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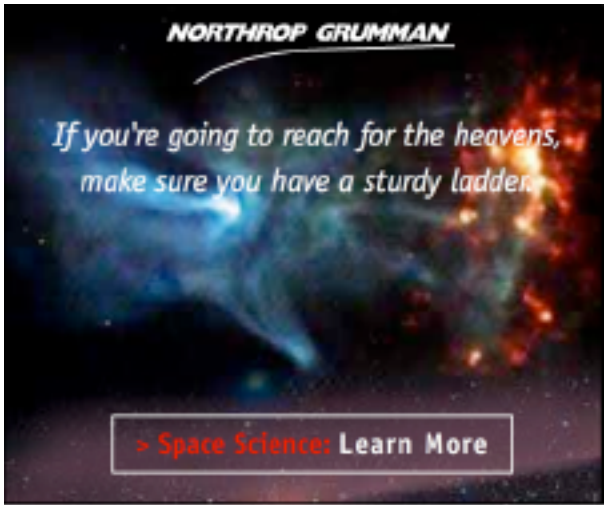
Novel Experiment Prepares to Join Dark Energy Hunt

By retrofitting a Texas telescope with a low-cost, modular instrument, researchers hope to find clues to what is driving the accelerating expansion of our universe

By Alan S. Brown



An experiment is gearing up in Texas to take on one of the universe's biggest mysteries by compiling a three-dimensional map of the early cosmos. The hope is that the survey will help inform astronomers and cosmologists about the nature of dark energy, a mysterious and hypothetical agent thought to constitute nearly three quarters of the universe's mass.

Dark energy is the term used by cosmologists to explain why the expansion of the universe is accelerating rather than slowing due to gravitation. Yet the name only hints at how little we know about it. Is dark energy a particle, a wave or a fundamental property of space-time? Has it always been there? Is it constant, or does it grow stronger as the universe expands? Hypotheses abound, but there is scant observational evidence to back them up. After all, it was not until 1998 that studies of distant supernovae provided the first solid evidence for a universe undergoing accelerated expansion.

The Hobby-Eberly Telescope Dark Energy Experiment (HETDEX) is one of three ambitious projects aiming to provide those missing observations. The others are the Baryon Oscillation Spectroscopic Survey (BOSS), which achieved first light in September 2009 at the 2.5-meter Apache Point telescope in New Mexico, and the Dark Energy Survey (DES), which will add a digital camera with more than 500 megapixels to the Blanco four-meter telescope in Chile.

"Both BOSS and DES will refine our understanding of acceleration in the midlife universe, roughly five billion years ago," explains HETDEX project scientist Gary Hill of the University of Texas at Austin. "HETDEX goes further back. We are going to measure the expansion rate 11 billion years ago." Such observations fall in what might be called the adolescence of the 13.7-billion-year-old universe.

To elucidate the nature of cosmic expansion, HETDEX will map the positions of a million galaxies by measuring the spectrographic emissions of small, hydrogen-rich galaxies forming stars only 2.7 billion years after the big bang. "This is the sweet spot where dark energy should have enough effect so that it's detectable," Hill says.

Astronomers will use those observations to compare the distribution of galaxies five billion and 11 billion years ago and to determine whether the expansion rate has changed or remained constant over the eons. That should rule out some proposed explanations for dark energy.

Hill is retrofitting the 9.2-meter Hobby-Eberly Telescope, one of the world's largest optical telescopes, to run the experiment. Located in the Davis Mountains in western Texas, the telescope's primary mirror sits at a fixed angle

while a moving instrument package above the mirror tracks its targets. Four optical correcting mirrors within the package reduce light sources to small, high-contrast images.

The HETDEX project plans to double the size of the 0.5-meter correcting mirrors and increase the mass of the hardware atop the telescope to roughly eight metric tons. When completed later this year, the upgrade will widen Hobby-Eberly's field of view by 30 times, to roughly half the area of the full moon. That augmentation will enable the telescope to capture data from large swaths of the sky, reducing the amount of calibration needed to correct for temperature, humidity and other atmospheric conditions when comparing one area of the sky to another.

A modular spectrograph, the first of its kind, will break down the light gathered by the telescope into its component wavelengths. Instead of building one large instrument, plans for HETDEX call for between 150 and 192 smaller modular spectrographs in four enclosures surrounding the telescope. Each spectrograph covers a small patch of the field of view; software then reassembles the complete spectral image from the individual parts.

Economics lie behind the modular approach. "Instead of one big instrument that would require a huge amount of engineering, we are taking a relatively simple spectrograph and replicating enough of them to drive the cost down," Hill notes. He originally expected per-unit bids to come in at half the $40,000 cost of his initial prototype, but so far they have been substantially lower.

Hill plans to spend a total of $34 million to retrofit the Hobby-Eberly Telescope for HETDEX, with nearly a quarter of the money being raised from private donors. That is far less than the cost of one large spectrograph, which in any case would have been too large to build onto Hobby-Eberly, he adds. The funds will pay for the spectroscopes and their temperature-controlled housings, as well as continued engineering, a new instrument package and reinforcements to bear the bulked-up assembly atop the telescope.

In addition to saving money, prototyping helped researchers assess performance and work out bugs before committing to a final design. "We really, really learned a lot about optical cable design," Hill says. At least 33,600 optical fibers will branch from the instrument package at the top of the telescope to the spectrographs below. One twist and a fiber will stop transmitting. "We had to invent new techniques to make it work," Hill says.

The prototype is currently installed on the neighboring 2.7-meter Harlan J. Smith Telescope. Because of its ability to capture a wide field of view and a broad spectrum of light, time on the instrument is already oversubscribed, says Hill's University of Texas at Austin colleague Karl Gebhardt.

The low-cost modular approach has attracted attention from researchers at other observatories, yet it has limitations. "When people build large, monolithic instruments, they configure them to do many different things," Hill notes. "Our system is designed to do one thing very well and at much less expense."

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