Observational Studies of the Magnetic Field in Solar Active Regions

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The author focuses his much interest on the photospheric magnetic field in active regions, because only in these regions observations can provide both the longitudinal and transverse components of the magnetic field, which allow us to approach the problems how free magnetic energy is built up and where energy is released in configurations, through analyses of the features such as magnetic non-potentiality, current helicity and magnetic topology. In this thesis, the author at first introduces the observational calibration for the Multi-Channel Solar Telescope (MCST) of Huairou Solar Observing Station (HSOS) and his software used for HSOS data reduction, then presents his studies during 1994–1997. The obtained results mainly include as follows:

1. The author tested two observational methods in calibrating the longitudinal field measurements. One is the line profile method, and the other is the Doppler velocity method. The both methods showed that the calibrated results working at FeI5324.19A and H_β were in good agreement with those in previous theoretical calibration.

2. The author designed a software called DCP for reductions of the HSOS vector magnetograms. DCP includes the functions such as calibration, removal of 180-ambiguity of the transverse field measurement, calculation of the vertical electric current and elimination of projection effect, etc.

3. The author calculated the imbalance of current helicity over the whole AR's area for 40 active regions and obtained: (i) In 90% of cases there existed significant excess of current helicity of some sign. So one can suggest that the build up of large-scale currents in an active region due to small-scale fluctuations is rather typical phenomenon. (ii) In 82.5% of cases the excess of current helicity in the northern (southern) hemisphere was negative (positive).

4. The author applied the Poincare index method to diagnose the 3-D singular structures in an observed transverse field. He found that in some cases the deduced 2-D saddle points and magnetic lanes correspond to the separatrices on the photosphere. When comparing with the bright kernels in H_β and the emitting loops in SXR in some flaring events, it showed that the energy release contributing to the coronal heating appeared to be closely associated with these structures.

5. The author analysed the evolution of structures of magnetic fields and electric currents. Combining the emissions in H_β and SXR, he deduced the spatial magnetic configuration of a 1N/M1.1 flare and its relationship with the photospheric current distribution, which suggested that the flare may be due to the interaction of two emerging current loops.