Inversion of NIR Si I and Ca I lines using Gregor/GRIS data

Carlos Cristo Quintero Noda
Instituto de Astrofísica de Canarias,
Universidad de La Laguna,
E-38200, La Laguna, Tenerife, Spain

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Outline

I. Introduction

- Gregor (1.5m) telescope started operation this year
- It has several instruments, among them, the Spectrograph GRIS

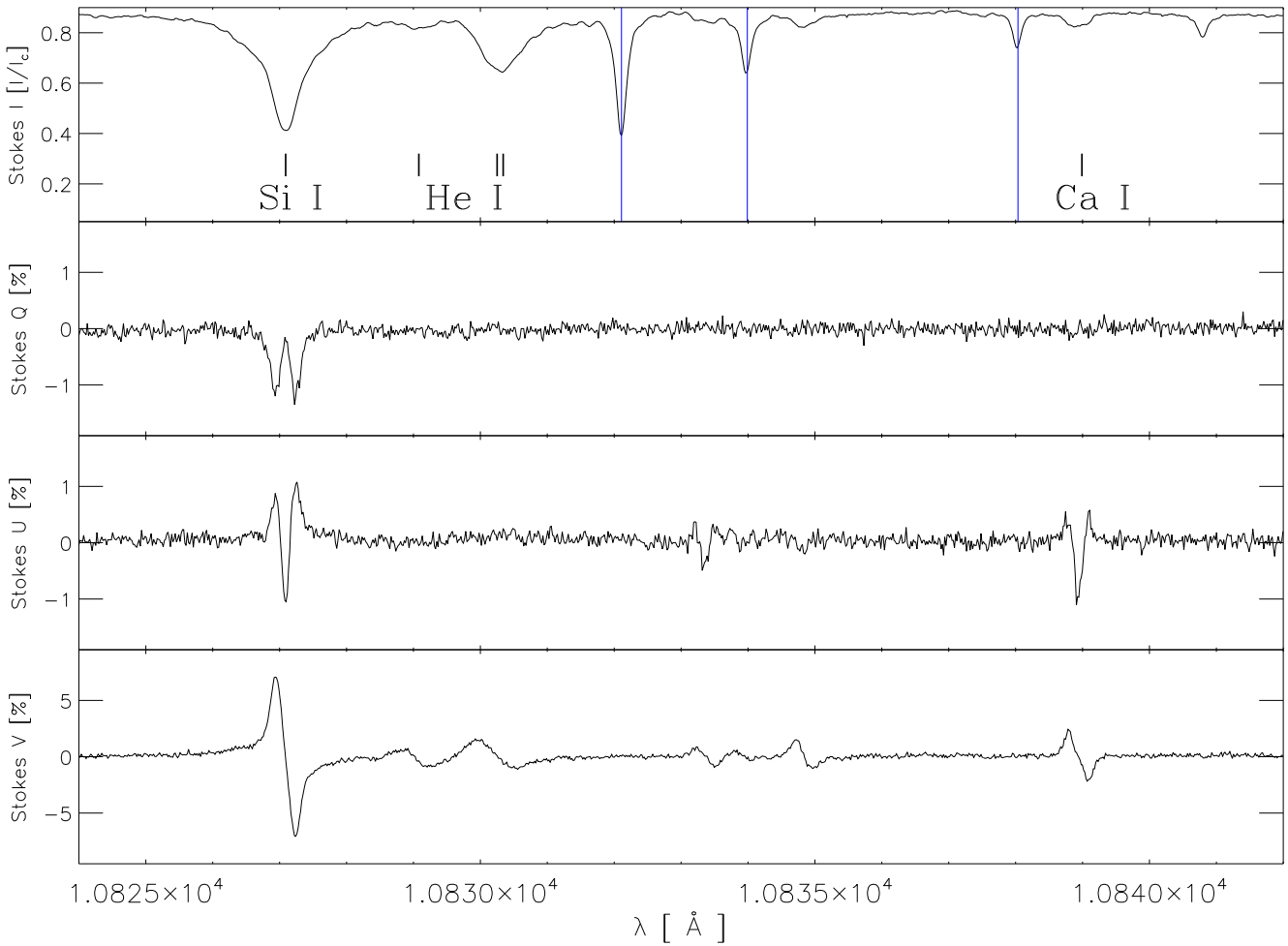
Spatial resolution (diff. limit)	$0.''18 \sim 0.''25$
Spatial sampling	0.126 arcsec/pixel
Wavelength range	10000 to 23000 Å (NIR)
Spectral sampling	$0.018 \sim 0.025$ Å/pixel
Pol. noise level (4 s, 10830 reg.)	1×10^{-3}

- Si I (10827Å) and He I (10830Å) lines are present in the spectral range.
- These lines are proposed for the Solar-C project.

II. Data analysis

NIR spectra

- Gregor/GRIS spectra is wider than VTT/TIP. More lines inside the FOV.

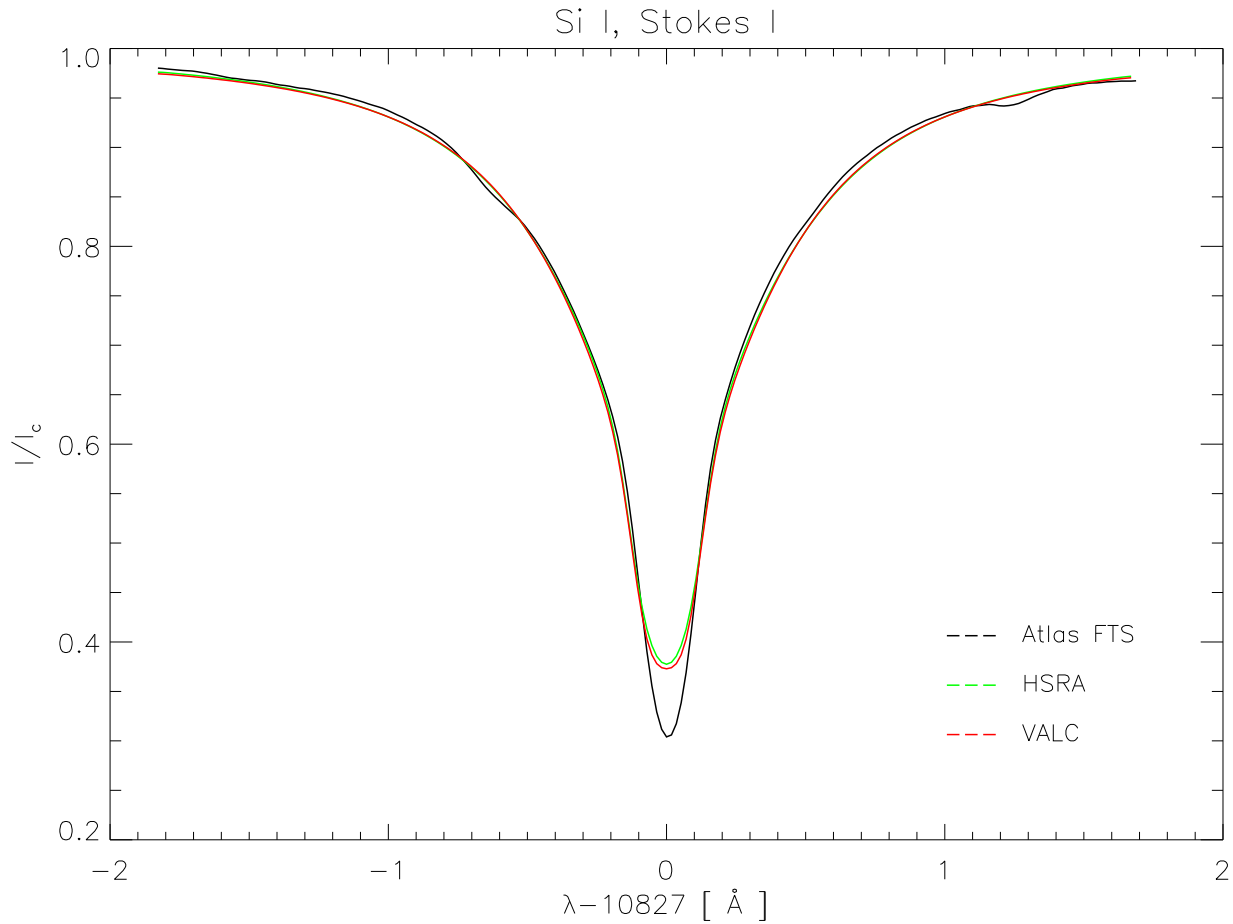


- The Ca I complements the information given by the Si I at lower heights.

II. Data analysis

Si I NLTE nature

- Si I is very deep producing that its formation region extends beyond the solar photosphere. Part of the line is under NLTE conditions.

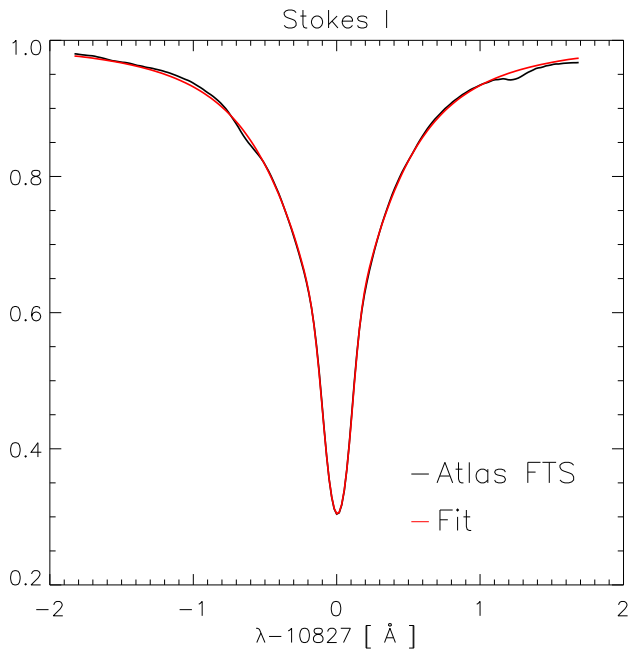


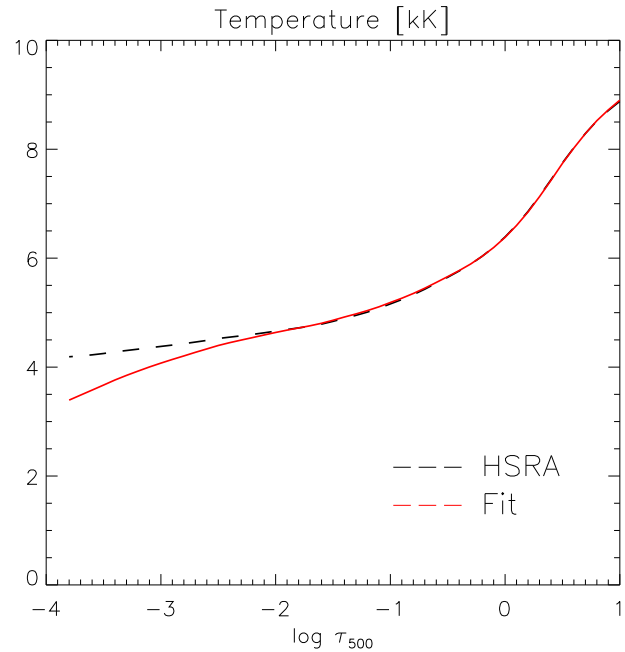
- A LTE synthesis (using SIR) cannot reproduce the observed FTS atlas.

II. Data analysis

Si I LTE inversion I

- The inversion of the Si I produced wrong temperatures (NLTE masking)



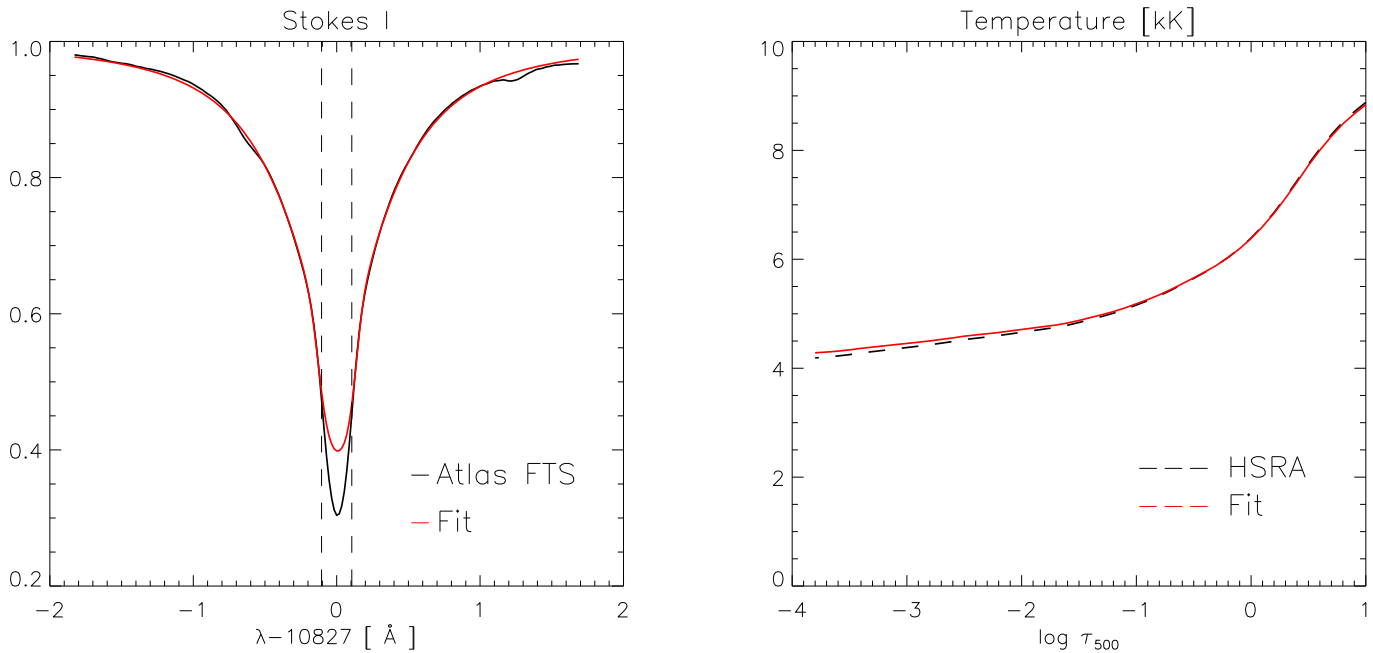


- The inversion code makes the atmosphere cooler than HSRA to reproduce the depth of the line.

II. Data analysis

Si I LTE inversion II

- One approximation consists in removing the core of the line from the inversion.

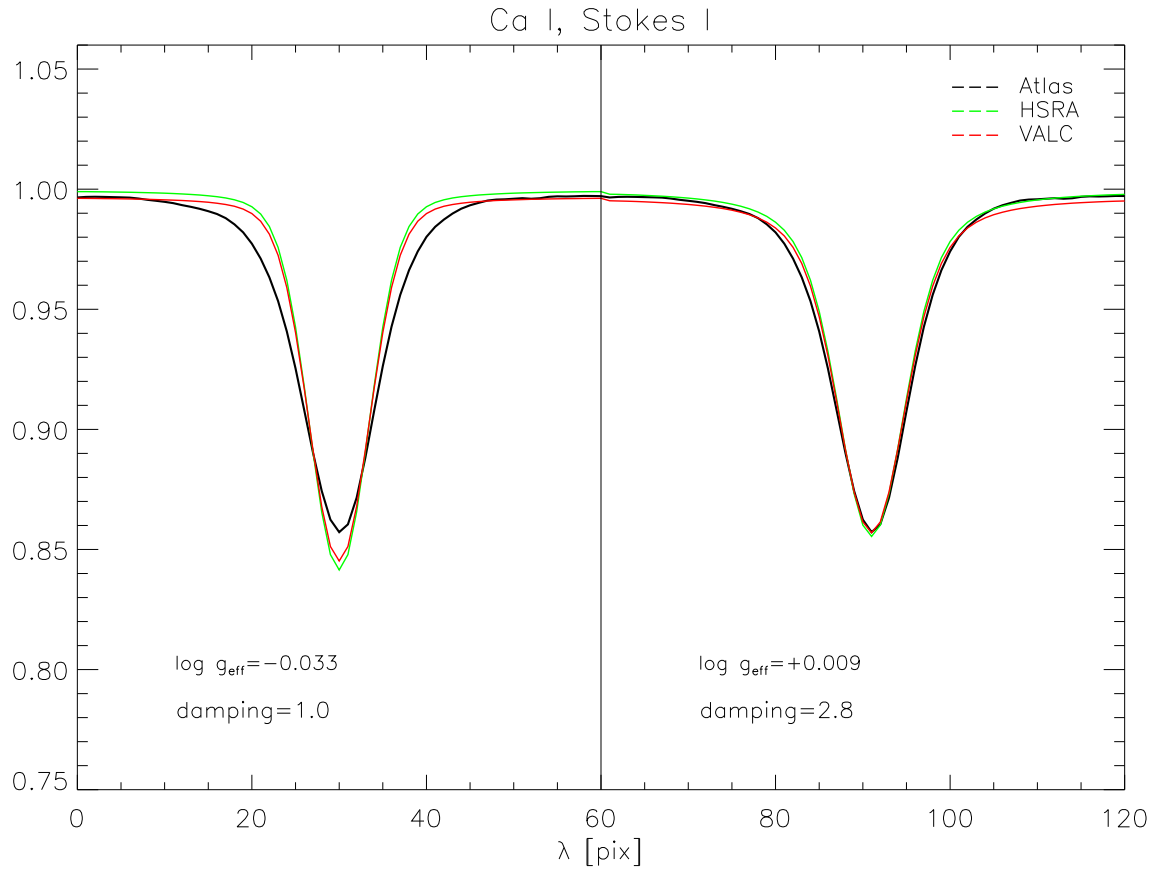


- The temperature stratification resembles the reference one. We will used this approximation.

II. Data analysis

Ca I 'new' line

- To my knowledge, this is the first time that this line is inverted with 1D LTE inversion codes (before with ME).
- We need to parametrize the line, oscillator strength, damping...

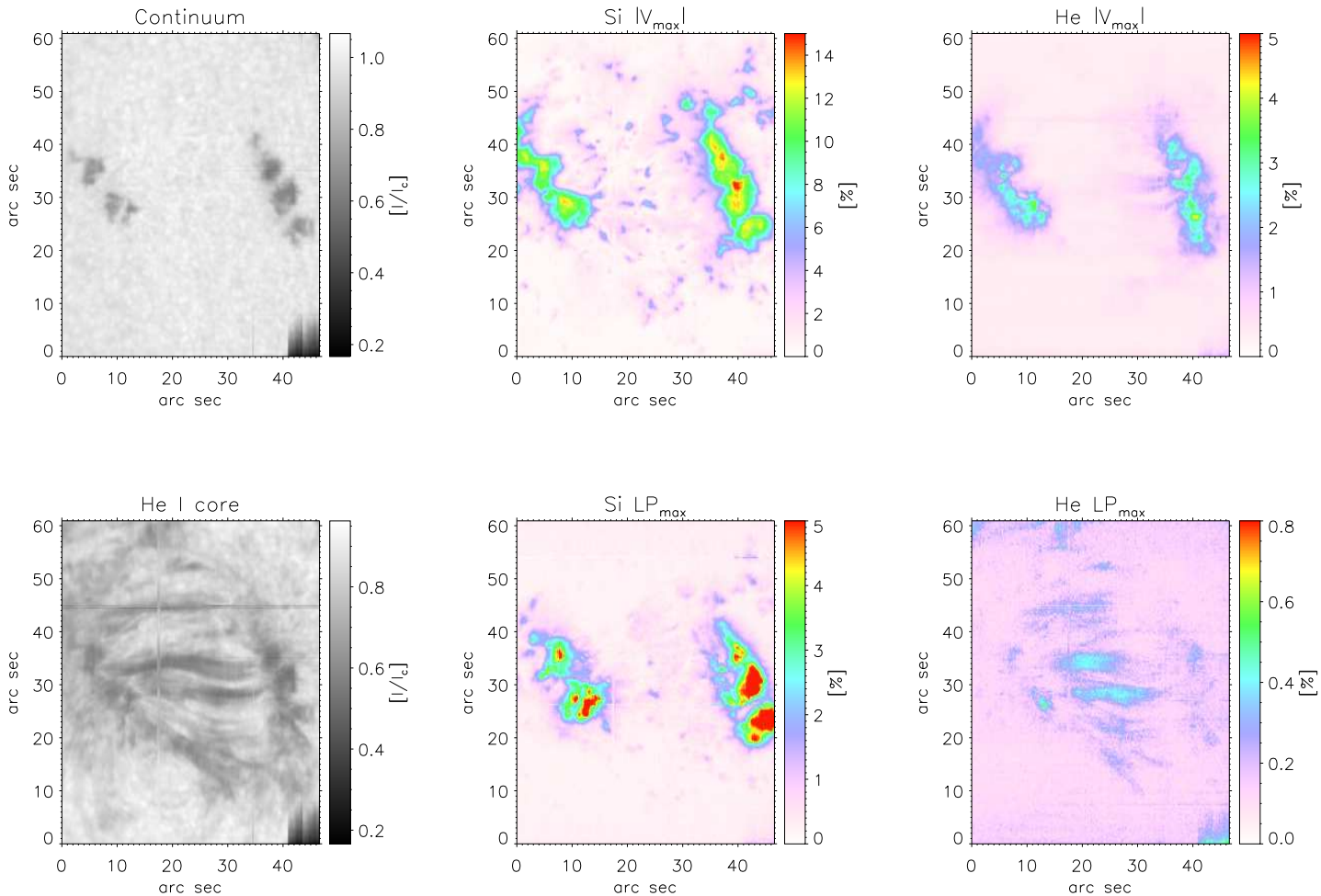


- Semi-empirical approximation. The synthetic profile matches the FTS atlas.

II. Data analysis

AR12098

- We are going to examine the AR12098 measure on June 24^{th}, $\mu = 0.92$



- The observation conditions were good. The AR presents structure at the photospheric and chromospheric levels making it appealing.

II. Data analysis

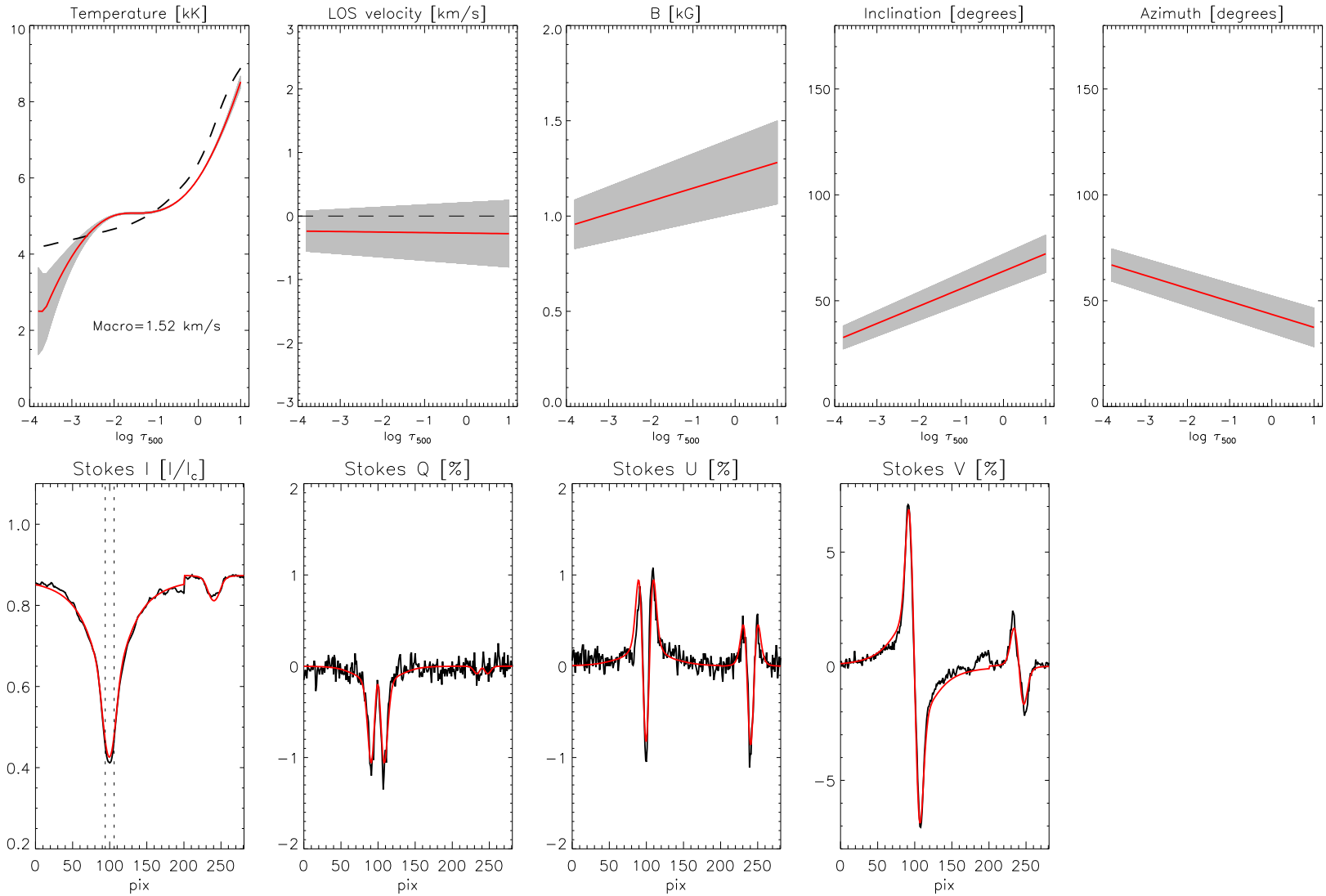
Inversion configuration

- We invert Si I and Ca I lines simultaneously.
- A single magnetic component is used. We allowed gradients in temperature, LOS velocity, and the 3 components of the magnetic field vector.
- We also invert the macroturbulence. No spectral PSF available yet.
- Microturbulence is set to 0 and not inverted.
- We initialized each pixel several times with random initial atmospheric models. We chose the best fit.

III. Inversion results

Simultaneous inversion of Si I and Ca I lines

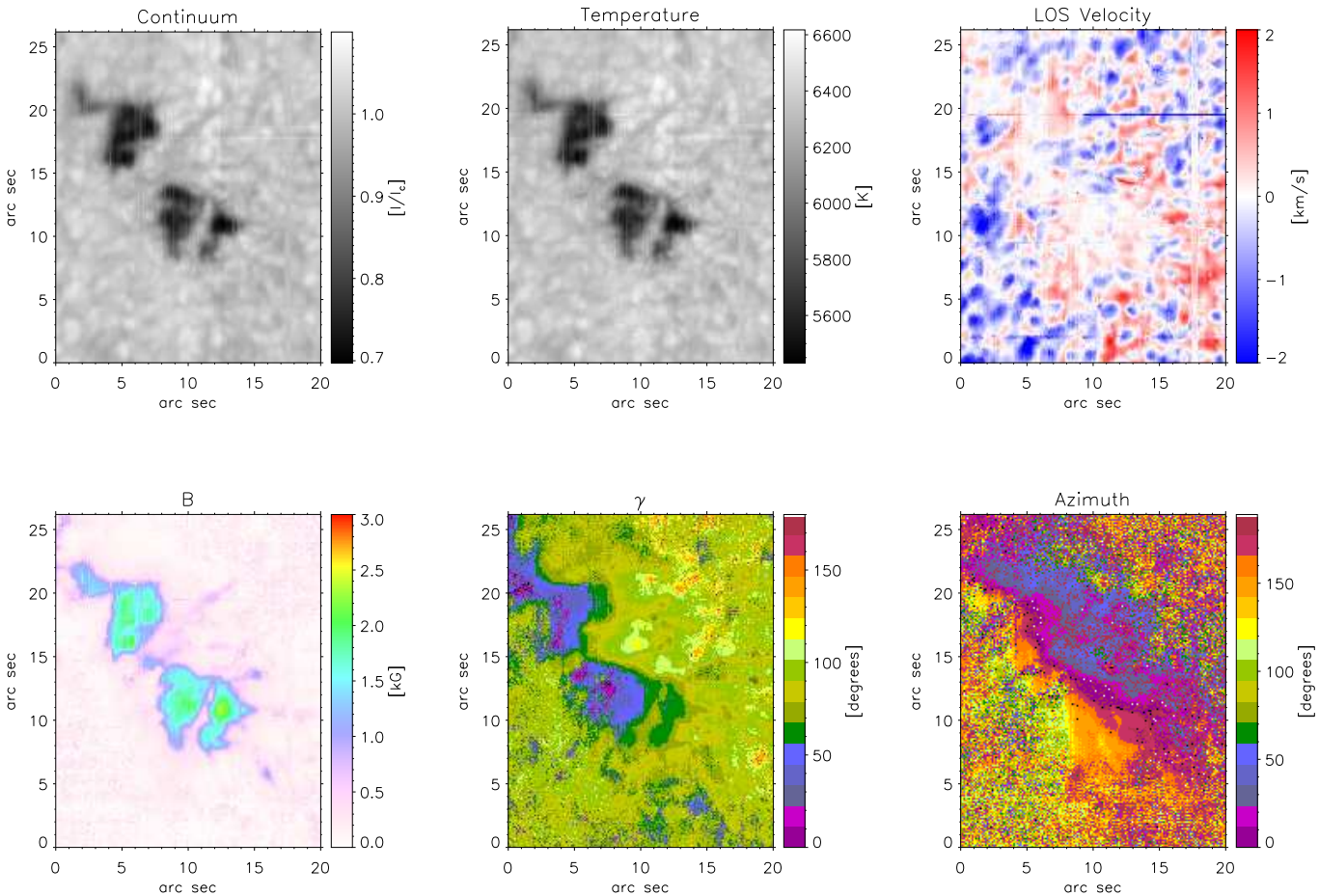
- We selected the pixel showed before to check the fits.



III. Inversion results

AR12098. 2D map I

- A fragment of the observed region at log $\tau_{500} = 0$

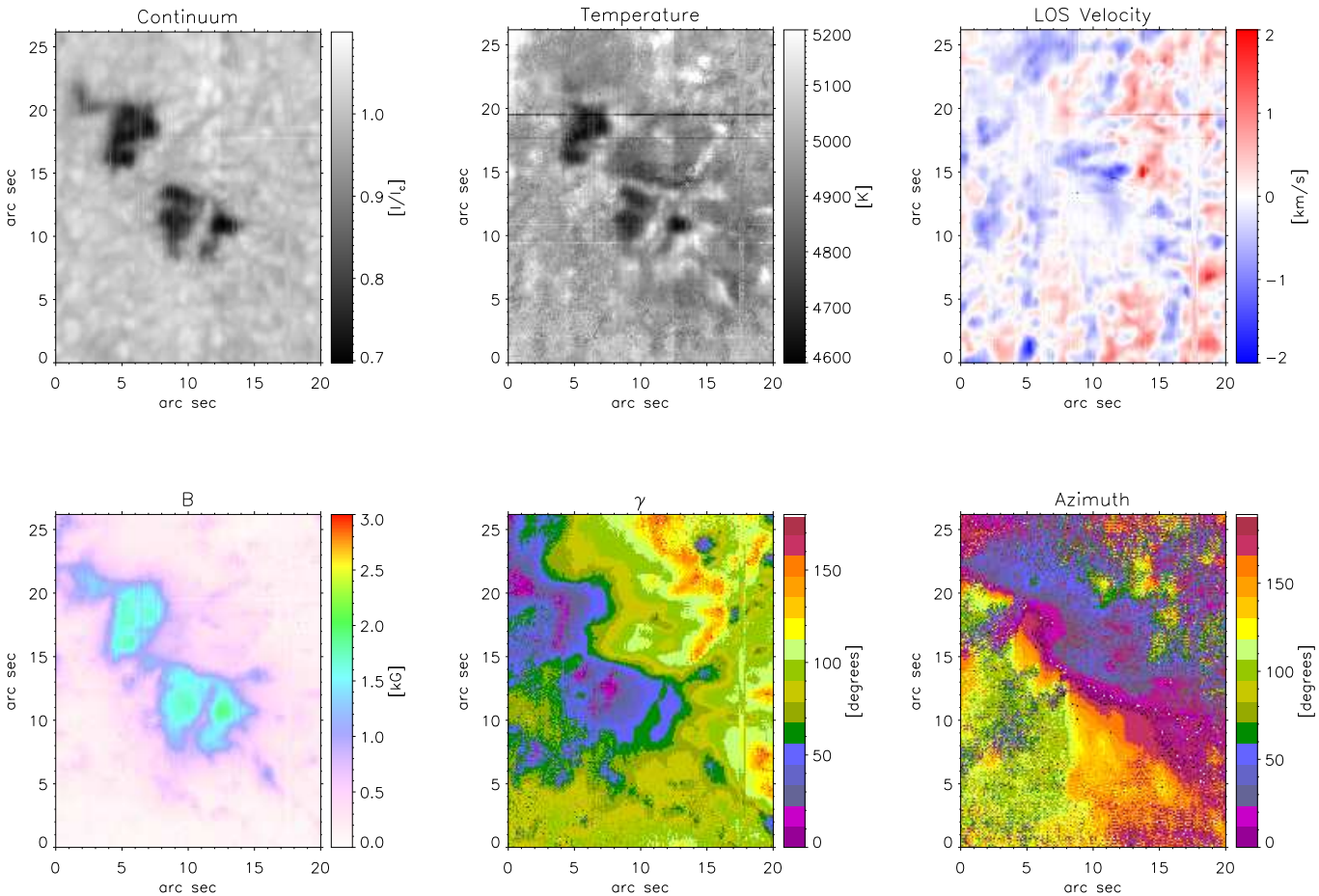


- The temperature, as the LOS velocity, reproduces the granulation pattern. The magnetic field is slightly inclined and with ∼2kG values.

III. Inversion results

AR12098 2D map II

- A fragment of the observed region at log $\tau_{500} = -1.5$

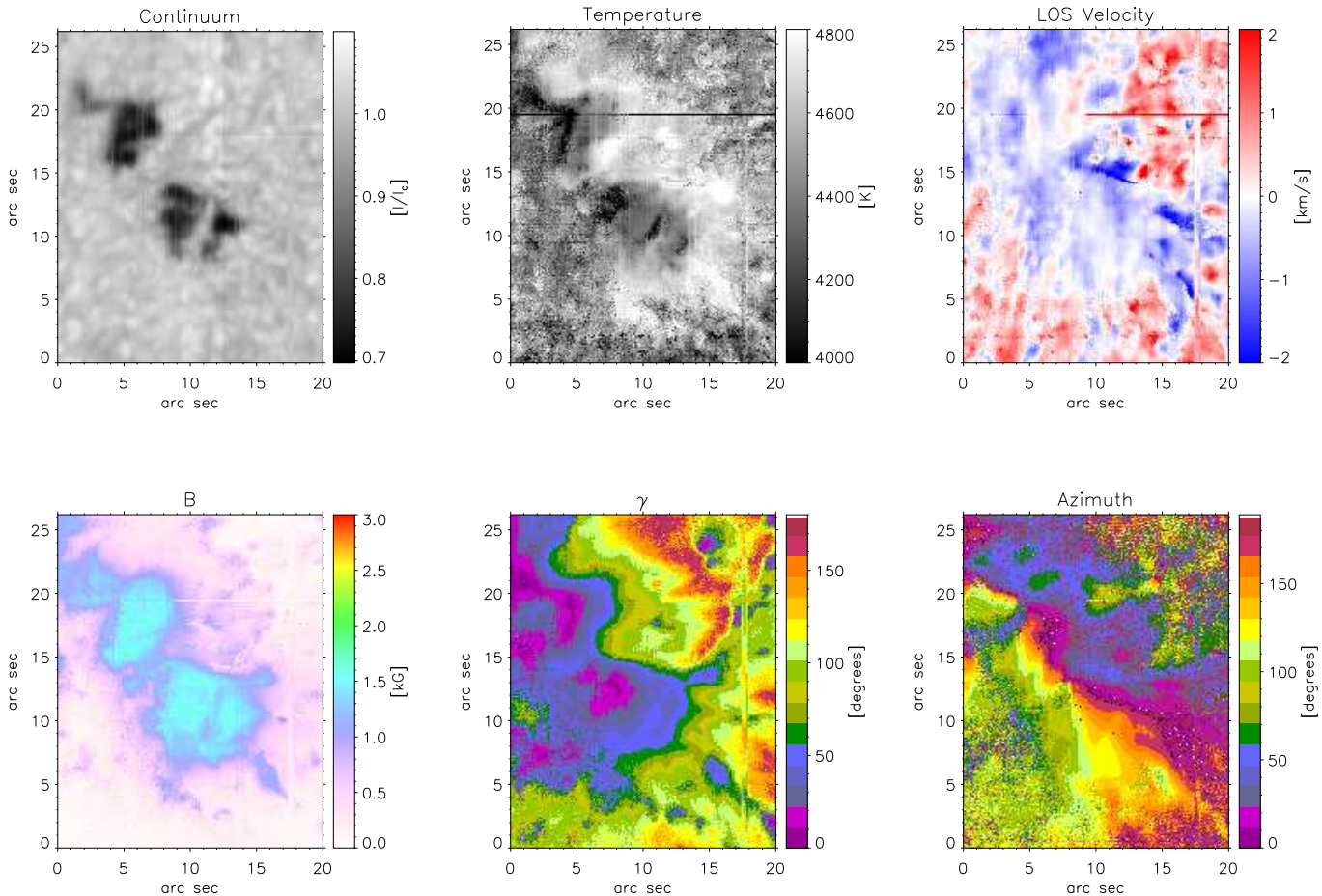


- Magnetic field lines are opening while the field intensity is lower. LOS velocity close to 0.

III. Inversion results

AR12098 2D map III

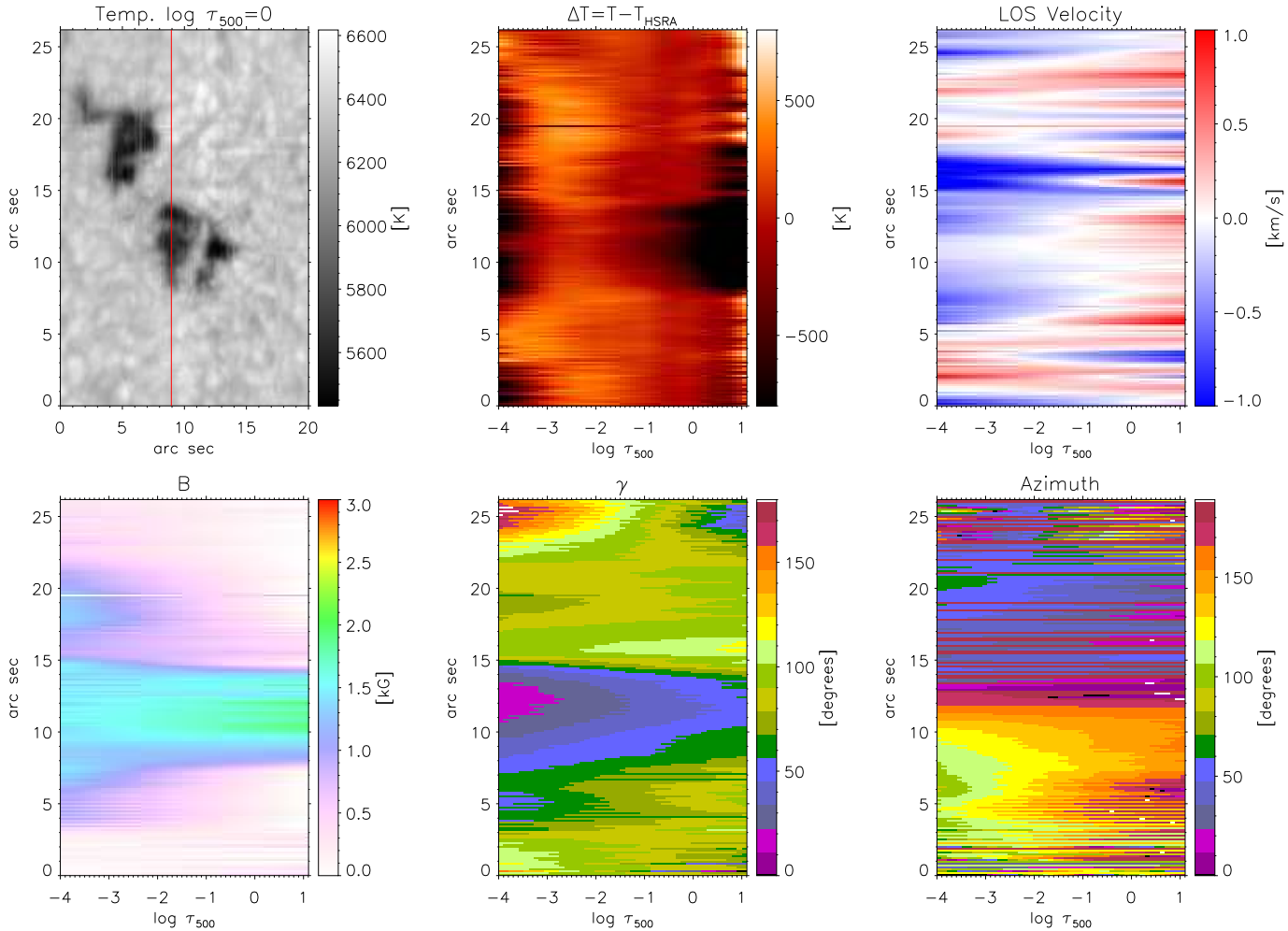
- A fragment of the observed region at log $\tau_{500} = -3.0$



- Temperature and LOS velocity resembles the magnetic structure. The field lines are more vertical.

III. Inversion results

AR12098 vertical cut

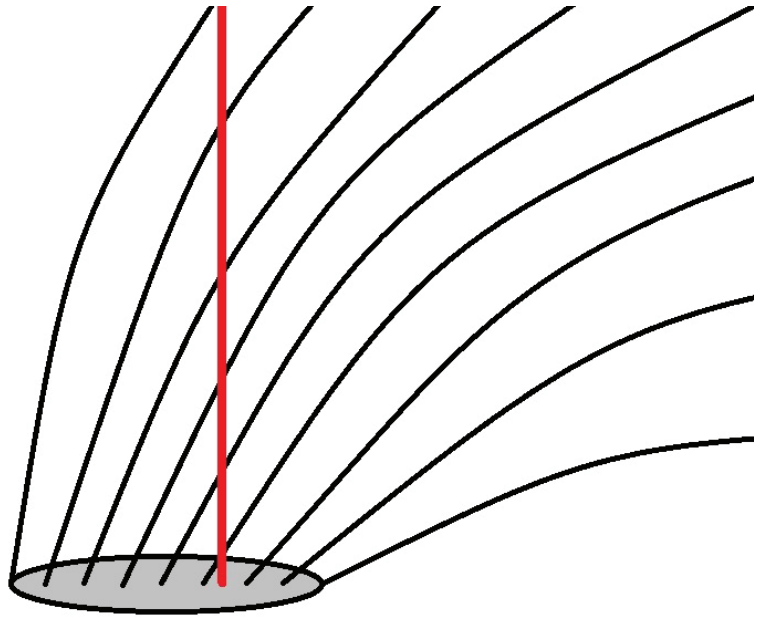


- Field lines are opening and becoming more vertical.

III. Inversion results

Sketch

- A possible explanation for the behavior magnetic field lines.



- As we move up, the magnetic field lines become more vertical. They correspond to the bottom part of the loop also observed with the He I

IV. Discussion

Physical description of the loop

- To fully described the magnetic structure we need:
  - to invert the opposite footpoint of the loop.
  - to invert the He I with the existing codes, Hazel or Helix+.
  - However, it is difficult to establish the He I formation region.
  - Can we infer the location of the apex of the loop from the observed opening of field lines?
- In addition, the LTE approximation for the Si I line is an incorrect approach. We are losing information of the top of the photosphere.
- How important is the impact of NLTE effects on the polarization Stokes parameters?
- This is something I need to check as future work.

V. Future perspectives

Improvements

- We can solve the problem of the NLTE nature of the Si I line.
- We need to invert the line using a NLTE code as NICOLE.
- However, we need an atomic model. The two available models are too large Bard & Carlsson (2008) and Sukhorukov & Shchukina (2012).

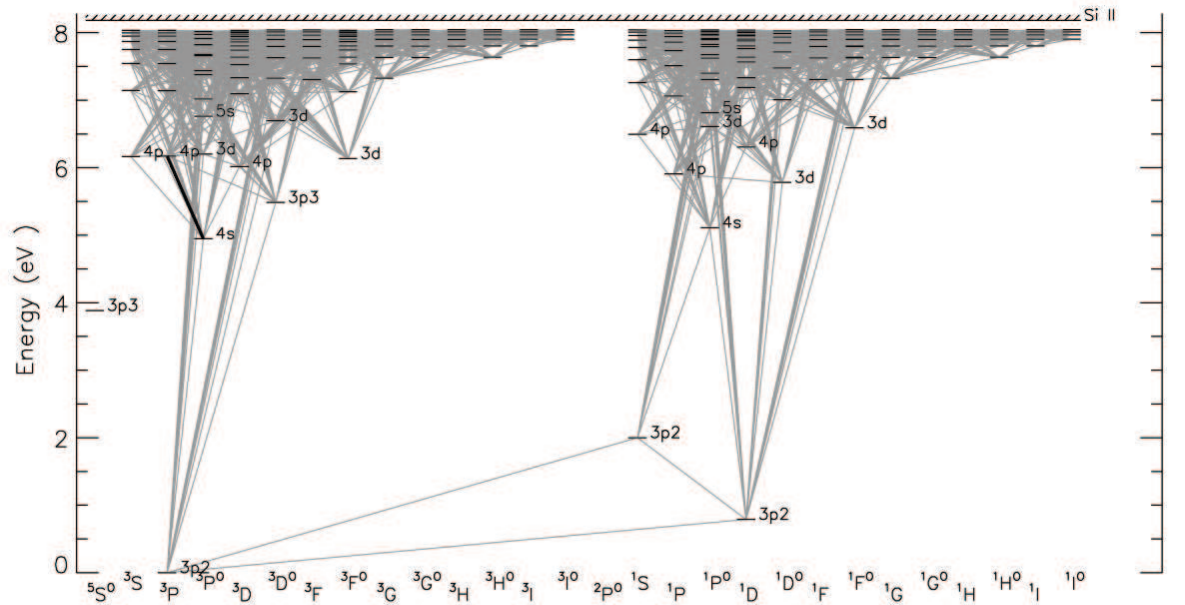


FIG. 1.—Complete data set from TOP, augmented with Rydberg levels results in 238 energy levels and 3152 radiative transition treated in detail in our model. The triplet transition which gives rise to the Si I 1082.7 nm line is marked with a thick dark line.

- I propose the design of a simplified model for the Si I line.

V. Future perspectives

My role

- I will use NICOLE with this simplified model on a 3D simulation.
- If I am able to retrieve the physical information with a small error
- We will have a proper way to analyze the Si I from Gregor/GRIS data and from Solar-C.
- We can invert simultaneously Si I and Ca I with NICOLE.
- I also plan to perform inversions of the He I with the same Gregor/GRIS observations using the Hazel code.
- I hope to have more results soon.

Thanks