same easy-to-polish curvature. "This is a low-risk option with more bang for the buck," says Thomas Sebring of the National Optical Astronomy Observatories (NOAO) in Tucson, Arizona. Together with astronomers from the University of Texas and Pennsylvania State University, Sebring is proposing a 30-meter telescope based on the design of the Hobby-Eberly Telescope at McDonald Observatory in Fort Davis, Texas.

Besides having a spherical mirror, Sebring's instrument, also called the Extremely Large Telescope, would be built on a rotating platform, aimed at a fixed altitude of 55 degrees above the horizon, making the structure easy and cheap to build. "We're talking about $250 million, which is probably a conservative estimate," Sebring says. The design would limit the amount of sky the scope could survey, however, and to compensate for image distortions created by the spherical primary mirror, it would need at least three additional corrective mirrors, introducing additional light loss. This makes little sense to Nelson. "The purpose of a telescope is to collect light," he says. "If you're throwing away light, you're throwing away money—tens of millions of dollars."

That drawback has not stopped a team at ESO from proposing an instrument with a full 100-meter spherical mirror, a behemoth known as the "Overwhelmingly Large," or OWL, Telescope. With a primary mirror as large as a football field and a telescope structure nearly as high as the Great Pyramid, the OWL is an exercise in superlatives. OWL would have 10 times the light collecting area of all professional telescopes ever built before, says project manager Gilmozzi. And unlike less ambitious giant telescope concepts, OWL would be fully steerable.

ESO recently established a special project office for OWL. Optical engineer Philippe Dierickx says a final choice for the optical design of OWL is expected at the end of this year, but the current design incorporates 2000 identical 2.3-meter mirror segments. A mirror factory would have to produce one segment per day to complete the job in 8 years. Mechanical engineers Enzo Brunetto and Franz Koch have completed detailed designs for the highly modular Eiffel Tower–like telescope structure. "It will consist of 4100 identical pipes and 850 nodes, fitted together like the elements of a construction kit," says Gilmozzi.

OWL would require a hangarlike enclosure, which would slide over the telescope when it is in a horizontal position, and four petallike, air-conditioned mirror covers to keep the reflecting surface cool during the day. The total moving mass is expected to be some 17,000 tons—more than 35 times the moving mass of the 5-meter Hale telescope at Palomar Mountain in California, for example. Gilmozzi hopes to complete a design study in 2002 and build the scope for $900 million. OWL is an ambitious project, but "we're using the technology we have," says Gilmozzi. "The telescope could be fully commissioned some 20 years from now, just around the time of my retirement."

Because of the costs of the monster telescopes discussed at the Bäckaskog workshop, they will certainly require international cooperation. They will also require major advances in the field of adaptive optics, needed to compensate for the blurring effect of Earth's atmosphere. Current adaptive optics systems use small, deformable mirrors in the light path to compensate for atmospheric blur, but unblurring the image in a 50- or 100-meter telescope will be much harder, because the distortion could vary across the width of the mirror. "We need to reconstruct a three-dimensional view of atmospheric disturbances," explains adaptive optics specialist Roberto Ragazzoni of Padua University in Italy. Despite these challenges, even cautious people like Nelson say there are no serious limits on the size of ground-based telescopes. "These things don't violate the laws of physics."

—GOVERT SCHILLING

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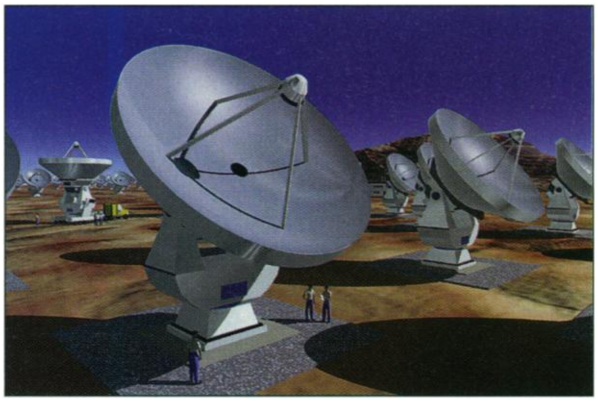
ASTRONOMY

Lofty Observatory Gets Boost

The United States and Europe have breathed life into plans to build a giant new astronomical observatory in Chile that could be fully operational in 2009. Last week, science officials from both continents signed an agreement in Washington, D.C., laying out a 3-year plan for the design and development of the Atacama Large Millimeter Array (ALMA).

Located 5000 meters above sea level on the Chajnantor plain in the Chilean Andes, ALMA (Spanish for "soul") will be Earth's highest continuously operated observatory. It will consist of 64 12-meter dishes, observing the universe at millimeter and submillimeter wavelengths. This relatively unexplored part of the electromagnetic spectrum, between infrared and radio waves, opens a window into some of the coolest and dustiest objects in the universe, such as the clouds of dust and gas that form planetary systems, as well as into the farthest reaches of space and time. ALMA will have a collecting area of some 7000 square meters, larger than a football field and far surpassing any existing millimeter-wave telescope. And its high, dry location is largely free of atmospheric water vapor, which absorbs millimeter waves (*Science*, 19 March, p. 1836).



ALMA's eyes. An artist's conception shows some of the 64 dishes that will make up the planned millimeter array.

CREDIT: ESO

"It will take us back to the era where we see galaxies form," says Bob Dickman, coordinator of the Radio Astronomy Unit at the U.S. National Science Foundation (NSF). "No matter how distant the first galaxies are, ALMA will detect them," adds Ewine van Dishoeck of Leiden University in the Netherlands. By combining signals from multiple dishes—a technique called interferometry—the array will create images of these distant objects as sharp as a single imaginary dish spanning the 10-kilometer width of the array. Interferometry is a household word in radio astronomy, but it requires great finesse at the shorter millimeter and submillimeter wavelengths that ALMA will observe.

Major partners in the agreement are the U.S. National Radio Astronomy Observatory and the European Southern Observatory, an intergovernmental organization with eight member states. Research institutes in France, Germany, the Netherlands, and the United Kingdom will also take part, while Japan is expected to join later. Europe will chip in $16 million and the United States $26 million for the first phase of design and development; in 2001 the partners will make a final decision about whether to proceed. The observatory's total cost is expected to exceed $400 million.

—GOVERT SCHILLING