Coronal Magnetism

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The corona is a magnetically dominated system

Coronal magnetism is the source of Space Weather

- Coronal Mass Ejections
- Energetic Particle Acceleration
- Coronal Heating
- Solar Wind Acceleration

Are not understood and will remain so until we are able to obtain routine measurements of coronal magnetic fields
Coronal Magnetometry Techniques

Gyroresonant Emission: Radio observations (B > 250 G)
Hanle Effect: EUV emission lines (O VI 103.2 nm)
Zeeman Effect: Vis, IR emission lines (Line-of-Sight B)
Resonance Scattering: Vis, IR emission lines (Plane-of-Sky Direction)
MHD Wave Seismology: Wave phase speed (Plane-of-Sky B)

Few Measurements Exist
Coronal Magnetometry - Zeeman Effect

Based on Judge et al. (NCAR Tech Note 446, 2001):
Visible/IR magnetometry with Zeeman Effect most promising
FeXIII has the best expected S/N

<table>
<thead>
<tr>
<th>Ion</th>
<th>$\lambda$ ((\mu)m)</th>
<th>Log $I_{\text{erg cm}^{-2} \text{s}^{-1} \text{sr}^{-1}}$</th>
<th>Figure of merit (max s/n ($V$))</th>
<th>Max $V/I$</th>
<th>Log $T_e$</th>
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Vis NIR Coronal Magnetometry Challenges

- Corona is $10^5$ - $10^6$ times fainter than photosphere
  Scattered light is significant - need coronagraph

- Coronal magnetic fields are weak 1-10 Gauss

- Coronal lines are much broader than in photosphere
  Need high S/N - lots of photons

- Coronal features are large
  Need large field-of-view, ~$1^\circ$

Very Difficult Measurement
Methodology

- Corona is multi-thermal: need to observe many emission lines emitted at different temperatures – need wavelength diversity

- Line-of-Sight field strength derived from Longitudinal Zeeman effect in Circular Polarization (V/I 10^{-4} / G) – need high S/N

- Plane-of-Sky direction derived from Resonance Scattering effect in Linear Polarization (Q/I, U/I 5-10%)

- Line-of-Sight velocity derived from Doppler effect in Intensity

- Plasma Density derived from line Intensity ratios

- Wave phase speeds can also provide magnetic field – need high cadence Doppler
The COronal Solar Magnetism Observatory is a proposed facility designed to measure magnetic fields and plasma properties in the large-scale solar atmosphere. It comprises:

- 1.5 m Aperture Coronagraph (Corona)
- Disk Imager / Polarimeter - ChroMag (Chromosphere/Photosphere)
- K-coronagraph (CME)

1.5-m coronagraph pictured here
What Kind of Coronagraph?

Lens has much less scattering than mirror
10x less from microroughness, 4x less from dust
Can achieve 1° FOV easier with lens (asphere)
1.5 m Refracting Coronagraph

Is preferred
And is feasible

Scattered Light Analysis

Finite Element Analysis of Lens

Optical Design
COSMO Large Coronagraph

1.5 m refractive coronagraph
1° field-of-view
Synoptic operation
Low scattered light
Will obtain measurements of coronal B with 1 Gauss precision in 12 minutes, 2 arcsecond spatial resolution

Would be the largest refracting telescope in the world, $30M
COSMO is Complementary

Most existing and planned solar telescopes have small FOV, and will observe at high spatial resolution and are not synoptic. COSMO LC is unique and complementary.

The COSMO coronagraph will have a light gathering power (étendue) that exceeds that of the DKIST by a factor of 15.

COSMO more like LSST than DKIST