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Magnetic and velocity fields over active regions

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Abstract. In order to understand the nature of dynamics over an active region (AR), it is necessary to study the velocity and magnetic fields simultaneously. We present the preliminary results from our analysis of spectropolarimetric observations of active region NOAA-8426 over two days. These observations were done using Advanced Stokes Polarimeter (ASP) instrument of HAO-NSO (Elmore et al. 1992, Lites 1996) with the Richard Dunn Vacuum Tower Telescope, USA. The line-of-sight (LOS) magnetic field information is derived using least squares fitting of the Stokes-V profiles, in a weak field approximation. Simultaneous LOS velocity information over these AR is obtained in two ways : (i) Zero-crossing (ZC) velocities using Stokes-V profiles, and (ii) centre of gravity (COG) velocities using Stokes-I profiles. The former corresponds to the magnetised plasma whereas the latter to the gross plasma over the AR. Average relative velocities of isolated polarity regions of the AR are presented in this paper.

1. Introduction

The evolution of the magnetic field and the plasma dynamics in solar atmosphere above the active regions are inter-related and govern the behaviour of each other. Most of the studies related to the active region magnetism and plasma dynamics are limited to magnetic field observations at photosphere and plasma velocities at other atmospheric heights (Klimchuk, 1989). Simultaneous observations of the velocity and magnetic field of an active region at a given height will greatly help in quantitatively understanding the role of magnetic field in plasma dynamics. Here we present the preliminary results of magnetic and velocity fields of an active region in two phases.

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2. Observations and Analysis

The active region NOAA-8426 was situated near disk centre. It was observed on 3rd January (N15 E19.8, we call this dataset AR1) and 5th January (N15 W2.6, we call this dataset AR2), 1999. The Stokes profile maps were made by scanning the spectrograph slit over the active regions. The polarization profiles in photospheric line Fe I 630.15 nm are used in our present study. The spectral range of 630.1 to 630.3nm with a dispersion of 1.667 pm/pixel was covered. The spatial scale was 0.44 arcsec/pixel and the slit width was 0.6 arcsec. The scanning step size was 0.6 arcsec. These observations are corrected for dark current, gain, instrumental polarization and cross-talk using ASP pipeline (Skumanich et al. 1997). The wavelength calibration of the observations is done using O_2 telluric line 630.2 nm which is also present in the observations. The telluric line positions are slightly dependent on air pressure with a statistical error of ± 0.2 pm (Sigwarth et al. 1998). Since we are interested in relative flows of the opposite polarity regions, absolute wavelength calibration is not necessary. The magnetized plasma motions are inferred from the zero-crossing wavelength position of Stokes-V profiles. The zero-crossing wavelength is defined as the wavelength position where the Stokes-V signal crosses over from positive to negative. In order to avoid errors we measure the zero-crossing positions only for profiles having large Stokes-V signal. The magnetic as well as non-magnetic plasma motions are inferred from centre of gravity (COG) wavelength position of Stokes-I profiles. The COG wavelength is defined as $\lambda_{COG} = \sum I \times \lambda / \sum I$. This method gives correct values of line centre even in the umbral regions as reported by Balasubramanian et al. (1997). The line-of-sight (B_l) magnetic field is determined using least squares minimization of the observed Stokes-V profiles under the weak field approximation i.e., the Zeeman splitting is less than the line width. The average position of zero-crossing wavelength and COG wavelength is measured for positive and negative polarity regions separately. We define these regions as parts of the field of view having magnetic field values greater than 500 G. In the absence of an absolute wavelength calibration, this method is safest for determining relative flows in the opposite polarity regions.

3. Results and Conclusion

In both AR1 and AR2 the COG wavelength over magnetized plasma show redshift as compared to a quiet region. This is expected because of the well known convective blue shift of spectral lines over a quiet region. This gives confidence in the analysis method. The flow velocities described below are, as measured in positive polarity region w.r.t negative. Following this convention the results can be summarized as follows :

(1) The AR1 shows (a) zero-crossing velocity of $\sim$ 400 m/sec, and (b) centre of gravity velocity $\sim$ 240 m/sec.

(2) The AR2 shows (a) zero-crossing velocity of $\sim$ 200 m/sec, and (b) centre of gravity velocity of $\sim$ - 115 m/sec.

In summary, there is an upflow of magnetized plasma in negative polarity regions with respect to the positive polarity regions in AR1 as well as AR2. The sense of COG flows in AR1 and AR2 is however, opposite. These results indicate the presence of plasma flows in active regions from one polarity region to another. The characterstics of such flows over active regions and their relationship to various forms of solar activity is not well understood. Our large dataset is currently being further analysed, which will yield a better understanding on the behaviour of such flows.

4. Acknowledgement

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