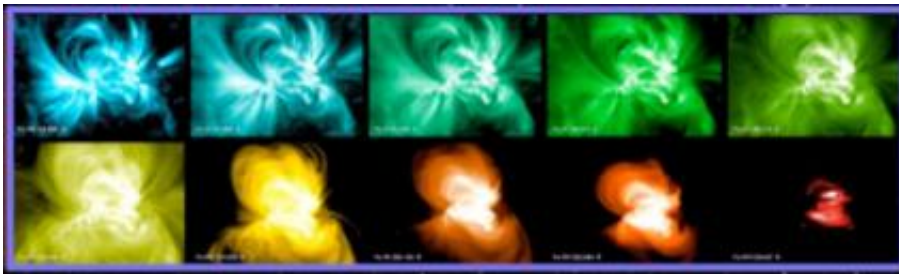


Scientists Explore the Mystery of Active Region Outflows

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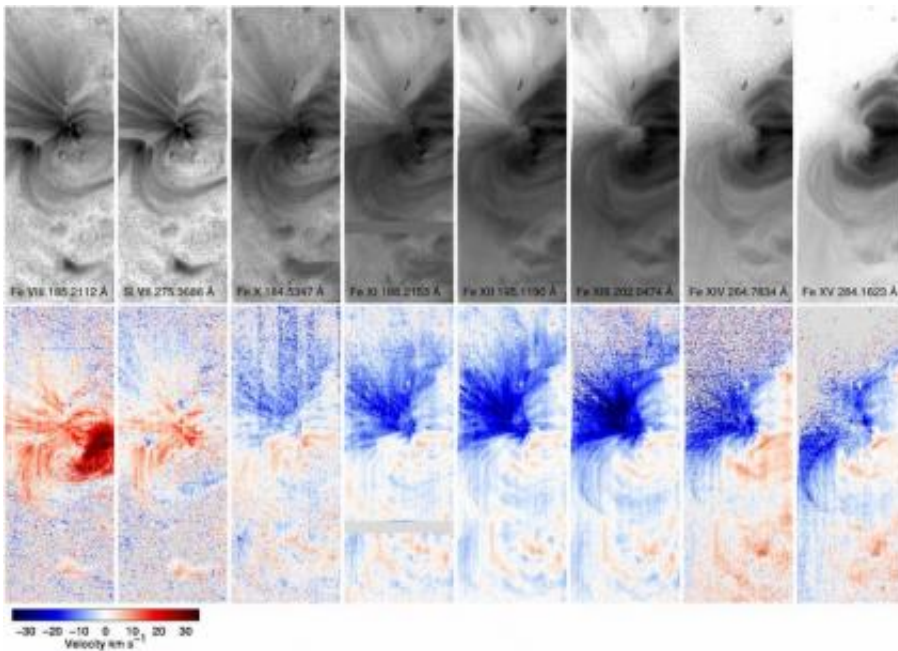
Hinode EIS instrument image of a solar active region, observed over a progressive temperature range from 600,000 to 4,000,000 K. Each image is in the light emitted by an Iron (Fe) ion in the series from Fe VIII to Fe XVII. Temperatures increase from left to right across the top panel and then continue to increase from left to right across the bottom panel.

(PhysOrg.com) -- The Japanese Hinode spacecraft that launched in September 2006 contains the Extreme-ultraviolet Imaging Spectrometer (EIS), which provides measurements of properties of the solar corona such as its temperature, density, and dynamics (flows and turbulence).

These measurements are critical for understanding the physical origins of [solar activity](#), which is the basis for [space weather](#) and adverse effects on the near-Earth environment. Scientists from the Naval Research Laboratory's Space Science Division have uncovered some surprising results in studying the measurements from Hinode.

Using the solar instruments including EIS on the Hinode spacecraft, NRL scientists, led by Dr. George Doschek, have made the surprising discovery of [plasma](#) outflows at the edges of solar active regions where almost no bright emission was seen in the extreme-ultraviolet [light emission](#). The outflows near active regions are considered potentially important for space weather because if the flows are along open [magnetic field](#) lines, the plasma eventually becomes part of the solar wind, which has significant space weather consequences at the Earth. However, the flows could also be trapped in very long magnetic flux tubes, which confine the plasma and prevent it from becoming part of the solar wind. Therefore much research has gone into trying to understand the origin and properties of the flows.

The intense research on the outflows has so far only deepened the mystery of their origin and relationship to the solar wind and neighboring active regions, rather than clarified it. For example, the flows look like coronal hole regions on the Sun, or, regions where the plasma does not exceed about 1 million degrees K and flows outwards along open field lines becoming the fast solar wind. However, the plasma that makes up the active region flows is substantially hotter than coronal hole plasma, reaching temperatures of about 2 million degrees.



Hinode EIS image of the temperature structure of outflows near an active region. Top panel: images of a solar active region in monochromatic radiation for spectral lines formed at different electron temperatures ranging from about 560,000 K (leftmost) to 2,000,000 K (rightmost). Bottom panel: images of the Doppler line-of-sight plasma flow velocity for the images in the top panel. Blue indicates away from the Sun (outflow), red is towards the Sun (downflow). In the lines of Fe VIII and Si VII, formed at about 560,000 K, the flows are red, indicating downflows. At 1 million degrees (Fe X) the result is a bit ambiguous. Then, at higher temperatures, the prevalent blue color indicates a strong outflow.

Furthermore, although the average outflow speeds do not normally exceed the 40,000 miles per hour speed of the slow solar wind, there are regions in some of the outflows where the speed reaches about 450,000 mile per hour. "This is tantamount to discovering a whole new type of solar region in the Sun's atmosphere," Doschek explains. Work to detect the outflows in particle data obtained at the Earth has so far failed to establish a firm connection with the active region outflows.

Most recently, NRL Space Science Division scientists, led by Dr. Harry Warren, working with spectra from EIS on [Hinode](#), have investigated the temperature structure of the outflows and have found a surprising result. The outflows turn into downflows toward the Sun for plasma temperatures in the outflow regions less than about 1 million degrees.

NRL scientists made the downflow discovery by imaging the active regions in radiation from the solar plasma at various temperatures. The downflows were discovered from EIS data when maps were made of the flow velocity in spectral lines formed at these different temperatures. EIS provided images of intensities of the active region in monochromatic light from different spectral lines and, simultaneously provided co-located maps of flow velocity. In the lines of Iron (Fe) VIII and Silicon (Si) VII, formed at about 560,000 K, the flows are downflows towards the Sun. At 1 million degrees (Fe X) the result is a bit ambiguous. Then, at higher temperatures, a strong outflow from the Sun is observed. NRL scientists are now working is to understand the reason for the switch in flow direction, and to establish whether or not the flows actually become part of the [solar wind](#).

Provided by Naval Research Laboratory

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