Characterizing the Background Corona with SDO/AIA

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Abstract
Characterizing the nature of the solar coronal background would enable scientists to more accurately determine plasma parameters, and may lead to a better understanding of the coronal heating problem. Because scientists study the 3D structure of the Sun in 2D, any tool-of-the-trade includes both foreground and background material, and thus, the issue of background subtraction arises. By investigating the intensity values in and around an active region, using multiple wavelengths collected from the Atmospheric Imaging Assembly (AIA) on the Solar Dynamics Observatory (SDO) over an eight-hour period, this project aims to characterize the background as smooth or structured. Different methods were employed to measure the true coronal background and create minimum intensity images. These were then investigated for the presence of structure. The background images created were found to contain long-lived structures, including coronal loops, that were still present in all of the wavelengths, 131, 171, 193, 211, and 335 Å. The intensity profiles across the active region indicate that the background is much more structured than previously thought.

Introduction
The goal of this project is to characterize the solar backdrop, which is the region of undetected temperature, approximately 1 MK. This region has significant heating problems because the solar surface is only 5500 K. In essence, the corona is photospheric in nature, which leads to even greater heating problems for both foreground and background material. In order to accurately determine plasma parameters such as density and temperature, it is important to properly account for the coronal background. It is uncertain whether the background contains a smooth or structured.

AIA, one of these instruments on board SDO, collects high-resolution full-disk images of the corona in seven extreme ultraviolet bandpasses, each centered on distinct spectral lines. One of the advantages of these narrow-band filters is the ability to simultaneously supply temperature measurements for large areas of the corona. Each instrument may have multiplexing capability that enables the observation of different spectral lines (Jian et al., 2015). However, the coronal images are isolated with a single spectral line, resulting in the response functions being wide and/or double peaked (see figure 12). This makes the analysis more difficult.

Method
Eight hours of AIA data at a two-minute cadence was downloaded from the Virtual Solar Observatory in five wavelength channels, 131, 171, 193, 211, and 335 Å. Beginning on February 16, 2014 at 18:00 UT and ending on February 17, 2014 at 02:00 UT. The author region (AR4597) was selected at disk center in order to reduce both projection and background effects. Choosing an active region at disk center also reduced the ambiguity of the geometry of the loops. (Likewise, the line of sight was shortest, and therefore, there was less foreground material to contaminate the intensity measurements.)

Other Interactive Data (Data) was used to process and analyze the data. This data was processed using the aia_prep routine to change the data from unsigned 16-bit to unsigned 8-bit. This included making all enhancements and noise-equivalent as well as removing bad pixels. Additionally, the instrument jitter was removed using cross-correlation technique and the data was corrected for the effects of solar rotation. This technique was used to eliminate the images of the corona by creating minimum images. These minimum images were created using several methods, including spatial and temporal ones, in order to find the most robust method. The preferred method added the minimum image using the fifth lowest intensity value for each pixel through the eight-hour time period. The fifth lowest was used as opposed to the minimum value in order to remove the possibility of sudden drops in the intensity values. Coronal structures were detected through the active region in the minimum images were plotted in order to investigate if there was any structure present.

Results
Contrary to expectations, the loops were still present in the minimum images. Usually, such features appear and disappear within a few hours. However, the coronal loops were still present in all five wavelengths after eight hours. When the intensity values were plotted through the active region (figure 4) structured, not smoothly varying intensity profiles can be seen. Figure 5 shows results from the Differential Emission Measure (DEM) method plotted along the center diagonal that showed the temperature of the plasma in this region. This method uses information from the intensity along this cut in different AIA channels in conjunction with the instrument response function to make the best guess of the temperature of the plasma.

It is very important to accurately determine the coronal background in order to correctly determine plasma parameters such as temperature and density. Accurately knowing these parameters may lead scientists to a better understanding of the coronal heating problem.

Future work will examine these long-lasting background loops in more detail to see if there is something special about them that could explain their longer lifetime, e.g. if they have a different temperature profile to other loops, they are rooted in a particular magnetic field, or the magnetic field at the footpoints is doing something different to the rest of the region. In any case, when a new AR emerges or expands, it is observed. Figure 6 shows some new work being done to characterize the multi-wavelength nature of this AR. Scan the QR code below for a link to the movie.

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References