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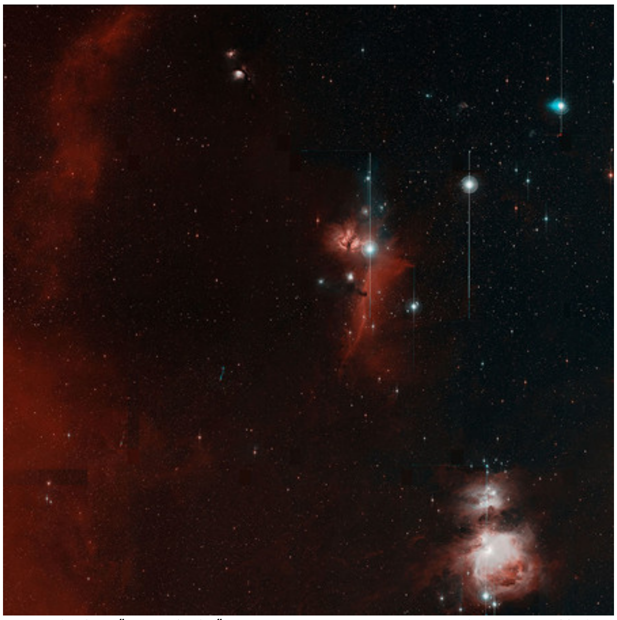
Zwicky Transient Facility Opens Its Eyes to the Volatile Cosmos

"First-light" image demonstrates power of new camera to observe cosmic events

A new robotic camera with the ability to capture hundreds of thousands of stars and galaxies in a single shot has taken its first image of the sky, an event astronomers refer to as "first light." The recently installed camera is part of a new automated sky-survey project called the Zwicky Transient Facility (ZTF), based at Caltech's Palomar Observatory located in the mountains near San Diego. Every night, ZTF will scan a large portion of the Northern sky, discovering objects that erupt or vary in brightness, including exploding stars (also known as supernovas), stars being munched on by black holes, and asteroids and comets.



ZTF took this "first-light" image on Nov. 1, 2017, after being installed at the 48-inch Samuel Oschin Telescope at Palomar Observatory. The full-resolution version is more than 24,000 pixels by 24,000 pixels. Each ZTF image covers a sky area equal to 247 full moons. The Orion nebula is at lower right. Computers searching these images for transient, or variable, events are trained to automatically recognize and ignore non-astronomical sources, such as the vertical "blooming" lines seen here.
Credit: Caltech Optical Observatories

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- DOWNLOAD OPTIONS: High-Res Images and Video
- VIDEO: Roger Smith on retrofitting Palomar for ZTF
- Zwicky Transient Facility Website
- Palomar Transient Factory Website
- Rare Brightening of a Supernova's Light found by Palomar Observatory
- The "Supernova of a Generation" Shows Its Stuff
- GROWTH Website
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"There's a lot of activity happening in our night skies," says Shrinivas ("Shri") Kulkarni, the principal investigator of ZTF and the George Ellery Hale Professor of Astronomy and Planetary Science at Caltech. "In fact, every second, somewhere in the universe, there's a supernova that's exploding. Of course, we can't see them all, but with ZTF we will see up to tens of thousands of explosive transients every year over the three-year lifetime of the project."

From 2009 to 2017, ZTF's predecessor, the Palomar Transient Factory, caught the blinking, flaring, and other real-time changes of transient objects in the sky. The project took advantage of the fact that Palomar has three telescopes—the 48-inch Samuel Oschin Telescope, the 60-inch telescope and the 200-inch Hale Telescope—all under the management of Caltech. During the Palomar Transient Factory's surveys, the automated Samuel Oschin Telescope acted as the discovery engine, with the automated 60-inch following up on any targets found and gleaning information about their identities. From there, astronomers would use the larger 200-inch Hale Telescope—or the W. M. Keck Observatory, which is co-managed by Caltech—to study in detail the various cosmic characters that enliven our night skies.

"Going from one telescope to the next allowed us to perform a sort of triage and pick out the most interesting objects for further study; it was a vertically integrated observatory," says Kulkarni. "The reason we called it the Palomar Transient Factory is because it did astronomy on an industrial scale."

Credit: Caltech

The Zwicky Transient Facility is the powerful sequel to the Palomar Transient Factory. The name Zwicky refers to the first astrophysicist at Caltech, Fritz Zwicky, who arrived at the university in 1925 and who would go on to discover 120 supernovas over his lifetime. ZTF's new state-of-the-art survey camera, recently installed at the Samuel Oschin Telescope, can see 47 square degrees of sky at a time, or the equivalent sky area of 247 full moons. That's seven times more sky than its predecessor could see in a single image. What's more, ZTF's upgraded electronics and telescope-drive systems enable the camera to take 2.5 times as many exposures each night. ZTF will scan the entire sky over three nights and the visible plane of the galaxy twice every night.

By scanning the sky so much faster, astronomers will discover not only a greater number of transient objects but also will be able to pick up the more fleeting events, those that appear and fade quickly.

"ZTF will be faster than its predecessor because each image probes a wider swath of sky out to greater distances," says Richard Dekany, the project manager for ZTF at Caltech. "Each image the camera takes is more than 24,000 by 24,000 pixels."

The images are so huge that they are hard to display on computer screens at full resolution. Roger Smith, the team's technical lead at Caltech, has calculated that it would take 72 ultra-high-definition monitors to display one of ZTF's images at full resolution. "I'd like to build that so we can really see the glory of ZTF's full resolution," says Smith, who has been working on the project along with Dekany, Kulkarni, and many others since it received funding from the National Science Foundation (NSF) in 2014.

About half of ZTF is funded by the NSF; the rest comes from its partners, including the Weizmann Institute for Science, the Oskar Klein Center at Stockholm University, the University of Maryland at College Park, the University of Washington, the Deutsches Elektronen-Synchrotron, Humboldt University, Los Alamos National Laboratory, the TANGO Consortium of Taiwan, the University of Wisconsin at Milwaukee, and Lawrence Berkeley National Laboratory.

ZTF images will be adjusted, cleaned, and calibrated at Caltech's astronomy and data center known as IPAC. IPAC software will search the flood of data generated by ZTF for light sources, in particular those that change or move. These data will be made public to the entire astronomy community.

"The data archive will grow by 4 terabytes of data each night," says George Helou, the executive director of IPAC and a co-investigator on the NSF grant. "This is a unique project promising new types of discoveries."

Other NSF co-investigators include Caltech's Tom Prince, the Ira S. Bowen Professor of Physics, and Bryan Penprase, dean of faculty at Soka University of America. ZTF's project scientist is Matthew Graham of Caltech.

Smith says that designing and building ZTF to capture such large images was particularly challenging given that the camera itself has to fit into a relatively small 70-year-old telescope tube. "The camera obstructs the light passing through the telescope toward the primary mirror, so we had to keep its size down while also maximizing the amount of sky it can observe," he says.

ZTF's new first-light image is a taste of what's to come. It showcases the large scale of the images and highlights the turbulent star-forming nebula known as Orion.

Astronomers are excited for the unexpected findings to come. One of the Palomar Transient Factory's biggest discoveries came in 2011 when it caught a supernova, named SN 2011fe, just hours after it had exploded. ZTF will further expand our knowledge of young supernovas along with a host of other cosmic objects, including planets around young stars, exotic binary star systems, and near-Earth asteroids.

"ZTF will survey the dynamic universe unlike ever before," says Mansi Kasliwal, assistant professor of astronomy at Caltech and a member of the ZTF team. "With its immense survey speed, ZTF can look at moving objects in the solar system, such as near-Earth asteroids, as well as cataclysmic eruptions of stars flickering in our own Milky Way galaxy. ZTF will find supernova explosions in faraway galaxies and even find electromagnetic counterparts to gravitational-wave sources detected by LIGO. It's going to give us a treasure trove of discoveries." Kasliwal notes that the gravitational-wave counterparts, once identified using ZTF, can be studied in detail using the Global Relay of Observatories Watching Transients Happen (GROWTH) project, led by Kasliwal.

In the future, even larger surveys will build on ZTF's rapid scans of the sky; these surveys include the upcoming Large Synoptic Survey Telescope (LSST), scheduled to be operational in 2023. "ZTF will be 10 times faster than the Palomar Transient Factory, while the upcoming LSST will be 10 times faster than ZTF," says Kulkarni. "ZTF is a step toward the future."

ZTF's science survey phase is scheduled to begin in February of 2018. The project will be completed by the end of 2020.

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