The Seventh Hinode Science Meeting 12 to 15 Nov., 2013

S7-P-18 The Magnetic and Velocity Field Structure of the Sunspot Chromosphere

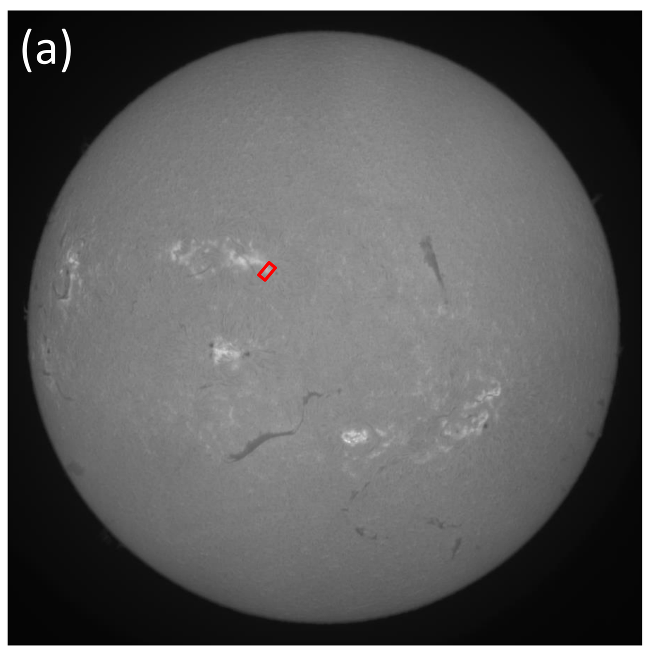
Akihito Oi[1], Kiyoshi Ichimoto[1], Yukio Katsukawa[2], Yoshinori Suematsu[2]
([1]Kwasan and Hida Observatories Kyoto University, [2]National Astronomical Observatory of Japan)

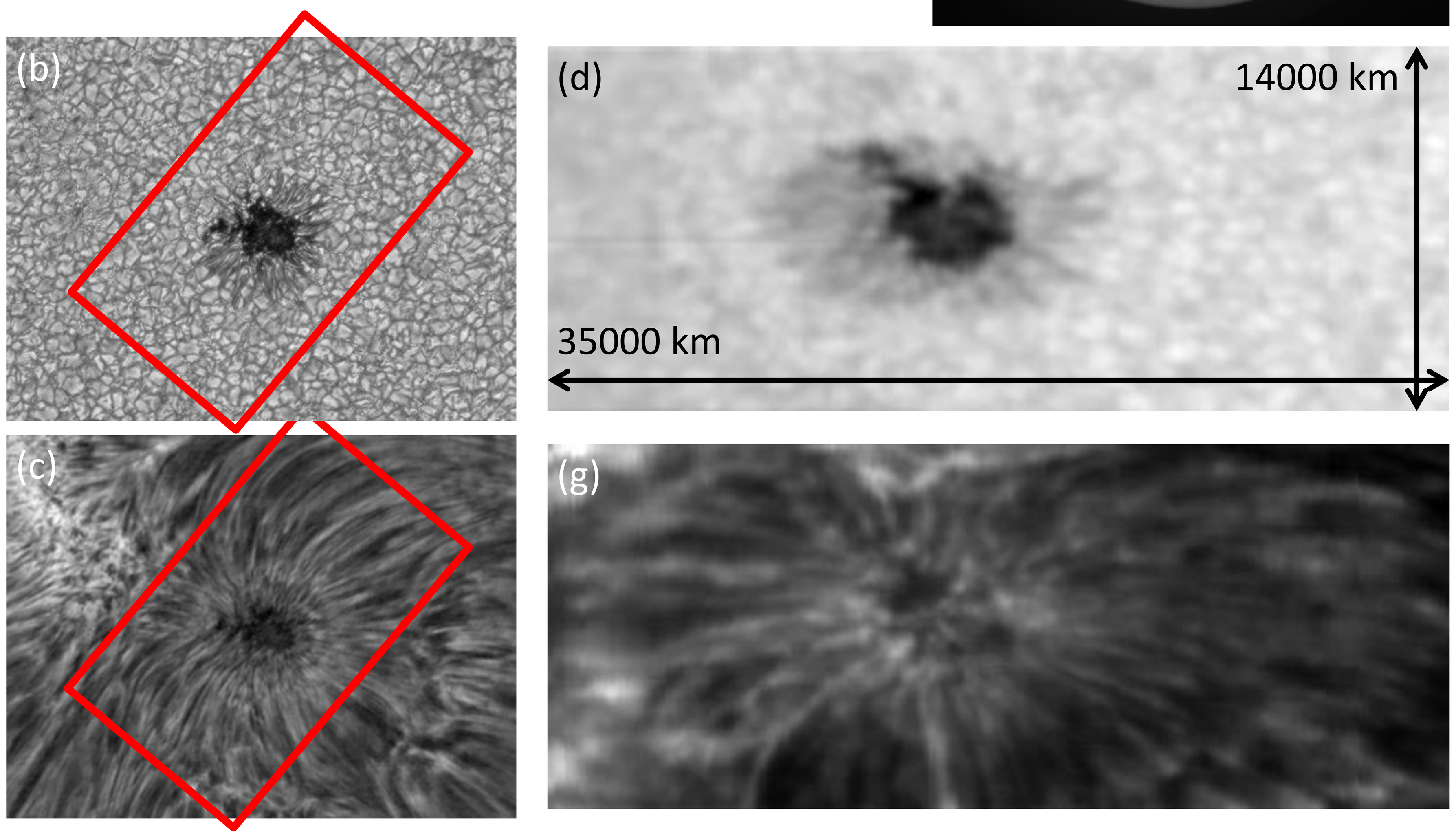
It has been known that supersonic flows toward a sunspot are common phenomena in a chromosphere above a sunspot. The flows are called an **inverse Evershed flow**, and have line-of-sight velocities of 10 to 20 km s^{-1}, in some cases over 50 km^{-1}. It is necessary to obtain more knowledge on the phenomenon in terms of how magnetic field structures in the chromosphere drives the flow. In this study, we analyzed the chromospheric magnetic and velocity fields in the sunspot chromosphere utilizing precise polarimetric measurements and the Hanle effect. Recent developments of both observation technologies and theoretical modeling of the Hanle effect have allowed us to perform diagnostics of weak polarization signals in the chromosphere.

Observations

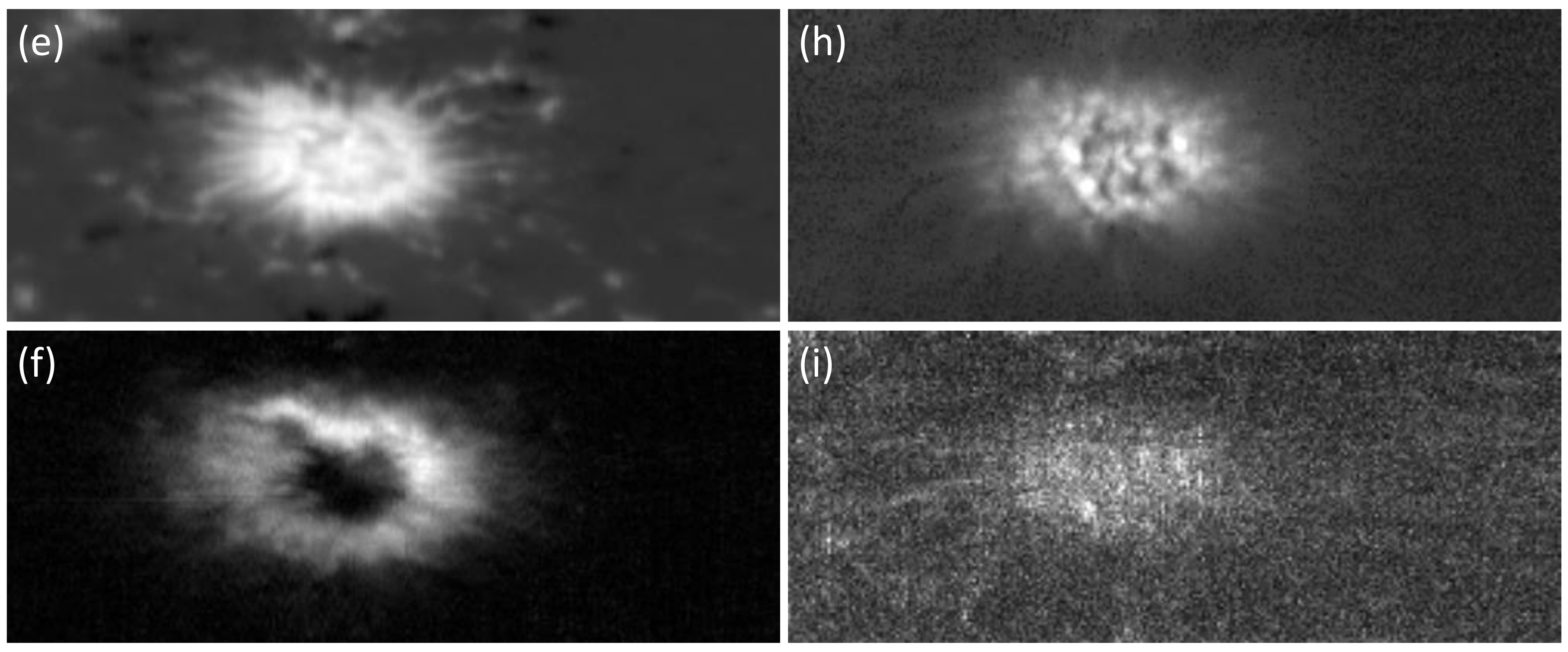
Target: AR 10781, Date: 3 July, 2005
The German Vacuum Tower Telescope (VTT) / Tenerife Infrared Polarimeter (TIP-II)
- Chromospheric He I 1083.0 nm line
- Photospheric Si I 1082.7 nm line

The Dutch Open Telescope (DOT)
- Hα filtergrams





(a) Hα image obtained by the Solar Magnetic Activity Research Telescope (SMART) at Hida observatory on 3 July 2005. (b) continuum and (c) Hα image obtained by DOT. The active region had uni-polar spot located at N12 and E5 (μ ~ 1). Red box: field of view of VTT/TIP.
Maps of (d) continuum, (e) circular polarization, (f) linear polarization at Si I 1082.7 nm line, (g) He I 1083.0 nm equivalent widths, (h) circular polarization, (i) linear polarization at He I line obtained by VTT/TIP.



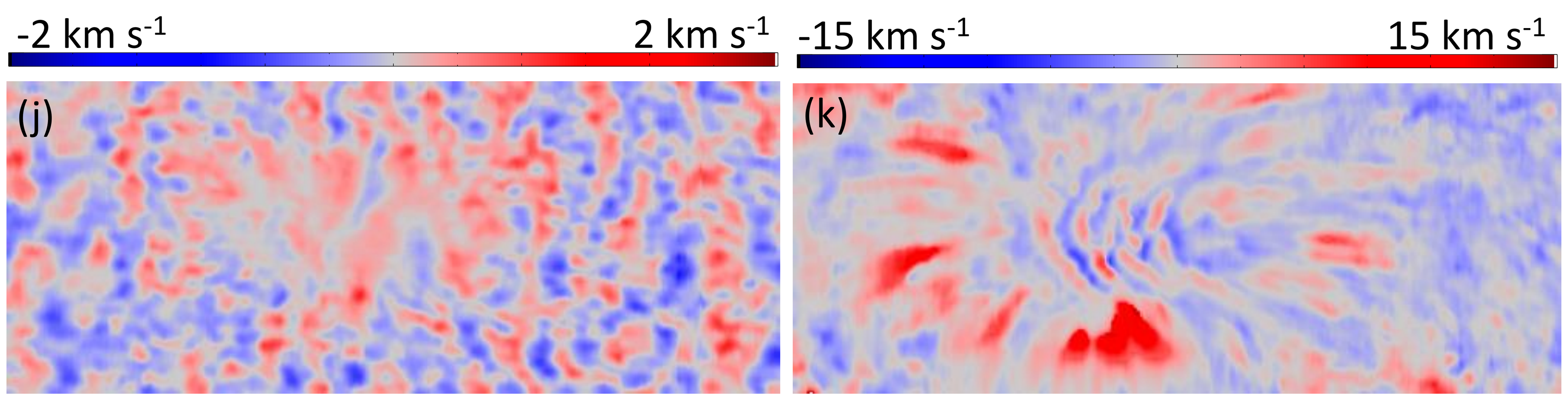
Analysis and results

The line-of-sight velocity fields
- estimated Doppler shifts at Si I and He I lines fitting quadratic function

The magnetic fields
- summing the maps to enhance the SN ~10^{-3} → ~2×10^{-4}
- selected the pixel observed the signal of linear polarization over 0.001
- retrieved chromospheric magnetic fields using the code HAZEL (Hanle and ZEeman Light)

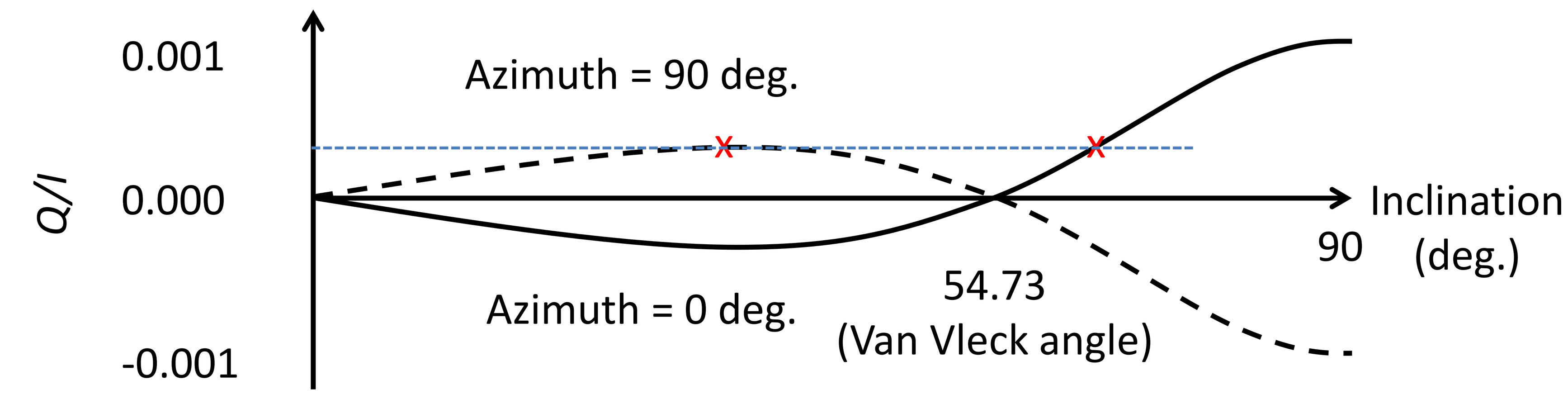
(l) white: summing and selected pixel

(j) line-of-sight velocity fields at photosphere and (k) chromosphere. Blue: blue shift, red: red shift. We can see the inverse Evershed flows at chromosphere.

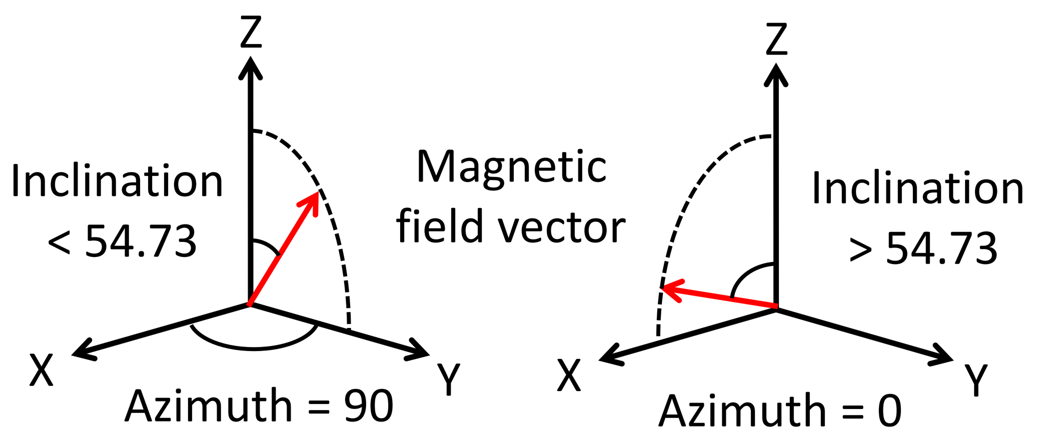


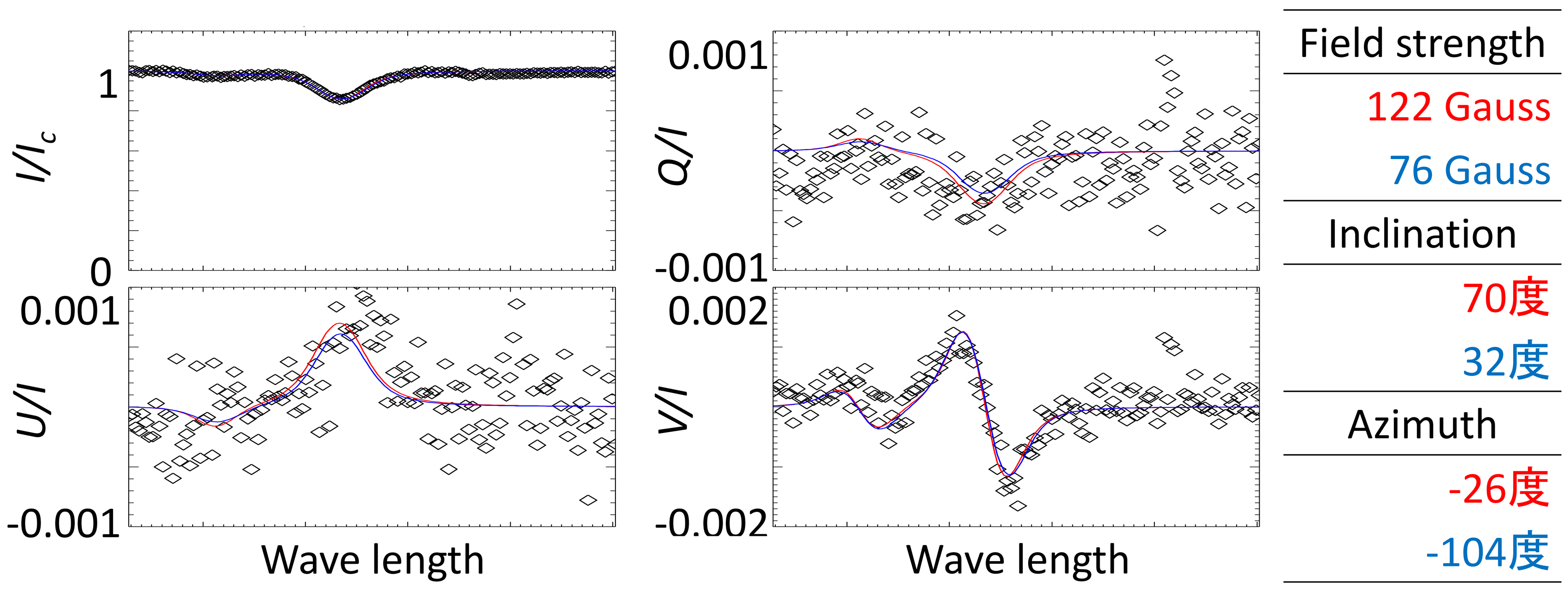
Van Vleck ambiguity

Two different magnetic field vectors give rise to exactly the same emergent Stokes profiles, it is impossible to distinguish between them using only the 10830 Å multiplet.

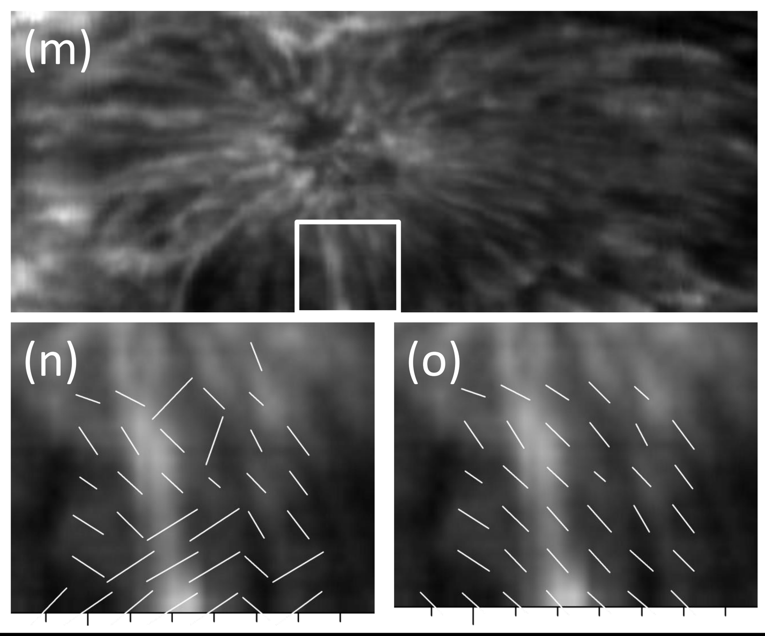


Variation of two type Stokes Q signal for different inclinations of magnetic field vector at μ ~ 1. Case of azimuth = 0 or 90 deg. (The Z-axis is placed along the vertical to the solar atmosphere.)





Sample of Van Vleck ambiguity retrieved by HAZEL. Red: case of inclination angle > 54.73, blue: case of inclination angle < 54.73. Magnetic field strength is changed with inclination angle.



(n) and (o) closeup of He I 1083.0 nm equivalent widths where white box in (m). Bar: magnetic field vectors, inclination angles are illuminated by lineal length. We can see two types azimuth angles of magnetic fields (n), then we give azimuth angle along fibril structures seen in a chromospheric intensity image as a final guess retrieved HAZEL (o).

Summary and Conclutions

- We get Illustration of the magnetic and velocity field structure of the sunspot chromosphere
  - observational evidences were identified which indicate that the small flux tube in the lower atmosphere may be essential to drive the chromospheric inverse Evershed flows

One possible way to resolve the Van Vleck ambiguity
- to give azimuth angle along fibril structures seen in a chromospheric intensity image as a final guess retrieved by HAZEL

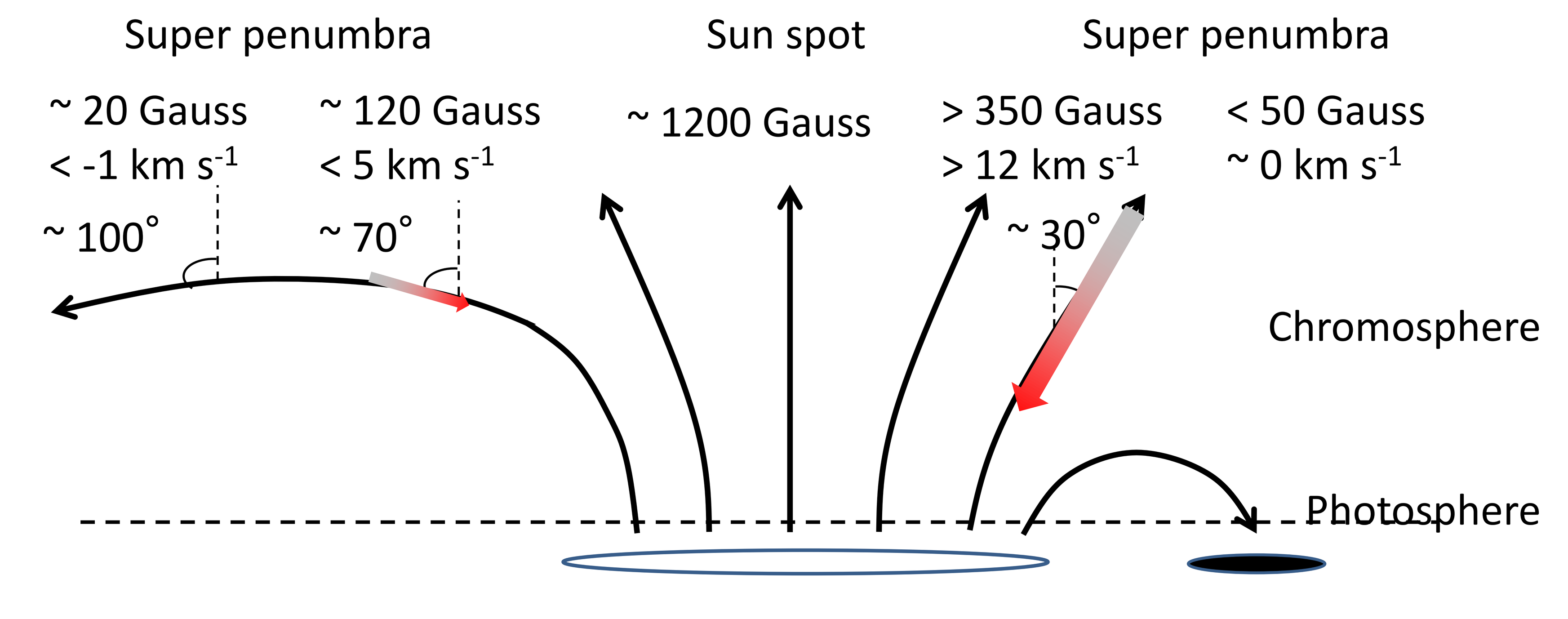


Illustration of the magnetic and velocity field structure of AR 10781.