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Three Dimensional Structure of Active Regions

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Abstract. We present the preliminary results of the modeling of the three dimensional structure of the magnetic field above the active regions observed with Advanced Stokes polarimeter and Dick Dunn telescope at National Solar Observatory, USA. The observed photospheric magnetograms are extrapolated to chromospheric heights using the Fourier expansion technique to compute the potential (current-free) magnetic field in Cartesian geometry. The photospheric surface is assumed to be flat, but the tilt of the boundary plane with respect to the plane of the sky is taken into account, depending on the location of the active region. The best fit of the observed and computed scatter plot is achieved by considering the height of the chromospheric emission at 800 km.

Keywords : Sun – Active Regions – Magnetic Field – Stokes Polarimeter

1. Introduction

The magnetic field of the solar atmosphere above active regions plays a major role in governing the physical nature of chromospheric and coronal plasmas. It is believed that the kilogauss field is contained deep in the atmosphere where the external gas pressure exceeds the magnetic pressure $B^2/8\pi$, with a much weaker internal gas pressure ensuring the total pressure balance. At higher layers the ambient gas pressure being lower, the field lines of a magnetic element open out until uniform merging occurs from nearby elements. This forms a canopy at a height of about 1500 km (Gabriel, 1976). Most of the observational studies of the active region magnetism are based on the photospheric measurements that are used for inferring the coronal field (D'emoulin et al, 1997). The study of chromospheric magnetograms obtained with Mgb_2 line and Wilson depression data showed

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that the field covers the supergranules completely at heights mostly less than 500-600 km above the photosphere ($\tau_{5000} \sim 1$), up to 700-800 km away from the network and below 600 km in active regions and plages (Giovanelli, 1980). As the magnetic field structure within the active region is not dealt in Giovanelli's model, it can not explain many of the recent observations of coronal features. We have initiated an extensive program to study the nature of chromospheric magnetic field by comparing the observed and computed field for various types of active regions. In this paper, we present the preliminary results of our study of three dimensional magnetic field structures of solar active regions. The photospheric magnetograms are extrapolated into the chromosphere by using the potential model and compared with the observed chromospheric magnetograms.

2. Observations and Analysis

The observational data set consists of the NSO/KP synoptic observations and the observations obtained from the NSO/KP with Advanced Stokes Polarimeter (ASP). The photospheric and chromospheric Stokes profile maps of the active region NOAA 8426 (E6.2, N15.8) was obtained with ASP on 4 January 1999. Each observing run consisted of about 20 repetitions. During the observations, appropriate flat-field and calibrations were also obtained. The active region was situated near the central meridian of the solar disk and was a compact bipole, in which the positive and negative flux were nearly balanced. The photospheric and chromospheric magnetic field observations at NSO/KP are made with the FeI 8686 Å and CaI 8542 Å respectively and those at NSO/SP are in FeI 6302 Å and MgI 5173 Å respectively. The NSO/KP synoptic full disk magnetograms are obtained with the littrow spectrograph having slit size of 0.7 × 550 arc-second. It takes about 45 minutes for one full disk observation. A slit width of 0.5 arc-second was used in case of the ASP Dick Dunn Vacuum Telescope. The photospheric magnetograms were extrapolated into the chromosphere by using the potential field model in order to compare the magnetic field obtained with the chromospheric lines. The details of the method are described by Venkatakrishnan and Gary (1989). The method uses a Fourier expansion technique to compute the potential (current-free) magnetic field in Cartesian geometry. The photospheric surface is assumed to be flat, but the tilt of the boundary plane with respect to the plane of the sky is taken into account, depending on the location of the active region. The best fit of the observed and computed scatter plot is achieved by considering the height of the chromospheric emission at 800 km.

3. Results

1) The heights of the chromospheric magnetic field estimated from the observed magnetograms is consistent with that obtained with the thermodynamical estimations of the line formation for the used spectral lines.

2) A large fraction of the active region magnetic field is consistent with the potential-field model of extrapolating the observed photospheric field into the chromospheric heights.

3) The active regions show potential-field configuration in the initial stage of their evolution compared to the later stages.

4. Acknowledgements

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