Ca II 854.2 nm Spectropolarimetry Compared with ALMA and with Scattering Polarization Theory

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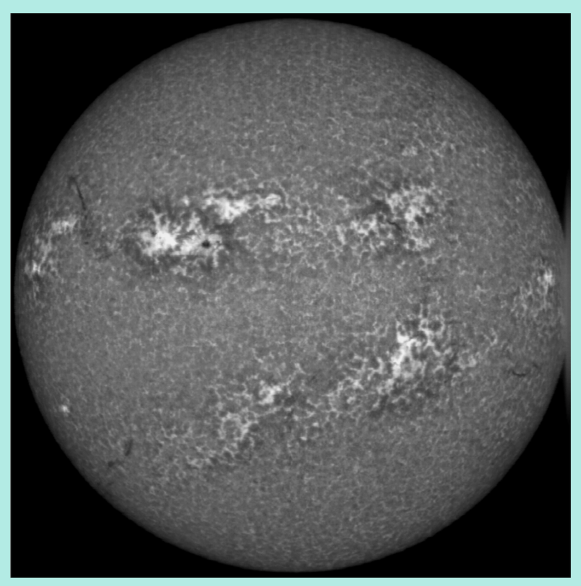
Compare Ca II 854.2 nm and ALMA Chromosphere Observations

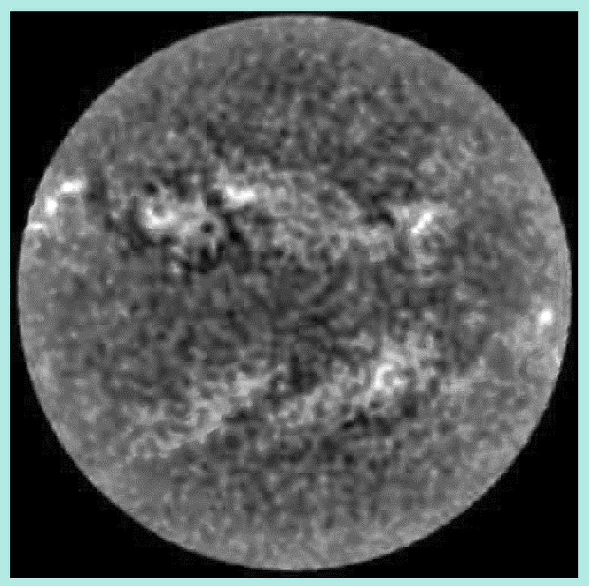
- **Casual agreement but substantial differences**
- Varied associations with LOS chromospheric magnetic field
- Obvious differences due to different radiative transfer processes:
  - ALMA ⟶ limb brightening; Ca II ⟶ limb darkening
  - ALMA ⟶ prominent network; Ca II ⟶ prominent plages

✓ *Combined observations of this sort will aid understanding of the chromosphere*

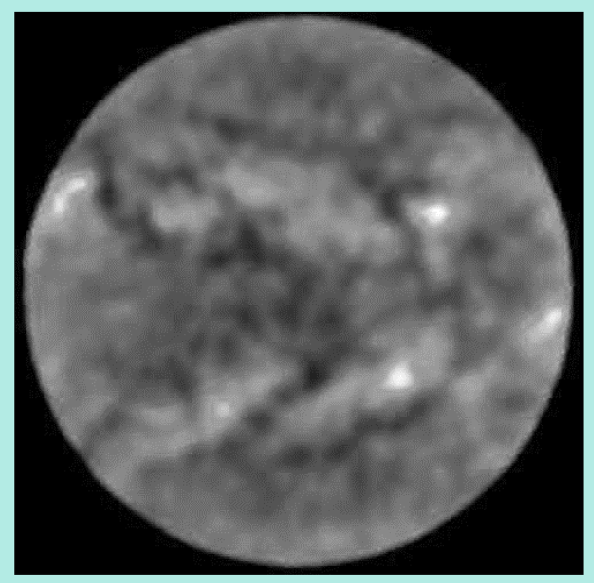
1. Full-disk SOLIS/VSM 854.2 nm and ALMA observations on 2015.12.17



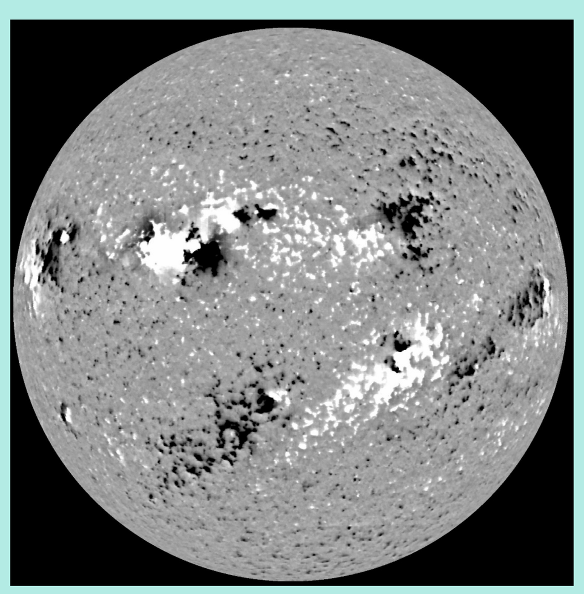
854.2 nm (line core intensity)^0.2, (1753 - 1837 UT)



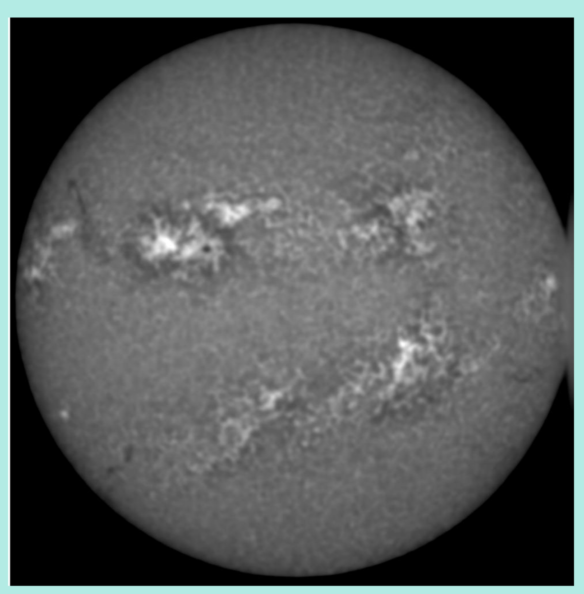
ALMA single dish, λ=1.3 mm (230 GHz), 25″ FWHM, 5300<T_b<7400, (1433 UT)



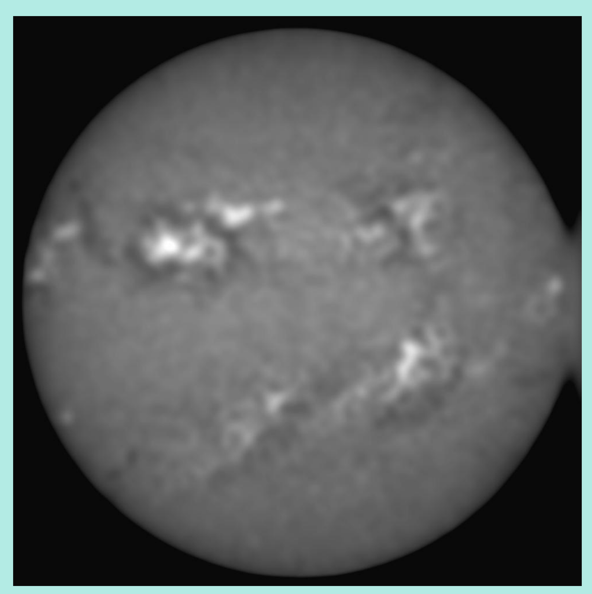
ALMA single dish, λ=3 mm (96 GHz), 58″ FWHM, 6700<T_b<8800, (1815 UT)



854.2 nm line core LOS magnetic field, ±50G, (1753 - 1837 UT)

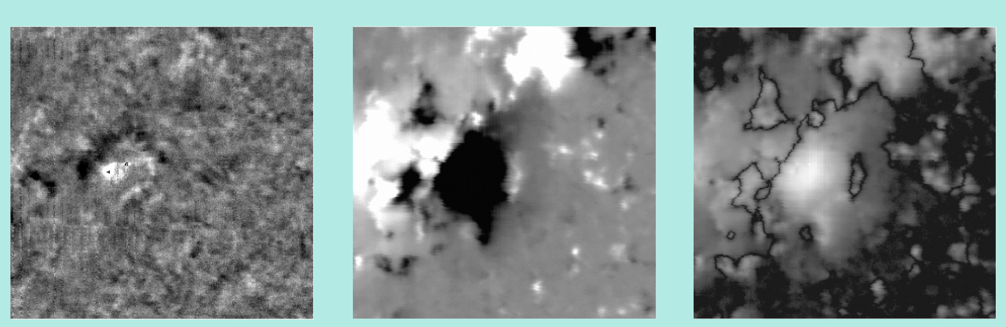


854.2 nm (line core intensity)^0.2, 6″ gaussian blur, (1753 – 1837 UT)

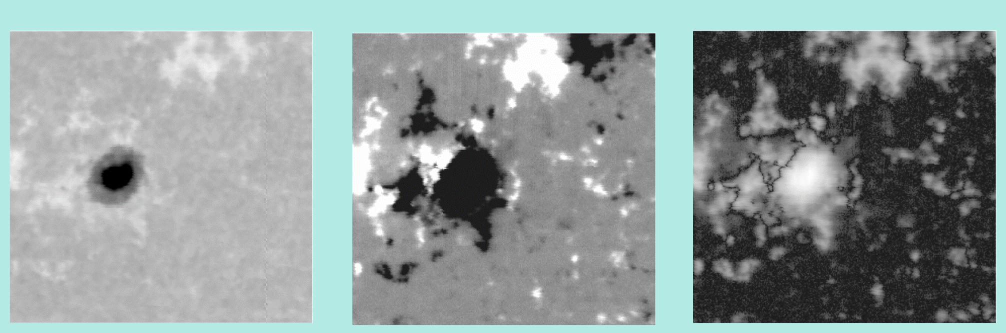


854.2 nm (line core intensity)^0.2, 16″ gaussian blur, (1753 – 1837 UT)

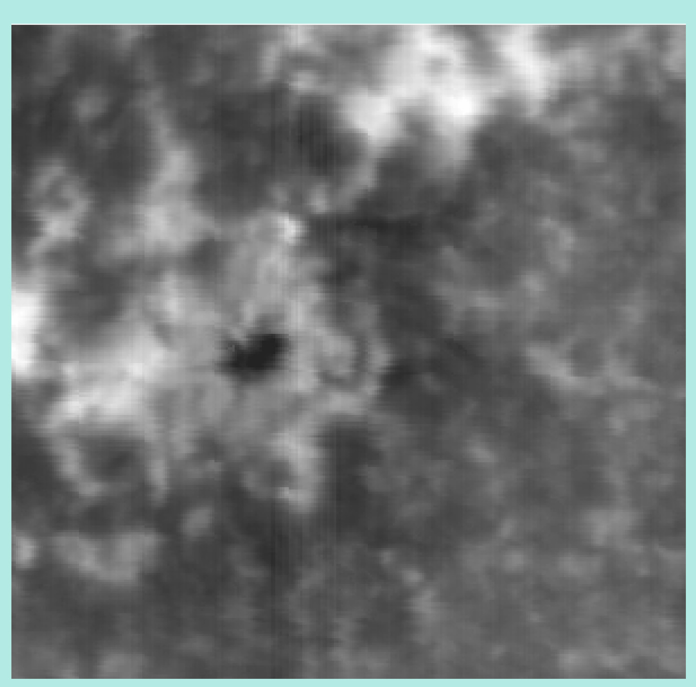
2. AR 12470 SOLIS/VSM 854.2 nm and ALMA observations on 2015.12.16



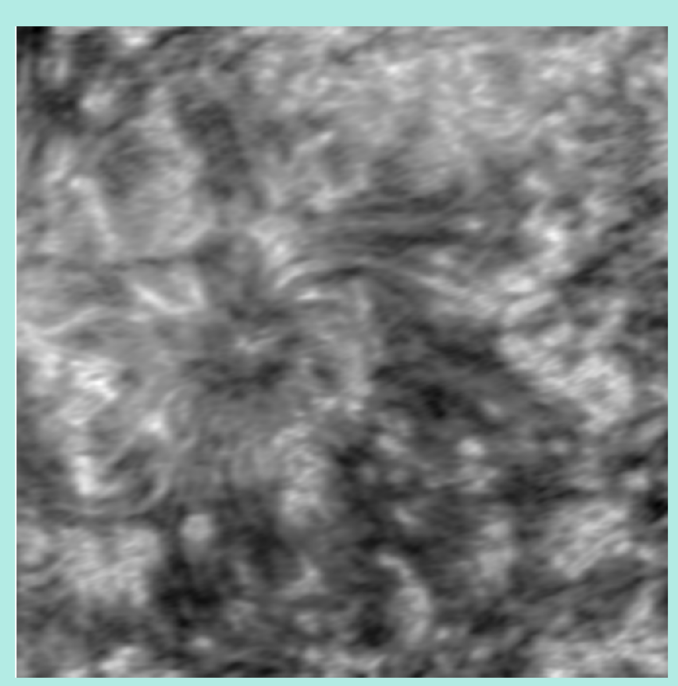
854.2 nm chromosphere. (*left*) LOS velocity ±5 km/s, (*center*) LOS magnetic field ±100 G, (*right*) log (|B_{LOS}|)



854.2 nm photosphere. (*left*) line wing intensity, (*center*) LOS magnetic field ±100 G, (*right*) log (|B_{LOS}|)



854.2 nm chromosphere. (line core intensity)^0.2, (1835 - 1840 UT)

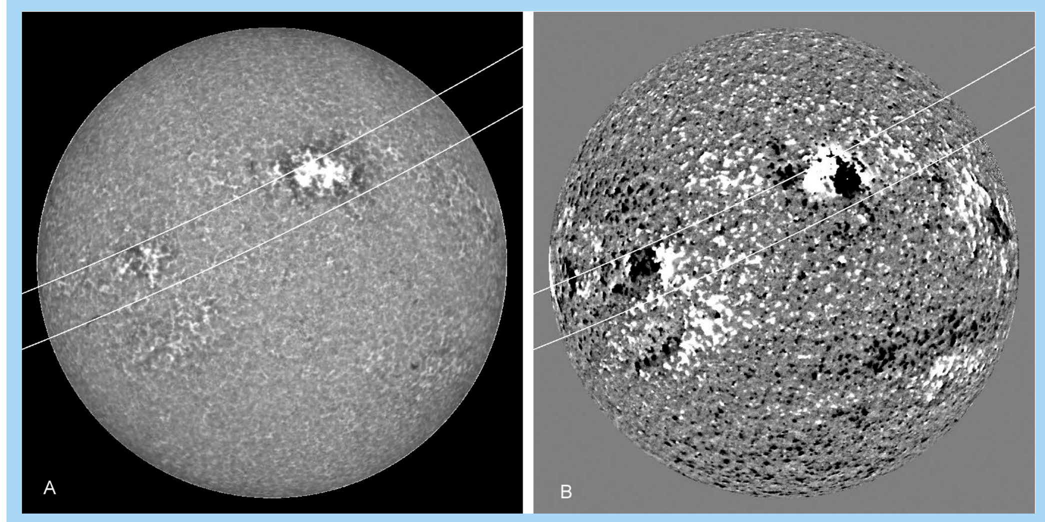


ALMA single dish+array. λ=3 mm (96 GHz), 6800<T_b<11000, (1832 UT)

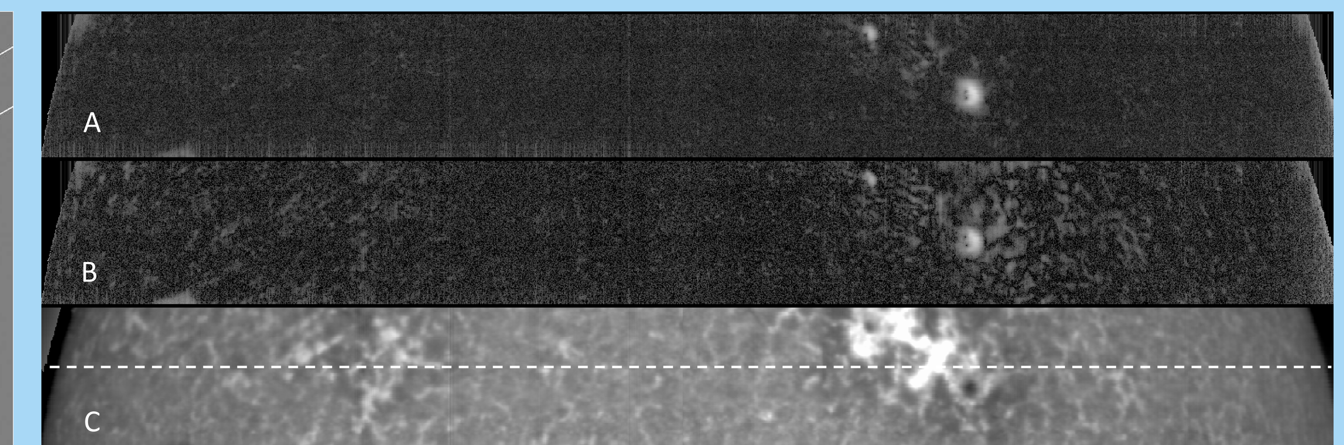
Discover Ca II 854.2 nm Linear Polarization Predicted by Theory

- **Linear polarization structure is ubiquitous in the core of Ca II**
- Overwhelms Zeeman effect except in sunspots and strong plages
- Bright (dark) features tend to be polarized parallel (perpendicular) to closest limb
- Correlated with bright Ca II mottles & dark Hα fibrils

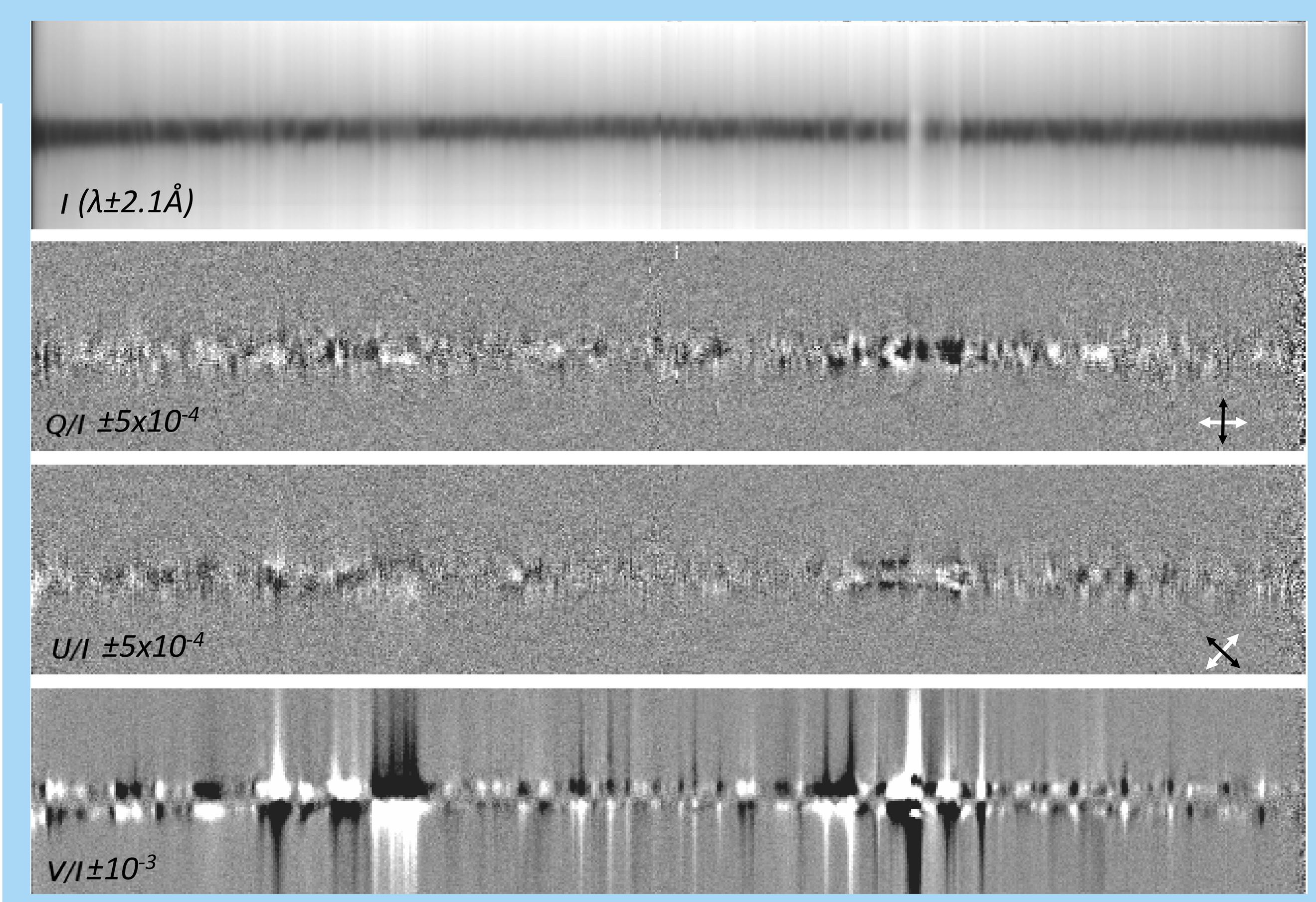
✓ *Consistent with theory of scattering in inhomogeneous and dynamic chromosphere*



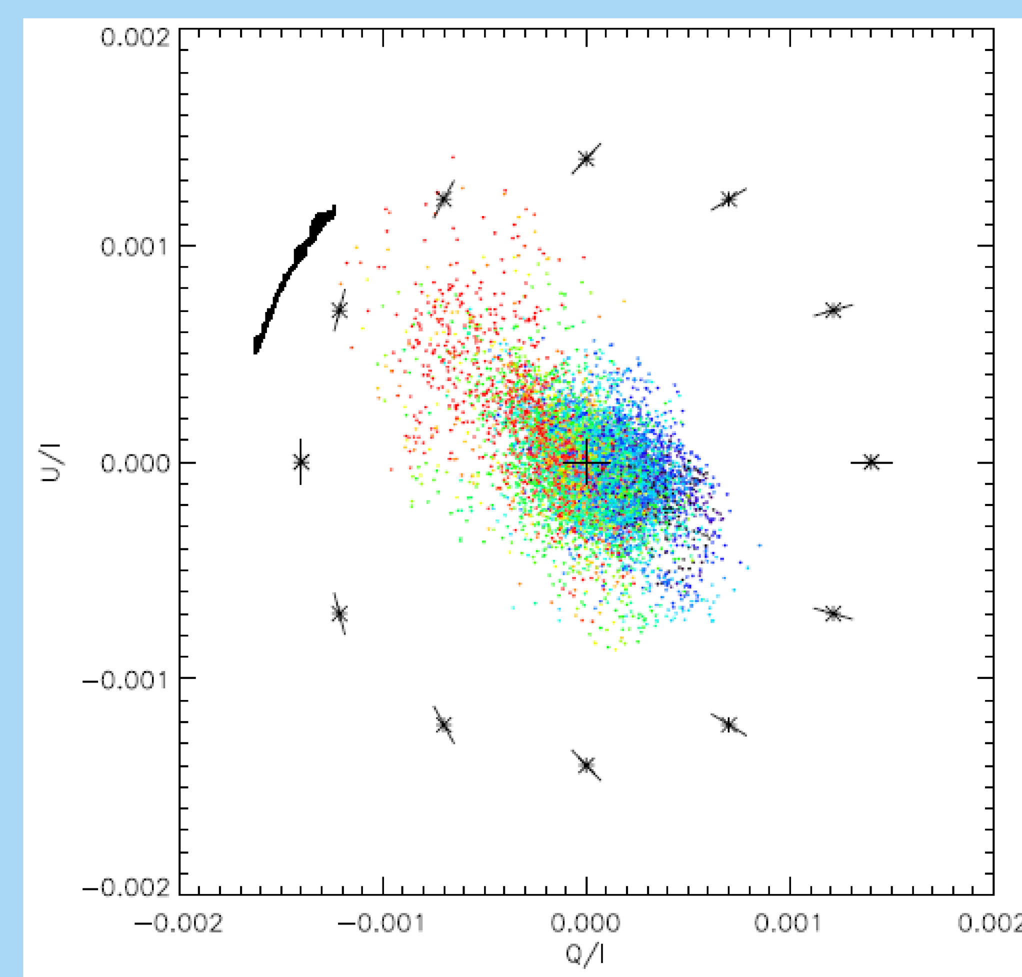
1. SOLIS/VSM 854.2 nm observations on 2016.03.23. (A) Ratio of line-core to far-wing intensities. (B) LOS magnetic field from near line core (±20 G). High-sensitivity, slit-scan area is shown by boundary lines.



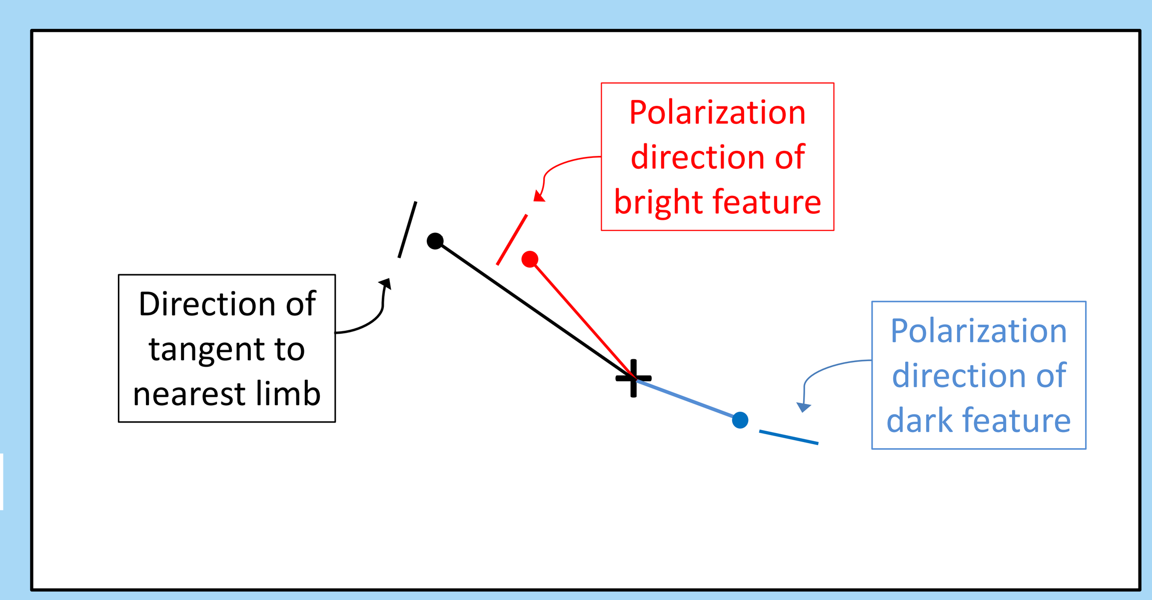
2. Linear polarization fraction in line wing and line core. (A) Zeeman effect dominates the 0.1 to 0.3 Å average from both sides of the line core. (B) Scattering polarization averaged ±0.1 Å across the line core. (C) Line core intensity with dashed line indicating position of spectra below. Linear polarization strength is displayed on a log intensity scale ranging from 10^{-5} to $5x10^{-2}$ for (A) and 10^{-4} to $5x10^{-2}$ for (B).



3. Linear polarization is ubiquitous in line core spectra. Full Stokes spectra from the dashed-line slit position. The linear polarization noise levels are $\pm1.2x10^{-4}$. Note increase of polarization strengths moving toward the limb. Note erratic wavelength variations of linearly polarized features compared with circularly polarized features.



4. Bright (dark) features polarized ~∥ (⊥) to closest limb. *Q/I* vs. *U/I* quiet-region line-core measurements covering just 0.4<*μ*<0.5. Warm (cool) colors indicate bright (dark) features relative to average. The clock dial indicates linear polarization direction (and also for the short arc of black points the nearest-limb tangent directions for the observed points). Note that brighter features tend to be more strongly polarized and rotated a bit clockwise from the tangent direction of the nearest limb. Some absorption features, e.g. a disk filament, (not shown here) show large rotations from limb alignment.



Interpreting this complicated diagram for single spatial pixels.

ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada) and NSC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The National Radio Astronomy Observatory is a facility of the National Science Foundation (NSF) operated under cooperative agreement by Associated Universities, Inc.

This work utilizes SOLIS data obtained by the NSO Integrated Synoptic Program (NISP), managed by the National Solar Observatory, which is operated by the Association of Universities for Research in Astronomy (AURA), Inc. under a cooperative agreement with the National Science Foundation. This paper makes use of the following ALMA data: ADS/JAO.ALMA#2011.0.00020.SV.. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ.