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Measurements of Chromospheric and Coronal Magnetic Fields by Nobeyama Radioheliograph

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The magnetic fields of the corona and the chromosphere are important to understand various coronal phenomena and improve the space weather research. 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 Nobeyama Radioheliograph (NoRH).

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 slope of 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, from Selhorst et al (2005). The radio spectral slope of the quiet region is about 0.15 using this assumption. The observed radio spectral slope is between 0.2 and 0.6 around the active region. The ratio between the observed radio magnetic field and the corresponding photospheric magnetic field is about 0.4 to 0.6.

The observed radio magnetic field contains both of the coronal and chromospheric components. 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 onboard the SDO spacecraft and potential field extrapolations using the photospheric magnetic field. 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. Circular polarization observations at multiple frequency bands can separate the coronal and chromospheric components more accurately.

Keywords: Sun: radio radiation, Sun: magnetic fields, Sun: corona, Sun: chromosphere, Nobeyama Radioheliograph, circular polarization degree