Summary

COSMO is a proposed synoptic facility designed to measure magnetic fields and plasma properties in the large-scale solar atmosphere. 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. COSMO comprises a suite of three instruments chosen to enable the study of the solar atmosphere as a coupled system: (1) a coronagraph with a 1.5m aperture to measure the magnetic field, temperature, density, and dynamics of the corona; (2) an instrument for diagnostics of chromospheric, prominence and photospheric magnetic fields and plasma properties; and (3) a white light K-coronograph to measure the density structure and dynamics of the corona and coronal mass ejections. COSMO will provide a unique combination of magnetic field, density, temperature, and velocity observations in the corona and chromosphere that have the potential to transform our understanding of fundamental physical processes in the solar atmosphere and their role in the origins of solar variability and space weather. We describe the COSMO suite of instruments, COSMO mission science objectives, and the synergies of COSMO with other missions such as Daniel K. Inouye Solar Telescope (DKIST) and the Frequency Agile Solar Radio telescope (FASK).

Proposed Suite of Instruments

A Large Coronagraph (LC) devoted to obtaining daily, synoptic observations of magnetic fields and plasma properties of the large-scale solar corona. The science requirements call for a 1.5 meter coronagraph with a large field of view (1 degree), and 2 arcsecond spatial resolution. The post-focus instrument will be a filter-based imaging spectropolimeter capable of observing coronal emission lines at visible and IR wavelengths formed over a wide range of temperatures.

A Chromosphere and Prominence Magnetometer (ChroMag) devoted to polarimetric measurements on the disk and above the limb. Vector magnetic field observations will be made using the chromospheric lines of H 587nm, H 665nm, Ca 854nm and H 1083nm, as well as the photospheric line of Fe 617nm. ChroMag has a spatial resolution of 2 arcseconds and a +/- 1.25 Res unit field of view. It is currently under construction and will be completed in 2022.

A K- Coronograph (K-Cor) to observe the column density of electrons in the corona. This instrument was constructed and put into operation at Mauna Loa in Sept 2013. K-Cor high temporal cadence (15 sec) and field-of-view from 1.05 to 3 Res can track CMEs from their onset through the middle corona. K-Cor data is available at: https://www2.hao.ucar.edu/miso/miso-home-page

Science Objectives

1. Understand the storage and release of magnetic energy by characterizing the physical processes leading up to eruptions
2. Understand CME dynamics and consequences for shocks by characterizing local and global interactions
3. Determine the role of waves in solar atmospheric heating and solar wind acceleration by characterizing spatial and temporal wave properties
4. Understand how the coronal magnetic field relates to the Sun’s dynamics and evolving global heliosphere by characterizing variations on solar cycle time scales
5. Constrain and improve space-weather forecast models by incorporating coronal and chromospheric magnetothermal observations

1.5 m Coronagraph FeXII

Figure 1. Below Right: Rendering of 1.5m aperture 95% refractive Large Coronagraph (LC). The dome is positively pressured with HEPA filtered air to maintain cleanliness of the objective lens. The dome is ~13 meters in diameter. Below Left: Smaller dome (5.5 m diameter) with solar ported community spar carrying the K-Cor and ChroMag instruments. Space is available on the spar for community developed instruments.

Advances in Interpretation Tools

Sarah Gibson and colleagues have been developing tools for comparing forward models of coronal magnetic fields with observations from COSMO, UC-OMP, CoMP, and other instruments. Figure 5 shows a simulation of a coronal cavity compared to CoMP. The forward modeling tools are available at: https://www2.hao.ucar.edu/miso/forward-model

Technology Demonstration

Fig. 2: Measurements (Lin et al. 2004) of circular polarization of FeXIII coronal emission line at 1074.7 nm. Observations were made with the Optical Fiberbundle Imaging Spectro-polarimeter (OFIPS) behind the 46cm aperture Solar coronagraph. The fibers subtend 20 arcsec. The measurement required 70 min integration time. This success is due in large part to the use of IR emission that has high sensitivity to the Zeeman splitting.

Another prototype demonstration, illustrated in Fig. 3, shows coronal properties measured by the HAO/NCAR Upgraded Coronal Multi-channel Polarimeter (UCOMP) instrument observing in Fe XII emission line at 1074.7 nm on 10 Feb 2022. UCoMP is an imaging spectropolarimeter employing a tunable birefringent filter based on lithium niobate crystals that demonstrates a key technology of the COSMO LC filtergraph. These data have a spatial sampling of 3 arcseconds per pixel and required 1 hour of integration time. Neither of these demonstrations have the spatial or temporal resolution required to meet COSMO scientific objectives due to the small coronagraph apertures.

See Ben Berkery’s poster: ‘An introduction to the UCoMP hardware and data products’

COSMO Complementarity to DKIST and FASR

The full coronal field-of-view (FOV) of COSMO, shown by the yellow annulus at right, complements the very high resolution, small field-of-view (FOV) of DKIST, shown by the small blue circle. The recent Decadal Survey, Pathways to Discovery in Astronomy and Astrophysics for the 2020s cited the need for global synoptic measurements of the coronal magnetic field to supplement the restricted FOV of DKIST. The COSMO FOV captures large scale structures such as Coronal Mass Ejections (CMEs) that cannot be fully observed by DKIST.

COSMO also complements observations from the Frequency Agile Solar Radio telescope (FASR). FASR will acquire observations of the coronal magnetic field on the solar disk, which COSMO cannot observe. COSMO can detect both strong and weak (quiet Sun) coronal magnetic fields, whereas FASR is only sensitive to stronger magnetic fields, such as in and around active regions.

COSMO Status

1. COSMO was endorsed in the last Helio Decadal Survey
2. Large Coronagraph PDR passed Nov 2015
3. K-Cor is in operation at Mauna Loa Solar Observatory.
4. Chromosphere Imager (ChroMag) is under construction and will be completed in 2022
5. We are currently funded by NSF to perform:
   1) COSMO Site survey (ongoing). See NEWS on COSMO webpage
   2) Final design for the 1.5-m Large Coronagraph (contracted to European Industrial Engineering)