The Chromospheric Lyman-Alpha SpectroPolarimeter (CLASP) is a sounding rocket experiment for making precise measurement of the polarization profile of the Lyman-α line from the solar atmosphere. The Lyman-α line is an ultraviolet emission line (wavelength 121.6 nm), emitted high in the solar atmosphere, at the chromosphere and the transition region (located between the chromosphere and the corona). CLASP aims to make the first ever measurement of the Hanle effect polarization caused by the magnetic field in the chromosphere and transition region, and infer the magnetic field strength and orientation. It is a pathfinder experiment that aims to establish this technique as a measurement tool for chromospheric and transition-region magnetic fields.
Above the sun’s “surface” (photosphere) are layers of hotter plasma called the chromosphere, transition region and the corona (Figure 1). While the photosphere is ~ 6000 K temperature, the chromosphere and the corona are ~ 10,000 K and over 1 million K, respectively. The heating mechanism of these high-temperature layers is one of the longstanding mysteries of solar physics. While the chromosphere is cooler than the corona, its higher density means the amount of heating needed to maintain the chromosphere is 10 to 100 times larger than that of the corona.

Observations by the Hinode satellite discovered a variety of dynamic events in the chromosphere such as jets and waves, indicating that these events may be responsible for heating the chromosphere and corona. In addition, Hinode observations of the photosphere show numerous transient horizontal magnetic field structures which may drive the dynamics of the chromosphere.

Magnetic fields dominate the dynamics in the chromosphere, transition region and the corona, and likely play a central role in the heating mechanisms. Direct measurement of magnetic fields in the solar atmosphere is therefore vital for understanding the heating mechanisms. CLASP aims to detect the Hanle effect polarization caused by the magnetic field in the chromosphere for the first time, and measure the magnetic field. CLASP is a pathfinder mission for demonstrating this technique, and also serves as a technology development testbed for the Solar-C satellite.

Fig. 1: The Hinode satellite discovered dynamic chromospheric activities ((A) – (C)) and ubiquitous horizontal magnetic fields in the photosphere (D). These discoveries show the importance of direct measurement of magnetic fields in the chromosphere and the transition region.

The magnetic field at the photosphere is measured by observing the Zeeman effect. However, this technique is difficult to apply to the chromosphere and transition region because it has poor sensitivity to weaker magnetic fields predicted for the chromosphere, and because thermal broadening of chromospheric lines is large compared to the Zeeman splitting. The Hanle effect provides an attractive alternative, as it is sensitive to weaker magnetic fields than the Zeeman effect, and is unaffected by thermal broadening. Recent advances in understanding and modeling of the Hanle effect show promise for retrieving magnetic field information from Hanle polarization measurements.
Numerous vacuum-UV emission lines are produced in the chromosphere and transition region. The Lyman-α line is the brightest of them, and predicted to be sensitive not only to the chromospheric magnetic fields in active regions (>100 Gauss) but also those in the quiet sun (~10 Gauss), as shown in Figure 3.

CLASP is a spectropolarimeter designed to measure the polarization profile of the Lyman-α line from the solar disk at an unprecedented accuracy of 0.1%, with high wavelength resolution (0.01 nm). The goal is to observe the linear polarization caused by the atomic polarization and the Hanle effect, and infer the magnetic field and orientation in the chromosphere and transition region above the quiet sun for the first time.

**CLASP Observing Target**

- **Target:** Quiet Sun chromosphere & transition region, on-disk, close to limb.
- **Telescope:** 30 cm aperture Cassegrain
- **Spectrograph:** Spherical constant line-space grating (Al / MgF₂ coated)
- **Context imager:** Lyman-α narrowband, 550 arcsec × 550 arcsec, Resolution: 2.2 arcsec
- **Observing polarization:** Stokes I, Q, U
- **Polarimeter type:** Dual-beam spectropolarimeter with rotating 1/2-wave plate
- **Spatial resolution:** 1.5 arcsec (slit width), 2.9 arcsec (along slit)
- **Spectral resolution:** 0.01 nm
- **Field of view:** 1.5 arcsec × 400 arcsec
- **Observing time:** approx. 5 minutes
- **# photons collected:** > 4×10⁶ (summed over 0.005 nm bin, 1.5 arcsec × 4.4 arcsec, 5 minutes)
- **Polarization sensitivity:** 0.1% (2σ)
CLASP consists of a spectropolarimeter (shown in green in Figure 4) and a slitjaw imaging system (yellow) fed by a Cassegrain telescope (blue).

The telescope is a “cold mirror” design, using a multilayer coating on the primary mirror that reflects the target Lyman-α wavelength while transmitting visible and infrared light. Over 95% of the incident solar energy is transmitted through the primary mirror and onto a heat absorber behind the mirror instead of entering the spectropolarimeter.

The spectropolarimeter utilizes a concave diffraction grating as both the spectral dispersion element and the beamsplitter. Each exit beam (−1 and +1 order) is focused by a separate off-axis parabolic mirror. A reflective polarization analyzer on each beam, at 90-degree angle from each other, allows observation of two orthogonal polarization states simultaneously. A continuously rotating 1/2-wave plate in front of the slit determines and modulates the polarizations seen by the two channels.

The beam that does not pass through the slit is reflected by the slit surface and imaged by the slitjaw system, comprising a fold mirror, two off-axis parabolic mirrors, a set of Lyman-α narrowband filters and a CCD camera. The system provides real-time images for pointing as well as context images for data analysis and co-alignment.

**CLASP Schedule**

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**CLASP International Cooperation**

Japan: Experiment structure, telescope optics, polarimeter optics, slitjaw optics, waveplate rotation mechanism

Spain: Modeling of Hanle effect

Norway: Modeling of chromosphere

France: Diffraction grating

USA: Sounding rocket, flight operations, CCD cameras, avionics