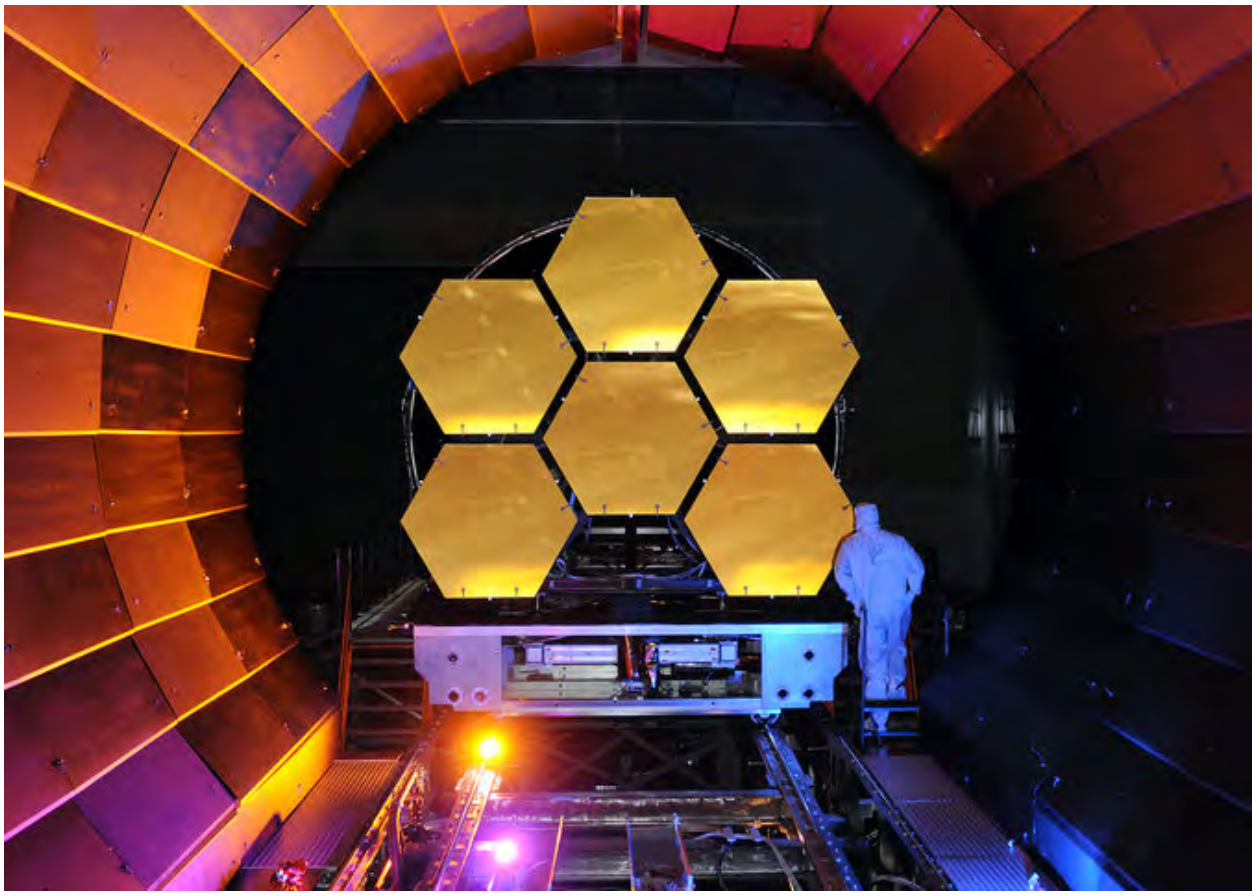
SPACE & COSMOS

More Eyes on the Skies

By DENNIS OVERBYEJULY 21, 2014

Photo



Testing the mirrors for the James Webb Space Telescope, which NASA says is on track to be launched in 2018. CreditBall Aerospace

The future, it is often said, belongs to those who plan for it. And astronomers have been busy working the proverbial smoke-filled rooms (or whatever passes for them today) where the destiny of big science is often shaped and crisscrossing one another in airports on fund-raising trips. Now they are about to have something to show for it.

More than a decade after competing groups set out to raise money for gargantuan telescopesthat could study planets around distant stars and tune into the birth of galaxies at the dawn of time, shovels, pickaxes and more sophisticated tools are now about to go to work on mountaintops in Hawaii and Chile in what is going to be the greatest, most expensive and ambitious spree of telescope-making in the history of astronomy.

If it all plays out as expected and budgeted, astronomers of the 2020s will be swimming in petabytes of data streaming from space and the ground. Herewith a report card on the future of big-time stargazing.

On June 20, officials from the European Southern Observatory blew the top off a mountain in northern Chile called Armazones, breaking ground for what is planned to be the largest, most powerful optical telescope ever built. Known as the European Extremely Large Telescope, or E-ELT, it will have a segmented mirror 39 meters (about 128 feet) in diameter, powerful enough to see planets around distant stars. By comparison, the largest telescopes now operating are 10 meters in diameter.

Photo

The European Southern Observatory consortium's Very Large Telescope array, in Chile, is made up of four eight-meter telescopes. CreditEuropean Southern Observatory

The European Southern Observatory is a consortium of 14 European nations and Brazil, which has agreed to join but is still waiting for its Parliament to ratify the move. Brazil's official entrance would put the group more than 90 percent of the way toward the $1.5 billion in 2012 dollars the telescope is projected to cost, enough to begin big-ticket items like a dome, said Lars Christensen, a spokesman for the consortium.

The telescope should be ready on June 19, 2024. "We'll all be back here," said Tim de Zeeuw, the group's director general, at the groundbreaking.

That's not the only mega telescope project out there. Two years ago, another group of astronomers blasted away the top of another mountain in Chile, Las Campanas, where they plan to build the Giant Magellan Telescope. That telescope will have at its heart a set of seven eight-meter mirrors ganged together to make the equivalent of a mirror 25 meters in diameter. Three of those mirrors have been

cast and polished at the University of Arizona, one of the Giant Magellan partners. A fourth mirror is on order for next year.

Wendy Freedman, the director of the Carnegie Observatories, one of the spearheads of the Magellan collaboration, said by email that members were now in the final phases of forming a limited liability corporation, the legal and financial entity that will build and own the telescope. To date, the group has raised about $500 million of the $880 million (2012 dollars) needed for their telescope. On Monday, Dr. Freedman announced that the São Paulo Research Foundation in Brazil was joining Giant Magellan.

She expects construction to begin later this year. “Our plan is to be on the air with the first four mirrors taking early science data in 2021,” she said. “So things are continuing to go very well.”

In Hawaii, there will be no blasting needed, just some grading with a bulldozer, on Mauna Kea, where yet another group of astronomers plans to build a telescope 30 meters in diameter — the simply named Thirty Meter Telescope — on a plateau just below the nearly 14,000-foot summit. Mauna Kea, the highest peak in the Pacific, is already home to 12 telescopes, including the twin 10-meter telescopes at the Keck observatory and a pair of eight-meters, making it the busiest mountain in astronomy.

Photo

A rendering of the Thirty Meter Telescope, to be built by an international consortium in Hawaii.CreditCaltech, University of California, and the Canadian Universities for Research in Astronomy

It is also a sacred place for Hawaiians, many of whose ancestors have been buried up there. As a result, it's not so easy gaining permission to add yet another telescope, said Michael Bolte of the University of California, Santa Cruz, a co-director of the project, an international collaboration led by Caltech and the University of California and now doing business as Thirty Meter Telescope International Observatory LLC.

"I think we're finally free and clear to build on that site," Dr. Bolte said in an interview, saying they had chosen an unobtrusive spot for the telescope. He expects to begin grading a road to the site this summer as soon as the project clears its last hurdle with the Hawaiian authorities.

The Thirty Meter Telescope will cost $1.2 billion in those same 2012 dollars. By early next year, when India and Canada are expected to become full members of the corporation, Dr. Bolte said, they will have 85 percent of the money needed; they are still looking for more partners. A grand groundbreaking ceremony is being scheduled for Oct. 7.

“It’s a crazy science,” Dr. Bolte said, ticking off the names of historical benefactors of astronomy and telescope financiers, “that facilities at the forefront tend to be built with private money,” something that rarely happens in, say, physics.

Big Mirrors, Big Views

Hale reflector on Palomar Mountain, in San Diego County, was considered the practical earthly limit, but in the 1980s, astronomers devised ways to build bigger, thinner, mirrors that would not sag, leading to a bevy of eight-meter mirrors as well as the two 10-meter Kecks. The Magellan, the smallest of the new breed, however, will be six times as powerful as the Kecks in scooping up distant dim starlight; the others will be even more powerful.

Northern Chile is dry and high, with little light pollution. The area already bristles with telescopes, and more are under construction.

Source: European Southern Observatory

The Hubble Space Telescope is only 94 inches, about 2.4 meters in diameter. It gains its power not from size but from being above the atmosphere, which blurs and filters the light from stars.

Increasing their powers even more, the new telescopes will be equipped with a technology that did not exist the last time around: adaptive optics, the ability to adjust the shape of the mirrors to minimize or cancel the effects of the atmospheric turbulence that causes stars to twinkle. The result, astronomers say, is that these telescopes will be able to detect fainter objects than Hubble can, like planets or bits of galaxies coming together, and more clearly.

A Boom in Chile

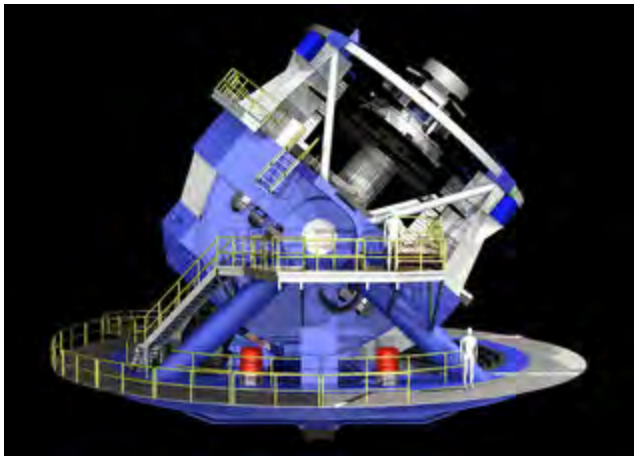
The inauguration of these new telescopes, early in the next decade, will further enshrine the Atacama Desert in Chile, which is bone-dry, high, dark and blessed with remarkably steady air, as the center of world astronomy. The region already is home to, among other observatories, the Atacama Large Millimeter/sub-millimeter Array, or ALMA, an international project that is the world's most expensive radio telescope, and the European Southern Observatory's Very Large Telescope, an array of four

eight-meter telescopes near the site of the coming Extremely Large Telescope.

The whole neighborhood, in fact, is booming. But for red tape, construction was also supposed to have started this month on theLarge Synoptic Survey Telescope on Pachón Mountain, in, yes, Chile. That telescope, a joint project of the National Science Foundation and the Department of Energy, is eight meters in diameter. That mountain was dynamited back in 2011. The project director, Steve Kahn of Stanford, said that a news release was already written and waiting for the moment when the project, officially the LSST Corporation, receives formal approval from the National Science Foundation to start spending money.

“I am sure we will get started officially soon, but unfortunately, this process isn’t over until it is over,” Dr. Kahn wrote in an email.

Photo



The Large Synoptic Survey Telescope, a project of the National Science Foundation and the Department of Energy, will photograph almost the whole sky every few days, also from Chile. CreditLSST Corporation

A ceremony for laying the “first stone” is planned for next spring in Chile, he said.

The National Science Foundation has budgeted $473 million to build the telescope. The Energy Department is kicking in $165 million for a 3,200-megapixel camera, which will produce an image of the entire sky every few days and over 10 years will produce a movie of the universe, swamping astronomers with data that will enable them to spot everything that moves or blinks in the heavens, including asteroids and supernova explosions.

Among the Stars

What about outer space, where the stars actually are?

It was front-page news two years ago when the National Reconnaissance Office, which operates spy satellites, gave NASA two space telescopes the same size and design as a Hubble that had been sitting in a warehouse. Some astronomers, notably the former astronaut and Hubble repairman John M. Grunsfeld, NASA’s associate administrator for science mission, suggested that one of these could be used to jump-start a mission to study dark energy.

The National Academy of Sciences had ranked that mission atop the to-do list for this decade, but it was ambushed by the rising cost of NASA’s James Webb Space Telescope (more on that later).

Partners in Telescope Making

A billion-dollar telescope capable of outperforming Hubble can’t be built by a backyard stargazer or even a single university. The Thirty Meter Telescope in Hawaii and the Giant Magellan in Chile, both now on the verge of construction, are

the products of international teams that have pursued their dreams even through a global recession.

- Thirty Meter Telescope
- Association of Canadian Universities for Research in Astronomy
- California Institute of Technology
- Department of Science and Technology of India
- National Astronomical Observatories of the Chinese Academy of Sciences
- National Astronomical Observatory of Japan
- University of California
- Giant Magellan
- Australia Astronomy Limited
- Australian National University
- Carnegie Institution for Science
- Harvard University
- Korean Astronomy and Space Science Institute
- Harvard-Smithsonian Center for Astrophysics
- Texas A&M University
- University of Arizona
- University of Chicago
- University of Texas at Austin
- Sao Paulo Research Foundation

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A committee from the academy has recently endorsed the idea of using the spy telescope, which is 2.4 meters in diameter, for the mission, instead of the originally envisioned one-meter telescope. The academy agreed that the bigger telescope would enhance the scientific returns of the mission, now known as Wfirst-AFTA, for Wide Field Infrared Survey Telescope-Astrophysics Focused Telescope Assets, but warned that it could increase the cost and complexity. Congress directed NASA to spend $56 million on the

mission in the last fiscal year, 2014, and the proposed budget for 2015 includes about $14 million.

If this keeps up, said David Spergel, an astronomer at Princeton who is involved with the academy and the telescope, the mission could start as early as 2023, near the time the European Space Agency will send up its own dark energy probe, known as Euclid. By then, he said, the mission's name would probably be less of a mouthful. "The good thing about Wfirst-AFTA," Dr. Spergel wrote in an email, "is that there is no way that we will keep that name."

Among the possibilities that NASA is studying closely is adding a coronagraph to the telescope. Coronagraphs are basically opaque disks that were invented to black the intense light from the sun so astronomers could study the feathery faint corona of hot gases streaming outward from it. Exoplanet hunters are eager to deploy them to look for planets around distant stars. Getting a coronagraph on the dark energy telescope would be a valuable step toward a future mission, once known as the Terrestrial Planet Finder and now known by the placeholder name of New Worlds Telescope, long a dream of exoplanet hunters, that would be able to study Earthlike planets for signs of habitability, weather and life.

And then there is the most expensive and high-flying "big eye" of all, NASA's James Webb Space Telescope, which Nature magazine once called "the telescope that ate astronomy." Named for a former administrator of NASA, it is the successor to Hubble (which is still going strong, thank you), but is almost three times its size, with a 6.5-meter-diameter mirror that will have to fold out like a flower in orbit.

The Webb telescope was supposed to be launched this year, but was late and burned past its $5 billion budget like one of NASA's rockets, devouring money that could have gone toward other projects. The House Appropriations Committee once voted to cancel it, but the

project was reinstated with a budget cap of $8 billion and a launch date of 2018.

Since then, no news has basically been good news for Webb. It is still on track for 2018, NASA says. In July the agency reported that it had finished testing the framework that will hold the leaves of the telescope mirror and scientific instruments in place.

Photo

A rendering of the Giant Magellan Telescope that will be constructed atop a mountain in Chile.CreditGiant Magellan Telescope

Heat and Light

The Webb telescope was built to study the first stars and galaxies that emerged in the hundred million years or so after the Big Bang, a missing period in cosmic history. It is therefore designed to record infrared radiation rather than visible light because objects at that distance and vintage are flying away from us so fast, by the rules of the expanding universe, that their light has been "redshifted" to longer wavelengths.

As it happens, infrared, or heat radiation, is an excellent way to study planets, which tend to emit more heat than light. Astronomers have long hoped that spectroscopic observations of an exoplanet atmosphere might reveal the signatures of life, such as oxygen or chlorophyll.

Recently, some astronomers have suggested they might even be able to see industrial pollution as well, in particular chlorofluorocarbons, the greenhouse gases that also destroy ozone. Over a few millenniums of industry, the thinking goes, some of these gases could build up to levels detectable from far away and stay that way for 50,000 years.

It would be ominous, however, Henry W. Lin, a student at Harvard, and his colleagues wrote in a paper submitted to The Astrophysical Journal, if astronomers see the markers of pollution around some distant planet but no indications of present life. That detection, they wrote, "might serve as an additional warning to the 'intelligent' life here on Earth about the risks of industrial pollution." The future belongs to those who plan and care for it.

Last but hardly least is the Hubble Space Telescope, which has been providing humanity with matchless cosmic postcards from its perch above the sky ever since it was launched in 1990 and first fixed in 1993. Hubble was last visited and serviced by astronauts —

presumably for the final time — in 2009. Matt Mountain, the director of the Space Telescope Science Institute, reports that it is doing well. A recent NASA review concluded, he said in an email, that "Hubble is operating at or near the highest level of performance and scientific productivity in its history."

Recent estimates of its orbit suggest that it will re-enter Earth's atmosphere no earlier than 2027 and will probably stay up well into the 2030s. Its main instruments are likely to still be working in 2020. That means the Hubble will still be operational when the Webb telescope goes up in 2018.

"It looks like it," Dr. Mountain said. "We are certainly setting our planning that way."

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