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Extremely large telescopes will add more firepower to search the cosmos

February 11 2015, by Bryan Gaensler

Artist’s concept of Giant Magellan Telescope once completed, with its seven mirrors. Credit: Giant Magellan Telescope - GMTO Corporation, CC BY-SA

As an astronomer, I get a lot of requests for help. "I'd like to buy a telescope," the conversation usually goes. "Can you give me some tips on what to look for?"

Sadly, there's little advice I can offer, because the telescopes used by professional astronomers have become unrecognizably different from those you might buy for your backyard. Lens caps, eyepieces and finderscopes are nowhere to be seen. Instead, we are now entering a world where telescopes involve 20-ton mirrors, 250-foot high domes, and billion-dollar budgets.

The power of a telescope is defined by the size of the mirror it uses to collect starlight. Like a bucket collecting raindrops, the bigger the mirror, the more light one can gather, and hence the fainter an object one can see. What's more, the bigger the mirror, the sharper your vision: if you double the diameter of your mirror, in principle you can now see features twice as small as before.

Frustratingly, a full understanding of our place in the Universe requires us to see things far smaller and fainter than we can currently achieve. Out of this need has emerged a vision of a new generation of mega-facilities: the Extremely Large Telescopes, or ELTs.

Bigger than big

There are three Extremely Large Telescopes now beginning to take shape, all almost unbelievable in their sheer scale, audacious in their engineering challenges and thrilling in the scientific mysteries they aim to solve.

The first of the ELTs expected to come online will be the Giant Magellan Telescope (GMT), to be built on a mountain peak in northern Chile and aiming for "first light" in 2021. Close behind will be the Thirty Meter Telescope (TMT), to be built on the top of Mauna Kea in Hawaii and scheduled for completion in 2022. And the biggest of them all, the European Extremely Large Telescope (E-ELT), will also be in the mountains of northern Chile, and will begin operations in 2024.

Artist's rendering of an aerial view of the Thirty Meter Telescope. Credit: Thirty Meter Telescope,

The size of these telescopes is hard to comprehend: even the smallest, the GMT, will have a mirror 83 feet across, with a total area larger than a tennis court. The TMT will easily top this, with a mirror 100 feet in diameter. And the E-ELT will be even larger, with a mirror spanning 130 feet.

The largest single mirror ever made is a mere 27 feet across. How does one go about building something so much bigger?

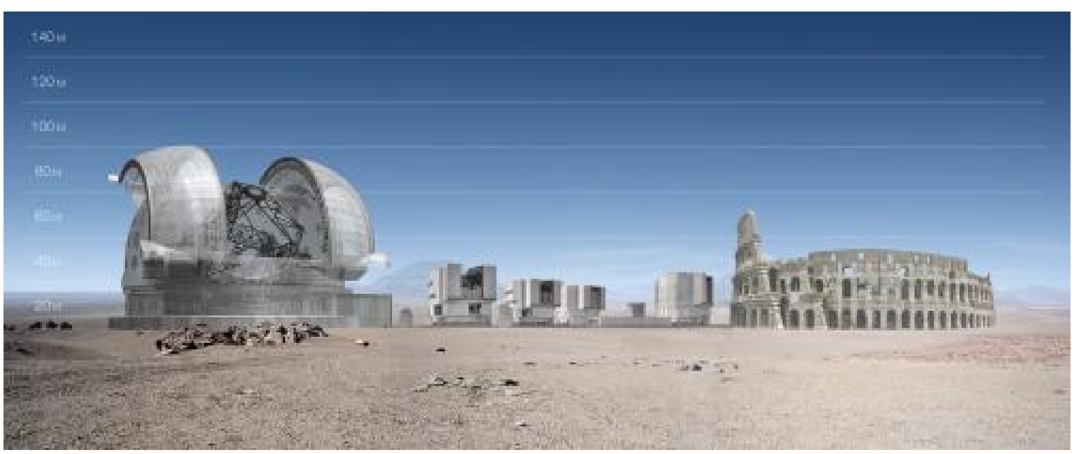
The answer is: you don't.

All three ELTs will use a mosaic of smaller mirrors, segmented together and operating in concert. But even this simplifying technique takes us into uncharted territory.

For the Giant Magellan Telescope, the plan is to build *seven* of these

27-foot mirrors, to be arranged in a circle like the petals of a giant flower. But to make just one of these mirrors is a herculean effort: 20 tons of ultra-pure glass is cast in a giant rotating oven, takes six months to cool, and then another year to polish into the required curved shape. When the mirror is finally ready, it needs to be delivered from the mirror lab in Arizona to the mountain in Chile. And the whole process must then be repeated another six times.

The Thirty Meter Telescope and the European Extremely Large Telescope are taking a different approach, using a much larger number of small mirrors, each 5 feet across and fit together in a honeycomb pattern. But the number of mirrors then required is enormous: 492 for the TMT, and a staggering 798 for the E-ELT. What's more, to perfectly maintain the shape needed to keep the light in focus and to correct for the blurring effects of the atmosphere, the precise shapes and orientations of the individual mirror segments need to be continually adjusted. This requires thousands of individual motors attached to the back of the mirrors, each making minute adjustments many times per second, all orchestrated by a dedicated supercomputer.

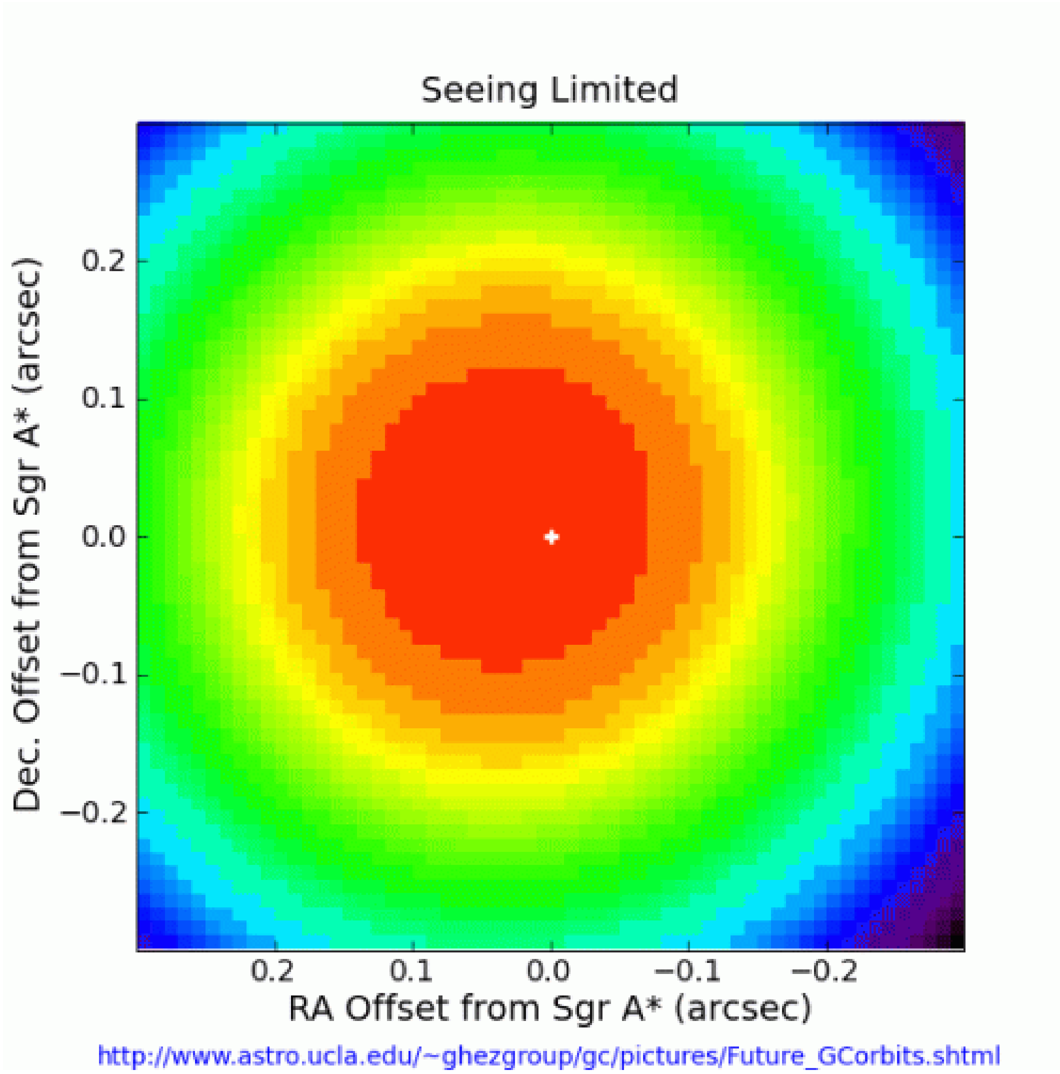


The E-ELT dome (on the left) will be 100 meters in diameter, about the size of the Colosseum in Rome (on the right). Credit: European Southern Observatory, CC BY

These facilities will be so complex that rarely will scientists steer the telescope themselves; specially trained telescope operators will be at the controls. Instead, we astronomers will never need to leave our offices, the collected data arriving via a link in an email.

Stargazers no longer gaze at the stars

Is the romance now gone? No. The stargazers are as entranced as ever with the heavens. But to understand our Universe, we need to gaze more deeply than we've ever done before.



Stars orbiting very close to the supermassive black hole at the center of the Milky Way. The animation starts with a standard image, then one produced with the most powerful telescopes currently available, then the type of image expected to be produced using an ELT. Credit: Keck / UCLA Galactic Center Group

The view of the night sky as seen with the naked eye or with a modest-sized telescope is terribly misleading. A typical photograph of the starry sky is about as representative of the Universe as a concert mosh pit might be of all of planet Earth. Or to put things more scientifically, our ordinary view of the sky is overwhelmingly biased by the brightest, nearest, biggest objects.

But the big prizes for modern astronomy – the things we seek to discover and understand – are inevitably extremely faint, distant or small. The new frontiers are stars so old that they're a fossil record of the beginnings of the Universe, the mysterious Dark Energy that is forcing the cosmos to expand ever faster, and the hunt for tiny Earth-like planets orbiting other stars.

These and other related challenges were barely on the radar twenty years ago, but now they dominate worldwide astronomy. So how to make further progress? How do we see what the Universe really looks like? The answer lies with these bigger telescopes, far bigger than anything we've dared build before.

Source: The Conversation

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