Initial Observations With the Upgraded Coronal Multi-channel Polarimeter (UCoMP)

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Upgraded Coronal Multi-channel Polarimeter

- The Upgraded Coronal Multi-channel Polarimeter (UCoMP; Landi, Habbal and Tomczyk, 2016) is a 20-cm aperture Lyot coronagraph with a Stokes polarimeter and a narrow-band electro-optically tuned birefringent filter. It can image the intensity, full Stokes polarization, and Doppler shift across coronal emission lines in the visible and near-IR.
- The UCoMP is an upgrade of the Coronal Multi-channel Polarimeter (CoMP) instrument. It has a broader wavelength range (530 - 1083 nm) than CoMP (1074 - 1083 nm) increasing the number of available emission lines, a larger field-of-view (± 2 Rsun) compared to CoMP (± 1.3 Rsun), and higher spatial resolution (6 arcseconds) compared to CoMP (9 arcseconds).
- The UCoMP demonstrates the technology of a large aperture birefringent filter based on Lithium Niobate crystals and is a pathfinder instrument for the Coronal Solar Magnetism Observatory (Tomczyk et al., 2016).
- The instrument is located at the Mauna Loa Solar Observatory (MLSO) of HAO/NCAR. It was installed in the Spring of 2021, started taking science data in spring 2021, and is currently undergoing commissioning.

Instrument Properties

Coronal lines observed:
FeXIV 530.3 nm†
FeX 637.4 nm
NiXV 670.2 nm*
ArXI 691.8 nm†
FeXV 706.2 nm
SXII 761.1nm*
FeXI 789.4 nm
NiXV 802.4 nm*
SVIII 991.3 nm*
FeXIII 1074.7 nm
FeXIII 1079.8 nm

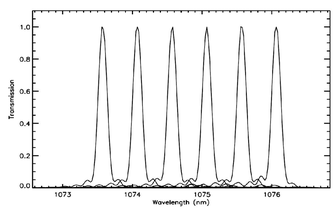
Chromospheric lines:
HI 656.3 nm†
HeI 1083 nm†

Filter Clear Aperture:
50 mm

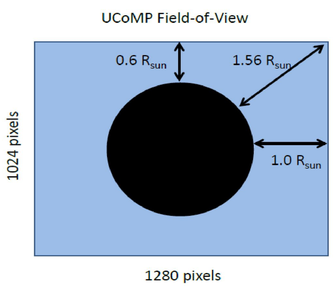
Spatial Sampling:
~3 arcseconds/pixel

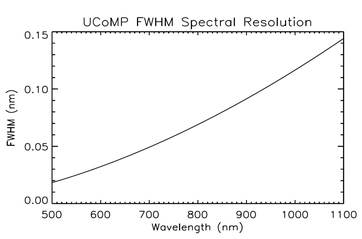
Field of View:
Above the limb from 1.04 to 2 R_{sun}

Spectral Resolution:
The spectral resolution of the UCoMP is set by the Lithium Niobate crystals in the birefringent filter (on right).



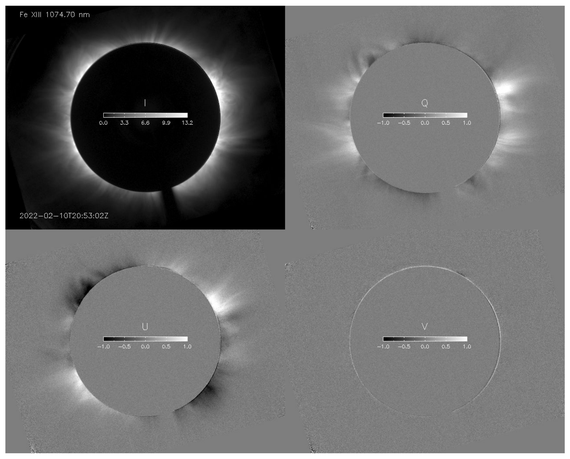
An example of 6 tunings of the filter in the vicinity of the Fe XIII 1074.7 nm line is shown here.





science quality data collection began spring 2021
† no data for this wave region after 14 November 2022
* data collection for this wave region began on 14 November 2022

UCoMP Level 1 Data Samples

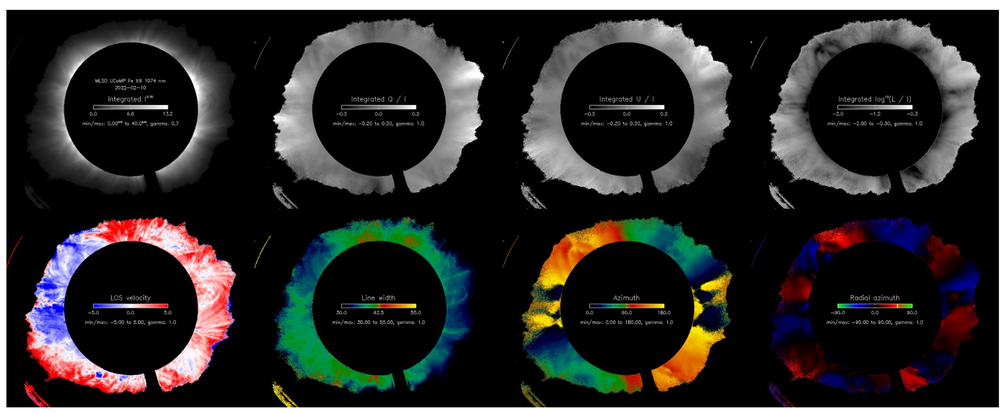


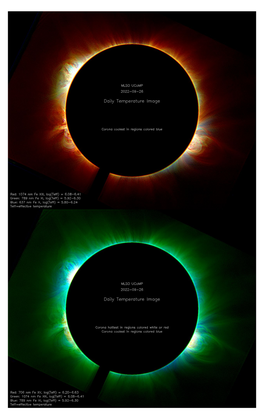
The basic observables from the UCoMP are the Stokes parameters, I Q, U and V, as a function of spatial position and wavelength across the coronal emission lines, seen on the left above for center line of 1074 nm data on 2022-02-10. Stokes I is the intensity, Q and U are the net linear polarization horizontally and at 45 degrees, respectively, and Stokes V is the net circular polarization. The right above shows the intensity at line center for the other four coronal lines that are currently available, data observed on 2022-09-26.

The quicklook images above are currently available on the MLSO website.

NOTE: Mauna Loa Observatory has been offline since late November 2022 due to volcanic activity. Observations are expected to restart in spring 2024.

UCoMP Level 2 Data Products

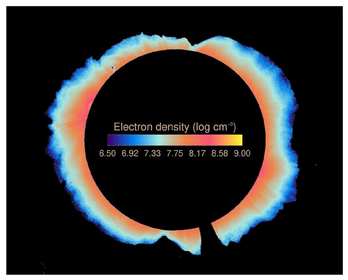


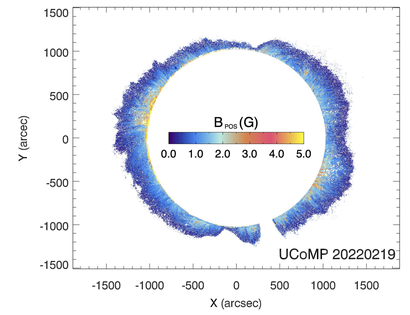


On the left above, some Level 2 data products derived from the Level 1 data products in 1074 nm Fe XIII taken on 2022-02-10 with I, Q and U as above and L = sqrt(Q^2+U^2). The rotation of the corona is visible as the blue to red variation of the line-of-sight (LOS) velocity obtained from a fit of the intensity vs. wavelength. The line width shown here includes the instrumental profile. The azimuth of the magnetic field is obtained from azimuth = 0.5 atan(U/Q) and is measured counterclockwise from horizontal and is subject to a 180 degree ambiguity. The Radial Azimuth of the magnetic field is the azimuth measured counterclockwise from the local radial direction. On the right, temperature composite images with varying lines in red, green, and blue channels from data observed on 2022-09-26.

The quicklook images above are currently available on the MLSO website.

Wave Diagnostics of the Coronal Magnetic Field





Ubiquitous Alfvenic waves are observed in time series of UCoMP Doppler maps. These waves are important in that they can contribute to coronal heating and accelerate the solar wind. Also significant is that the measurements of the wave speed can be used to derive the plane-of-sky (POS) component of the coronal magnetic field from:

$$v_A = \frac{B}{\sqrt{4\pi\rho}}$$

Above left shows the electron density (ρ) obtained from the ratio of the Fe XIII 1074 and 1079 nm lines. The right image shows a map of the POS component of the coronal magnetic field inferred from wave phase speeds (see Zihao Yang, 2020).

Summary

Instrument commissioning and the development of the data processing pipeline are ongoing. **Quicklook images from the data from the instrument are currently available through the Mauna Loa Solar Observatory web site (https://www2.hao.ucar.edu/mlso/mlso-home-page) website. FITS data will be available soon, through the same website.**

The UCoMP instrument, like its predecessor CoMP, provides unique measurements of polarization, magnetic fields, plasma temperature and density, flows and waves in the solar corona. The limited aperture of UCoMP is not sufficient to constrain the line-of-sight (LOS) component of the coronal magnetic field; an aperture ≥1.5 m is needed from DKIST or the proposed COSMO Large Coronagraph (Tomczyk et al., 2016).

Please direct any questions to Michael Galloy (mgalloy@ucar.edu).

ACKNOWLEDGMENTS and REFERENCES

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Landi, E., Habbal, S.R. and Tomczyk, S. 2016, Coronal Plasma Diagnostics from UCoMP ground based observations, JGR Space Physics, 121, 8273.
Tomczyk, S., et al. 2016, Scientific objectives and capabilities of the Coronal Solar Magnetism Observatory, J. Geophys. Res. Space Physics, 121, 7470–7487.
Yang, Z., Bethge, C., Tian, H. et al. 2020, Global maps of the magnetic field in the solar corona. Science 369, 694.