Measurements of Coronal and Chromospheric Magnetic Fields Using Polarization Observations by the Nobeyama Radioheliograph

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The magnetic fields of the corona and the chromosphere are important to understand various phenomena in the solar atmosphere. In magnetized plasma, ordinary and extraordinary modes of the free-free emission have different optical depths. Hence, the radio circular polarization observation enables us to derive the longitudinal component of the magnetic field. In this study, we have derived coronal and chromospheric magnetic fields from circular polarization observations by the Nobeyama Radioheliograph (NoRH) [1].

NoRH observes the full solar disk every 1 second at 17 GHz (intensity and circular polarization) and 34 GHz (intensity). We selected an active region located near the center of the solar disk that has large longitudinal component of the magnetic field. Then, a frequency spectral index of the radio brightness temperature was derived from the ratio of brightness temperatures at 34 GHz and 17 GHz. The brightness temperatures of the quiet Sun at 17 GHz and 34 GHz are assumed to be 10000 K and 9000 K, respectively [2]. The radio spectral index of the quiet region is about 0.15 using this assumption. The observed radio spectral index is between 0.2 and 0.6 around the active region.

The longitudinal component of the magnetic field is derivd as follows [3],

$$\begin{aligned} B_l[G] &= \frac{10700}{n\lambda[cm]}\frac{V}{I} \\ n &\equiv \frac{d(\log I)}{d(\log \lambda)} \end{aligned} \qquad (1)$$

where I is the brightness temperature, V is the brightness temperature of the circularly polarized component, λ is the wavelength in cm, and n is the power-law spectral index of the brightness temperature. The derived magnetic field is about 200 G at the center of the active region, and 70 G at the edge of the active region. The ratio between the observed radio magnetic field and the corresponding photospheric magnetic field is about 0.4 to 0.6 at the center of the active region (Fig. 1).

The observed radio magnetic field contains both of the coronal and chromospheric components [4]. We assume that the solar atmosphere observed at microwave range has two components; the optically thin corona and the optically thick chromosphere. The radio circular polarization images are compared with the ultraviolet images observed by AIA and the photospheric magnetic field observed by HMI, both onboard the SDO spacecraft. Around the edge of the active region, the location of the observed radio circular polarization corresponds to that of the coronal magnetic field and its loop structures. On the other hand, the chromospheric component is dominant at the center of the active region. Hence, it is suggested that the 17 GHz observation can derive both of the coronal and chromospheric magnetic fields. For the future studies, circular polarization observations at multiple frequency bands are required to separate the coronal and chromospheric components more accurately.

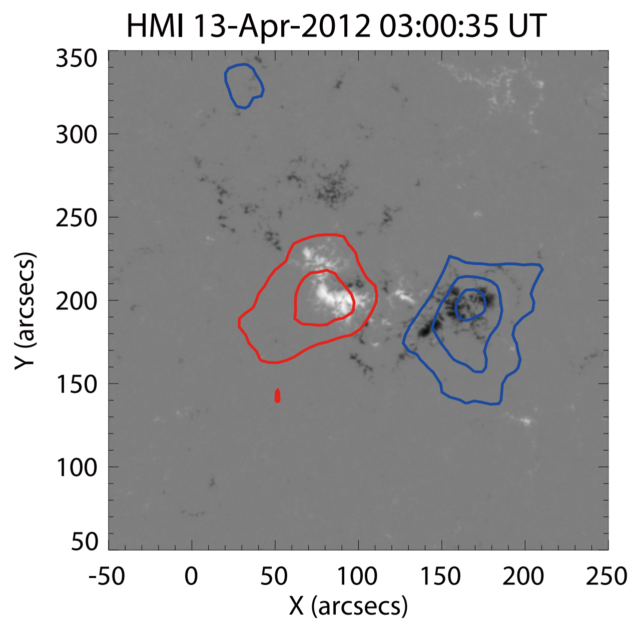

Figure 1: Magnetic fields observed by HMI at 03:00 UT on April 13, 2012. Radio circular polarization at 17 GHz is superimposed as contours: positive components in red, 0.5 %, 1.0 %; negative components in blue, 0.5 %, 1.0 %, 1.5 %.

References

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[4] Grebinskij, A., et al.: 2000, *A&AS*, **144**, 169.