Want To Make A Giant Telescope Mirror? Here's How

by Joe Palca
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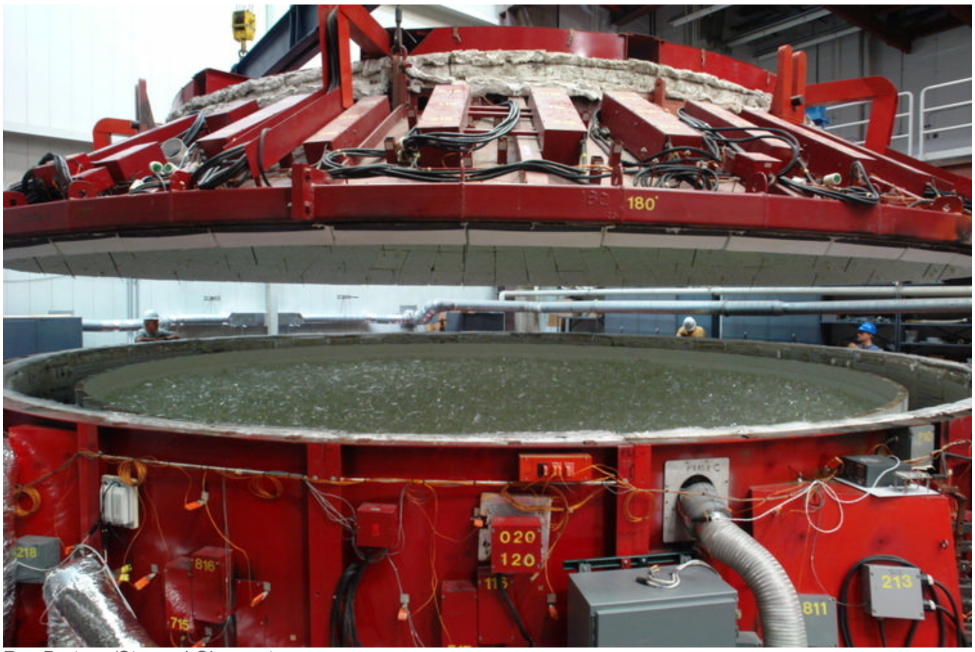
Morning Edition



Ray Bertram/Steward Observatory
Temperatures inside this giant oven will reach 2,100 degrees Fahrenheit. Large blocks of glass inside the oven will melt as the whole oven spins around at a rate of five times per second, creating a curved and smooth telescope mirror.

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The world's largest mirrors for the world's largest telescopes are made under the football stadium at the University of Arizona.

Why there? Why not?

"We wanted some space, and it was just used for parking some cars, and this seemed like a good use," says Roger Angel.

Angel is *the* master of making big mirrors for telescopes. For 30 years he has been using a method called spin casting to make the largest solid telescope mirrors in the world.

At the moment, he's making the second of seven mirrors, each 27 feet across, that will go into the Giant Magellan Telescope (GMT), which will be sited on a peak in the Andes Mountains in Chile.

In the old days, you made mirrors by ladling molten glass into a mold. With spin casting, "we just put these chunks of solid glass, lay them over the mold while they're cold," says Angel.

Then they heat the furnace to 2,100 degrees Fahrenheit. At that temperature the glass chunks melt, turning into a clear, syrupy liquid that oozes into the mold. Having the furnace spin while this is happening encourages the glass to flow into the parabolic shape it will eventually become. It will stay in the oven for two-and-a-half months while it slowly cools down to room temperature.

Ray Bertram/Steward Observatory
The pieces of glass that technicians are arranging inside the rotating oven will melt down into the curved surface of the telescope mirror. Each piece of glass is hand-inspected.

A Hard Shape To Tackle
The first GMT mirror is getting its final polishing in a cavernous hall next door.

Ray Bertram/Steward Observatory

After the mirror is cast, it moves to the Large Polishing Machine, where the mirror's shape is refined and perfected — down to the millionth of an inch.

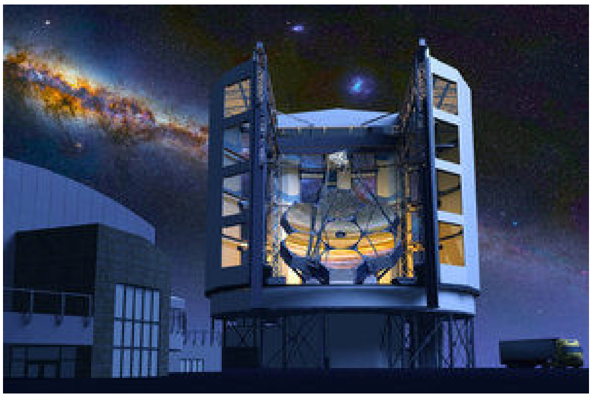
Angel has made several mirrors as large as these. "But the shape of this mirror is more challenging by about a factor of 10 than the previous ones that we've made," he says.

That's because the shape is aspherical. Instead of being a shallow symmetrical bowl, one side of the mirror is higher than the other. It's a shape dictated by where the mirror will focus starlight once it's set in the telescope.

Not only is it devilishly hard to grind and then polish an aspherical mirror, it's hard to know when you've done it right. The mirror is 27 feet across, but the differences in height across the surface are smaller than a millionth of an inch.

Imaging The Skies

To see the earliest objects in the universe, astronomers need really big telescopes. That's because the light from these objects is very dim, and you need a big "light bucket" to capture the light they give off. Telescopes now use adaptive optics to correct for the blurring of the atmosphere, so large ground-based telescopes can do even better than the Hubble Space Telescope in resolving small objects, such as planets orbiting stars. Here's a look at some next-generation telescopes in the works:



Large Telescopes

Angel and his colleagues have developed three separate tests to convince themselves they've polished their mirror properly. No one wants a repeat of the experience of the Hubble Space Telescope. It also has an aspherical mirror, and it wasn't until the telescope reached orbit that astronomers discovered the mirror wasn't shaped exactly right. Luckily, the space shuttle astronauts were able to install corrective lenses that fixed the problem.

'Opportunity For New Discovery'

The giant mirrors will give astronomers two things they really want in a telescope: high sensitivity so they can see really, really dim objects; and high resolution so they can see fine details.

Wendy Freedman, an astronomer at the Carnegie Institution for Science and chair of the GMT board of directors, says to get a sense of GMT's resolving power, imagine you're looking at the face of the dime. "And you were to take that dime, and put it 200 miles away. Then with GMT, you could resolve the face of that dime. It's quite spectacular."

Freedman says the resolution of the new telescope should let astronomers see planets around other stars, and its sensitivity should let them see some of the earliest objects to form in the universe. Freedman says astronomers can only imagine what they'll learn when GMT starts operating.

"The opportunity for new discovery in astronomy usually follows when we make a big leap in sensitivity or resolution like this," she says.

But those discoveries are a ways off. It will be a while before the giant mirrors are shipped to Chile and assembled into a telescope. Under the rosiest scenario, the telescope won't achieve "first light," as it is known, until 2020.

Still, Freedman and Angel are convinced it will be worth the wait.