THE CHRONICLE
of Higher Education

A New Motion Picture of the Universe, With Free Admission for Colleges Large and Small

February 7, 2010

Giant telescope promises to reveal the hidden nature of the cosmos, and let small institutions become big players in astronomy

By Ben Terris

Even as digital cameras get smaller and smaller, researchers in Tucson are in the midst of building a behemoth: a 3.2-billion-pixel giant that will weigh as much as a VW Bug. That's what it takes, after all, when the goal is to map half the visible universe.

This digital camera, which will be the world's largest, will be fixed atop the most powerful surveying telescope ever built, the Large Synoptic Survey Telescope. When the instruments hit full power, in 2016, they will provide the first comprehensive motion picture of space, aiming to reveal the proximity of potentially lethal asteroids and a better understanding of two of the most elusive concepts in physics and cosmology: dark matter and dark energy.

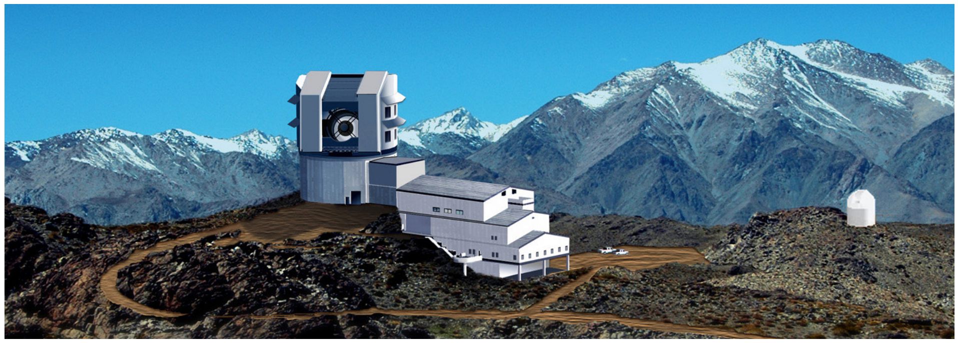
The giant tool may also transform the basic nature of academic astronomy. All the data—100 times more than in any previous astronomy database—will be public, so many scientists will no longer need access to an observatory to do research, allowing small institutions to become players along with large ones.

Jason S. Best, a professor of astronomy and astrophysics at Shepherd University, a 4,000-student institution in West Virginia, is looking forward to that. "Data is everything," he says. "With LSST not only will I be able to continue with the research I am doing, but I will be able to expand in all directions."

The potential power has, of course, lured major institutions. Already 19 universities, including the Johns Hopkins University, Princeton University, and the University of Arizona, have signed on as partners, and the full project will draw in hundreds of academic researchers.

"There are other projects in the works similar to LSST, but this is certainly the most ambitious," says Alexei V. Filippenko, an astrophysicist at the University of California at Berkeley. "We know that the sky isn't completely static—that things go bump in the night, things explode, and there are eruptions of stars—and this will let us see it move."

The LSST is under construction now, and scheduled to see first light in 2014 from its mountaintop site of Cerro Pachón, in Chile. The device will survey the entire southern sky every three days. Over the course of 10 years it will document more than 10 billion stars and galaxies (enough to allow everyone on Earth to name a celestial object). In total the project will produce over 200 petabytes of data. According to researchers at LSST, if all of the publicly archived information that exists in the world today—every digitally archived book, movie, and Web page—were converted into bytes, it would total a comparable number.



Michael Mullen Design, LSST Corporation

From its mountaintop site of Cerro Pachón, in Chile (rendered above), the new telescope will look for dangerous asteroids and help researchers learn more about dark matter and dark energy.

"In one sense, it's about the simplest kind of experiment you could do: survey the whole sky," says Steven Kahn, deputy director of the project and a professor of physics at Stanford University. "But the implications are profound. All the observation that's been done since beginning of time only amounts to one tiny fraction of the sky. For us to really know about our universe requires us to look at our entire universe."

The Bigger the Better

J. Anthony Tyson, director of LSST and a professor of physics at the University of California at Davis, has been building cameras for telescopes since the 1970s. In 1976 a camera he built while working in Bell Laboratories in New Jersey—one he still keeps in his office today—captured the first images of distant "faint blue galaxies." Using a technique called gravitational lensing, researchers could see how the light from these blue galaxies was bent by invisible masses known as "dark matter," thought to make up nearly 90 percent of the universe. The amount of bent blue light gave astronomers a way to measure the amount and location of this massive darkness.

Even then, however, Mr. Tyson knew that to understand dark matter better he would need an enormous telescope to collect a big enough data set. "In any kind of a survey, whether it's testing pharmaceutical products, exit polls, or astronomy, the bigger the sample size the better," Mr. Tyson says. "For us, that means billions of galaxies, not millions."

In 1998, Mr. Tyson began working on what he wanted to call the Dark Matter Telescope. But when he and his colleagues realized that a telescope of this magnitude could do much more than just detect dark matter, the project took on a new moniker. It included "synoptic," Mr. Tyson says, because the word comes from the Greek "synopsis." "It really means 'the big picture,'" he says.

In 2002, Mr. Tyson received financing from the National Science Foundation to begin work on the camera; by 2003 the project was receiving both public and private money, and Mr. Tyson created a nonprofit called the LSST Corporation in Tucson, which is something of an astronomy capital because of its clear skies year round.

Expansive goals have expensive price tags. So far the LSST Corporation has spent about $20-million on the project. And while private donations like the $30-million that came from Charles Simonyi and Bill Gates help, LSST needs more money. Mr. Tyson says that construction should total around $450-million, and that the telescope's operations will cost about $37-million a year.

In order to prove to public agencies and private donors that the LSST is worth backing, scientists working on the project are spending much of their time honing and highlighting its goals.

In addition to plumbing dark matter, a major objective is to learn about dark energy—the name given to the unexpected recent discovery of the acceleration of the universe's expansion.

"Imagine you threw a baseball into the air and when it reached the top of its arc, instead of slowing down and falling back to earth it started speeding up," says Mr. Kahn. "That's what seems to be happening to the universe." This long after the Big Bang sent everything outward, he says, gravity should be slowing down expansion, but the universe's expansion is accelerating.

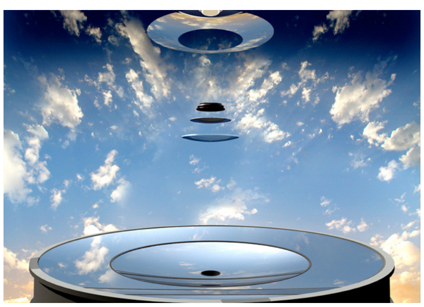
In other words, there is a force out there that could turn modern physics on its head.

"We know that our version of physics is wrong," says Mr. Kahn. "We just don't know exactly how it's wrong."

That is where the LSST's ability to capture movement comes in. It will look back about 13 billion years in time (for the telescope will be looking at stars and galaxies 13 billion light-years away), and be able to chart celestial matter over cosmic time and see better than ever how matter has moved throughout space—and get a much better view of the dark-energy acceleration.

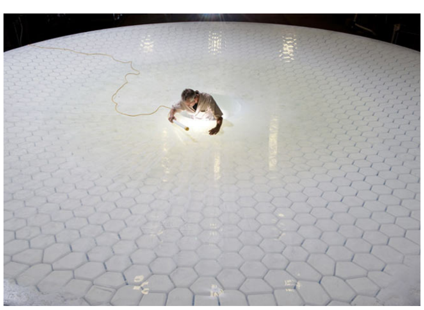
The LSST will also have the capability to help keep the Earth safe from potentially fatal objects. Thousands of photographs of each part of the sky, taken over a 10-year period, will highlight the changing position of objects in deep space, some of which could be asteroids.

In 2005 Congress mandated that NASA locate 90 percent of near-Earth objects that were larger than 140 meters in diameter. Mr. Tyson says LSST can do better.



Todd Mason, Mason Productions Inc., LSST Corporation

The Large Synoptic Survey Telescope has a combination of mirrors (above, at top and bottom of illustration) and three camera lenses (center) that can capture the movements of billions of stars and galaxies.



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A mirror for the LSST is under construction at the Mirror Lab at the U. of Arizona's Steward Observatory.

"NASA is tasked with finding asteroids that will destroy the Earth," he says. "But we can find ones that are smaller but could still destroy New York City."

Putting Their Heads Together

For LSST to be successful, however, will require more than just dozens of petabytes of data. It will take thousands of man-hours and a powerful data-management system. It will take the cooperation of dozens of universities. Without many astronomers to makes sense of the information, Mr. Tyson says, a big database wouldn't serve much purpose. The collective knowledge of many will create more projects and make more discoveries than a small number of even the best scientists, he says.

Every 17 seconds the camera will take a photograph of 10 degrees of the sky (an area Mr. Kahn says is approximately 40 times the size of the moon) and produce what Jeffery Kantor, project manager for data management, says is about 6.4 gigabytes of data (about one DVD's worth).

And what does an organization do with such an enormous amount of data? Make it available to all those who want it, right from their own laptops. Surveys like the Sloan Digital Sky Survey, which has observed around 230 million objects in space, have made their data available to the public, but only after a proprietary period. LSST will allow anyone to see data 60 seconds after each photograph is taken.

Mr. Kantor says the best way to deal with so much data is to make the software open-source. That, he says, will allow for more scientists to become involved in a way that will help both themselves and the project.

"One of the benefits to us for open-source is that if we are calculating something a certain way, and someone else has a better algorithm, we can use that and improve our system," he says. "And for the researchers publishing results, showing the processing software that you use allows people to verify that the results were gotten in a legitimate way."

So far 254 scientists have proposed about 100 different projects in a 600-page document called the LSST Science Book. To keep the masses organized, LSST has set up 12 collaborative groups to work on projects like studying supernovae, the solar system, active galactic nuclei, and other galaxies.

"The spirit of the collaborations is that we help put it together as an organization but the groups all function semi autonomously," says Michael A. Strauss, chair of the collaborative groups and a professor of astrophysics at Princeton University.

Mr. Strauss says that right now all the work by scientists in the collaborative groups is done free of charge.

Because anyone in the world has the ability to use the information from LSST, Mr. Strauss says, "we can't even begin to imagine all the research possibilities" that will come from this data.

"It's certainly a new paradigm," he says. "We will make the information public not just to be altruistic and friendly, or completely because we want a better chance of getting funded, but because the data is so rich there's no point in keeping it all to ourselves. There's enough for everyone to get what they want out of it."

A More Democratic Astronomy

Right now large research universities dominate the field of astronomy, but this data set will level the playing field for smaller colleges.

"Smaller universities, state schools, community colleges all have capable scientists, but until now have not had the right resources," says Mr. Kahn. "This is a way that anyone with a computer can carry out research anywhere they are."

Mr. Best, the astronomer from Shepherd University, says the benefits extend from research to teaching: "It will give my students the chance to make real contributions to science now."

Joel M. Weisberg, chair of the department of physics and astronomy at Carleton College, says he is pleased that the program aims to draw out underrepresented institutions in science. In his words, this seems like a project "without any downside."

"Science is very collaborative," he says. "Anything that can enable people at smaller institutions, both faculty and students, to collaborate with people working at the cutting edge enables lots of excitement and opportunities to places that wouldn't otherwise have them."

There are, however, aspects of science that are more competitive than collaborative. What about the fear of having your own research scooped by another astronomer working from the same data?

Mr. Kahn admits he does not know how that will affect the project. "This is one of the challenges of working with this new paradigm," he says. He points out, though, that the huge amounts of data do not favor lone wolves. As with the human-genome project, he notes, a larger community than normal will be required to best deal with the deluge of information.

"Anything that is really important is going to be a lot of work because there is so much data," he says. "It makes sense to do that in teams. And this project will allow for teams that might never have existed otherwise."