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Observing and Modeling of Solar Coronal Structures Using High-Resolution Eclipse Images and Space-based Telescopes with Wide Field-of-View

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ABSTRACT

We present a comparison of the solar corona observed during the total solar eclipses of 2010 July 11 and 2012 November 13. The white light images were taken at Easter Island in 2010 and at Northeast Queensland, Australia, in 2012, while the concurrent EUV images were taken with SDO/AIA and PROBA2/SWAP. The 2010 eclipse was observed at the beginning of Sunspot Cycle 24 [1], which peaked near our 2012 observation. We compare a plethora of coronal features in the white light images and reveal some interesting differences in the enhanced EUV images taken by SDO/AIA and PROBA2/SWAP. We construct potential field models using our newly refined Coronal Modeling System (CMS2) software with line-of-sight photospheric magnetograms from SDO/HMI. The source surface heights derived from detailed comparison between our models and observations are compared to the standard source-surface model. We also compare the dynamics of the two eclipse observations. Similar to the 2010 eclipse, a CME was observed at the 2012 eclipse using temporally spaced eclipse images. We address unresolved problems in the models and observations with the hope of correcting for future eclipse observations, such as the 2017 total solar eclipse across the continental U.S.

Space-based Observations from SDO/AIA, SDO/HMI and PROBA2/SWAP

<table>
<thead>
<tr>
<th>Date</th>
<th>SDO/AIA 171Å</th>
<th>SDO/HMI 45s LOS Magnetogram</th>
<th>PROBA2/SWAP 174Å</th>
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Eclipse Observations & Composite Eclipse Images

- A SWAP mosaic image showing the entire solar disk (M. Lu and D. B. Seaton, SDSC/ROB.)
- Radial filtered SWAP mosaic, using off-azimuth images in the 174-Å passband (M. Lu and D. B. Seaton, SDSC/ROB.)
- A SWAP mosaic image (nearly in eclipse) showing the entire solar disk (E. Wertz et al., SDO/SDO/MSA/NASA.)

Comparing Potential Field Models and Observations

- Construct a map of the radial magnetic field $B(r, \theta, \phi)$ as a function of longitude and latitude on the solar surface ($r = R_\odot$). This map can be constructed from one or more magnetograms.

Limitations of Our Potential Field Models:

- The radial magnetic field, $B(r, \theta, \phi)$, is computed from the line-of-sight data using $B = B_{\odot} \cos \theta$, where $B_{\odot}$ is the heliocentric angle. This formula is accurate only when the observed field is radial on the Sun, and when we observe near the center of solar disk. This process corrects an inaccurate description of the magnetic field in sunspot penumbrae away from disk center because the field there has a strong horizontal component. For what we are studying, the large structure over the quiet region or across sunspot groups, this LOS-to-radial field extraction is reasonably accurate.

- The best way to model magnetic features observed near the limb during eclipses is to use HMI's high-resolution line-of-sight magnetograms from a few days before (west-limb models) and after (east-limb models) the time of the eclipse and select the region near the center of the solar disk. This method sets the temporal resolution of our model and limits the type of dynamical events that can be studied.

Constructing Potential Field Models

Step One: Construct a map of the radial magnetic field $B(r, \theta, \phi)$ as a function of longitude and latitude on the solar surface ($r = R_\odot$). This map can be constructed from one or more magnetograms.

Step Two: Apply spherical-harmonics expansion fitting the coefficients of expansion terms based on observed magnetic field data to the global magnetogram. The combination of linearized synoptic data and HMI's high-res LOS magnetograms can improve the fit of our model.

Select References:


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