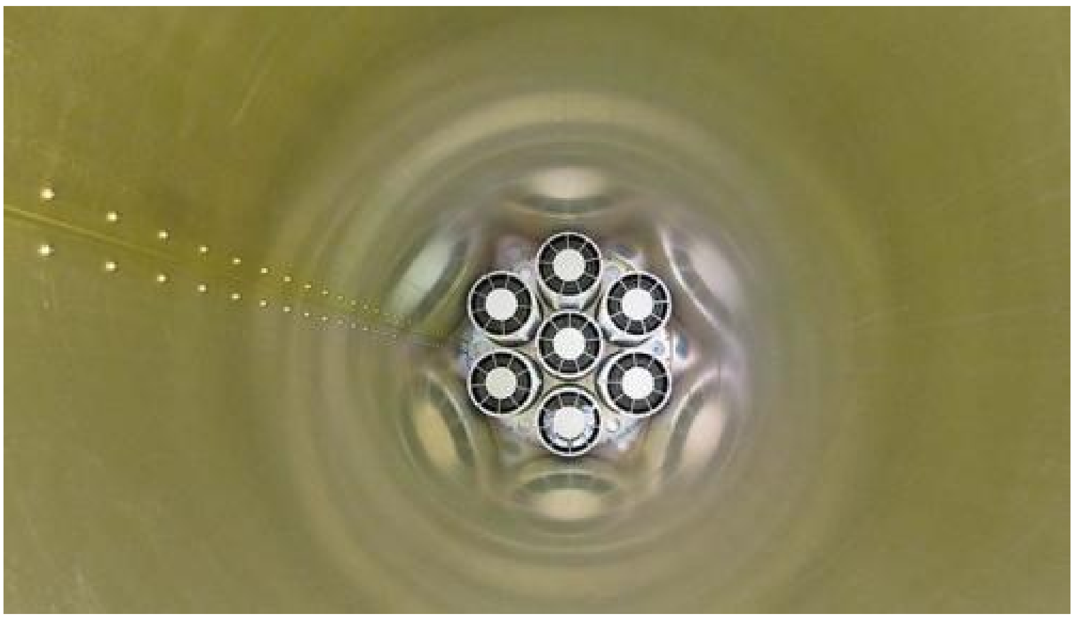
FOXSI: A next-generation X-ray telescope ready to fly

November 1 2012



Looking down the telescope tube on FOXSI the Focusing Optics X-ray Solar Imager reveals state-of-the-art optics that will help focus hard x-rays, which usually simply pass right through telescope mirrors. Credit: NASA/S. Christe

Those who watch the sun are regularly treated to brilliant shows – dancing loops of solar material rise up, dark magnetic regions called sunspots twist across the surface, and dazzling flares of light and radiation explode into space. But there are smaller, barely visible events, too: much smaller and more frequent eruptions called nanoflares. Depending on how many and how energetic these are, nanoflares may be the missing piece of the puzzle to help understand what seeds the cascade that causes a much bigger flare, or to explain how the sun transfers so much energy to its atmosphere that it's actually hotter than the surface.

At the beginning of November, 2012 a NASA mission called FOXSI (for Focusing Optics X-ray Solar Imager) will launch from White Sands, N.M. to study these nanoflares. To do so, it will make use of a state-of-the-art x-ray telescope that will be able to focus incoming x-rays from the sun in a way that has never before been possible.

"Most people like to look at the really big flares. They're complicated and do crazy things," says Steven Christe, a solar scientist at NASA's Goddard Space Flight Center in Greenbelt, Md. who is the project scientist for FOXSI. "But FOXSI is geared to look at very, very faint events."

FOXSI is due to launch no earlier than Nov. 2, 2012 on board what is known as a sounding rocket, rockets that take short trips some 200 miles up and gather as much data as possible in about six minutes. During that time FOXSI will first look at an active region on the sun, with its characteristic flares or loops and then switch its gaze to a more quiet region to observe an undiluted patch of smaller flares. Since the nanoflares happen constantly, Christe points out that the sounding rocket need not wait for a special time frame to launch, an advantage when it comes to finding an acceptable launch window.

However, viewing such faint events requires extra sensitive optics. FOXSI carries a telescope—built by NASA's Marshall Space Flight Center in Huntsville, Ala. – that is unlike any previous ones launched into space for solar observations.

"This is really the next generation solar hard x-ray telescope we are testing out here," says Säm Krucker, the principal investigator for FOXSI and a solar scientist at the University of California, Berkeley, and at the University of Applied Sciences Northwestern Switzerland. "The technology we're using will capture much better images of the sun at this particular range of x-rays."

Previously, techniques to collect and observe the high energy x-rays streaming from the sun were hampered by the fact that x-rays at high energies cannot be focused with conventional lenses the way visible light can be. When an x-ray encounters a standard glass lens it passes through the lens completely. X-ray telescopes have therefore relied on imaging that doesn't rely on focusing. This is a very effective technique when looking at a single bright event on the sun, such as the large burst of radiation and x-rays from a solar flare, but doesn't work as well when searching for many faint events occurring simultaneously.

The FOXSI instrument, however, makes use of new iridium-coated nickel/cobalt mirrors that do successfully cause x-rays to reflect, as long as the x-rays come in from a nearly horizontal direction. Several of these mirrors in combination help collate the x-ray light before funneling it to the detector. These focusing optics make faint events appear brighter and crisper.

Another advance for the telescope comes in the very building of the optics system. In general, better optics require more accurate mirrors, which in turn requires labor- and money-intensive polishing to get a flawless finish. The FOXSI mirrors use a replication technique whereby a surface is perfectly polished once and mirrors are created off of that surface by nickel-plating it. This process can be repeated many times thus saving time and money.

By using such optics on the sounding rocket, Christe hopes they'll be able to perfect their performance for use on a sun-observing satellite some day. This is another benefit of sounding rockets: testing innovative technology on a less expensive rocket sets the instruments up for potential deployment on a permanent spacecraft. Instruments like those on FOXSI will be important to nail down the mystery of what causes these small flares and what they in turn effect.

"There are two basic possibilities," says Christe. "One is that small flares are similar to large flares. But then we'd have to explain why they appear at a different rate and in different places than the big ones. So we need to determine whether these small events are really happening all the time, all over the sun. The other possibility is that they are fundamentally different than large flares and that would be extremely interesting and would point to a difference in the physics that powers large versus small flares."

Another question to solve is whether all those tiny flares add up to enough energy shooting into the sun's corona to heat it to the temperatures of over a million degrees K (kelvin). Just what heats the corona is part of what's known as the "coronal heating problem" – a question of how it gets so much hotter than the sun's surface, which is a mere 6,000 K.

"If you think of a stove," says Krucker, "the surface of the stove is hotter, and the air gets cooler as you move farther away. But with the sun, something else is happening to make the atmosphere 1,000 times hotter than the surface."

Answering such large questions will not be solved by a single rocket launch, but FOXSI's data will provide new insights into the x-ray portion of the sun's spectrum, filling in yet another piece of the puzzle while also paving the way for future sun-observing technology.

Provided by NASA's Goddard Space Flight Center