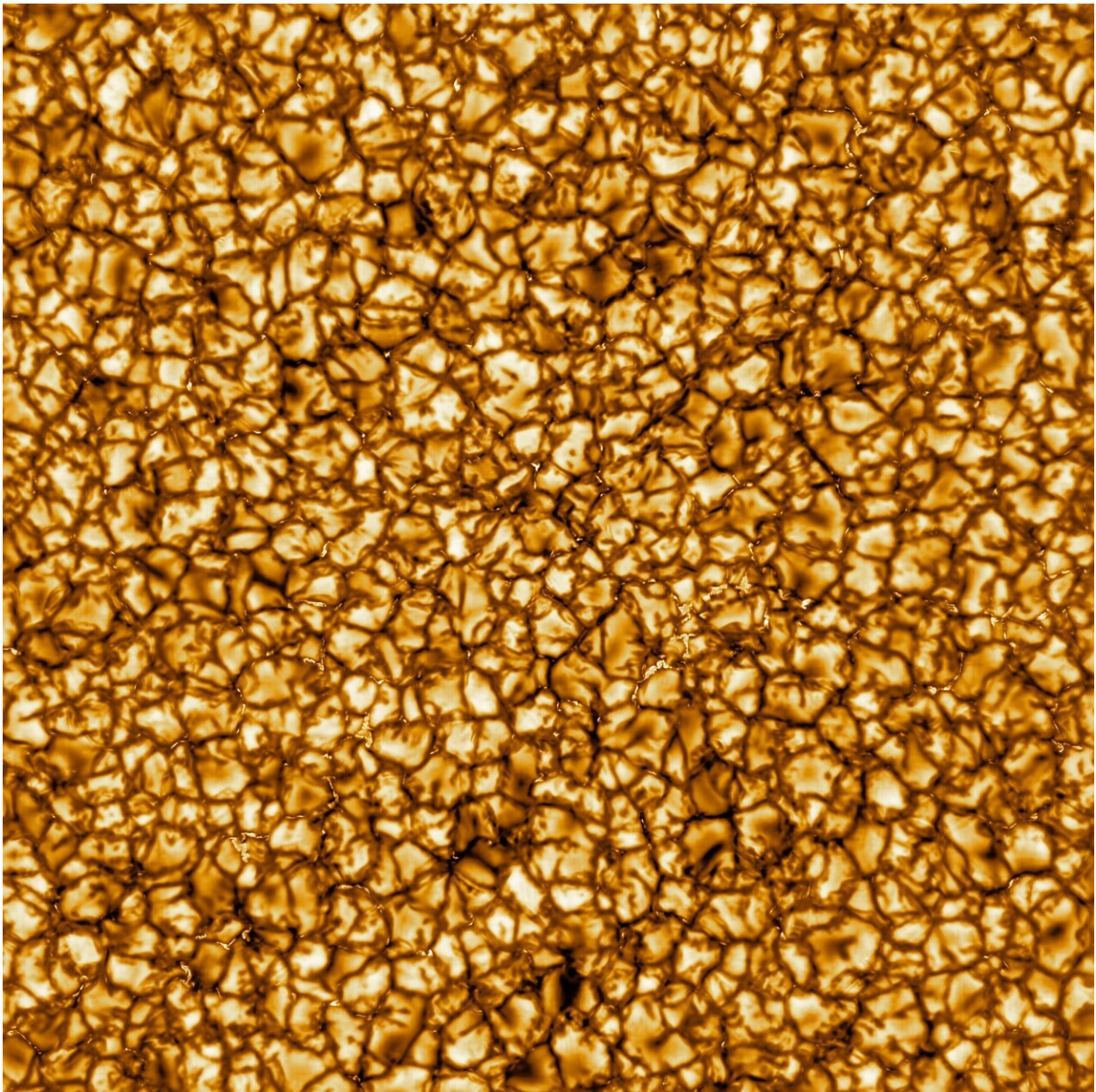


# NSF's newest solar telescope produces first images, most detailed images of the sun

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The Daniel K. Inouye Solar Telescope has produced the highest resolution image of the sun's surface ever taken. In this picture, taken at 789 nanometers (nm), we can see features as small as 30km (18 miles) in size for the first time ever. The image shows a pattern of turbulent, "boiling" gas that covers the entire sun. The cell-like structures -- each about the size of Texas -- are the signature of violent motions that transport heat from the inside of the sun to its surface. Hot solar material (plasma) rises in the bright centers of "cells," cools off and then sinks below the surface in dark lanes in a process known as convection. In these dark lanes we can also see the tiny, bright markers of magnetic fields. Never before seen to this clarity, these bright specks are thought to channel energy up into the outer layers of the solar atmosphere called the corona. These bright spots may be at the core of why the solar corona is more than a million degrees. Credit: NSO/AURA/NSF

Just released first images from the National Science Foundation's Daniel K. Inouye Solar Telescope reveal unprecedented detail of the sun's surface and preview the world-class products to come from this preeminent 4-meter solar telescope. NSF's Inouye Solar Telescope will enable a new era of solar science and a leap forward in understanding the sun and its impacts on our planet.

Activity on the sun, known as [space weather](#), can affect systems on Earth. Magnetic eruptions on the sun can impact air travel, disrupt [satellite communications](#) and bring down power grids, causing long-lasting blackouts and disabling technologies such as GPS.

This first images from NSF's Inouye Solar Telescope show a close-up view of the sun's surface, which can provide important detail for scientists. The image shows a pattern of turbulent "boiling" plasma that covers the entire sun. The cell-like structures—each about the size of Texas—are the signature of violent motions that transport heat from the inside of the sun to its surface. That hot solar plasma rises in the bright

centers of "cells," cools off and then sinks below the surface in dark lanes in a process known as convection. (See video available with this news release.)

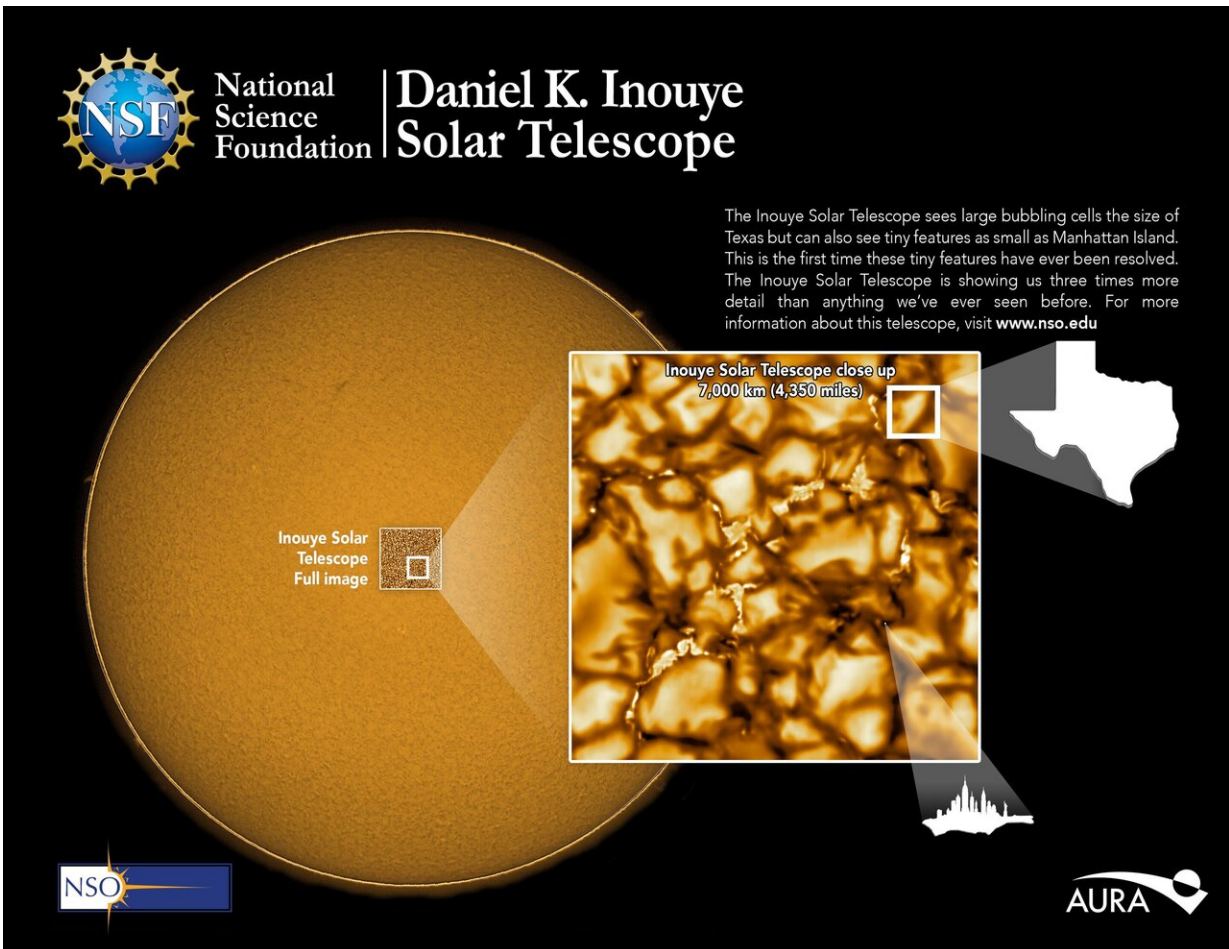
"Since NSF began work on this ground-based telescope, we have eagerly awaited the first images," said France Córdova, NSF director. "We can now share these images and videos, which are the most detailed of our sun to date. NSF's Inouye Solar Telescope will be able to map the magnetic fields within the sun's corona, where solar eruptions occur that can impact life on Earth. This telescope will improve our understanding of what drives space weather and ultimately help forecasters better predict solar storms."

## **Illuminating what we know about our nearest star**

The sun is our nearest star—a gigantic nuclear reactor that burns about 5 million tons of hydrogen fuel every second. It has been doing so for about 5 billion years and will continue for the other 4.5 billion years of its lifetime. All that energy radiates into space in every direction, and the tiny fraction that hits Earth makes life possible. In the 1950s, scientists figured out that a solar wind blows from the sun to the edges of the solar system. They also deduced for the first time that we live inside the atmosphere of this star. But many of the sun's most vital processes continue to confound scientists.

"On Earth, we can predict if it is going to rain pretty much anywhere in the world very accurately, and space weather just isn't there yet," said Matt Mountain president of the Association of Universities for Research in Astronomy, which manages the Inouye Solar Telescope. "Our predictions lag behind terrestrial weather by 50 years, if not more. What we need is to grasp the underlying physics behind space weather, and this starts at the sun, which is what the Inouye Solar Telescope will study over the next decades."





The NSF's Inouye Solar Telescope images the sun in more detail than we've ever seen before. The telescope can image a region of the sun 38,000km wide. Close up, these images show large cell-like structures hundreds of kilometers across and, for the first time, the smallest features ever seen on the solar surface, some as small as 30km. Background image: NSO Integrated Synoptic Program/GONG. Credit: NSO/AURA/NSF

Solar magnetic fields constantly get twisted and tangled by the motions of the sun's plasma. Twisted magnetic fields can lead to solar storms that can negatively affect our technology-dependent modern lifestyles.

During 2017's Hurricane Irma, the National Oceanic and Atmospheric Administration reported that a simultaneous space weather event brought down radio communications used by first responders, aviation and maritime channels for eight hours on the day the hurricane made landfall.

Finely resolving these tiny magnetic features is central to what makes the Inouye Solar Telescope unique. It can measure and characterize the sun's magnetic field in more detail than ever seen before and determine the causes of potentially harmful solar activity.

"It's all about the magnetic field," said Thomas Rimmele, director of the Inouye Solar Telescope. "To unravel the sun's biggest mysteries, we have to not only be able to clearly see these tiny structures from 93 million miles away but very precisely measure their [magnetic field](#) strength and direction near the surface and trace the field as it extends out into the million-degree corona, the outer atmosphere of the sun."

Better understanding the origins of potential disasters will enable governments and utilities to better prepare for inevitable future space weather events. It is expected that notification of potential impacts could occur earlier—as much as 48 hours ahead of time instead of the current standard, which is about 48 minutes. This would allow for more time to secure power grids and critical infrastructure and to put satellites into safe mode.

## **The engineering**

To achieve the proposed science, this telescope required important new approaches to its construction and engineering. Built by NSF's National Solar Observatory and managed by AURA, the Inouye Solar Telescope combines a 13-foot (4-meter) mirror—the world's largest for a [solar telescope](#)—with unparalleled viewing conditions at the 10,000-foot

Haleakalā summit.

Focusing 13 kilowatts of solar power generates enormous amounts of heat—heat that must be contained or removed. A specialized cooling system provides crucial heat protection for the telescope and its optics. More than seven miles of piping distribute coolant throughout the observatory, partially chilled by ice created on site during the night.

The dome enclosing the telescope is covered by thin cooling plates that stabilize the temperature around the telescope, helped by shutters within the dome that provide shade and air circulation. The "heat-stop" (a high-tech, liquid-cooled metal donut) blocks most of the sunlight's energy from the main mirror, allowing scientists to study specific regions of the sun with unparalleled clarity.

The telescope also uses state-of-the-art adaptive optics to compensate for blurring created by Earth's atmosphere. The design of the optics ("off-axis" mirror placement) reduces bright, scattered light for better viewing and is complemented by a cutting-edge system to precisely focus the telescope and eliminate distortions created by the Earth's atmosphere. This system is the most advanced solar application to date.

"With the largest aperture of any solar telescope, its unique design, and state-of-the-art instrumentation, the Inouye Solar Telescope—for the first time—will be able to perform the most challenging measurements of the sun," Rimmele said. "After more than 20 years of work by a [large team](#) devoted to designing and building a premier solar research observatory, we are close to the finish line. I'm extremely excited to be positioned to observe the first sunspots of the new solar cycle just now ramping up with this incredible telescope."

## **Ushering in a new era of solar astronomy**

NSF's new ground-based Inouye Solar Telescope will work with space-based solar observation tools such as NASA's Parker Solar Probe (currently in orbit around the sun) and the European Space Agency/NASA Solar Orbiter (soon to be launched). The three solar observation initiatives will expand the frontiers of solar research and improve scientists' ability to predict space weather.

"It's an exciting time to be a solar physicist," said Valentin Pillet, director of NSF's National Solar Observatory. "The Inouye Solar Telescope will provide remote sensing of the outer layers of the sun and the magnetic processes that occur in them. These processes propagate into the solar system where the Parker Solar Probe and Solar Orbiter missions will measure their consequences. Altogether, they constitute a genuinely multi-messenger undertaking to understand how stars and their planets are magnetically connected."

"This image is just the beginning," said David Boboltz, program director in NSF's division of astronomical sciences and who oversees the facility's construction and operations. "Over the next six months, the Inouye telescope's team of scientists, engineers and technicians will continue testing and commissioning the telescope to make it ready for use by the international solar scientific community. The Inouye Solar Telescope will collect more information about our sun during the first 5 years of its lifetime than all the solar data gathered since Galileo first pointed a telescope at the sun in 1612."

On December 15, 2013 the [telescope](#) formerly known as the Advanced Technology Solar Telescope was renamed the Daniel K. Inouye Solar Telescope in honor of the late senator from Hawaii. Senator Inouye was a tireless proponent of science, technology, engineering and math, especially when it came to enriching the lives of the people of Hawaii. NSF's Inouye Solar Telescope, located on Haleakala on the Island of Maui, Hawaii, will provide a state-of-the-art scientific and educational

resource for Hawaiians and the entire global community for the next 50 years.

Provided by National Science Foundation

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