earthquakes and epidemics, he says. Without advances in science and technology — which drive innovation and attract investors — the cuts could also set back economic growth in Mexico, he adds.

In June, Lazcano and 56 other Mexican scientists wrote an open letter to the government urging officials to reverse these recent funding cuts. As of 13 August, more than 19,000 people had signed the letter online.

RIPPLE EFFECTS

Juan Martínez, an ecologist at the Institute of Ecology in Xalapa, says that the cuts enacted in May are pushing the institute to its limit. "We don't have money to pay [for] electricity," says Martínez, who has signed the open letter. To save energy, the institute has banned employees from charging their phones, turning on the air conditioning, working past 6 p.m. during the week or coming in over the weekend.

Cuauhtémoc Sáenz-Romero, a forest geneticist at the Michoacan University of Saint Nicholas of Hidalgo, worries that he'll have to end collaborations with scientists abroad. He is part of a working group at the Food and Agriculture Organization of the United Nations that is developing improved forest conservation and management strategies across the United States, Canada and Mexico.

The Mexican National Forest Commission was supposed to pay for Sáenz-Romero and two of his colleagues to attend the group's next meeting in Idaho in October. But the commission won't be able to fund the trip. Because the Mexican delegates cannot attend, the meeting has now been cancelled, and it is unclear when it will be rescheduled.

Despite these reports, CONACYT director Elena Álvarez-Buylla insists that the cuts enacted in May are aimed at reducing overspending and will not affect research projects at institutions funded by the agency.

CONACYT plans to have allocated at least 1.6 billion pesos to basic-science projects by the end of 2019, Álvarez-Buylla says. Decisions on new grants will be made at the end of the year, which means that researchers won't get funds until 2020.

Lack of sufficient federal funding in Mexico pre-dates the current administration. Soledad Funes, a molecular biologist at UNAM, says that, over the past decade, calls for basic-science grant applications from CONACYT have been irregular. Funes is currently relying on a 250,000-peso grant provided by her university to continue her research.

Scientists at institutions that don't provide such grants have turned elsewhere for money. Enrique Espinosa, an immunologist at the National Institute for Respiratory Diseases in Mexico City, has started a crowdfunding campaign for money to buy reagents, attend scientific conferences and support a graduate student until they receive a scholarship.

The mounting funding uncertainty has also discouraged Mexican researchers abroad from returning. Jorge Zavala, an astronomer at the University of Texas in Austin, rejected a well-paid academic position at the Institute of Astrophysics, Optics and Electronics in Tonantzintla last year because he wasn't sure how long the money would last.

The post was part of a CONACYT programme covering salaries for young scientists working at Mexican institutions that couldn't afford to pay their researchers. But Zavala wasn't sure whether the programme would have continued under López Obrador's administration.

Zavala plans to apply for academic positions in Europe or the United States in the near future. At some point, he says, "I might go back to Mexico, if things get better." ■

COSMOLOGY

Sky map to plot dark energy

A telescope in Arizona will survey galaxies to reconstruct 11 billion years of cosmic history.

BY DAVIDE CASTELVECCHI

Astronomers are about to embark on their most ambitious galaxy-mapping project ever. Over the next five years, they will use a telescope in Arizona — retrofitted with thousands of small robotic arms — to capture light spectra from 35 million galaxies and reconstruct the Universe's history of expansion. Their main aim: to elucidate the nature of dark energy, the enigmatic force that is pushing the Universe to accelerate at an ever-faster pace.

The Dark Energy Spectroscopic Instrument (DESI) is scheduled to see 'first light' in September. After a commissioning period, its survey of the northern sky — using the 4-metre Mayall Telescope at Kitt Peak National Observatory near Tucson — could start by January 2020. Roughly three-quarters of DESI's US$75-million budget comes from US Department of Energy (DOE), with major contributions from the United Kingdom and France.

DESI is the first in a new generation of experiments investigating the past expansion of the Universe, which come two decades after the first strong evidence of dark energy was found in 1998. Others include ground-based and space observatories set to come online in the 2020s.

The survey will reconstruct 11 billion years of cosmic history. It could answer the first and most basic question about dark energy: is it a uniform force across space and time, or has its strength evolved over eons? ▸

JOHN BRILEY FOR THE WASHINGTON POST/GETTY

The 4-metre Mayall Telescope at Kitt Peak National Observatory near Tucson.

The survey will track cosmic expansion by measuring features of the early Universe, known as baryon acoustic oscillations (BAOs). These oscillations are ripples in the density of matter that left a spherical imprint in space around which galaxies clustered. The distribution of galaxies is highest in the centre of the imprint, a region called a supercluster, and around its edges — with giant voids between these areas.

Superclusters formed in regions where dark matter — invisible material that drives the formation of such large structures — had concentrated under its own gravitational pull.

COSMIC RULER

This primordial pattern of galaxy clustering has remained unchanged since about one million years after the Big Bang. As the Universe grew, BAOs have tracked its expansion; they are now about 320 megaparsecs wide (1 billion light years). Cosmologists use this distance as a ruler; by tracking the size of the BAOs across time, they can reconstruct how the Universe itself expanded.

"The pattern in the map is basically constant; the scale is increasing," says Daniel Eisenstein, a physicist at Harvard University in Cambridge and a spokesperson for DESI.

Tracking BAOs requires a 3D map of galaxies made by measuring their redshifts — the lengthening of the electromagnetic waves in their spectra of light. Redshifts measure how fast a galaxy is receding from the Milky Way, which indicates how far away that galaxy is.

The more redshifts that are measured, the more precise the BAO tracking. Eisenstein and others have found the unmistakable BAO signature in previous galaxy surveys, in particular the US-based Baryon Oscillation Spectroscopic Survey (BOSS) and the Australia-based Two-degree-Field Galaxy Redshift Survey. Together, those surveys mapped nearly 2.4 million galaxies.

"Within a few months, we will surpass what we had for BOSS."

The number of galaxies that DESI will track will eclipse the previous surveys by an order of magnitude. "Within a few months, we will surpass what we had for BOSS," says Michael Levi, a physicist at the Lawrence Berkeley National Laboratory (LBNL) in California and DESI's director.

DESI will achieve such a speed-up thanks to a radically different design. Surveys such as BOSS used optical fibres, placed into holes drilled into custom metal plates, to capture each galaxy's light and deliver it to a separate spectrograph to measure the redshift. But the plates needed to be changed to measure each different part of the sky, which was slow.

DESI will replace the metal plates with 5,000 tiny robotic arms, arranged in a closely packed beehive pattern. Once images of galaxies are projected on the telescope's focal plane — each about 100 micrometres wide — the robotic arms will quickly position optical fibres to within 10 micrometres of the centre of each image, explains Joseph Silber, a mechanical engineer at the LBNL who led the design and construction of the robotic system.

Although BOSS typically changed about five plates a night, DESI's focal plane can be refigured for another part of the sky in a few minutes; the main limitation is how long the exposures need to be to get enough light. Depending on the season and the weather, DESI could take 30 or more exposures, each with thousands of redshifts, in a night.

Other astronomy experiments have used robotic positioners before. But, Silber says, "DESI is definitely the biggest one tried so far."

In addition to probing dark energy, DESI will study dark matter's role in the growth of galaxies and clusters of galaxies by measuring motion in clusters, says DESI spokesperson Nathalie Palanque-Delabrouille, a cosmologist at the French Alternative Energies and Atomic Energy Commission (CEA) Saclay Research Centre outside Paris. This will provide "exquisite tests" of the favourite models of how dark matter drives the growth of large structures, she says. ■