Simulations reproduce complex fluctuations in soft X-ray signal detected by satellites

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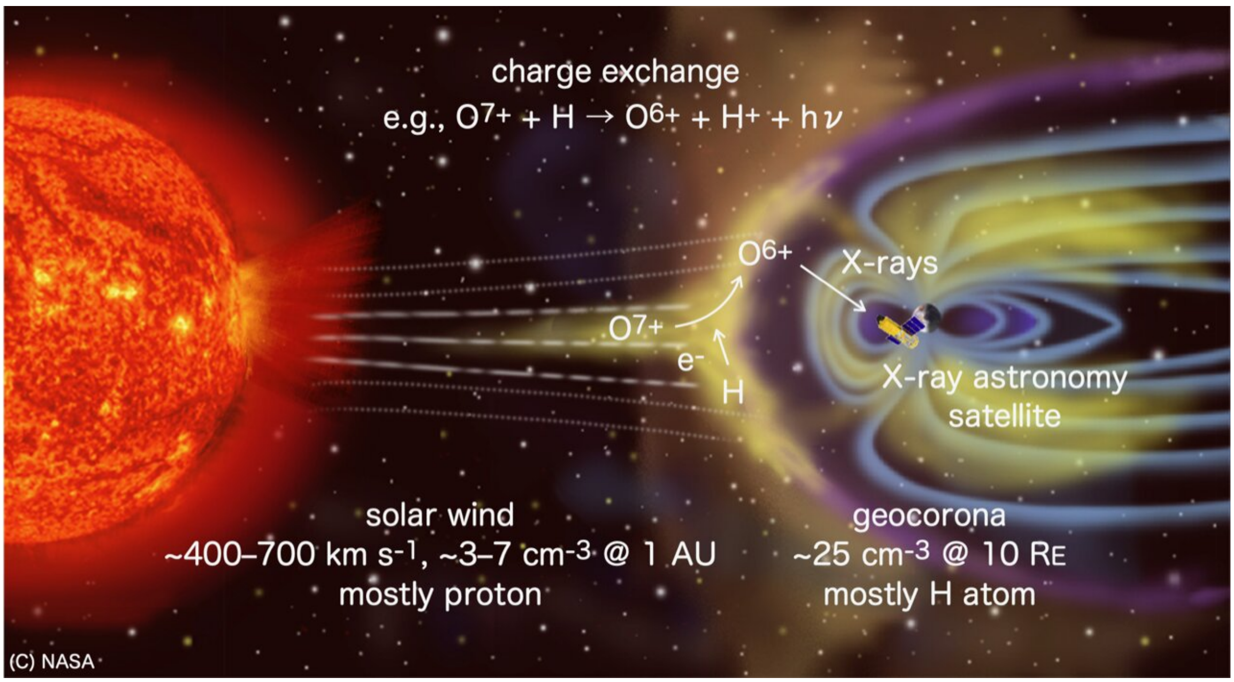
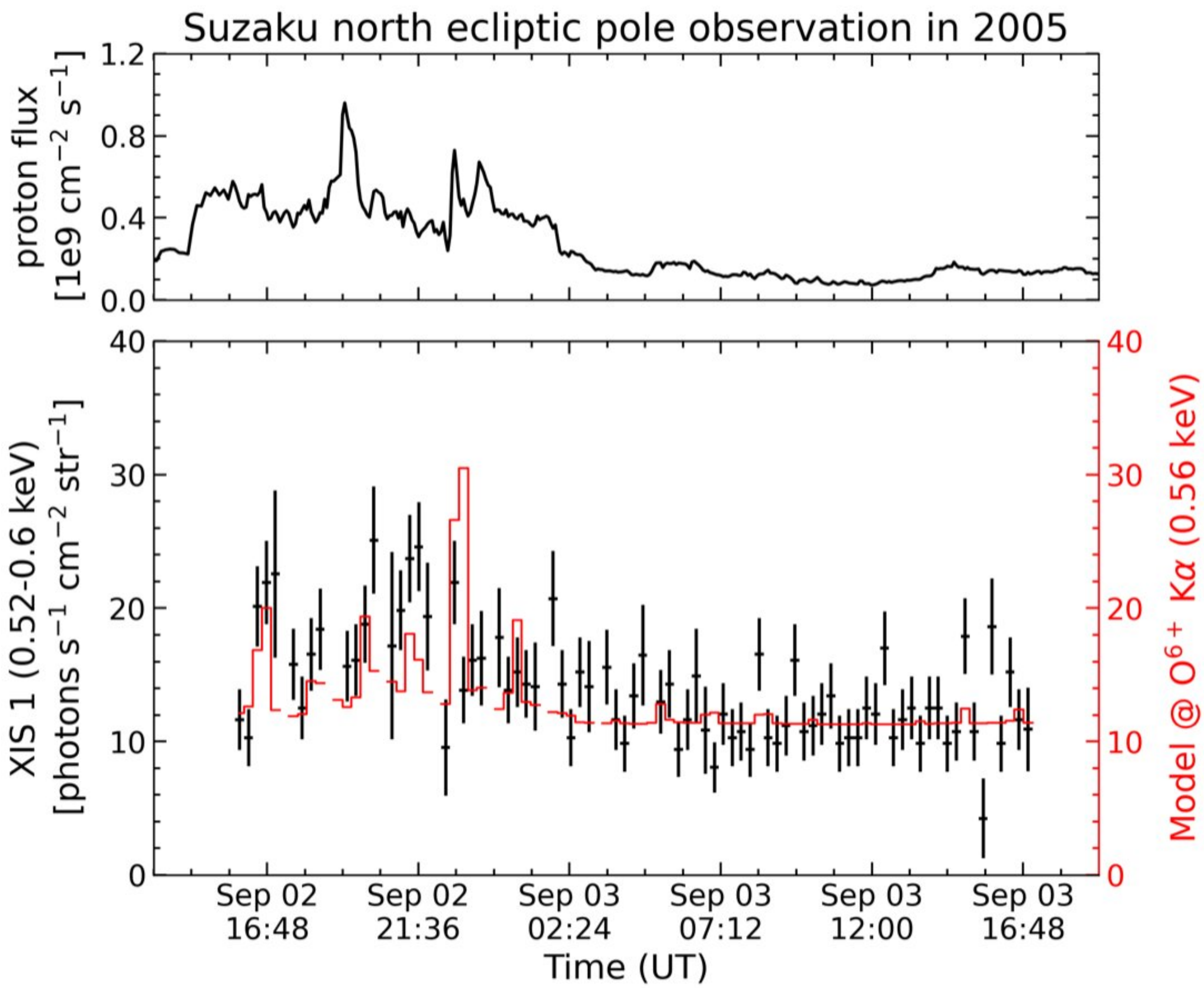


Charged particles from the sun coming towards earth interact with the geocorona, a wide cloud of hydrogen atoms extending into space from the Earth. Charge is transferred to the hydrogen atoms, and soft X-rays are emitted. Credit: Tokyo Metropolitan University

Researchers from Tokyo Metropolitan University have used numerical methods to model the variations observed in soft X-ray signals detected by X-ray satellites. They analyzed data from the Suzaku telescope and compared it with modeling of solar winds interacting with the most upper parts of our atmosphere. They succeeded in capturing how the signal varied with the orbital motion of the satellite, with implications for how predictions can be made for future satellite experiments. Their findings are published in the journal *Publications of the Astronomical Society of Japan*.

In the 1990s, the German orbital X-ray telescope ROSAT began detecting large variations in signals in the soft X-ray part of the spectrum that lasted a day or so. These were similar to the copious flux of soft X-rays from the comet Hyakutake discovered around the same time. It was proposed that these were due to solar wind, fluxes of charged particles arriving from the sun, and how they interact with neutral ions in the upper extremities of our atmosphere, or the geocorona. More detailed observations in the 2000s confirmed the telltale spectra of these events, known as solar wind charge exchange events (SWCX), and the mechanism itself was widely accepted.

However, modeling how solar wind gives rise to the measurements taken by orbital telescopes proved much more difficult. It requires successfully capturing the arrival of solar wind events, how the charged particles interact with neutral atoms, and how that affects the magnetosphere, not to mention how these phenomena combine to give rise to the variation in signal observed over time and space by the satellites.



The model (red) is found to closely reproduce the variations seen in the experiment. Credit: Tokyo Metropolitan University

Now, a team led by Associate Professor Yuichiro Ezoe of Tokyo Metropolitan University have successfully brought these aspects together to realize a model that can successfully reproduce how the signal varies over time. The team's focus was on data from Suzaku, an X-ray telescope satellite launched in 2005 by the Japan Aerospace Exploration Agency. In contrast to other satellites, Suzaku lies in a lower orbit, allowing it to observe the polar cusps of the magnetosphere, where solar winds are being strongly bent away. A highlight of the team's work is not only the wide range of astrophysical events they are able to bring together, but how it may be mapped onto real data.

The model showed excellent correspondence with experimental data, reproducing the signal observed up to a factor of two, an impressive feat in the field. Furthermore, they were able to reproduce the particularly strong variations in the signal when the line of sight of the satellite aligned with the polar cusps. There were some notable exceptions, like when a major geomagnetic storm was observed; nevertheless, successful reproduction of the variations holds significant promise for predicting the outcomes of the next generation of X-ray observations in space.

More information: Daiki Ishi et al, Modeling of geocoronal solar wind charge exchange events detected with Suzaku, *Publications of the Astronomical Society of Japan* (2022). DOI: 10.1093/pasj/psac095

Provided by Tokyo Metropolitan University

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