Mission studies the Sun in soft X-rays

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The NASA-funded MinXSS CubeSat will launch in late 2015 to study soft X-rays from the sun. There have not yet been long term studies of these soft X-rays, but observations show they may be important clues to understanding what heats the sun's atmosphere to 1000 times the temperature of its surface. Credit: NASA/U.Colorado

At any given moment, our sun emits a range of light waves far more expansive than what our eyes alone can see: from visible light to extreme ultraviolet to soft and hard X-rays. Different wavelengths can have different effects at Earth and, what's more, when observed and analyzed correctly, those wavelengths can provide scientists with information about events on the sun. In 2012 and 2013, a detector was launched on a sounding rocket for a 15 minute trip to look at a range of sunlight previously not well-observed: soft X-rays.

Each wavelength of light from the sun inherently carries information about the kind of process that emitted the light, so looking at soft X-rays provides a new way to figure out what is happening on our closest star. For example, the sun's atmosphere, the corona, is 1,000 times hotter than its surface, and scientists do not yet understand the details of why. The soft X-ray detector brought home data showing that a significant amount of soft X-rays - more than expected - were seen when there are even a small amount of magnetically complex sunspots. Identifying what process within these magnetically active regions contributes to the great increase in soft X-rays could hold clues for what's helping to heat the corona. A paper on these results appeared in the *Astrophysical Journal Letters* on March 18, 2015.

"Not only did we gather measurements that haven't been made routinely," said Amir Caspi, first author on the paper and a solar scientist at Southwest Research Institute in Boulder, Colorado, who worked at the University of Colorado in Boulder during the course of this study. "The detector we used also allowed us to gather the best measurements so far made in this energy range."

This soft X-ray detector hitched a ride into space on a NASA sounding rocket. During a 15 minute total flight, sounding rockets have about six minutes of time to gather data from space. The soft X-ray detector and its related components are only about the size of a pack of cards, so it could easily fly on board a rocket carrying another experiment - in this case, one that helps calibrate the Extreme Ultraviolet Variability Experiment, or EVE, on NASA's Solar Dynamics Observatory.

Sounding rockets and combining missions on a single launch vehicle provide an opportunity to conduct world-class science with a lower price tag.

The soft X-ray detector flew first on June 23, 2012, and again on October 21, 2013.

During both flights, there were only a few complex active regions on the sun's surface - indeed, very few during the 2012 flight. Yet, in both flights the detector saw 1000 times more soft X-rays than had been seen by another experiment in 2009. Even a slight extra amount of solar activity in the form of these active regions, led to substantially more output in the soft X-ray wavelengths.

Wavelengths of light correlate to particular temperatures of material on the sun, and this abundance of soft X-rays points to clouds of hot - 5 to 10 million degrees - gases above the active regions that wasn't present during the 2009 measurements when there were no active regions on the sun. That kind of information makes it clear that different heating mechanisms occur on the quiet sun and active regions, opening the door to determining the differences. One theory for the source of this mysterious heating is that numerous tiny explosions called nanoflares are constantly erupting on the sun. Nanoflares are too small to be seen by our telescopes, but powerfully energetic nonetheless. The soft X-rays might well be a result of nanoflares, thus giving us a way of investigating them.

The new soft X-ray data differed from previous data studies in another respect as well. By parsing out the amounts of each individual wavelength of light gathered, the team could identify what elements were present in the corona. Typically, the abundance of some of these atoms in the corona is greater than at the sun's surface. But not so in these recent observations. The mix of material in the corona was more similar to the mix seen at the solar surface, suggesting that some material from the surface was somehow rising up higher into the atmosphere.

"The difference we see in the abundances of the elements compared to previous studies suggest there may be a link between the heating mechanism and the coronal composition," said Caspi.

Untangling the elements present on the sun's surface and in its atmosphere during different events on the sun could offer another set of tools for interpreting what heats the corona.

Discovering that the soft X-ray emission was brighter than supposed has effects for understanding space weather events near Earth as well. Different wavelengths of light from the sun penetrate to different layers of Earth's atmosphere, causing different effects.

"The solar soft X-rays are deposited lower in Earth's atmosphere than the sun's extreme ultraviolet radiation," says Tom Woods, a co-author on the paper and the principal investigator for this experiment at the University of Colorado in Boulder. "The soft X-rays cause almost instantaneous changes in the ionosphere that can disturb radio communications and the accuracy of GPS navigation systems."

Such changes in the ionosphere happen during large explosions on the sun called solar flares. As humans attempt to better understand - and predict - the sun's effects on the space through which our communication signals travel, it's crucial that we have accurate models to simulate what the sun is sending our way and when.

The soft X-ray results so far are based on what amounts to only 10 minutes worth of data. However, this early data clearly shows the value of observing the previously understudied soft X-ray emissions. In the hopes of getting a longer data record - and of observing soft X-rays from solar flares—the team has been working to place the same kind of detector into the NASA-funded Miniature X-ray Solar Spectrometer, or MinXSS, CubeSat, currently scheduled to launch in late 2015. About the size of a loaf of bread, the MinXSS is part of NASA's CubeSat program, which started in October 2013. CubeSats are small satellites that ride along with larger missions to take advantage of yet another low cost way to perform experiments in space. MinXSS will provide 6-12 months of observations to advance our understanding of soft-X-ray emissions from the sun both from solar flares and during quiescent periods.

The soft X-ray detector used for this experiment was an Amptek X123-SDD.

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