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The Coronal Solar Magnetism Observatory

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Abstract. The Coronal Solar Magnetism Observatory (CoSMO) is a proposed new facility led by the High Altitude Observatory and a consortium of partners to measure magnetic field and plasma properties in a large (one degree) field of view extending down to the inner parts of the solar corona. CoSMO is intended as a research facility that will advance the understanding and prediction of space weather. The instrumentation elements of CoSMO are: a white-light coronagraph (KCor), already operational at the Mauna Loa Solar Observatory (MLSO); the Chromosphere and Prominence Magnetometer (ChroMag), due for deployment to MLSO next year; and the CoSMO Large Coronagraph (LC) which has completed Preliminary Design Review.

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1. Introduction

Measurements of coronal and chromospheric magnetic fields are arguably the most important observables required for advancing our understanding of the processes responsible for coronal heating, coronal dynamics, and the generation of "Space Weather" that affects communications, GPS systems, space flight, and power transmission. The Coronal Solar Magnetism Observatory (CoSMO) is a proposed ground-based facility that will be home to a suite of instruments designed for routine study of coronal and chromospheric magnetic fields and their plasma environment (Tomczyk *et al.* 2016).

CoSMO will provide measurements of the magnetic field and thermodynamic properties of coronal, chromospheric and prominence plasmas over a range of timescales from minutes to years. These measurements are required to understand the physics of coronal heating, solar wind acceleration, and the genesis and evolution of coronal mass ejections (CMEs), prominences and related activity. CoSMO measurements will lead to a dramatic improvement in our knowledge of the coupling of the Sun's magnetic field with the plasma physical properties from the photosphere through the heliosphere and how the field evolves over solar cycle timescales. As the facility matures, these measurements will be made available to the operational space weather community in a concerted effort to improve the predictability of ongoing space weather and also of extreme space weather events.

2. CoSMO Facility and Instrumentation

The **CoSMO facility** will be built and operated by a consortium consisting of the National Center for Atmospheric Research (NCAR), University of Michigan, University of Hawaii and George Mason University, on or adjacent to the site of the current NCAR

Mauna Loa Solar Observatory (MLSO), the best possible coronal observing site in Hawaii. The dome that will house the 1.5m apperture f/5 refractive Large Coronagraph (see below) will be 12.2 meters in diameter, and will be positively pressurized with HEPA filtered air to maintain cleanliness of the objective lens.

The white-light polarized-brightness (pB) **K-Coronagraph ("KCor")** (de Wijn *et al.* 2012) observes the column density of electrons in the corona. KCor is currently operational at MLSO. This instrument allows high temporal cadence observations of CMEs and shocks very close to the solar limb.

The **Chromospheric Magnetometer ("ChroMag")** (de Wijn *et al.* 2014) is devoted to polarimetric measurements on the disk and above the limb. Vector magnetic field observations will be made using the chromospheric lines of He 587nm, H 656nm, Ca 854nm and He 1083nm, as well as the photospheric line of Fe 617nm.

The **CoSMO Large Coronagraph ("LC")** (see Tomczyk *et al.* 2016) is devoted to obtaining the highest quality polarimetric data of coronal emission lines at visible and IR wavelengths. It will operate as a "light bucket" far from the diffraction limit. The LC can make detailed polarization measurements of the extended corona, in addition to making Doppler maps critical for event detection. Once operational, the LC will also be the only available instrument capable of providing near-simultaneous 2D measurements of the thermodynamic properties of coronal plasmas from near the photosphere to the extended corona (2 solar radii or more).

As a critical part of its make-up, CoSMO will also provide a unique community testbed for new instrumentation concepts to be built and deployed in the pristine observing environment on Mauna Loa.

For more details about the CoSMO instrument suite, see Tomczyk *et al.* (2016) and references therein.

3. Proof of Concept: CoMP

The concept for the observations to be performed by the LC has already been demonstrated by the Coronal Multi-Channel Polarimeter (CoMP) instrument, which is operational on a daily basis at MLSO, albeit with a very much smaller aperture (and therefore sensitivity) than will be the case for the LC. Figure 1 shows coronal properties measured by the CoMP instrument in October 2005 on the 20 cm aperture OneShot coronagraph at the National Solar Observatory's Sacramento Peak Observatory in New Mexico. The CoMP is a filter-based polarimeter observing the FeXIII emission line at 1074.7 nm. These observations have a spatial sampling of 4.5 arcseconds per pixel, and required 1.5 hours of integration time due to the small coronagraph. Nonetheless they do demonstrate that plasma velocities and magnetic field direction and strength can be measured in the corona.

The CoSMO/LC by contrast will allow magnetic fields of strength 1-2 Gauss to be measured at, e.g., 2 arcsecond resolution with a temporal resolution of 15 minutes, or 4 arcsecond resolution with a temporal resolution of 5 minutes.

4. Coming Developments

With the US's national strategy gearing up to improve space weather forecasting capability, a facility like CoSMO is a critical piece of the puzzle. We are in active development of a ChroMag prototype and building an upgraded CoMP ("UCoMP") instrument as scientific pathfinders towards CoSMO.

UCoMP will serve as a proof of concept for the plasma diagnostic capabilities of CoSMO/LC, by observing the solar corona in a number of coronal, transition region

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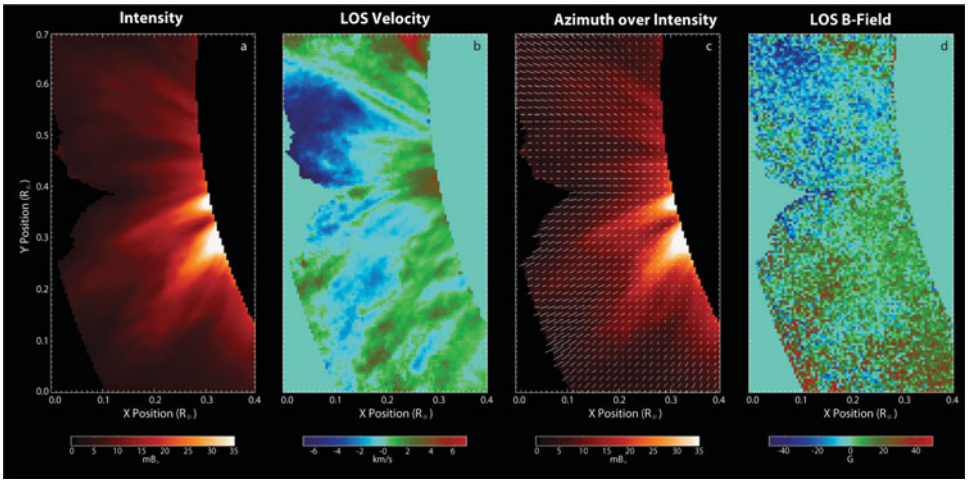

Figure 1. Inferred coronal plasma and magnetic field properties from CoMP observations. a) The intensity of FeXIII 1074.7 nm emission. b) The line-of-sight velocity of coronal plasma. c) Vectors showing the plane-of-sky direction of the magnetic field (the length of the vectors being proportional to the degree of linear polarization), superimposed on the intensity of FeXIII 1074.7 nm emission. d) The line-of-sight strength of the coronal magnetic field. (Adapted from Tomczyk *et al.* 2008.)

and chromospheric lines that will measure the plasma properties of both the quiescient and active corona, as well as CMEs. It will provide near-simultaneous 2D measurements of line intensities, Doppler velocities and widths, as well as plasma properties such as electron density, temperature distribution, and elemental composition everywhere from the photosphere to 2 solar radii (see Landi *et al.* 2016).

We hope that both UCoMP and the ChroMag prototype will be deployed to MLSO by summer 2018 and data will become available as soon as possible. Another interesting development is the "CoSMO Community Spar" – an eight-sided sun-pointing spar where we hope to work with sponsors to create a community instrument development program for space weather and synoptic observations that will be supported by the existing MLSO infrastructure on the mountain.

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