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Hα Polarimetry and Magnetic Field Structure in the Chromosphere

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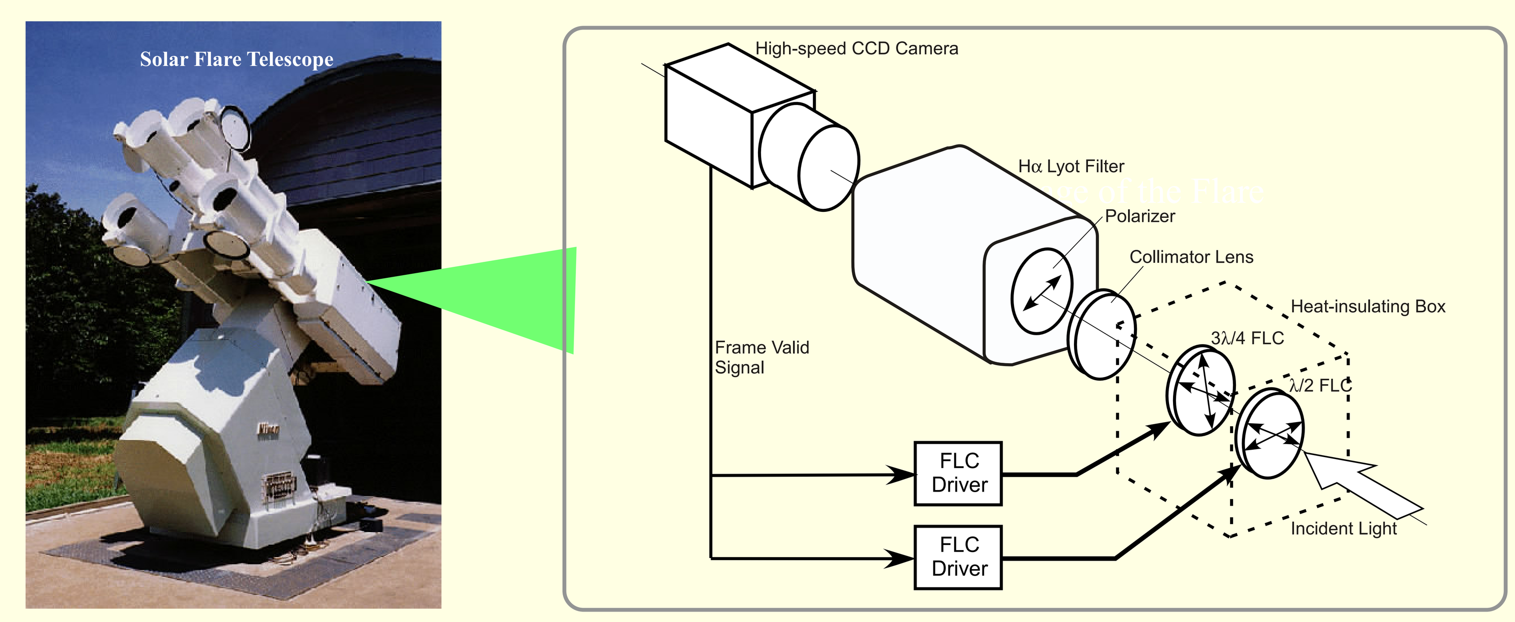
Abstract. We have developed a high-precision polarimeter with ferroelectric liquid crystals, and it enables us to get full-Stokes polarization data of the chromosphere in the Hα line with the precision of the order of 10^{-4}. It was revealed that polarization data taken at different wavelengths in the Hα wing show the magnetic field information at different heights in the chromosphere. This means that three dimensional magnetic field structure in the chromosphere can be inferred from the Hα polarimetry data.

1. Solar Flare Telescope and FLC Polarimeter

Ferroelectric liquid crystals (FLCs) enable us to modulate the polarization with high frequencies. The high-frequency modulation is essentially important to remove the seeing-induced error in the polarization measurement. We installed a FLC polarimeter into the Solar Flare Telescope of NAOJ, and observe the Sun in the Hα line. The precision of the polarimetry is the order of 10^{-4}, and we can obtain the full-Stokes signals, which correspond to the vector magnetic fields in the chromosphere. Polarization data are taken at several wavelength offsets from the line center.

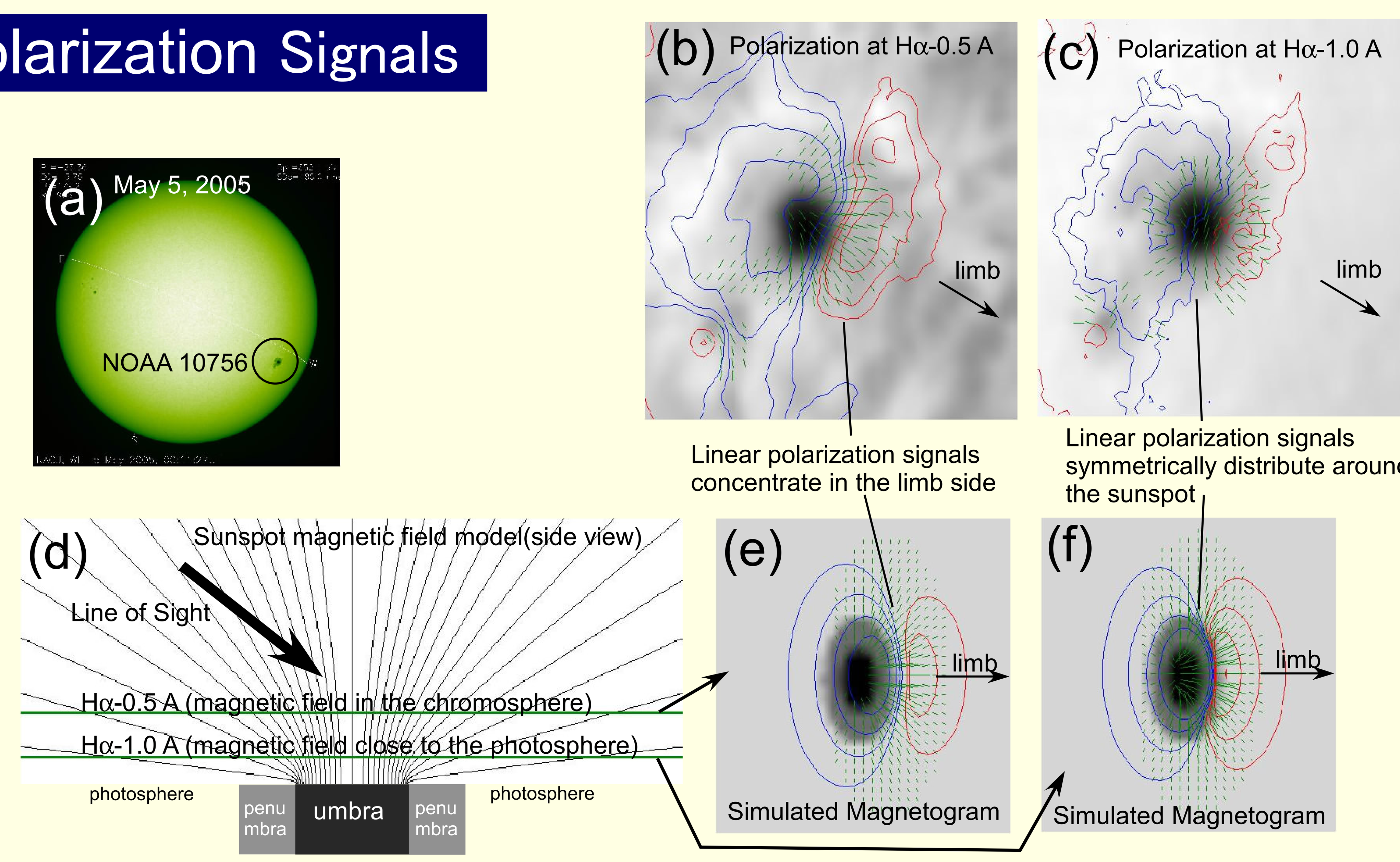


The Solar Flare Telescope and the outline of the polarimeter with Ferroelectric Liquid Crystals.

2. Wavelength Dependence of the Polarization Signals

NOAA 10756 was located at S07W52 on May 5, 2005. This is a good example to demonstrating that the Hα polarimetry can measure the polarization signals at various heights in the chromosphere.

Panels b and c show the polarization maps at Hα-0.5 A and Hα-1.0 A respectively. Circular polarization is shown by contours, and linear polarization is shown by sticks. The polarization maps are systematically different from each other, particularly in the linear polarization signals. This difference can be explained by the difference of height. Panel d shows a model of the sunspot magnetic field, and panels e and f show the expected magnetograms for two heights in the model. The model maps at the two heights reproduce the observation well. This fact means that we can obtain three-dimensional information of the chromospheric magnetic fields with the Hα polarimetry.



3. Highly-Sheared Magnetic Field in the Chromosphere

NOAA 10720 appeared in January 2005, and it was extremely flare-productive. The GOES X-ray plot is shown in panel a. An Hα picture and a polarization map at Hα-0.5A on January 13 are shown in panels b and c. Fibrils between two major sunspots are not sheared, and the linear polarization signals also show the non-sheared magnetic field. However, fibrils and the Hα map on January 14 (panel d) and linear polarization signals in the polarization map at Hα-0.5A (panel e) are highly sheared. The magnetic shear developed rapidly within a day. On the other hand, the polarization map at Hα-1.0 A (panel f) shows non-sheared polarization signals. Therefore, highly sheared magnetic field observed only in middle or upper chromosphere on Jan 14. After the observation on Jan 14, this region produced several X-class flares (red circles in panel a). This fact shows that the photospheric magnetograms, which have been used to study the magnetic field in active regions, are not sufficient to estimate the magnetic energy storage in active regions in such a case.