Frequently Asked Questions about the Inouye Solar Telescope

What does the Inouye Solar Telescope do that other telescopes don't?

The NSF's Daniel K. Inouye Solar Telescope is ground-breaking in more ways than one. Its thirteen-foot main mirror will collect more sunlight than any other solar telescope in the world. This means it will give us the highest resolution, sharpest, images of the Sun ever taken. The Inouye Solar Telescope employs a combination of a unique "off-axis" telescope design, to reduce scattered light, and cutting-edge techniques for measuring light filtered by the sun's magnetic fields, to produce the first ongoing measurements of magnetic fields in our Sun's atmosphere, or "corona".

Specifically, the telescope will provide daily measurements of the sun's inner corona, a region normally only observable during a solar eclipse. Providing this type of polarized data across the sun's atmosphere allows scientists to study its magnetic field at the fundamental scale that physical processes are taking place. This is key in better understand how magnetic fields are created and destroyed. Understanding these processes is essential in providing a platform for the development of new and improved instrumentation as we continue to learn more about our star.

Why do we need the Inouye Solar Telescope?

We live in the atmosphere of a star, the Sun. It has a tremendous influence on our lives, affecting everything from the food we eat, to the technology we depend on. The Inouye Solar Telescope is key in understanding the physics of the sun, what drives it and how it evolves. The telescope will enable scientists to study the magnetic field of the Sun in a way that no other solar telescope has before. We know the magnetic field is an essential part of the Sun's dynamic behavior, but there is still much we don't know about how this magnetism changes. Understanding this is key in making predictions about how the sun has behaved in the past, how it will behave in the future, and the effects it will have. In addition to all that, what we learn from the Inouye Solar Telescope will guide us in our understanding of how the sun and other stars affect the climate of their planets over long timescales, timescales of the cosmos.

Why do telescopes need big mirrors? Why is more light better?

A bigger mirror is better for the same reason that your pupils get bigger in the dark. The larger your pupils get, the more light they capture. This helps you see as best as you can under conditions where light is limited. Larger mirrors and apertures in telescopes work in a similar way. They catch more light to help us see very faint and distant objects. With the Inouye Solar Telescope, every ray of light is precious. The sunlight is divided between multiple instruments so that we can collect data in many different ways at the same time.

Why didn't we make the mirror bigger, to see even more?

Collecting solar light means collecting a lot of heat! As it is, one of the major technological challenges of the Inouye Solar Telescope is dealing with the heat. Making the mirror bigger means collecting more solar light and therefore even more heat! The size of the observatory's mirror — almost 14-ft — strikes a good balance between controlling the heating challenges, and giving us amazing data. As it is, the main mirror has *seven times* the collecting area of the next largest solar telescope!

How does studying the Sun tell us about the properties of other stars?

The Sun is the only star in the whole universe whose surface we can currently see in any kind of detail. It is close enough to us here on Earth that we can see its sunspots and filaments, its flares and its eruptions. Of course, the Sun is only one of billions of stars, but learning what we can from the Sun helps us to understand the physical characteristics of other stars such as their magnetism, atmosphere, and stellar activity levels.

Why build on Haleakalā?

Haleakalā is a high-elevation, shield volcano surrounded by ocean. This unique geography offers a site 10,023 feet above the clouds, with a clear blue sky and a stable atmosphere that is relatively free of dust. Haleakalā a particularly special location for solar astronomy. These winds bring cool air from the northeast and provide optimal wind-flow over the mountain. The winds are laminar, or smooth, with low levels of turbulence. Turbulence caused by Earth's ever-changing weather distorts lightrays from moment to moment. This distortion is what causes the twinkle of distant stars. But, the stars don't "twinkle" the same on Haleakalā.

How did they get the telescope into the dome?

The Telescope Mount Assembly (TMA) – the top end of the Inouye Solar Telescope – was designed and built by Ingersoll Machine Tools, a manufacturer located in Rockford, Illinois. The TMA was built from the ground up in the Ingersoll facility. Once tested and found to meet the required specifications, the TMA was dismantled and shipped across the ocean to Hawai'i. The TMA parts were lifted to the dome using a hydraulic lift outside of the facility. Like a ship in a bottle, the TMA was reassembled inside of the dome.

How do they coat the mirror so precisely?

The main mirror has a very thin (about a thousandth the thickness of a human hair!) aluminum coating that provides a highly reflective surface for collecting precious light particles. To ensure the even distribution of light, the mirror needs to be coated very precisely. First, the mirror is cleaned in several stages, which includes a mild soap wash, followed by a chemical scrub and acid rinse. Next, after a thorough rinse with deionized water, the glass is dried with cleanroom wipers and given a final buff with pure ethanol. In the final cleaning stage, a small amount of Argon gas is introduced to the coating chamber to create a plasma that ionically cleans the mirror. Once cleaned and inspected, the aluminum is heated slowly until it liquifies, and then vaporizes. The aluminum vapor fills the coating chamber and coats everything in its path, including the mirror surface and walls of the chamber. In only about 15 seconds, the required thickness is reached and the primary mirror is aluminized!

How do we measure magnetic field lines just by collecting light?

Like on Earth, magnetic field lines on the Sun are invisible, and so we can't observe them directly. However, the solar atmosphere is made up of ionized, or charged, gases called plasma that become intertwined with the solar magnetic fields throughout the solar atmosphere. The plasma emits light that is filtered by the magnetic fields. The instruments of the Inouye Solar Telescope observe this emitted light and measure just how much the light is polarized. Using physics and mathematics, scientists can then calculate the strength and direction of the magnetic field near where the light was emitted.

How do pictures of the Sun give us data on its properties?

Images from the Sun are collected using specialized cameras that allow only certain wavelengths, or colors of light into the cameras. We know that certain wavelengths are produced by plasma of a specific temperatures and heights in the Sun's atmosphere. Therefore, the features we observe in those wavelengths can be assumed to be those temperatures and heights. For example, we know that a dark patch in a H-alpha image means there is likely to be cool gas there, absorbing the light we're trying to capture, and making that patch dark. By studying the difference in brightness across the image, and how the image changes with time (e.g. a video sequence), we can get a detailed understanding of the dynamics happening on the Sun.

Who gets to use the Inouye Solar Telescope?

Scientists from all over the world will be allowed to apply to take observations with the Inouye Solar Telescope. However, the telescope will be operated only by team of expert "Telescope Operators" and scientists. The operators are given guidance on what to observer, when and how, by the "Time Allocation Committee", or TAC – a group of solar science experts from both NSO and across the wider solar science community. The TAC review the applications from solar scientists and prioritize them using a wide range of factors.

How does light get through the telescope?

The first thing incoming light will see is the main or “Primary” mirror. This is the large 4-meter mirror that the Inouye is famous for. Next of all, the light is focused onto a very hot spot, where the “heat stop” is placed. This is a vital element of the system that rejects the majority of the heat making it safe to pass the rest of the light into the system without damaging the delicate optics. The light is passed through the telescope using a number of essential mirrors which prepare the light for the Inouye’s cameras. The light is directed downward into the instrument, or “Coudé” Lab where it is carefully divided up using the Facility Instrument Distribution Optics, or FIDO. FIDO consists of a series of specialized optics, such as beamsplitters, windows, and mirrors. By arranging these optical tools in different ways, different portions of the incoming solar light get fed into different scientific cameras.

How do they keep the mirrors from melting or deforming?

Pointing a 13-foot, (4-meter) mirror directly at the Sun presents many challenges, not the least of which, is controlling the heat. This requires innovative cooling strategies to avoid damaging delicate telescope equipment and mirrors. More than seven miles of piping distribute coolant throughout the observatory. The coolant – dynalene – is partly chilled by ice, which is created at the observatory during the night. The coolant is distributed throughout the observatory and is fed across the back of the first two mirrors – the ones most susceptible to high temperatures.