

Coronal magnetic fields from the inversion of linear polarization measurements

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Abstract. Real 3-D coronal magnetic field reconstruction is expected to be made based on the technologies of IR spectrometry and tomography, in which the data from other wavelengths can be used as critical reference. Our recent studies focused on this issue are briefly reviewed in this paper. Liu & Lin (2008) first evaluated the validity of potential field source surface model applied to one of five limb regions in the corona by comparing the theoretical polarization maps with SOLARC observations in the IR Fe XIII 10747 Å forbidden coronal emission line (CEL). The five limb coronal regions were then studied together in order to study the spatial relation between the bright EUV features on the solar disk and the inferred IR emission sources, which were obtained from the inversion of the SOLARC linear polarization (LP) measurements (Liu 2009). The inversion for each fiber data in the field of view was made by finding the best location where the difference between the synthesized and the observed polarizations reaches the minimum in the integration path along the line of sight. We found a close relationship between the inferred IR emission source locations and the EUV strong emission positions.

Keywords. Sun: corona; Sun: magnetic fields; Sun: infrared

1. Introduction

The solar coronal magnetic fields play a dominant role in the coronal plasmas distribution and dynamics. During the last decades, a few useful methods have been developed based on model assumptions for radio observations to derive coronal magnetic field strength; or based on the scattering polarization of CELs to map coronal magnetic field direction. Some valuable progresses have been made recently which use the strong infrared Fe XIII 1075 nm CEL for Zeeman splitting observations (Kuhn 1995; Lin *et al.* 2000, 2004). Penn *et al.* (2004) studied the noise sources in coronagraphic magnetic field strength measurements. Tomczyk and colleagues found the direct evidence of Alfvén waves in the corona with their new instrument CoMP (Tomczyk *et al.* 2008).

The imaging coronal spectropolarimeter SOLARC (Solar Observatory for Limb Active Regions and Coronae) was installed on Haleakala. A line-of-sight (LOS) coronal magnetogram was shown by Lin *et al.* (2004) as one of the first results taken by SOLARC. Liu & Lin (2008) studied in detail a limb coronal region by comparing the observed circular and linear polarizations with the synthesized maps based on potential field model. The best consistence for both linear and circular polarizations was found at the layer in the corona above a sunspot near the solar limb, indicating that local coronal magnetic fields may be revealed from the IR polarization data with the proper coronal magnetic field inversion method. As a next step, only the LP data were used to study the five limb coronal regions together. The single points were solved along each LOS using the same method, by minimizing differences between observed and computed LP data which were

based on the extrapolation code by Liu & Zhang (2002). The derived points from the IR data were compared with the EUV images of Fe XII 195 Å (Liu 2009).

2. Results

The five west limb coronal regions had been shown in Fig. 2 of Lin *et al.* (2004) with PAH (i.e., the Position Angle in the Heliocentric coordinate system) of 296, 291, 286, 281, and 276 degrees, separately. The coordinate system and the parameters used in the paper

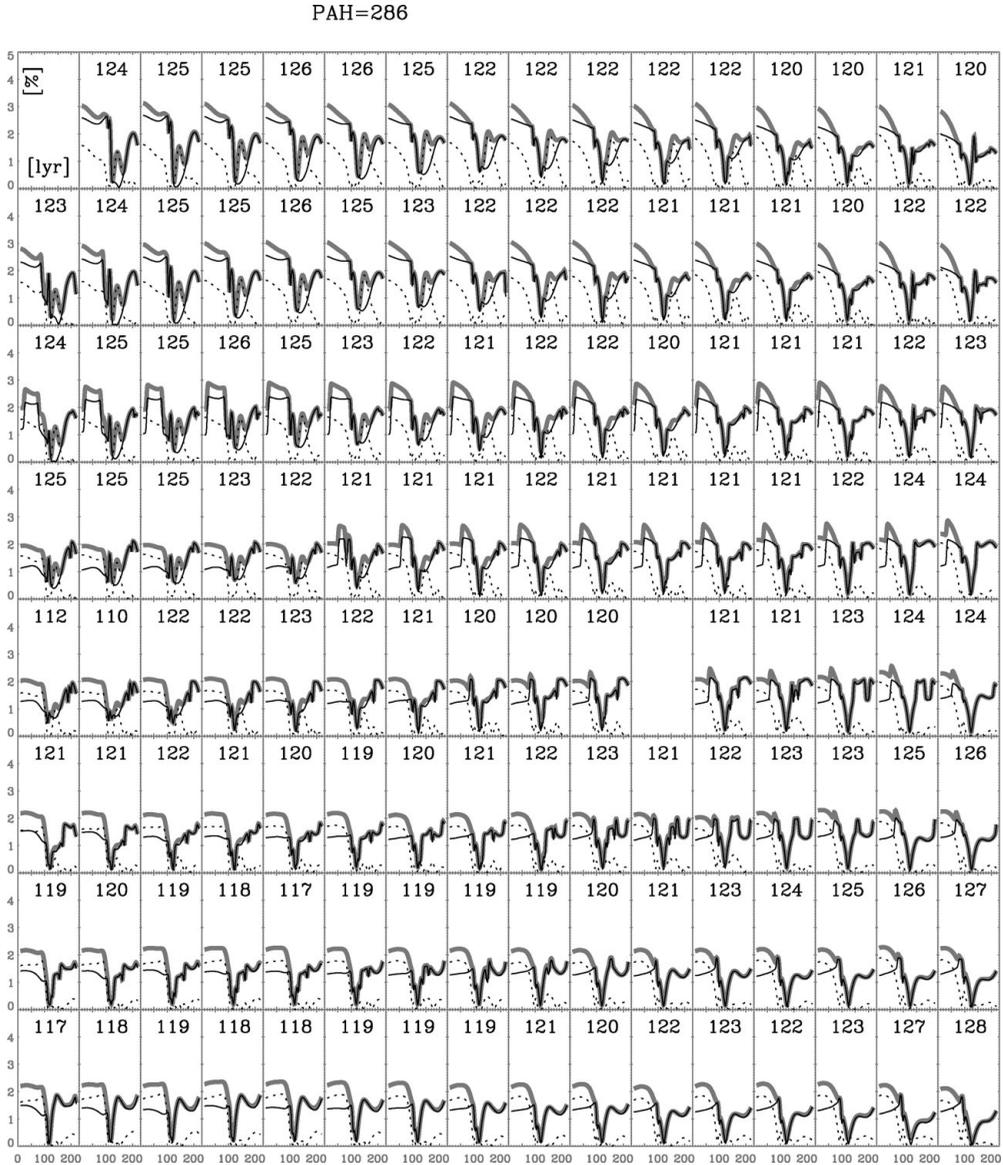


Figure 1. Error profiles for the coronal region at PAH 286 degrees. All the 16×8 fibers are shown for each coronal position. The location (z or $layer_{best}$) of the minimum error in a σ_{LP} profile (thick gray line) is shown in each frame. Most σ_{LP} profiles show a clear minimum value around the layer 120 above a sunspot located at the solar west limb. Note, $1 \text{ lyr} = 4.5 \text{ Mm}$.

of Liu (2009) are the same as in Liu & Lin (2008). Similar to results of the region PAH 286 (Liu & Lin 2008), the profiles of LP *vs.* z values (in unit of layer, i.e., lyr; Layerbest) in the other four regions also show a clear dip (Liu 2009). The identical peak/valley locations were noticed for different profiles. Such a common feature for different coronal regions is worthy of study. As a clear demonstration, Fig. 1 shows the LP profiles for each position in the coronal region with PAH of 286 degrees.

It can be seen that most derived IR emission sources were mainly distributed at around $z = 120$ where the sunspot region was located near the solar limb on the photosphere (Liu & Lin 2008). If we presume that the basic coronal structures in EUV wavelengths be kept stable and the same during the days before the solar limb SOLARC observation, it would be interesting to compare the inferred IR emission sources with the EUV bright features (Liu 2009). The EUV data have been pre-processed with the standard solar software procedures. For the coronal regions close to strong photospheric fields, their IR emission sources were mainly distributed in a cluster which discloses the root parts for bright EUV loops; while for a coronal region on the top of a bundle of transequatorial loops with weaker EUV brightness, their IR emission sources appeared to be distributed rather diffusely.

3. Conclusion

We applied the optimized method built in the paper of Liu & Lin (2008) for locating observed coronal magnetic fields from IR linear polarization data to all five coronal regions observed on 7 April 2004. The idea of this method is different from the traditional ways which take the corona emission as optically thin for IR observations along sight line (e.g., Judge *et al.* 2006). Practically, we usually operate SOLARC to observe the limb coronal regions with strong EUV 195 Å emissions for routine IR polarization measurements. Our recent results have confirmed the advantage by taking SOLARC observations with the reference from EUV wavelength images to obtain useful information for the study of local coronal magnetic fields. A general tendency can be seen from the comparison between IR and EUV emission sources: the higher the percentage of EUV bright points for a field of view, the more concentrated the distributions of the IR emission sources. In the next step, we plan to compare the inferred 3-D IR source regions with the 3-D structure of the bright EUV features with the help of coronal tomography technology or the 3-D STEREO EUV data.

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