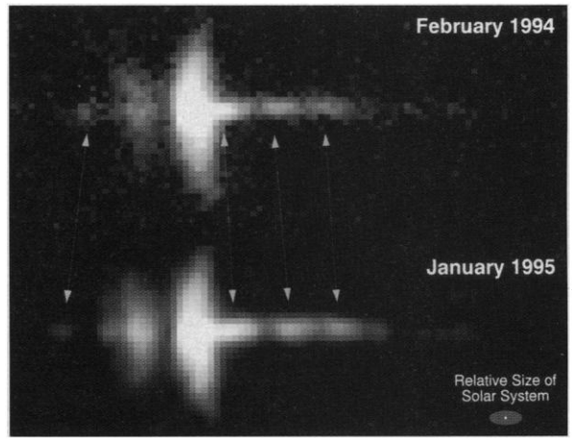
Double vision. The 10-meter Keck telescope on Mauna Kea and a companion, still under construction, may be linked in an interferometer to search for planets.

In the near term, he and others agree, the best hope for finding the firefly is to look at the searchlight. Long-term searches for wobbles in a star's position in space or Doppler shifts in its spectrum as it moves back and forth along the line of sight could reveal the gravitational tug of a giant planet in orbit around it. Such searches have been mounted before, but scarce funding restricted them to small telescopes. Now, with a 4-meter telescope like those at many large observatories and improved CCD detectors, participants at the meeting agreed that it might be relatively easy to spot telltale signatures of an alien Jupiter.

Seeing such a planet directly, however, would call for less tried technologies. One is adaptive optics—Angel's specialty—a strategy for continuously deforming a telescope mirror to cancel out ripples in the atmosphere, yielding a far sharper image than an ordinary mirror can. With an advanced version of the technology, predicts Angel, "We should be able to find Jupiters out to 30 light-years around the few dozen brightest stars."

A glimpse of a smaller alien planet, down to the size of Uranus (15 times the mass of Earth), might come from a generation of new optical and infrared interferometers—systems for merging light from two or more telescopes set tens or hundreds of meters apart. An interferometer, in theory, can yield an image as sharp as a single instrument with a mirror as large as the separation of the telescopes. A half-dozen groups around the world have interferometers on the drawing board or under construction. One of the most powerful, funded in part by NASA's ASEPS program, will link the 10-meter Keck telescope with a second 10-meter instrument now under construction nearby.

Besides those strategies for searching stars one by one, astronomers at the Boulder meeting also discussed the potential of new detectors that monitor the brightness of millions of stars at once. Such large-scale star watching might pick up the periodic dimming of a star's light as a planet orbiting it passed across the line of sight. An indirect hint of a planet could also come from an effect called gravitational microlensing. When a nearby star wanders across the line of sight to a background star, the farther star's light brightens for a few weeks, focused by the first star's gravity. Microlensing has already revealed stars too dim to be seen directly (*Science*, 5 May, p. 642); it could also signal a planet as small as Earth, which would cause a smaller brightness peak immediately before or after the brightening caused by the parent star. Says David Tytler of the University of California, San Diego, "With microlensing, we may quickly find the frequency of planets with different masses."



C. BURROWS/STScI & ESA/ WFPC 2 INVEST. DEFINITION TEAM/NASA

Recipe for another Earth? Hubble Telescope images reveal a dusty disk that feeds material into a newborn star, shoots out jets of material *(arrows)*—and may spawn planets.

By late summer, the study groups examining these possibilities will deliver their reports to an "integration team" headed by Charles Elachi of the Jet Propulsion Laboratory, which will combine them into a single

"road-map" proposal for a blue-ribbon panel headed by Nobel Prize–winning physicist Charles Townes. The panel will evaluate the final road map for NASA—and, NASA hopes, generate public interest in the planet search with the help of members who might include prominent writers and movie directors. The study groups aren't likely to recommend that NASA rely exclusively on any one technology. Instead, Beichman told the gathering, "what we need is a series of steps, on different paths, but with definite payoffs every few years."

Learning how common Jupiters are near other stars, for instance, would provide a test for current theories of planet formation. It would also yield clues to the existence and habitability of smaller, Earthlike worlds. In fact, argues George Wetherill of the Carnegie Institution of Washington, a planetary system may need a planet the size of Jupiter or Saturn to deflect comets that would otherwise bombard its smaller planets, forestalling the development of life.

Ultimately, however, astronomers would like to follow Goldin's dream to what Caltech's Anneila Sargent calls "the Emerald City"—actual images of Earthlike planets around other stars. Participants at the Boulder meeting agreed that doing so lies beyond the limit of any practical road map, as it would almost certainly require an interferometer orbiting Earth or the sun. That's a daunting prospect not only because of its cost, but also because of the difficulty of maintaining the spacing of the orbiting telescopes down to billionths of a meter and coping with the glare from myriad interplanetary dust particles. "And even if all those technical challenges can be overcome," says Beichman, "we might find Earths, but we won't get much of a picture."

For the foreseeable future, Goldin's Landsat image of an alien Earth may be only a remote hope. But a mere point of light from such a planet might be enough for astronomers to look for signs of life. The presence of oxygen or ozone in the light's spectrum would be a strong hint of life, and the presence of methane along with oxygen would be powerful evidence for methane-generating organisms, as the gas oxidizes quickly and vanishes unless it is somehow replenished.

"The realm of [extrasolar] Earthlike planets is difficult to explore," admits Beichman. "But we shouldn't think this is impossible—and we shouldn't forget the lesson of the pulsar planets: Expect the unexpected."

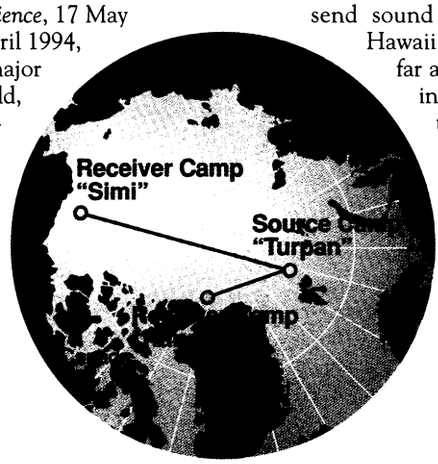
–Donald Goldsmith

Donald Goldsmith is an astronomy writer in Berkeley, California. His most recent book, Einstein's Greatest Blunder? The Cosmological Constant and Other Fudge Factors in the Physics of the Universe, *will be published in August by Harvard University Press.*

ACOUSTICS

Listen Up! The World's Oceans May Be Starting to Warm

For a strategy so quick and elegant, long-range acoustic thermometry—taking the temperature of entire oceans with pulses of sound—has been a long time coming. Expected to provide solid data on one environmental threat, global warming, the technique has run afoul of concerns that it could pose another: harm to marine mammals from the powerful sound (*Science*, 17 May 1991, p. 912 and 15 April 1994, p. 339). But while a major experiment is on hold, smaller tests in the Arctic and Pacific oceans have been allowed to go ahead and are heating up the field with evidence that measurable ocean warming is under way.



SOURCE: MIKHALEVSKY *ET AL.*

Cross talk. A transmitter at one ice camp broadcast sound across the Arctic Ocean to receivers at two others.

These early results, discussed last week at a meeting of the Acoustical Society of America in Washington, D.C., say nothing about the warming's cause, researchers emphasize. To determine whether the warming is the steady heating predicted by computer simulations of global warming or just a temporary change in slow-moving ocean "weather" will take repeated measurements in many ocean basins over decades. But these data do boost researchers' confidence in the technique's ability to deliver fast and frequent snapshots of ocean temperatures—a boon to a field long fettered, says William Kuperman, an oceanographer at Scripps Institution of Oceanography, by "the need to go to sea to get data."

Traditionally, taking the temperature of the deep ocean has meant steaming across the seas, stopping repeatedly to drop temperature probes. Using sound, goes a saying ascribed to the field's father, Walter Munk of Scripps, "is like having a 3000-knot ship." Pulses of low-frequency sound can travel thousands of kilometers through the ocean and still be detected. Because the speed of sound underwater depends on the water temperature, the time it takes a pulse to traverse an ocean basin reveals the average temperature at a wide range of depths. By making repeated measurements and comparing the pattern and rate of warming with the changes predicted by climate models, researchers hope to look for the signature of greenhouse warming.

That promise is on hold for the major experiment in the field, the Acoustic Thermometry of Ocean Climate (ATOC) experiment, conceived by Munk and his colleagues at Scripps. ATOC has been delayed a year and a half while the National Marine Fisheries Service decides whether plans to send sound from California and Hawaii to arrays of receivers as far as 6000 kilometers away in the Pacific pose a threat to marine mammals. Final word may come this month. Meanwhile, the Transarctic Acoustic Propagation Experiment (TAP), a U.S.-Russian-Canadian project in the Arctic Ocean, faced no such hurdles because of its smaller scale and the scarcity of mammals under the polar ice.

At the meeting, oceanographer Peter Mikhalevsky of Science Applications International Corp. in McLean, Virginia, reported that in April 1994, TAP transmitted sound signals from an ice camp near Spitzbergen to receiver arrays at two other camps, one 900 kilometers away in the Lincoln Sea and the other 2600 kilometers away in the Beaufort Sea. Decade-old temperature data gathered by ship and submarine enabled Mikhalevsky and his collaborators to predict sound travel times, assuming no change in Arctic temperatures. But the researchers found that travel times along both legs were slightly shorter than predicted, implying that the ocean had warmed by half a degree at middle depths.

That arctic waters could have changed so much in a decade "was, frankly, quite hard to believe," says Mikhalevsky. He notes, however, that a U.S.–Canadian research expedition aboard icebreakers last summer reported a similar warming using traditional in situ measurements (*Science*, 23 December 1994, p. 1947). Both the shipboard measurements and the acoustic data imply that the source of the temperature increase is warm water seeping from the Atlantic into the Arctic. But it's too soon to say whether the intrusion of warm water is the handiwork of global warming or just part of a natural cycle of variation