

Comparison of multi-height observations with a 3D MHD sunspot model



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Abstract

In sunspots the contribution to the horizontal pressure support from the curvature force and the geometrical height of formation which magnetic field measurements sample are poorly constrained observationally due to the effect of radiative transfer. In cool atmospheres, observations of the sunspot photosphere probes geometrically deeper layers, information on the magnetic field gradients cannot be easily derived even using multi-wavelength, multi-height observations. Recent MHD atmosphere models of sunspots analyzed with the Rybiki-Hummer radiative transfer code allow for direct comparison with simultaneous multi-height observations of the Fe I magnetic field diagnostics at 1565 and 630.2 nm in sunspots observed using the Facility Infrared Spectropolarimeter at the Dunn Solar Telescope.

1. Problem

Study of a previous multi-wavelength inversion has been made in Cabrera Solana et al. (2006)

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2. Observations and Analysis

NOAA 11101 was a small, regular α -spot with a fully formed penumbra observed near disk center on 2010-08-30 at 01:45 UT with the Facility Infrared Spectropolarimeter (FIRS) on the Dunn Solar Telescope at Sacramento Peak, New Mexico, USA. A detailed description of FIRS can be found in Jaeggli et al. (2010) and soon in Lin et al. 2011(?). Observations of the sunspot were made simultaneously with the 6302 and 15650 Å channels of FIRS.

Observations were reduced using the FIRS reduction pipeline, and the full-Stokes spectra were inverted with the Two Component Magneto-Optical (2CMO) inversion code, a simple Milne-Eddington inversion code which approximates the Voigt and Faraday-Voigt profiles to fully account for the magneto-optical effect. 2CMO performs an 11 parameter fit with a magnetic and non-magnetic component and the results have been determined to be consistent with other Milne-Eddington techniques. The reduction and inversion of similar observations are presented in Jaeggli et al. (2011) and Jaeggli (2011).

3. Sunspot Model

Model atmosphere produced by a 3D MHD sunspot simulation by Matthias Rempel (example previously shown in Rempel(2010)).

4. Spectral Synthesis

Spectral synthesis was carried out using the Rybiki-Hummer (RH) radiative transfer and chemical equilibrium code by Han Uitenbroek (see Uitenbroek 2000a,b).

5. Comparison

Direct comparison is unfair. In the model height increases as we move out of the atmosphere, note that the average gradient of the magnetic field at 1565 is positive, that is, magnetic field is increasing with height.

6. Discussion and Conclusions

Further Work

smaller sunspot model or observations of larger sunspots for better comparison
synthesize and invert "observed" Stokes profiles with realistic instrument profile applied

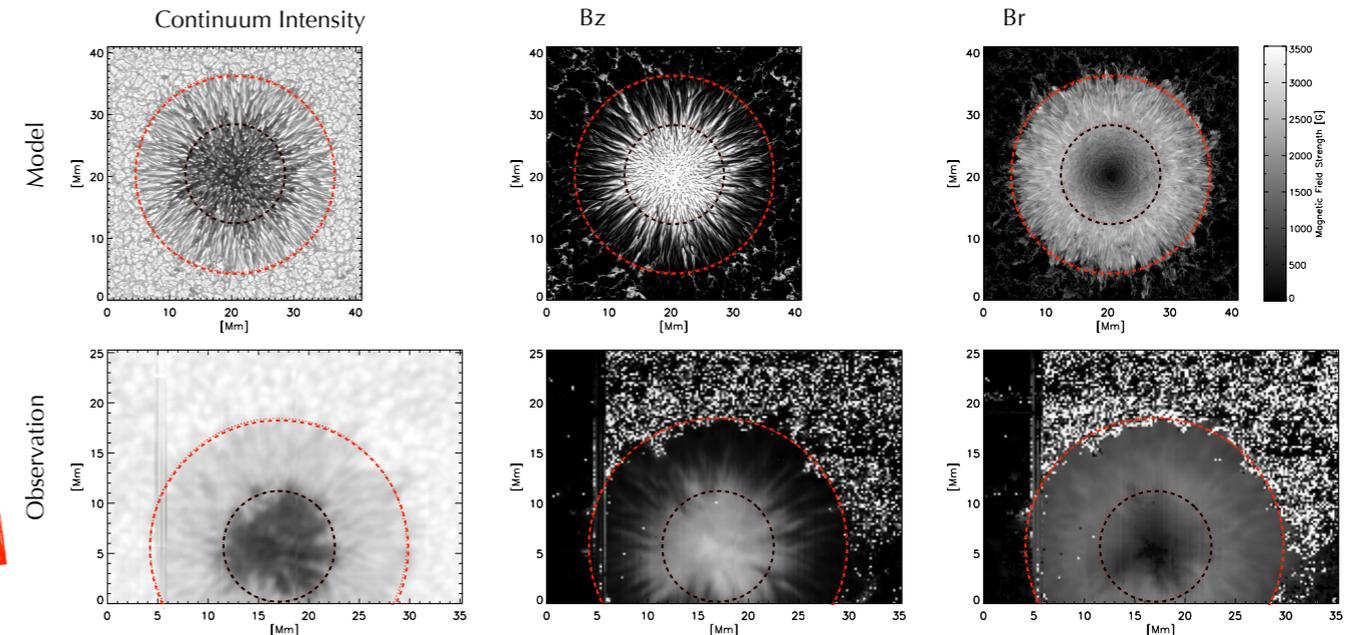


Figure 1. Maps of continuum intensity, B_z , and B_r for the 15650 Å channel for the Rempel sunspot simulation and the observation of NOAA 11101.

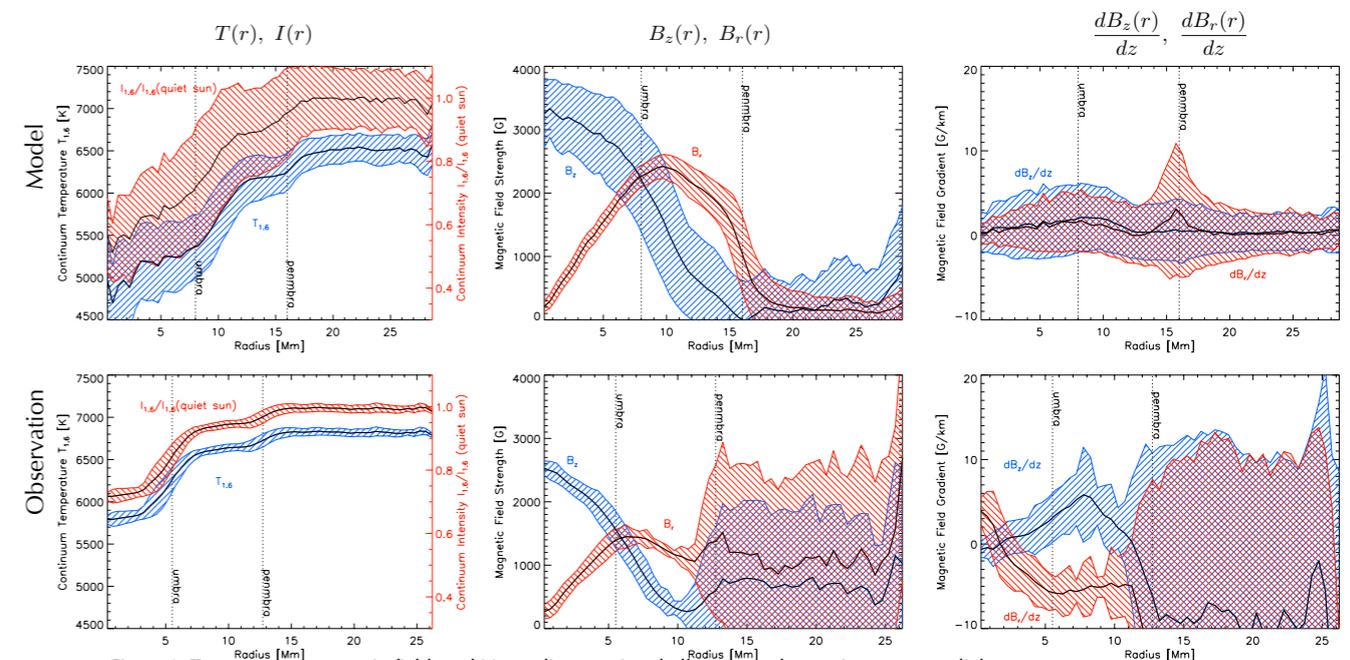


Figure 2. Temperature, magnetic field, and its gradients, azimuthally averaged to retrieve mean radial dependence. Lines indicated the mean values and the shaded areas indicate the 1-sigma error about the mean for each radial bin.

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