ISSUE 01
MARCH 2011

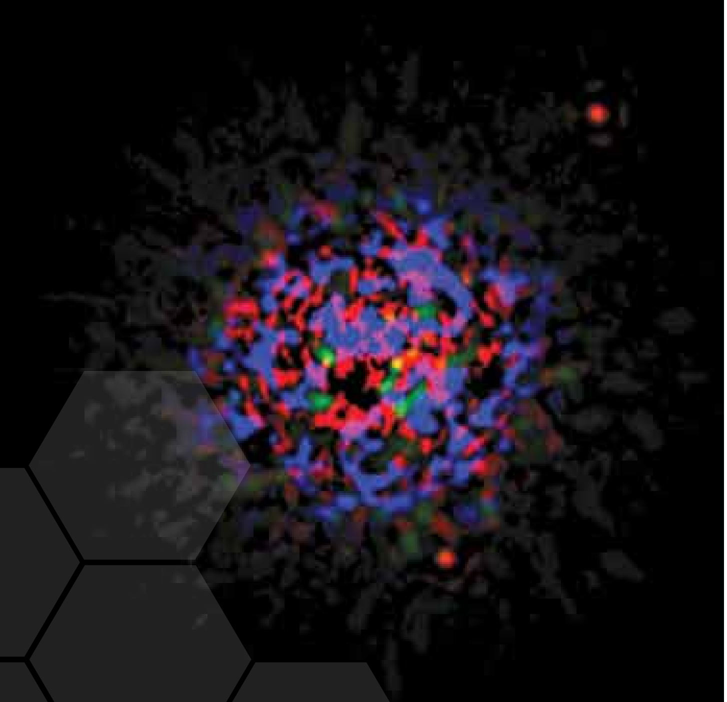
TMT SEGMENTS

QUARTERLY NEWS OF THE THIRTY METER TELESCOPE OBSERVATORY CORPORATION

IN THIS ISSUE

TMT SEGMENTS

ISSUE 01
MARCH 2011



Nature of Planets Around Distant Stars
Description of this image on page 7

Cover image: Dana Berry

TMTSEGMENTS
1111 South Arroyo Parkway, Suite 200
Pasadena, California 91105
USA

626 395 1602 telephone
www.tmt.org
info@tmt.org

Quarterly News of the TMT Observatory Corporation

Managing Editor
Charles E. Blue

Contributing Writers
Gary Sanders
TMT Project Manager

Garth Illingworth
University of California, Santa Cruz

Paul Gillett
Facilities Department Head

Design & Production
Sandbox Studio
Chicago, Illinois

PROJECT MANAGER'S CORNER: MAKING YOUR OWN STARS

Gary Sanders, *TMT Project Manager*

The image below is dramatic! The Gemini South Observatory in Chile has just made a major step in pioneering the kind of adaptive optics that TMT will use. Launching five laser beams from the top of the Gemini South 8-meter telescope, they have succeeded in creating a manmade five-star constellation about 90 kilometers above the Earth. At that altitude, a layer of sodium ions is excited by the light of a particular color.

Gemini used the desired wavelength of 589 nanometers and achieved this striking result.

Left image shows a 5 guide star constellation courtesy of Gemini Observatory.

While this is a beautiful image, how does it fit into the adaptive optics that Gemini and TMT will both use? We have written about adaptive optics in previous issues of Segments. To recap, to remove the blurring caused by the Earth's atmosphere, light from a sharp "guide" star near a science object to be studied is measured by a sensor placed at the image from the telescope. This sensor measures the distortion of the wavefront from the known sharp guide star and this measurement is sent to a fast computer that sends commands to a deformable mirror that applies the opposite distortion to the image of the science object. The result is a sharp image of the science object. This sensing and correcting is carried out about 1,000 times per second. This is the basic method used in adaptive optics.

But there is a problem. What if there is no sharp guide star near the science object so this trick cannot be performed? Indeed, when this occurs adaptive optics cannot be used. The solution is to launch a laser beam from the telescope to create an artificial guide star near the science object.

This technique has been used by a number of telescopes, notably by the Lick, Palomar, Keck, Gemini, Subaru, and VLT observatories.

But there is another problem. Launching a single laser beam creates one guide star. That permits the adaptive optics system to correct the image near the guide star. This is because the optical distortions in the atmosphere correspond to turbulent thermal cells in the atmosphere and these cells have a certain size. You

STORY CONTINUES ON PAGE 7

FEATURE: THE MOST DISTANT AND EARLIEST GALAXIES

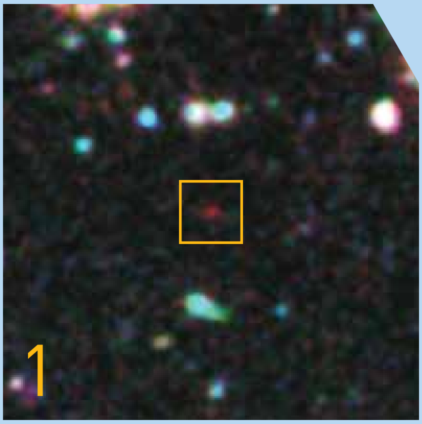
By Garth Illingworth and Rychard Bouwens

The first stars and tiny galaxies formed about 150-300 million years after the Big Bang, 13.7 billion years ago. They were the seeds that led to today's myriad galaxies, including our own Milky Way. But the details of when and how they developed are still unclear.

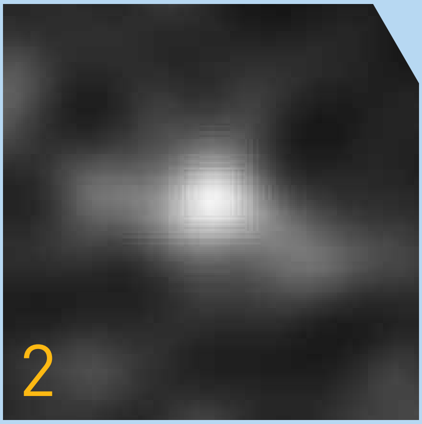
For decades, astronomers have been studying galaxies, nearby and distant, using evermore powerful telescopes. The Keck telescope dramatically enhanced our ability to characterize galaxies when it came on-line in the early 1990s, doing extensive studies of galaxies more than 12 billion light-years away. In addition, another telescope that has truly revolutionized our knowledge of the earliest galaxies is the Hubble Space Telescope. It has pushed back the frontier into the first billion years after the Big Bang.

This is a key period in the evolution of the universe. It is when the cosmos was transformed from the dark ages to one filled with (initially tiny) galaxies, and when the pervasive neutral hydrogen gas became ionized. This "reionization" was likely linked to the dramatic increases in the starbirth that occurred in the newly forming galaxies. Galaxies are suspected of causing the reionization through the ultraviolet light from their young blue stars. However, the role of galaxies

Above left photo: Jim MacKenzie; right photo courtesy of Garth Illingworth



The furthest galaxy yet seen, looking back in time 13.2 billion years, appears as a fuzzy red blob (magnified in 2).



This fuzzy galaxy is forming just 500 million years after the Big Bang when the universe was just 4% of its current age.

Images courtesy of NASA, ESA, G. Illingworth (University of California, Santa Cruz), R. Bouwens (University of California, Santa Cruz, and Leiden University), and the HUDF09 Team

Opposite page: The deepest infrared image ever taken of the universe using Hubble's new camera.

remains enigmatic. Our current measurements show that galaxies played a role but just don't seem to have the "oomph" (didn't emit enough ultraviolet light) to carry out all the reionization.

During the last decade we discovered more and more galaxies at this very early epoch. Only a few were known in 2002 when the Advanced Camera was installed in Hubble. Within four years of this new camera being installed on Hubble we found more than 500 such galaxies at 950 million years after the Big Bang, but only a few were known earlier than this time. Then a new infrared camera was placed on Hubble by the astronauts in 2009. Within months, this camera was able to discover more than 100 new galaxies as they were seen 600-800 million years after the Big Bang.

But we have been trying to go to even earlier times, closer to the first stars and galaxies and into a period when reionization was peaking. Just recently we reported in Nature on the discovery of a galaxy that is most likely to be forming and growing around 500 million years after the Big Bang. This is plausibly the most distant object ever seen. It was found in a Hubble image that is deepest ever taken of the universe in the infrared. The light from this young galaxy has taken 13.2 billion years to reach us. That is, we are seeing this galaxy as it was 13.2 billion years ago, when the universe was just four percent of its current age. This galaxy is tiny, about one-twentieth the size and just one percent of the mass of our Milky Way galaxy. But it is important for setting the stage for what the universe was like at such an early time.

It is tough to study galaxies when the universe was young. While we have made great progress with our current telescopes, and will make more over the next few years, new far more powerful telescopes are needed. Two new telescopes will make a huge impact. The 6.5 meter James Webb Space Telescope is the successor to Hubble and it will explore the epoch of the first stars and galaxies in the few hundred million years after they began to form.

The tiny size of these young galaxies tells us that the Thirty Meter Telescope (TMT) with its powerful adaptive optics will also play a decisive role in helping us understand much more about how these young galaxies are forming stars and influencing the universe around them.

To learn more see www.firstgalaxies.org

Photo courtesy of Hubblesite.org, NASA

Image: Dana Berry

TMT at the AAS and the AAAS

The Thirty Meter Telescope (TMT) was well represented at the January 2011 American Astronomical Meeting in Seattle, Washington. Volunteers from Caltech and the University of California staffed TMT's new exhibit booth, answered questions from the community and distributed TMT's latest brochures. (See "Elevator Talk Brochure" and "TMT General Information Brochure" on www.tmt.org.) Caltech astronomer S. George Djorgovski also highlighted the potential of TMT during an American Astronomical Society press conference on black hole research.

The TMT also cosponsored the Science Writers Reception at the American Association for the Advancement of Science (AAAS) meeting on February 19. Approximately 500 reporters and guests attended this event at the House of Sweden in Washington, D.C. The event was organized by the D.C.-area Science Writers Association.

Science Segments

To keep the astronomical community well informed about TMT's latest milestones and to build interest among the public, TMT is now producing its own series of audio podcasts called Science Segments. These podcasts, with new episodes appearing about once a month, cover new results in astronomy, the technology of telescopes, and other topics related to TMT's science mission and engineering innovations. You can find Science Segments on the TMT homepage.

TMT Hawaii Update

The University of Hawaii has applied for a Conservation District Use Permit (CDUP) to build and operate the Thirty Meter Telescope (TMT) on Mauna Kea. The permit was approved by the Board of Land and Natural Resources (BLNR) of Hawaii's Department of Land and Natural Resources (DLNR). The CDUP is the conclusion in what has been a multi-year process that began in July of 2009 when TMT's Board of Directors selected Mauna Kea as the preferred site for the telescope. The next step is a sublease from the University of Hawaii, which leases the Astronomy Precinct lands from the DLNR.

New Renderings Reveal Planned Design for TMT

Following the successful conclusion of the Thirty Meter Telescope's Environmental Impact Statement and Final Design Review of the observatory enclosure, TMT worked with acclaimed science animator and producer Dana Berry on a new, more accurate set of renderings of the observatory and its support building as they will appear on Mauna Kea.

These renderings accurately portray the observatory with a reflective dome. This aluminized coating was selected to help the observatory maintain a constant temperature and to blend in with the surrounding environment. The dome will reflect the color of the local lava field during the warmer months and will appear white when snow covers the top of the mountain.

Gold Medal of RAS Goes to Richard Ellis

Richard Ellis, a founding member of the Thirty Meter Telescope's (TMT) Board of Directors and a member of the TMT Science Advisory Committee, has received the Gold Medal of the Royal Astronomical Society. Awarded annually since 1824, the Gold Medal is the Society's highest honor and one of the premier prizes in astronomy. Ellis is cited for having "...been one of the most influential British astronomers in the past thirty years," and the Gold Medal recognizes his "outstanding personal research achievements and his leadership in astronomy."

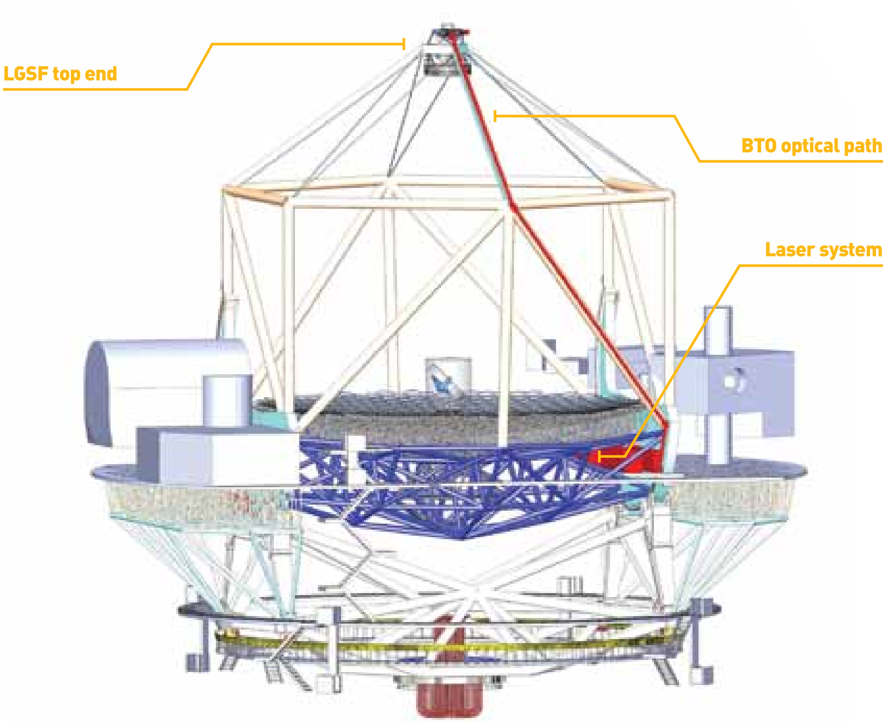
Photos courtesy of TMT, Dana Berry and Caltech

STORY CONTINUED FROM PAGE 3

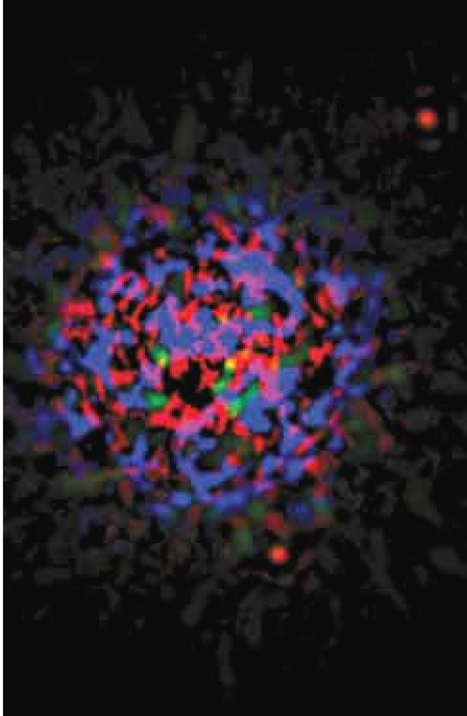
can correct for the atmospheric turbulence only nearby the guide star image. What if you want to correct a wider region of the image from the telescope? The solution is to use multiple deformable mirrors and several guide stars near or surrounding your science object image. This is a constellation and it is what Gemini has now done.

The Gemini image on page 3 clearly shows five stars. TMT will start its observing with six guide stars and will progress to nine artificial stars. By doing this and by using multiple sensor/deformable mirror combinations, the images will be sharpened over a wide visual field, sweeping away the distortions of the Earth's atmosphere. This is Multi Conjugate Adaptive Optics, a complex name for using an artificial constellation and doubling the adaptive optics system and making it all work together.

TMT will use six small 20-watt lasers mounted down on the elevation bearings of the telescope (see the image below) and will transport the light up the side of the telescope to the back of the secondary mirror. A "launch" telescope will send the six beams to their 90 kilometer destination. We are designing the detailed optics for this system now. The design is being carried out by our collaborators from the Institute of Optics and Electronics in Chengdu, China, a part of the Chinese Academy of Sciences. Both in China and in Pasadena, we found the Gemini image to be inspiring.



LGSF image
Image courtesy of the TMT Observatory Corporation

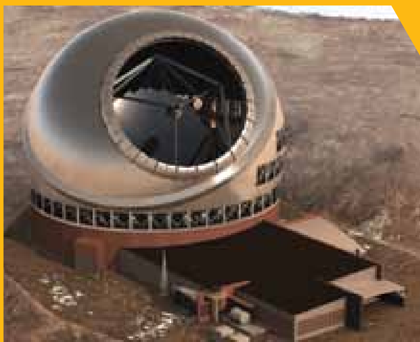


Science Case for TMT: Nature of Planets Around Distant Stars

More than 1,000 planets have been detected orbiting distant stars. The vast majority of these planets are gas giants larger than Jupiter. Smaller rocky worlds have also been discovered, including some potentially in their star's habitable zone. With TMT's sensitivity and resolution, astronomers will be able to detect more planets, bringing us closer to eventually detecting a true analog of Earth.
Image courtesy of Keck Observatory

TECHNOLOGY CORNER

Design Review for TMT's Calotte Enclosure



In the first week of December 2010, an expert panel of reviewers met at the new Thirty Meter Telescope (TMT) project office on Arroyo Parkway in Pasadena to perform the Final Design Review of TMT's Calotte Enclosure. TMT's calotte telescope enclosure is made up of a rotating base over a fixed base, a circular aperture in a cap structure mounted on an inclined track, and a cap cover, giving the observatory its distinctive appearance.

As with TMT staff, the review panel included people with extensive experience designing, constructing and operating large observatories, including some of those on Mauna Kea. The panel reviewed the current progress of DSL's enclosure design and evaluated its readiness to move into the detailed design phase and preparation of fabrication drawings—the last step before metal is actually cut and fabrication begins.

The key finding of the review panel is that indeed the enclosure design is ready to move forward. The panel members also made a number of recommendations that will be included in the detailed design. These ranged from reminders of the thin air on Mauna Kea and the importance of personnel lifts to how to ensure quality control and safety throughout the design, fabrication, and on-site construction of the observatory.

The calotte concept is not a new approach for enclosure designs and was selected because it had certain advantages over other potential designs. The calotte design is the most compact, which corresponds to a lower cost, and its smooth exterior, even while open for observing, is significantly less affected by unbalanced wind forces and should shed snow and ice much more quickly than other enclosure concepts.

The unprecedented size of the TMT enclosure, being well beyond those of existing enclosures made an expert panel review essential because it provided an independent look at the design choices that were made.

The TMT observatory is pleased with the panel's findings and is grateful to the panel members for the comments and suggestions the panel made.

By Paul Gillett
Facilities Department Head

Want to learn more?

Find us on the web at: **www.tmt.org**

Find us on Facebook (look for the "official" TMT page) and TMTHawaii on Twitter.

UPCOMING EVENTS

218th AAS Meeting
May 22–26, 2011
Boston, Massachusetts

The 218th annual meeting of the American Astronomical Society (AAS) will be held on May 22–26, 2011, at the Westin Copley Place in Boston, Mass. This meeting will be held in conjunction with the American Association of Variable Star Observers (AVSSO). For more information see: aas.org/meetings/aas218/

SPIE Optics + Photonics 2011
August 21–25, 2011
San Diego, California

SPIE Optics + Photonics is the largest interdisciplinary technical conference in North America covering the latest news and research in solar, nano, optical, photonics, and space optics research. For more information see: spie.org/x30491.xml