SH51G-2691

Chromospheric Temperature Diagnostics from SOLIS/VSM Ca II 854nm Observations

Using NLTE Inversions of the Representative Spectral Profiles

Sanjay Gosain[1,2]
1. National Solar Observatory, 3665 Discovery Drive, Boulder CO 80303
2. University of Colorado, Boulder CO 80301

Motivation:

→ To derive center-to-limb variation of Ca II 854.2 nm spectrum.

→ Infer temperature structure of solar atmosphere at various disk positions.

Introduction:

→ What is Center-to-limb variation or CLV?

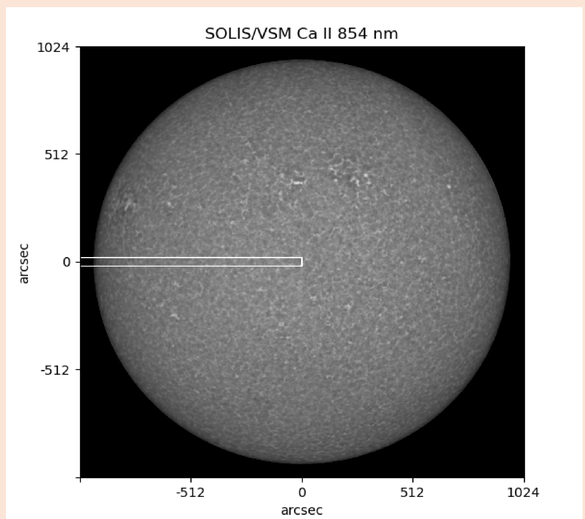
- It is the variation of any measured parameter from the center of solar disk to solar limb.

→ Why study CLV of solar spectrum?

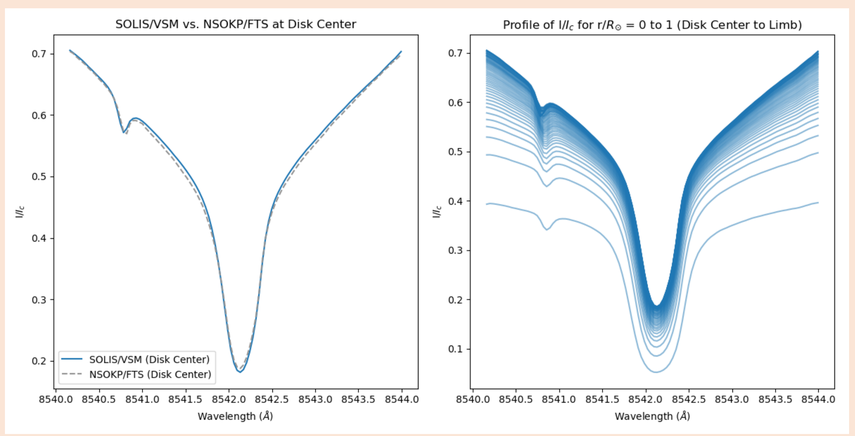
- CLV of continuum and lines is an important tool to diagnose the solar atmosphere.
- For the normalization of spectrum from limited field of view instruments such as DKIST.
- Other interests are (i) constraining elemental abundances, and (ii) atmospheric studies of exoplanets.

Background

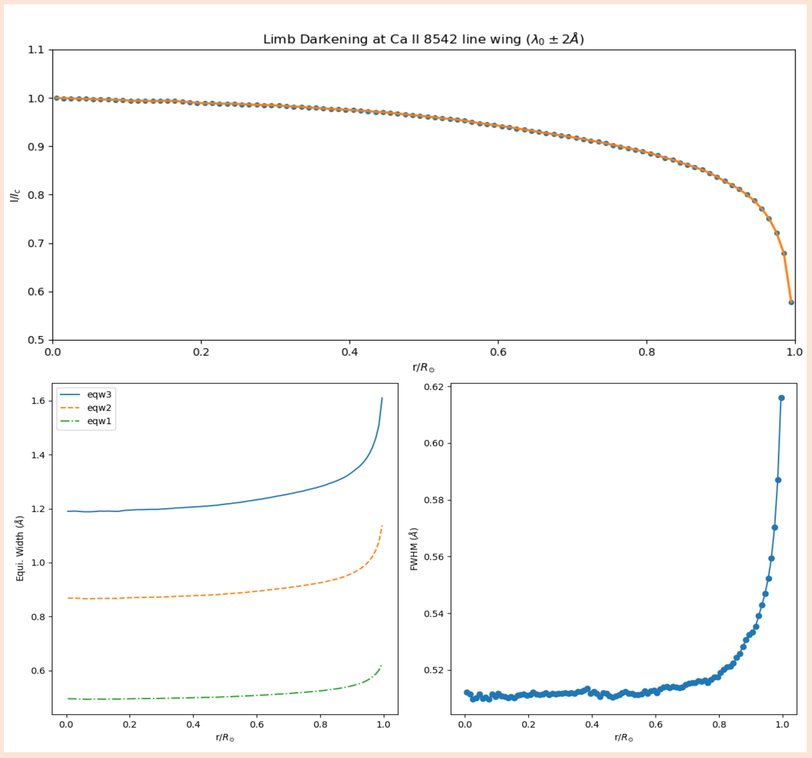
- Neckel and Labs (1994) presented continuum limb darkening from 330 to 1250 nm **(most widely used by solar community as a reference).
- Pietrow et al. (2023), presented CLV of various spectral lines observed by SST/CRISP and SST/CHROMIS. **(limited in spectral range and sampling due to filter based instrument).



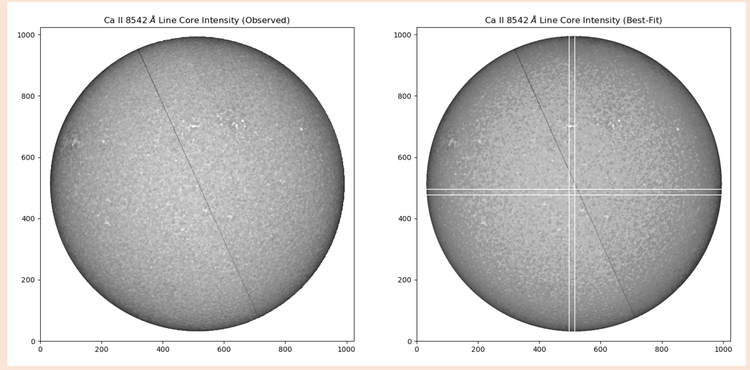
Spectro-heliogram shows the map of line-core intensity in Ca II 854.2 nm spectral line as observed by the SOLIS/VSM instrument operated by NSO/NISP. White rectangle shows the region used to construct the average Ca II spectrum and its center to limb variation.



***Left Panel**: Average quiet Sun spectrum near disk center by SOLIS/VSM is shown by solid curve. The corresponding FTS atlas spectrum is shown by dashed curve. Spectral range is from 854.0 to 854.4 nm (Line center +/-0.2nm). **Right Panel**: Average quiet Sun spectrum for 50 equidistant points (in normalized radius units) from disk center to limb. Averaging is done inside the white rectangle in adjacent full disk map. The bottom curve corresponds to limb while progressively increasing intensities correspond to positions towards disk center. NOTE: Spectra are corrected for Doppler shift due to solar rotation. (i) Dispersion: 0.00365 nm/pixel; (ii) Spectral Range: 854 to 854.4 nm; (iii)Background Stray light: 11%*



***Top panel**: Limb darkening as seen in the wings of the Ca II spectra in SOLIS/VSM observations. The wings are sampled 0.2 nm away from the line center. Near the limb the darkening profile is affected by the seeing, which is not accounted for. **Bottom-left panel**: Equivalent width computed for three different bandpasses centered on the line center, 'eqw1': 0.066 nm, 'eqw2': 0.15 nm and 'eqw3': 0.2 nm, and their CLV profile. **Bottom-right panel**: FWHM of the line core computed for a bandpass of 0.15 nm centered on the line center and its CLV profile.*



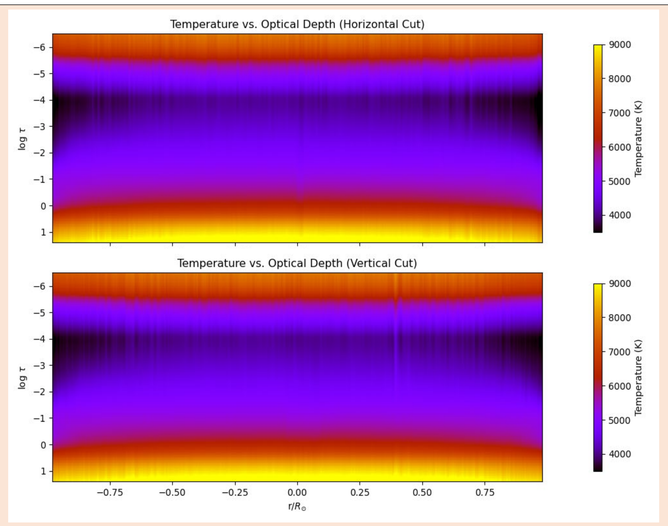
NLTE inversion of the Ca II spectral line was performed using CAISAR archive (Beck et al. 2019). Ca II line core intensity maps are shown, left panel: as observed and right panel: the best-fit model spectrum. Similarity shows that the overall fit of the model spectra to observations is good. NOTE: Inclined black line through disk center is artifact of camera.

Summary:

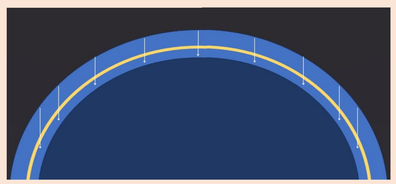
- Estimated background stray light of about 11%.
- Derived reference quiet Sun spectra from disk center to limb.
- Derived CLV profiles of equivalent width and FWHM of the line core.
- NLTE inversions of these reference profiles was performed to derive temperature vs optical depth vs radial distance.
- Inversions provide temperature stratification for different viewing angles.
- Chromospheric temperature minimum region is oversampled by the optical path due to inclined projection.

Conclusion:

- Mean model solar atmospheres can be tested against these observations for validity.
- These CLV profiles of wing intensities provide means to normalize spectra observed by high-resolution telescopes such as DKIST.



Temperature stratification versus optical depth, derived by NLTE inversion of the spectrum across the solar disk is shown. TOP PANEL: Horizontal cut across the solar disk from East to West limb. BOTTOM PANEL: Vertical cut across the solar disk from pole to pole. NOTE: Temperature minimum region spans a larger range of optical depth near the limbs.



A cartoon shows the solar visible disk (dark blue), the chromosphere (light blue) and the temperature minimum region (yellow region). Note how the optical path travels a larger distance in the temperature minimum region near the limbs due to inclined line-of-sight.