Abstract

The solar magnetic field governs all the solar activities occurring at the outer atmosphere of Sun. The magnetic field lines in the solar atmosphere are stressed or deformed by the convective motion at the photosphere. These stressed magnetic field configuration is believed to be responsible for activity phenomena like flares, filament eruptions, coronal mass ejections (CMEs) etc. Majority of the eruptive events occur in the regions of strong and complex magnetic fields called as active regions. These eruptive phenomena directly affect near-Earth space weather by the accompanying high-energy radiation and charged particles. In order to predict these events a detailed investigation of solar magnetic structures is required. Thus, measurement of solar magnetic fields is of utmost importance in solar physics. However, measurement of solar magnetic field is done remotely by measuring the polarization of solar spectral lines induced by Zeeman effect. Polarization measurement is quite a challenging task because the polarization state of incoming light can be modified due to several factors/components (Earth atmosphere, Telescope, other optical components) coming in the path of light beam.

Multi-Application Solar Telescope (MAST), a 50 cm off-axis Gregorian telescope, was installed at Udaipur Solar Observatory (USO), India, which has been made operational recently. For understanding the evolution and dynamics of solar magnetic and velocity fields, an imaging spectropolarimeter has been developed at USO as one of the back-end instruments of MAST. This system consists of a narrow-band imager and a polarimeter. This instrument is intended for the simultaneous observations in the spectral lines at 6173 Å and 8542 Å, which are formed in the photosphere and chromosphere, respectively. The focus of this thesis is on the development of a polarimeter for measuring the polarization signal induced in the photosphere and chromosphere. The polarimeter includes a linear polarizer and two sets of Liquid Crystal Variable Retarders (LCVRs). It is known that the retardance of LCVR depends on the voltage and temperature. Voltage at

a constant temperature is used for fast modulation.

However, fluctuations in the temperature and voltage reduces the accuracy in the polarimetric measurements. Thus we have characterized LCVRs of the polarimeter for various combinations of voltages and temperatures. Further, to achieve a sufficient polarimetric accuracy of 10^{-3} *, it is necessary to calibrate the polarimeter and remove the cross-talk arising from the polarimeter itself. The calibration of the polarimeter is performed by introducing a calibration unit (CU) consisting of a linear polarizer and a zero order quarter wave plate (QWP). Both elements are placed in computer controlled rotating mounts. The calibration unit is placed just after the folding mirror (M6) of MAST. Thus, during operations with MAST, calibration unit is used to generate known polarization by rotating QWP. The polarimeter response function or X-matrix is determined from a comparison between created input and measured output. The application of the inverse matrix* X^{-1} *on the measured Stokes vector removes the cross-talk arised due to properties of the polarimeter components.*

In the thesis, spectropolarimetric observations of various active regions obtained with the imaging spectropolarimeter for MAST are also presented. For verification, we have made comparison of line-of-sight observations of a selected active region obtained from the Helioseismic Magnetic Imager (HMI) onboard the Solar Dynamics Observatory (SDO) with that obtained from observations in the spectral line 6173 Å from MAST telescope. We found good agreement between both the line-of-sight observations, considering the fact that MAST observations are limited by atmospheric seeing.

It is important to note that MAST is a nine mirror system with two off-axis parabolic and seven plane oblique mirrors, the oblique reflections of these mirrors complicate the measurement as the instrumental polarization corrupts the incoming radiation. The polarization induced due to mirrors of telescope is linear. In order to get the vector magnetic field Stokes Q, and U profiles need to corrected using telescope matrix. We have planned to obtain the telescope matrix

both theoretically and experimentally. The thesis is concluded with a discussion on the ongoing experiment for the determination of telescope matrix using sheet polarizer.