Quiet Sun Magnetic Fields

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1. Introduction

Until recently, it was thought that solar magnetic fields existed only within "Active Regions", where we find sunspots. The vast remainder of the Sun was termed the "Quiet Sun" because it was considered to be magnetically "quiet." But along with advancements in instrumentation came the discovery of weak magnetic fields pervading the entire solar surface. While these newly discovered fields are individually weak, the net effect of the Quiet Sun's magnetic fields actually dominates the magnetic flux and energy budget of the entire Sun.

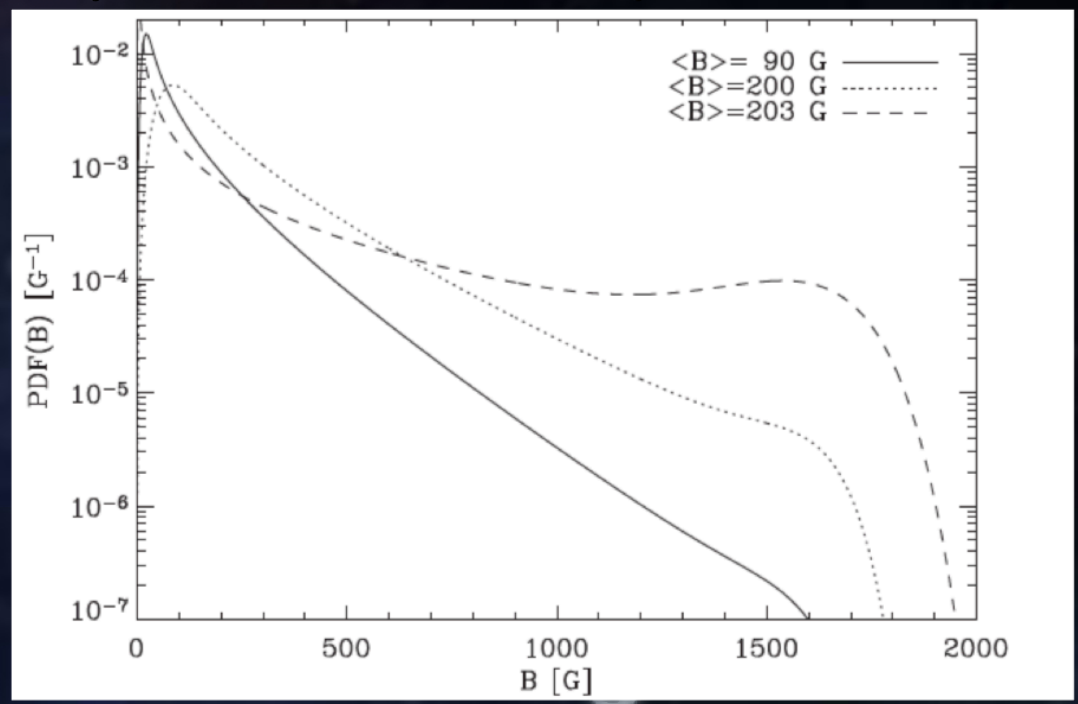
In order to understand the true significance of these magnetic fields, we need to obtain a proper understanding of their distribution throughout the Quiet Sun.

2. Project Goal

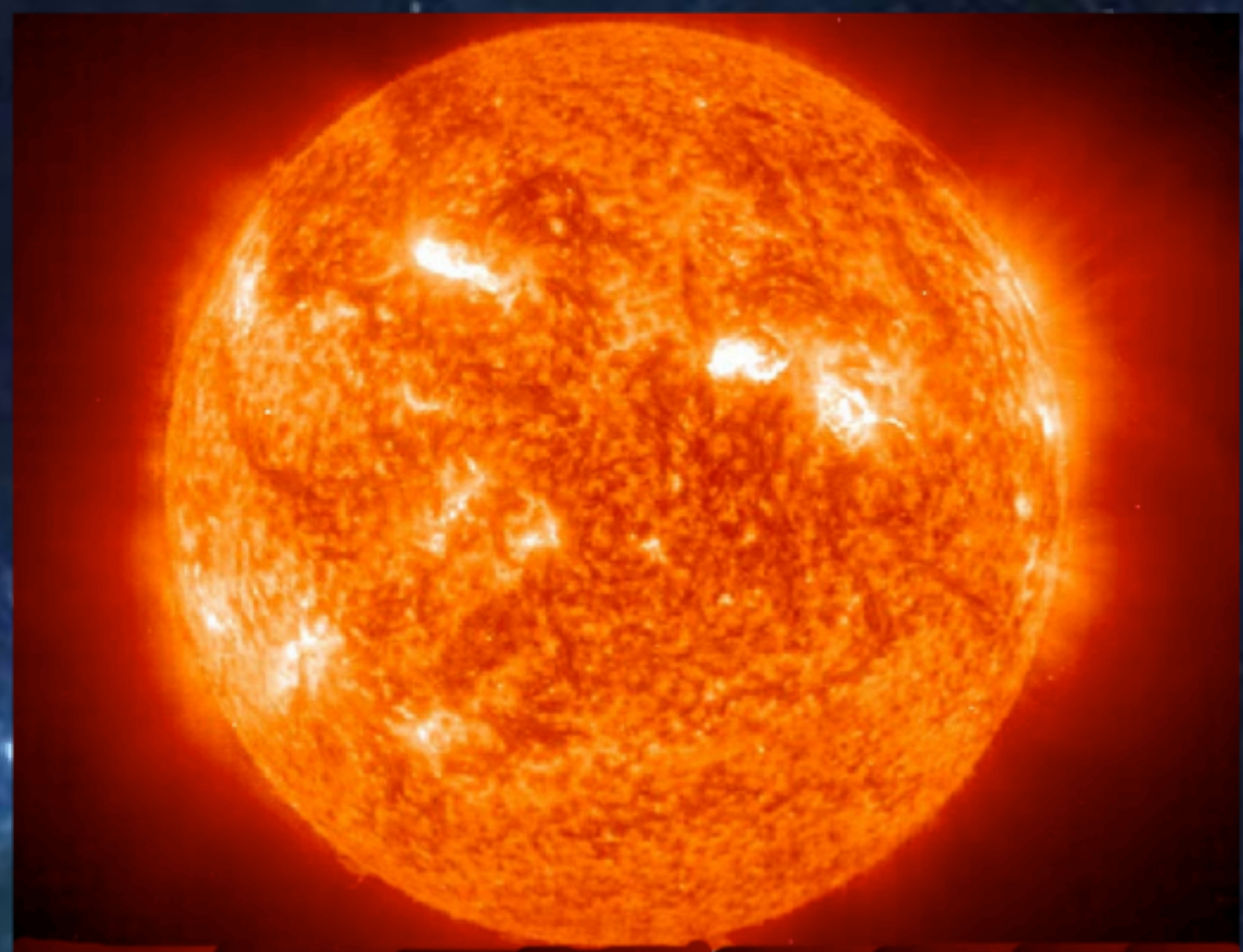
The goal of this project was to assist in the determination of the distribution of magnetic fields in the Quiet Sun.

3. Magnetic Field Distribution

This is a plot of observed magnetic field distributions (Sanchez Almeida & Martinez Gonzalez 2011). It shows the percentage of the Quiet Sun that harbors specific magnetic field strengths. The distributions are subject to observational and analytical biases.



There is a divide in the scientific community between the solid (bottom) curve and the dashed (top) curve. If the dashed curve is real, then there is a significantly higher amount of magnetic energy in the Quiet Sun than the solid curve suggests.

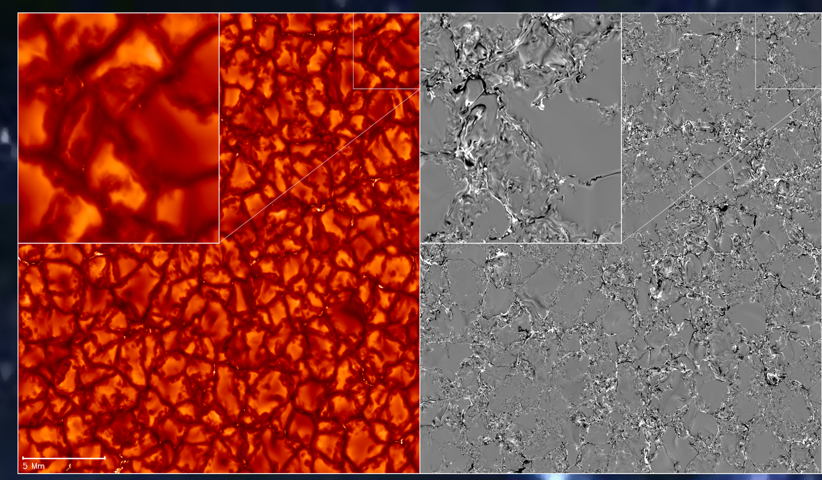


4. Methodology

1) Simulation: Create a simulation of the Sun.
2) Stokes Profiles: Calculate spectral data (Stokes profiles) from this simulation.
3) Degradation: Degrade the Stokes profiles, so as to introduce observational error. This will cause the data to look like an observation.
4) Inversion: Retrieve values of the magnetic fields, through the use of spectral line inversion codes, from this degraded simulation.
5) Results: Plot the magnetic field distribution of the degraded data. Then, plot the magnetic field distribution for the unaltered, simulated Sun.
6) Conclusions: Compare the two plots and examine how this combination of observational errors and analysis techniques affects the magnetic field distribution curve.

5. Simulation

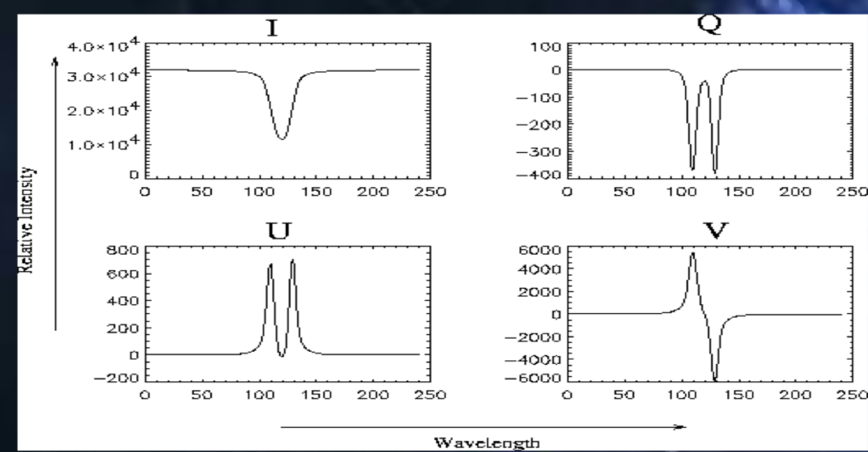
Matthias Rempel's Quiet Sun Simulation:



The simulations provide us with a model atmosphere with known physical properties, such as the magnetic field. So the magnetic field distribution can easily be determined.

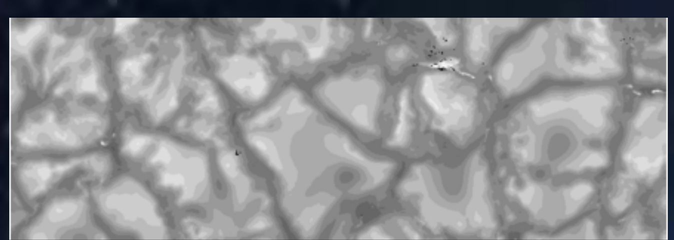
6. Stokes Profiles

The Stokes profiles below are I (intensity), Q (linear polarization), U (also linear polarization), and V (circular polarization). Light becomes polarized linearly and/or circularly in the presence of magnetic fields. Without magnetic fields, we would not see any signs of polarization; therefore, an abundance of information about the magnetic field is stored within these Stokes profiles.

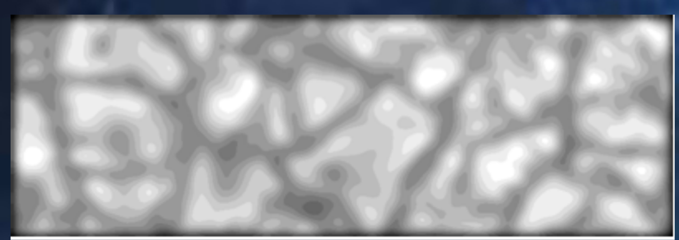


7. Degradation

Non-Degraded



Degraded



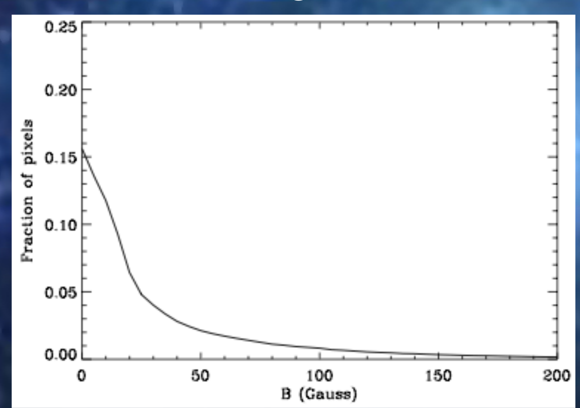
The Stokes profiles were first smeared spatially (x and y directions). Above is the result of this smearing. The degradation was done by convolving our data with a Gaussian profile that had 240km of FWHM (Full Width at Half Maximum).
Then, I degraded the data spectrally (in the wavelength direction). All smearing was done in order to replicate the limitations of the satellite, Hinode (Tsuneta et al. 2008).

8. Inversion

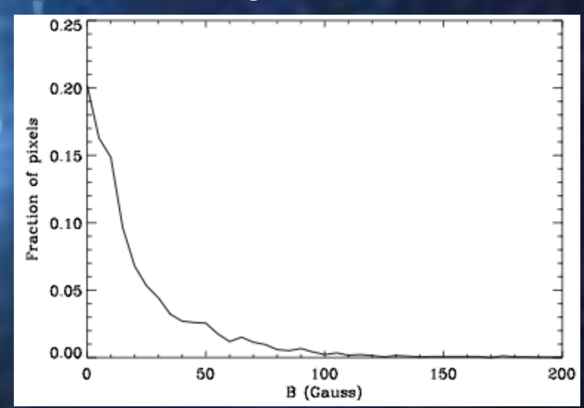
Spectral line inversion codes are tools that allow the extraction of the Sun's atmospheric, physical properties, from Stokes profiles.
By running the HEXIC spectral line inversion code, developed at HAO (High Altitude Observatory), I obtained the magnetic field of the synthetic, degraded, "observational" Quiet Sun.

9. Results

Non-Degraded



Degraded



10. Conclusions

The distribution curve obtained from the "observational", degraded data was shifted towards weaker magnetic field strengths, so our analysis and observational techniques are certainly not perfect.
After introducing observational errors and implementing our specific analysis technique, no bump at high field strengths in the magnetic field distribution curve was reproduced.
This validates our analysis technique.

Given more time, we would extend this process of analyzing different analysis procedures in order to validate or discredit them.

11. References

Sanchez Almeida and Martinez Gonzalez, "The magnetic fields of the Quiet Sun", 2011, Proceedings of the Solar Polarization Workshop 6, Astronomical Society of the Pacific, p. 451

Tsuneta et al, "The Solar Optical Telescope for the Hinode Mission: An Overview", 2008, Solar Physics, 249, 167.

12. Acknowledgements

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