UMass Amherst leads international astronomical camera project

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The Large Millimeter Telescope on the summit of Sierra Negra, an extinct volcano in Mexico. Credit: James Lowenthal

New discoveries in star formation, galaxy cluster physics, ultra-deep galactic exploration and magnetic field surveys of the universe are

coming soon, say a team of astronomers led by Grant Wilson at the University of Massachusetts Amherst, who are building the next-generation, most sensitive millimeter-wavelength polarimetric camera on Earth for studying the heavens.

Wilson and colleagues plan to use the camera to conduct a series of groundbreaking surveys in star formation and galaxy evolution that will be freely available to the public. Dubbed TolTEC, the state-of-the-art imaging system will be a part of the 50-meter (164-foot) diameter Large Millimeter Telescope (LMT) on the summit of Sierra Negra, an extinct volcano in Mexico.

The LMT, a joint project of UMass Amherst and Mexico's Instituto Nacional de Astrofísica, Óptica y Electrónica (INAOE), is the largest, most sensitive single-aperture millimeter-wavelength telescope in the world. TolTEC is funded by a recent $6.1 million grant from the National Science Foundation to Wilson and a large team of collaborators at UMass Amherst and Arizona State University, Northwestern University, the University of Michigan, the University of Wisconsin, Cardiff University, Wales, the U.S. National Institute of Standards and Technology and INAOE.

The new camera is expected to be operational by late 2018. It will offer 100-times-faster mapping speed than the LMT's current capability and "astonishing sensitivity" to astronomers. Wilson says, "It's hard to grasp the increased capabilities" of the new instrument. "The combination of the new camera and the LMT requires a new outlook on what types of investigations are possible." Observations that require today's telescopes five years to complete will be done in a little more than one week with TolTEC, for example.

Michael Malone, UMass Amherst's vice chancellor for research and engagement, says, "The TolTEC instrument will be a terrific addition to

the LMT and the astronomy community." Stephen Schneider, head of the astronomy department, says, "This is terrific for the research being done at UMass and INAOE, and a great affirmation of the importance of the LMT for future astronomical research."

Wilson says, "The speed-up has compounding benefits because you're limited in astronomy, at any telescope, to nights with nice weather. TolTEC's improved speed will just let us blaze through some projects in the very best weather periods at the LMT." Another benefit of TolTEC is that it can survey the sky simultaneously in three frequency bands compared to the current instrument's single band. And TolTEC will not only be sensitive to intensity or total light but to the incoming light's polarization state, he says. Such new capabilities will allow astronomers to probe an array of new phenomena.

Wilson, an astrophysicist and cryogenic systems expert, says the millimeter-wave-detecting camera will replace one named AzTEC that he and others previously built for collecting images of thermal radiation emitted by distant, dusty galaxies during the formation and death of stars. TolTEC will be a little larger than a smart car; when working it must be cooled to 4 degrees Kelvin (about minus 450 degrees F) and its detectors to only 0.1 degrees above absolute zero.

For the TolTEC project, Wilson and a scientific advisory board will oversee a series of workshops for members of the worldwide astronomy community in coming years that will help to prioritize and define up to 10 different projects centered on TolTEC observations. These surveys will be open for use by astronomers around the world with no strings attached and data will be available to all.

Lead project scientist Itziar Aretxaga of INAOE in Mexico and deputy project scientist Alexandra Pope at UMass Amherst are expected to lead the scientific advisory board. "That's what we're giving back to the

global community in exchange for the funds we have received to build this new instrument," Wilson says.

Pope says, "Currently, our census of dust-obscured star formation activity in galaxies is severely incomplete, especially in the distant universe. With TolTEC on the LMT, we will be able to make a complete census of dust-obscured star formation activity in galaxies over 13 billion years of cosmic time. We will also study how their environment is driving galaxies' evolution. Specifically, we will measure the build-up of stars in the most crowded structures in the universe, namely galaxy clusters, at all cosmic times in order to determine the balance between 'nature or nurture' in galaxy evolution."

Wilson is particularly excited about TolTEC's ability to detect and map magnetic fields through their imprint on galactic dust. "We have an opportunity to provide a new and unique view of the role that magnetic fields play in the formation of new stars," he says. "Our observations, coupled with pioneering theoretical work carried out by astronomers such as Stella Offner at UMass Amherst, have the potential to finally unlock some of the hardest to observe phenomena in the birth of new stars. We have a long way to go before we can make maps showing magnetic fields around forming stars, but I think we're going to have an outstanding horse in that race in the next few years."

Provided by University of Massachusetts Amherst

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