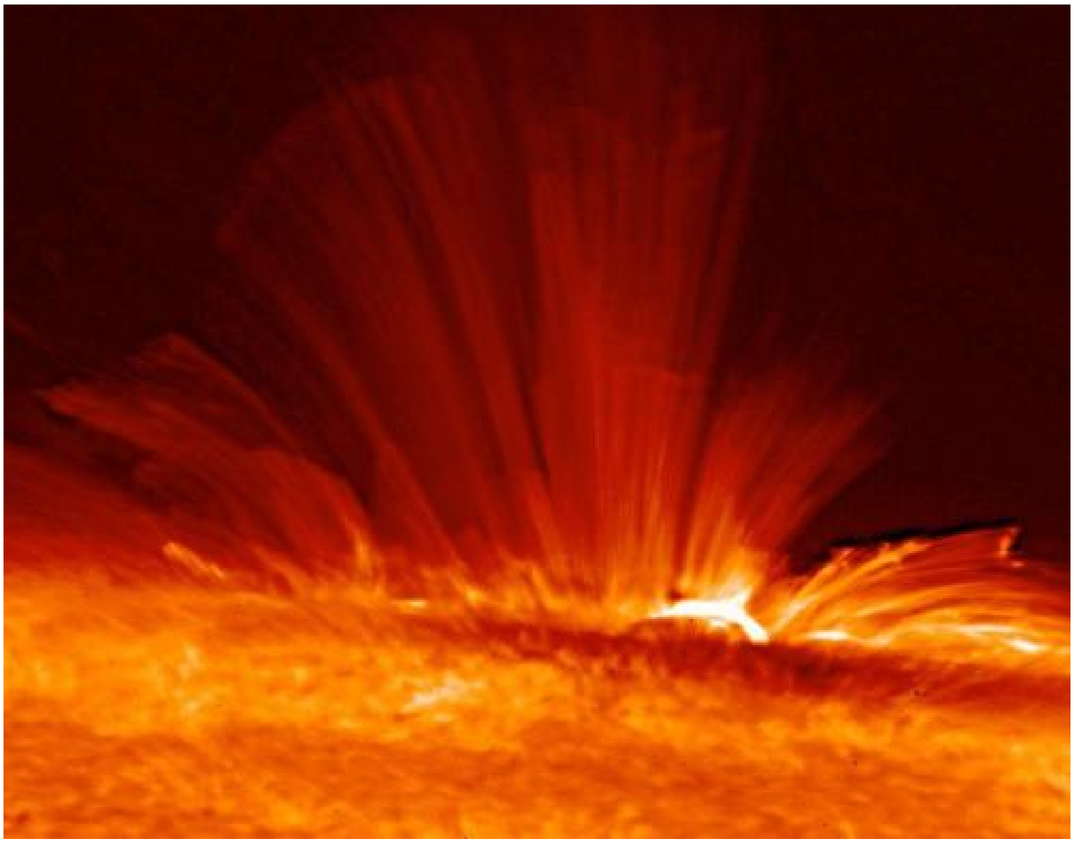
Hinode's first light... and five more years

November 2 2011, By Karen C. Fox



Vivid orange streamers of super-hot, electrically charged gas (plasma) arc from the surface of the Sun, revealing the structure of the solar magnetic field rising vertically from a sunspot. This extremely detailed image of the Sun was taken by Hinode's Solar Optical Telescope on November 20, 2006 and showed that the Sun’s magnetic field was much more turbulent and dynamic than previously known. Credit: Hinode, JAXA/NASA

(PhysOrg.com) -- On October 28, 2006, the Hinode solar mission was at last ready. The spacecraft launched on September 22, but such missions require a handful of diagnostics before the instruments can be turned on and collect what is called "first light."

Hopes were high. Hinode had the potential to provide some of the highest resolution images of the sun the world had ever seen -- as well as help solve such mysteries as why the sun's atmosphere is a thousand times hotter than its surface and how the magnetic fields roiling through the sun create dramatic explosions able to send energy to the farthest reaches of the solar system.

The X-ray telescope (XRT) began taking images on October 23, the Solar Optical Telescope (SOT) opened its front door on October 25, and the Extreme Ultraviolet Imaging Spectrometer (EIS) started collecting spectroscopic images on October 28.

The images were beautiful, the data good; first light science had been achieved.

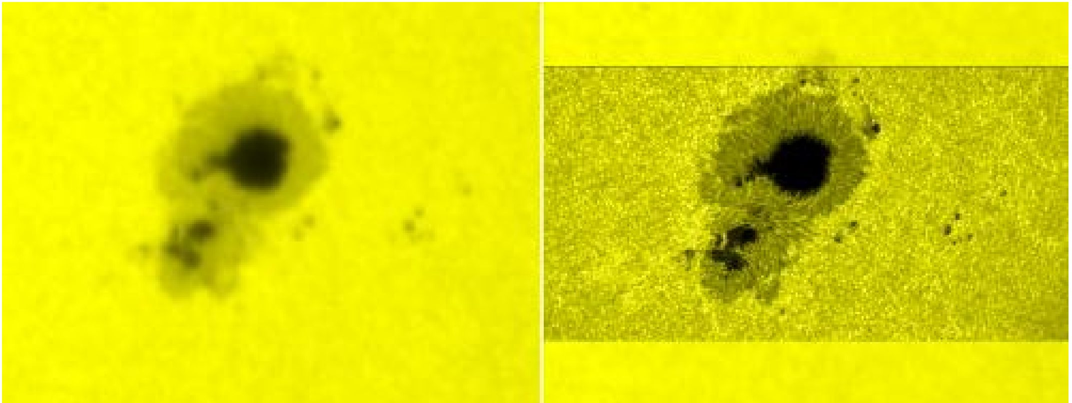
And so started five years in the life of a solar mission that would offer unprecedented details into the dynamics of the sun. Hinode – the word means "sunrise" in Japanese – is a mission led by the Japan Aerospace Exploration Agency (JAXA) with collaboration from NASA and other partners in the US, Europe, and Japan. Its instruments produce fantastic detail of both visible and magnetic features on the sun's surface and in its atmosphere, the corona. Such detail was unprecedented at its launch and still prized today. Hinode has helped find the origin of the solar wind, discovered potential candidates for how the corona gets so hot, and provided images of the complex magnetic structures looping up and out of active regions on the sun.

"One of the most notable contributions Hinode has made," says Jonathan Cirtain the co-investigator for the X-ray Telescope and an astrophysicist at NASA's Marshall Space Flight Center, "is to produce high resolution observations of what the magnetic fields look like on the sun."

The patterns of magnetic fields inside the sun, on its surface, and in the atmosphere give rise to space weather that can traverse billions of miles away from the sun. Previous solar experiments in space could only measure magnetic fields along the line of sight – that is, vertical fields climbing directly up from the sun's surface. But thanks to the Solar Optical Telescope, Hinode can also measure the horizontal component of these fields. The SOT incorporates these detailed magnetic measurements into its white and ultraviolet images of the sun and so has been able to map out complex magnetic loops on the surface of the sun. Most importantly, it offered the first space-based observations of the horizontal magnetic field structure, showing fields that were always on the move and far more dynamic than expected. This, in turn, holds clues to how magnetism deep inside the sun causes the constant change we observe in its atmosphere.

The X-ray Telescope observes million-degree and higher gas. These temperatures are reached in the sun's corona. Observing near the poles at areas of lower magnetism on the sun called coronal holes, the XRT saw ultra-hot, X-ray jets shooting up into the atmosphere. Such things had been seen, but never in such abundances, says Cirtain, who says he was surprised when he first found them.

"After the shock wore off, I ran around dragging other scientists into my office to show them the movie," he says. "It looks like the twinkle of Christmas lights, randomly oriented. It's very pretty."



Sunspot image from December 6, 2006. The left image was taken by the SOlar Heliospheric Observatory (SOHO), which was one of the first tools to monitor the sun from space, launched in 1995. The right image from Hinode's Solar Optical Telescope shows its high resolution. Credit: ESA/NASA/SOHO (left) and JAXA/NASA/Hinode (right)

More than just being pretty, these jets carry huge amounts of material high up into the corona. Scientists found that this extra material could account for some 20 to 25% of the particles that stream away from the sun, known as the solar wind. Understanding this wind is particularly important during solar minimum, when it becomes one of the strongest components of space weather throughout the solar system. Later work showed that these jets contain additional material that can be seen in other wavelengths besides X-rays and so may, in fact, account for all of the solar wind.

The third instrument is the Extreme Ultraviolet Imaging Spectrometer, which has been particularly helpful in trying to understand how the corona can be so much hotter than the sun's surface. The EIS tunes into specific wavelengths of light emitted by different particles in the sun's atmosphere. Since particles at particular temperatures emit light at a specific wavelengths, the spectrometer can be used to track a burst of material at a certain temperature as it moves through this complex system.

"A spectrograph can help you get really precise," says Therese Kucera at NASA's Goddard Space Flight Center in Greenbelt, Md who has worked with Hinode data. "With imagers alone you see a broad range of light mixed together, but the spectrograph can zero in on a narrow temperature band."

The spectrograph helped find one potential candidate to explain how extra heat is carried up to the corona – something called "nanoflares." Scientists have long been able to see occasional, gigantic solar flares erupting from the sun, but EIS spotted near-constant smaller bursts at active regions of the sun. Comparing these areas to XRT data showed mini bright flashes, and these numerous flares are now one candidate to explain the coronal heating mystery.

But Hinode, using the SOT, also found another candidate for heating the corona – fountains of hot material called spicules. Spicules had been seen before upon occasion, but Hinode helped show that these giant jets were far more common than believed, so spicules, too, might be carrying enough hot material up into the solar atmosphere to heat it to the recorded temperatures.

Newer missions like NASA's Solar Dynamics Observatory, launched in 2010, and planned missions like NASA Interface Region Imaging Spectrograph (IRIS) and a Japanese solar mission currently designated simply Solar-C will continue to build on these observations, teasing apart the way the constantly twisting and moving magnetic fields of the sun sends energy out to the corona, to Earth's magnetosphere, and ultimately to all corners of the solar system.

Hinode is a joint mission of the Japan Aerospace Exploration Agency, the National Astronomical Observatory of Japan, the National

Aeronautics and Space Administration and the Particle Physics and Astronomy Research Council.

Provided by JPL/NASA