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Imaging the Chromosphere using Photospheric Mn 539.4 nm

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Abstract. Archival full disk observations of the central depth of Mn 539.467, a photospheric line, have been found to correlate with chromospheric Ca K intensity. In this paper we present spectroheliograms taken in Mn I 539.467 and 542.32 nm lines and other nearby lines to see if the other photospheric lines show chromospheric structures. We see both Mn images and also Si I 542.118 mimic magnetograms the similar way, while strong Fe and Ti lines only faintly reveal magnetic features, and weak Fe lines of comparable strength to Mn show nothing.

Introduction. Full disk synoptic observations of the central depth of Mn 539.467 have been found to correlate with Ca K 393.3 intensity, while Fe photospheric lines show little or no correlation (Livingston & Wallace 1987). Such a correlation was a puzzle because Mn 539.4 nm is a ground state (0.00 eV) photospheric line, whereas CaK 393.3 is chromospheric. Other photospheric lines of similar strength to Mn do not exhibit this correlation in the full disk archives. Only the cores of very strong photospheric lines, like Na D, Mg b, deep Fe lines, faintly reveal chromospheric structure in spectroheliograms (Title 1966). In this paper we present spectroheliograms taken in Mn I 539.467 and 542.32 nm, and other nearby lines, to see if these images also sensitive to chromospheric conditions.

Observations. Two 3-D imaging spectroscopy data sets in Mn I 539.4 and 542.0 nm lines were obtained 15 September 2003 with the NSO Kitt Peak Vacuum telescope using the NASA/NSO spectromagnetograph (Jones *et al.* 1992). The region included plage in the N-E of the disk. Data reduction includes dark and flat-field correction, alignment of spectra to solar lines, normalization of the spectra to continuum(Malanushenko & Jones (2004)). Several spectroheliograms were extracted from the data. Limb darkening was removed by normalization to appropriate polynomial functions.

Results and Discussion. Figure 1(a–e) shows spectroheliograms in the cores of several spectral lines, and a magnetic field map (f), scaled to cover the identical area. All lines are photospheric.

The Mn 539.5 and 542.0 images are seen to spatially mimic surface magnetic fields with similar way. We cannot support the 'optical pumping' mechanism for Mn excitation, proposed by Doyle *et al.* (2001), because they predict different properties for our Mn lines, but we see them to be very similar. Regardless of the physical cause, we have demonstrated that the Mn I 539.5 and 542.0 lines both do map magnetic fields in spectroheliograms. Images in Fe I 539.3 and Ti II 541.9 (not shown) reveal only a faint chromospheric picture, and weak Fe 539.5 line shows virtually nothing.

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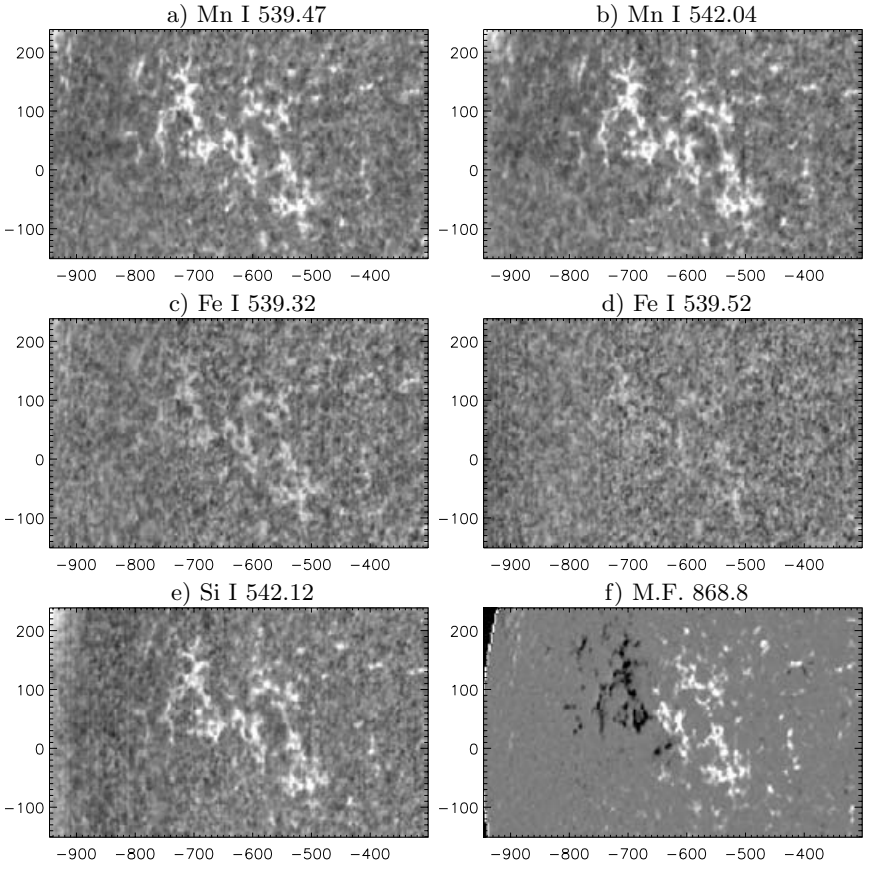

Figure 1. Spectroheliograms and magnetogram in core of several lines.

Beside the Mn lines there is another photospheric line, Si I 542.1 nm, which curiously shows the magnetic network and will probably track the solar cycle. The Kitt Peak full disk archives, which cover a dozen spectral windows and many lines, indicate no other examples. If we had not stumbled onto Si 542.118 we would have surmised only the Mn lines were so disposed.

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