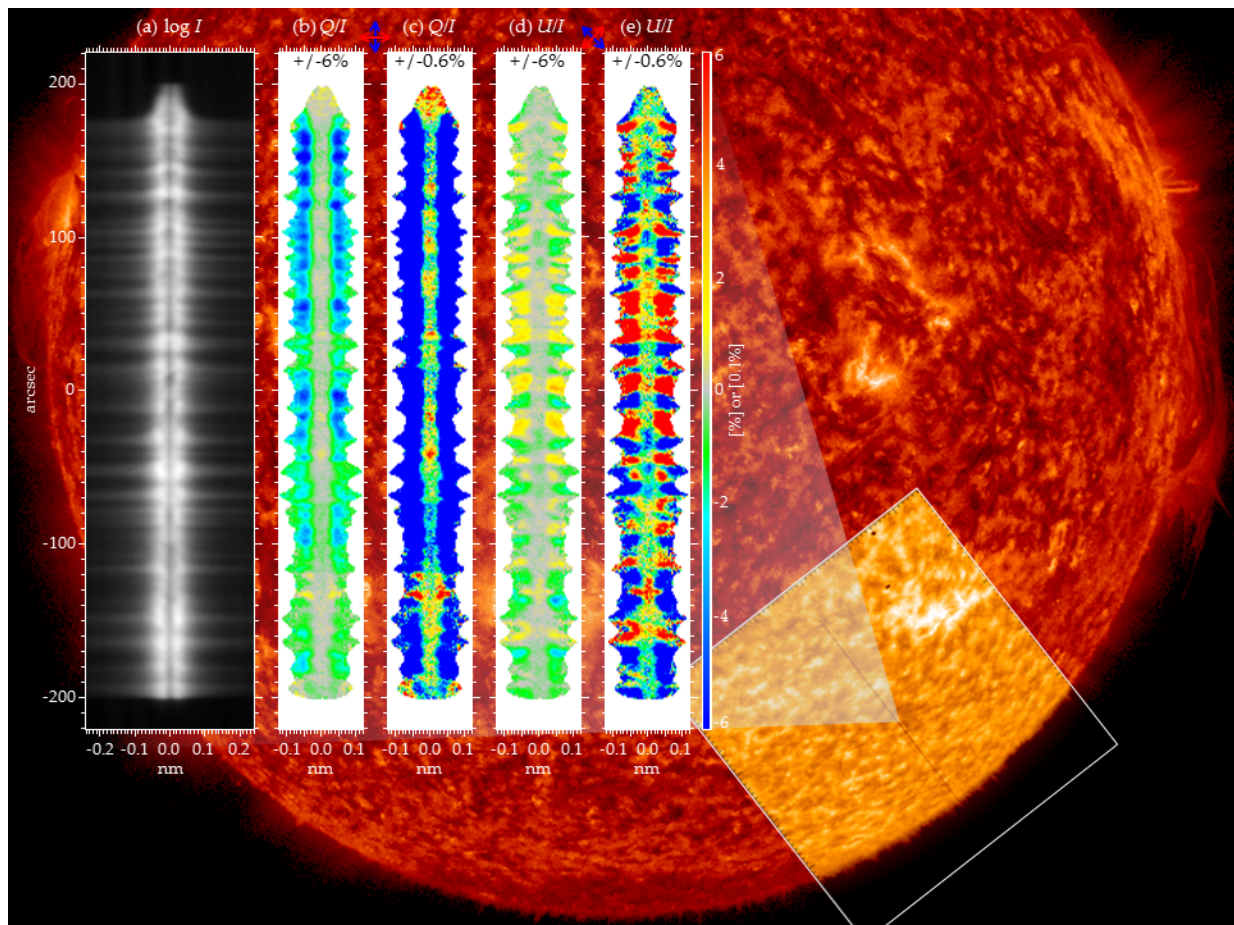


First direct exploration of magnetic fields in the upper solar atmosphere

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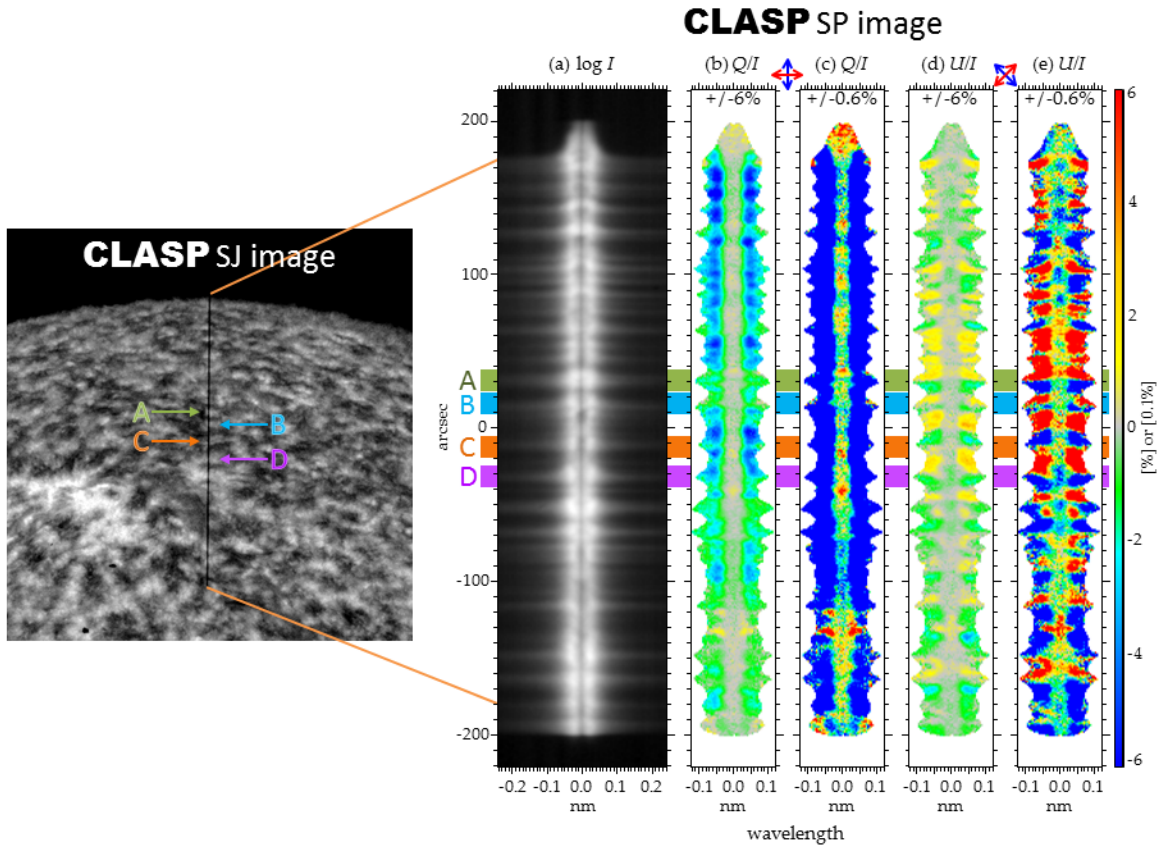


Polarization spectra of the hydrogen Lyman- α line from the Sun taken by the CLASP sounding rocket experiment. Credit: NAOJ, JAXA, NASA/MSFC; background full-Sun image: NASA/SDO

For the first time in the world, scientists have explored the magnetic field in the upper solar atmosphere by observing the polarization of ultraviolet light from the Sun. They accomplished this by analyzing data taken by the CLASP sounding rocket experiment during its 5-minute flight in space on September 3, 2015. The data show that the structures of the solar chromosphere and transition region are more complicated than expected. Now that ultraviolet spectropolarimetry, the method used in the CLASP project, has been proven to work, it can be used in future investigations of the magnetic fields in the upper chromosphere and the transition region to better understand activity in the solar atmosphere.

By analyzing the characteristics of light from the Sun, astronomers can determine how it has been emitted and scattered in the solar atmosphere, and thus determine the conditions in the solar atmosphere. Because magnetic fields are thought to play an important role in various types of solar activity, many precise measurements have been made of the magnetic fields at the solar surface ("photosphere"), but not so many observations have measured the magnetic fields in the solar atmosphere above the surface. While visible light is emitted from the photosphere, ultraviolet (UV) light is emitted and scattered in the parts of the [solar atmosphere](#) known as the chromosphere and the transition region. CLASP is a project to investigate the magnetic fields in the upper chromosphere and the transition region, using the hydrogen Lyman- α line in UV.

The international team used data from the CLASP spectropolarimeter, an instrument which provides detailed wavelength (color) and polarization (orientation of the light waves) information for light passing through a thin slit. The left side of Figure 1 shows the position of the spectropolarimeter slit on a background image taken by the slit-jaw camera onboard CLASP; the diagrams on the right side show the wavelength and polarization data.

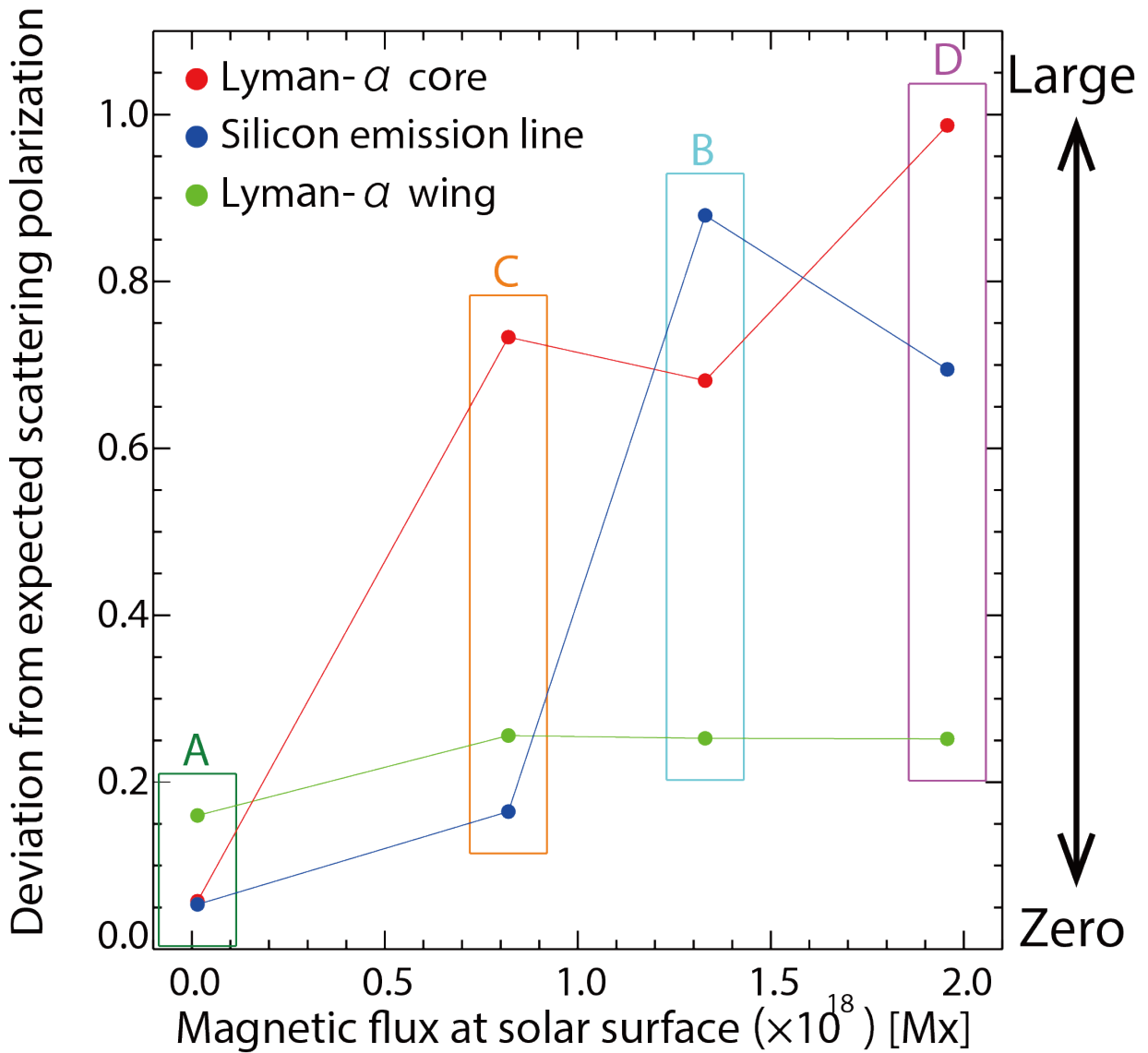


The position of the CLASP spectropolarimeter slit (left) and the polarization spectrum of the upper solar chromosphere and the transition region (right).
 Credit: NAOJ, JAXA, NASA/MSFC

The researchers discovered that the hydrogen Lyman- α line from the Sun is actually polarized. Some of the polarization characteristics match those predicted by the theoretical scattering models. However, others are unexpected, indicating that the structures of the upper chromosphere and transition region are more complicated than expected. In particular, the team discovered that polarization varied on a spatial scale of 10 - 20 arcsec (one hundredth - one fiftieth of the solar radius).

In addition to the scattering process, magnetic fields can also affect the polarization. To investigate if the measured polarization was affected by the magnetic [field](#), the team observed 3 different wavelength ranges: the core of the hydrogen Lyman- α line (121.567 nm), whose polarization is affected by even a weak magnetic field; an ionized silicon emission line (120.65 nm) whose polarization is affected only by a relatively strong [magnetic field](#); and the wing of the hydrogen Lyman- α spectral line, which is not sensitive to magnetically induced polarization changes. The team analyzed these 3 polarizations above 4 regions on the solar surface with different magnetic fluxes (regions A, B, C, and D in Figure 1). The results plotted in Figure 2 demonstrated that the large deviations from the expected scattering polarization in the Lyman- α core and the silicon line are in fact due to the magnetic fields, because the Lyman- α wing polarization remains almost constant.

These epoch-making results are the first to directly show that magnetic fields exist in the transition region. They also demonstrate that ultraviolet spectropolarimetry is effective in studying solar magnetic fields. Moreover, these results have shown that sounding rocket experiments like CLASP can play an important role in pioneering new techniques, even though they are small scale and short term compared to satellites.



Comparison of the polarization of 3 spectral lines with differing sensitivities to magnetic fields. A, B, C, and D correspond to the areas labeled in Figure 1. Credit: NAOJ

Dr. Ryoko Ishikawa, project scientist for the Japanese CLASP team, describes the significance of the results, "The successful observation of [polarization](#) indicative of magnetic fields in the upper chromosphere and the transition region means that ultraviolet spectropolarimetry has

opened a new window to such [solar magnetic fields](#), allowing us to see new aspects of the Sun."

These results appear as "Discovery of Scattering Polarization in the Hydrogen Ly α Line of the Solar Disk Radiation" by R. Kano, et. al. in the *Astrophysical Journal Letters* in April 2017 and "Indication of the Hanle Effect by Comparing the Scattering Polarization Observed by CLASP in the Lyman- α and Si III 120.65 nm Lines" by R. Ishikawa, et. al. in *The Astrophysical Journal* in May 2017.

More information: R. Kano et al, Discovery of Scattering Polarization in the Hydrogen LyLine of the Solar Disk Radiation, *The Astrophysical Journal* (2017). [DOI: 10.3847/2041-8213/aa697f](https://doi.org/10.3847/2041-8213/aa697f)

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