SIMULATION AND ANALYSIS OF *HINODE* SPECTROPOLARIMETRIC OBSERVATIONS

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Introduction

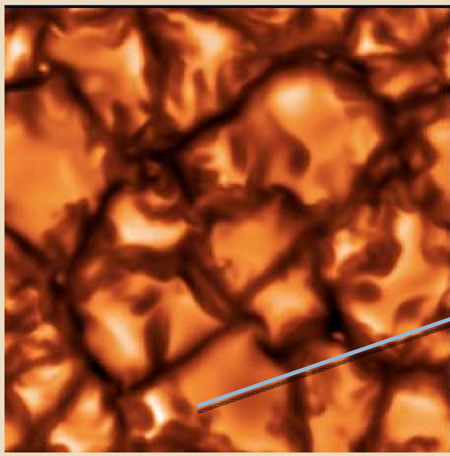
- The internetwork consists in highly inclined fields with weak flux densities (Lites et al. 2007, 2008, Orozco Suárez et al. 2007a,b)
  - Breaks the contradiction between the results from visible and infrared lines: visible points to kG field strengths, infrared to hG
- Analysis of the emergence of small-scale magnetic loops in the quiet-Sun internetwork (Centeno et al. 2007) and plage regions (Ishikawa et al. 2008)
- Discovery of the emergence of vertical magnetic fields in quiet-Sun granules (Orozco Suárez et al. 2008)
- *Hinode*/SP records the Fe I 630.15 and 630.25 nm spectral lines
  - At 1" these two lines seem not contain information to determine the intrinsic magnetic field with enough reliability (Martínez González et al. 2006)

Simulation of *Hinode*/SP observations

- Magnetohydrodynamics simulations of the quiet-Sun provides with "realistic" model atmospheres. Benchmark for a-priory testing the analysis techniques

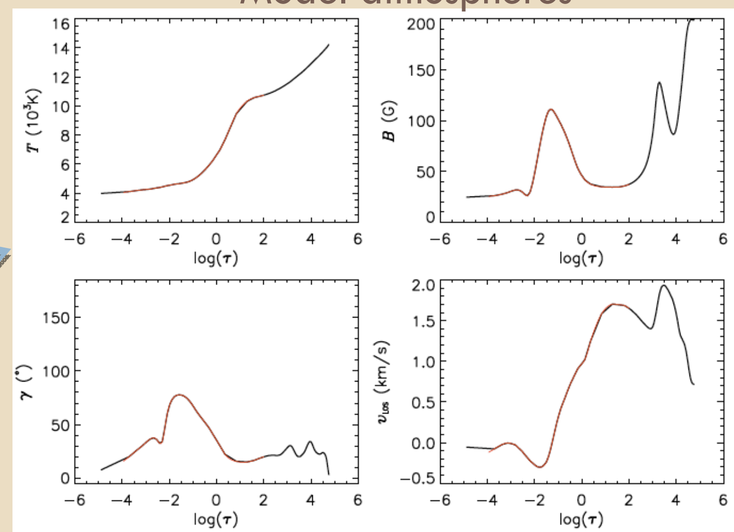
MHD simulations <*B*>=10G

Vögler & Schussler 2005



Spatial resolution 0.0285″ ≈ 20 km

Model atmospheres

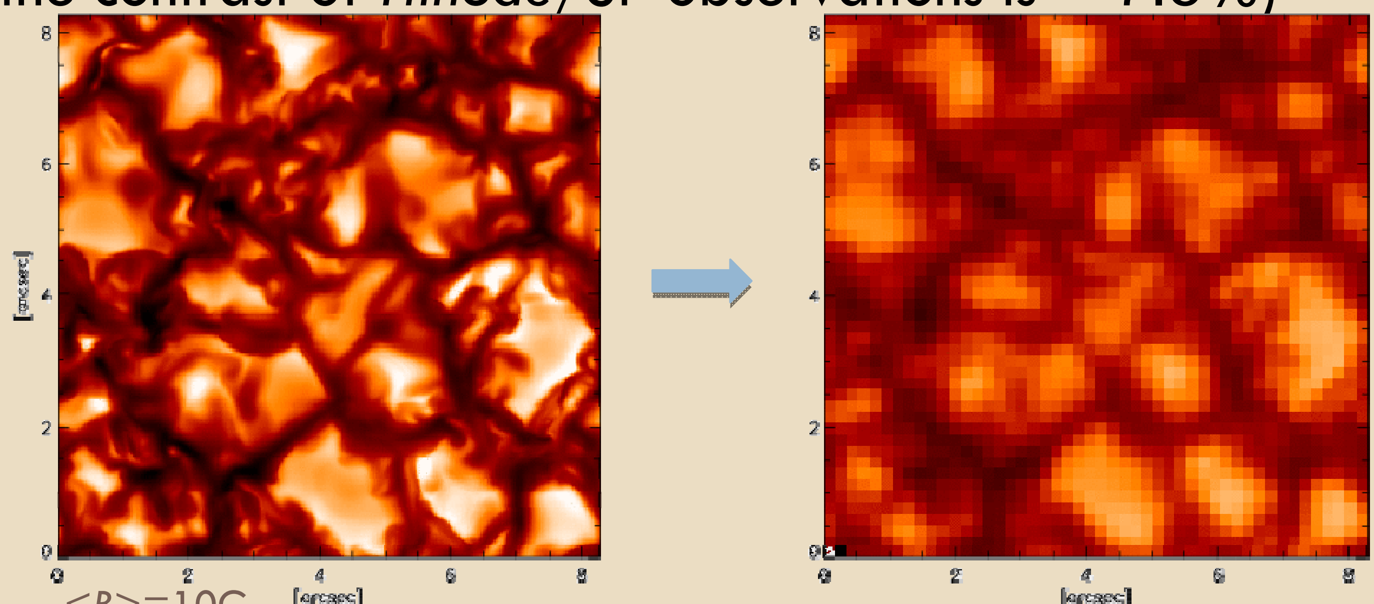


- Synthesis of Fe I lines at 630 nm and spatial degradation by telescope diffraction, CCD pixilation, and spectral resolution to match the *Hinode*/SP
- Analysis of the degraded profiles using an inversion based on Milne-Eddington atmospheres (in first approach)

Spatial degradation

- *Hinode*: 0.5 m telescope with spatial resolution ~ 0.26" @ 630 nm (~ 190km)
  - Telescope diffraction ➔ ~ 0.26"
  - CCD pixel size ➔ ~ 0.32"
  - Reduction of rms contrast from 13.7% to 8.5%

(the contrast of *Hinode*/SP observations is ~ 7.5%)

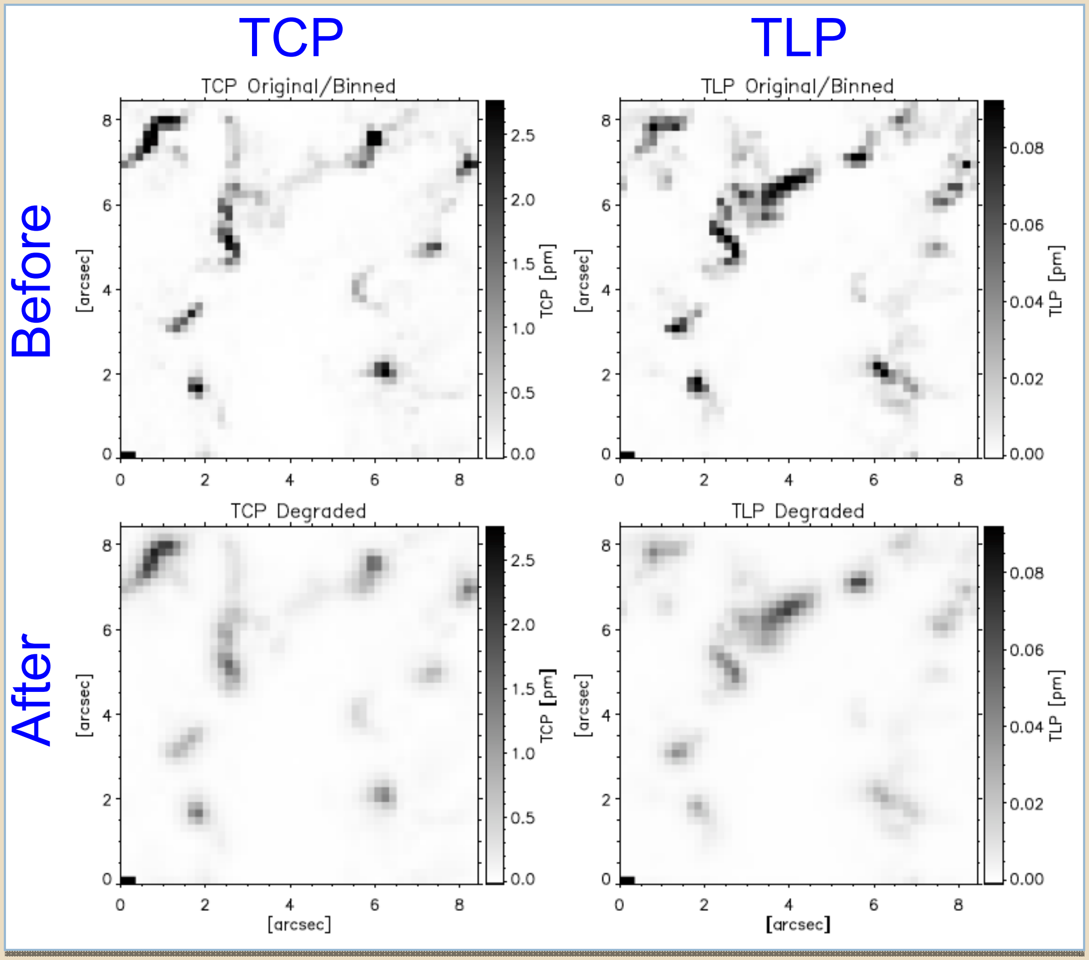


<B>=10G

S. Vargas & J.A. Bonet

Effects of diffraction (I)

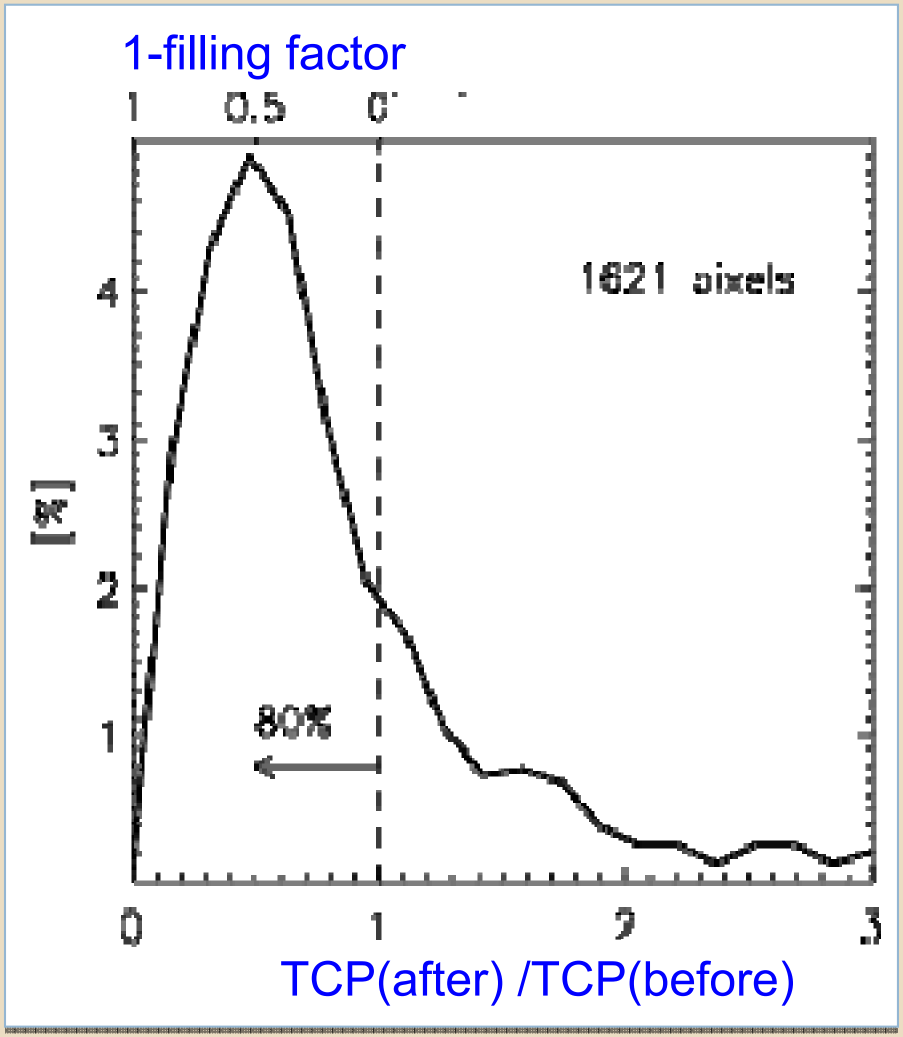
- Telescope diffraction affects each pixel differently depending on its neighboring pixels



- Diffraction makes the polarization signals to appear "blurred" and diminishes the image contrast (weakening of polarization signals)
- Small scale structure disappear after degradation
- Diffraction distributes part of the polarization signal of a pixel to nearby ones

Effects of diffraction (II)

- Modeling telescope diffraction



- 1621 pixels show Stokes Q, U or V amplitudes > $4.5\times10^{-3}\ I_c$
- The circular polarization is smaller after the degradation: 80% of pixels show weaker signals
- In pixels where the magnetic field is intrinsically weak the inversion will systematically fail
- Effects of diffraction are similar to those of a magnetic filling factor

Ratio of TCP in the original image with respect to that in the degraded image and corresponding to <B>=10 G

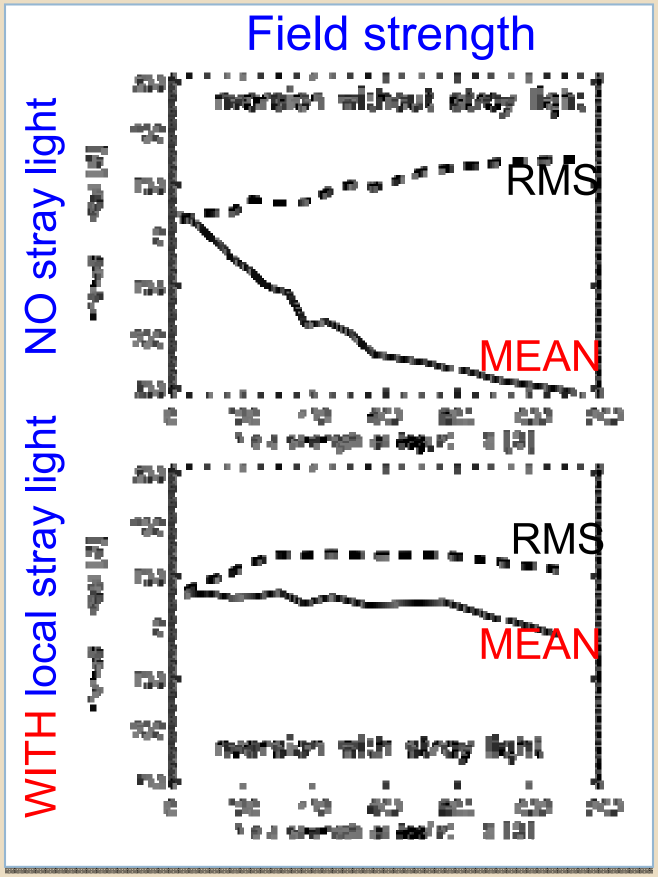
Inversion strategy: modeling telescope diffraction

- New ME inversion strategy
  - Invert the Stokes profiles assuming a homogeneous magnetic atmosphere occupying the whole resolution element and a contamination of "stray light" (filling factor ≠ 1)
  - The idea is to correct for the dilution of the polarization signals due to diffraction
  - The "stray light" profile is evaluated individually for each pixel by averaging the Stokes *I* profiles within a 1"-wide box centered on the pixel

(Orozco Suárez, Bellot Rubio, & del Toro Iniesta 2007)

Inversion results: quantitative analysis

- Mean and rms values of the errors defined as the difference between the inferred and the real parameters at optical depth log τ=-2.

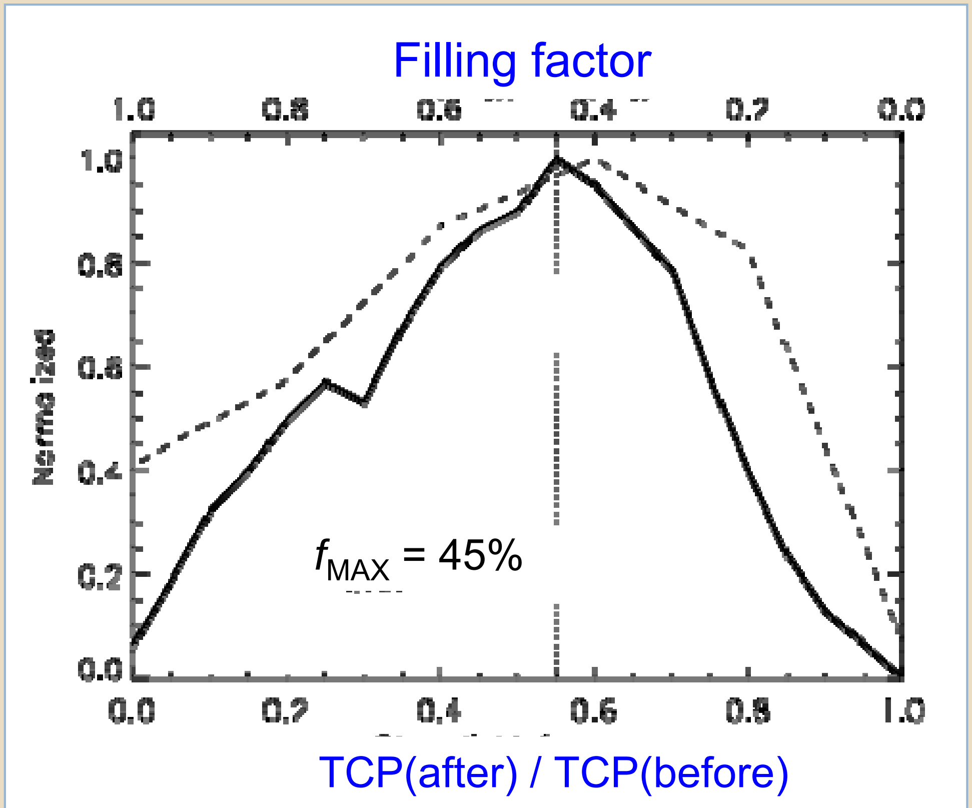


- Field strengths are underestimated if NO stray-light contamination is considered
- The inversion considering local stray-light contamination gives

Field strength error < 80 G

Field inclination error < 6º

Inversion results: filling factors



Histogram of filling factors derived from the inversion (solid) and the ratio of TCP in the degraded image with respect to that in the original image (dashed)

- The strong resemblance between the two distributions indicates that: the filling factors derived from the inversion actually model the effects of telescope diffraction and CCD pixel size
- The inferred filling factors represent the degradation of the instrument and NOT real magnetic filling factors

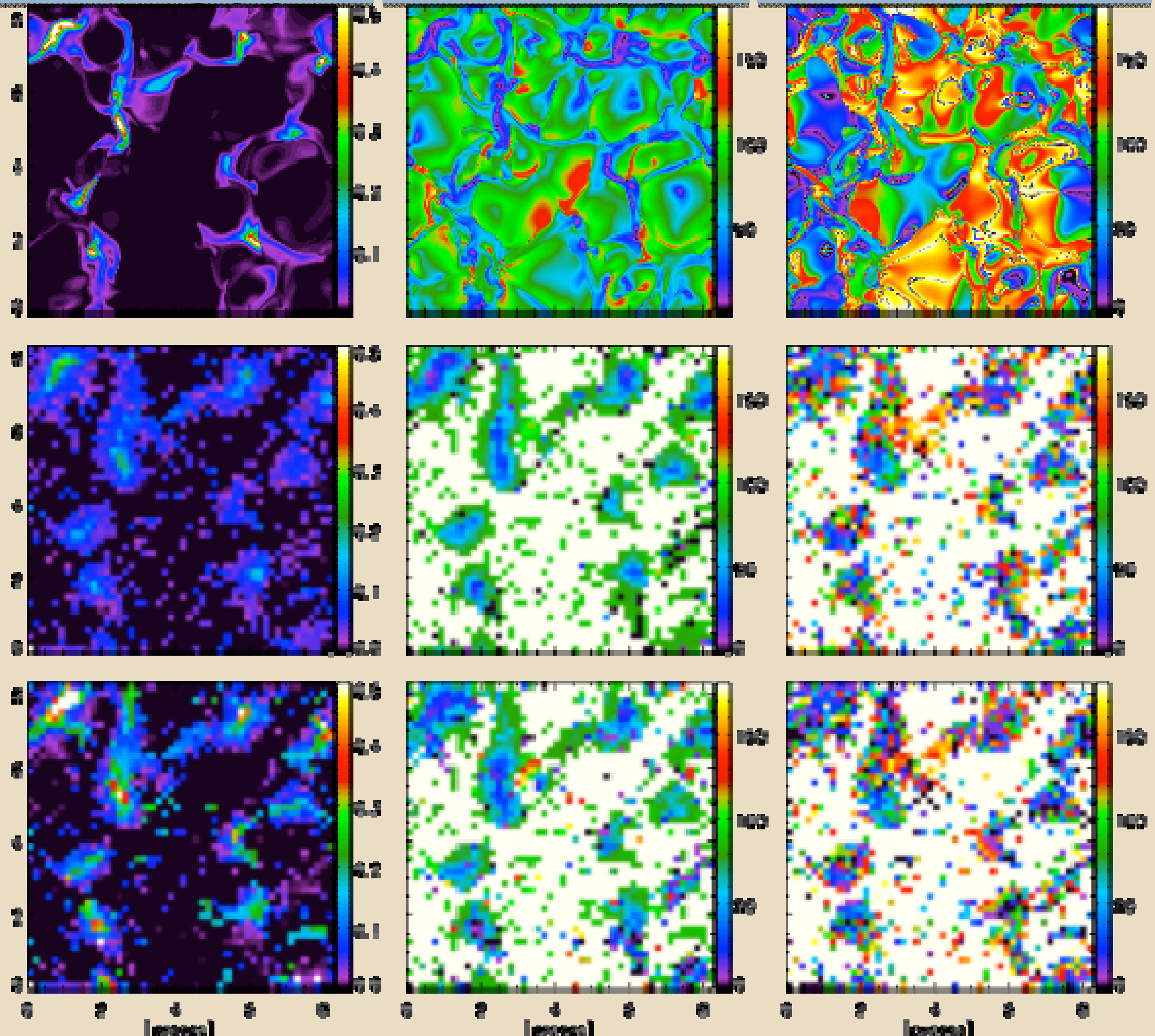
Conclusions

- The ME inversion recover the field strength with remarkably accuracy above 100 G when modeled telescope diffraction
- We infer weak field where the field is weak in the simulations and strong fields where it is strong
  - This is in sharp contrast with the results of Martinez Gonzalez et al. (2006) at 1" resolution which yield strong and weak fields depending on the initializations
  - This justify the use of the Fe I 630 nm line pair by space-borne instruments
- It is necessary to account for the effects of diffraction when interpreting the results of inversions: the retrieved filling factors are too small

20% → 50%

Inversion results (I): qualitative analysis

Field strength | Inclination | Azimuth



Real model stratification at log τ = -2

Results without using stray-light contamination

Results using local stray-light contamination