

# Observational Signatures of a Small-Scale Global Dynamo

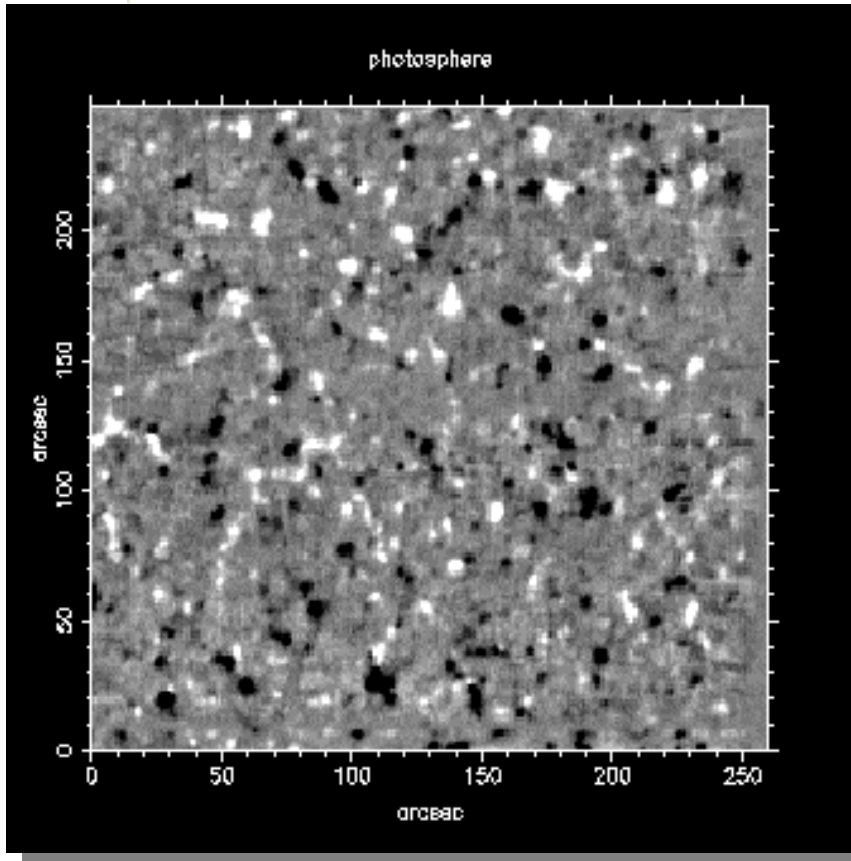


NSO

National Solar Observatory

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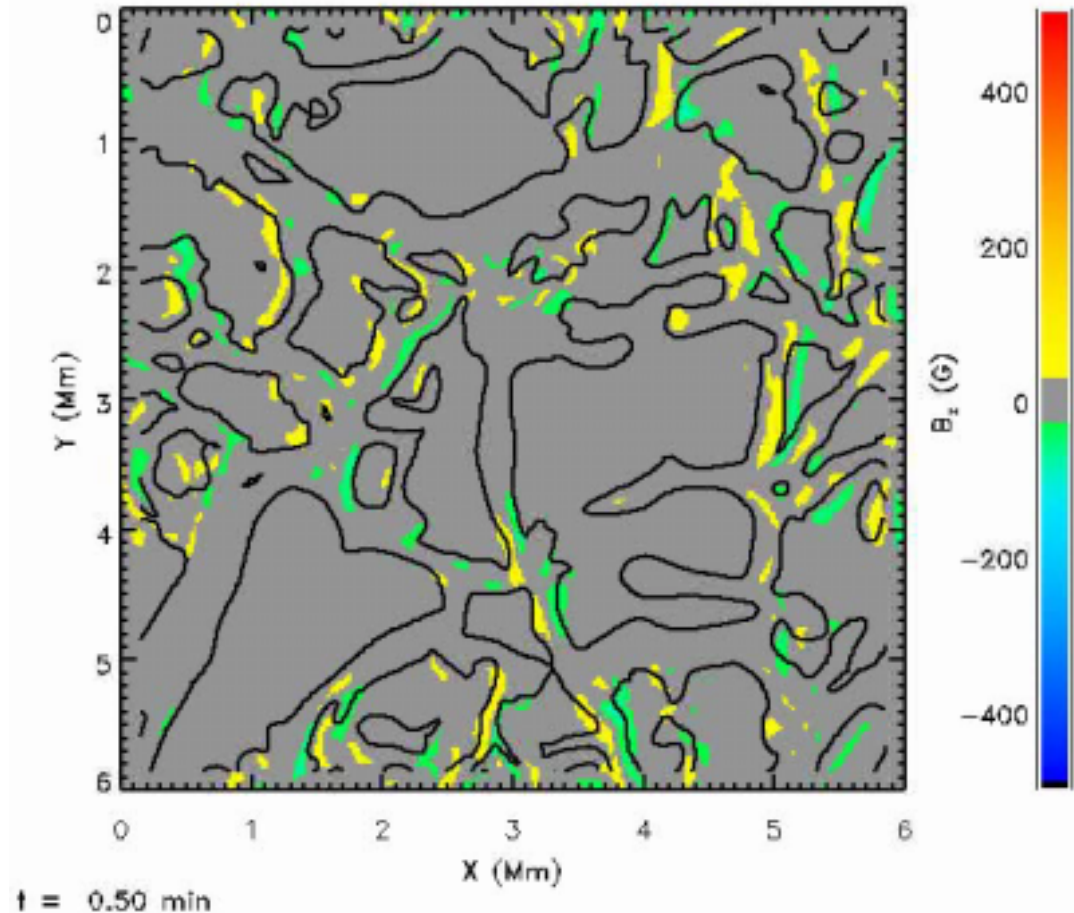
## Very Quiet Sun Photospheric Magnetogram

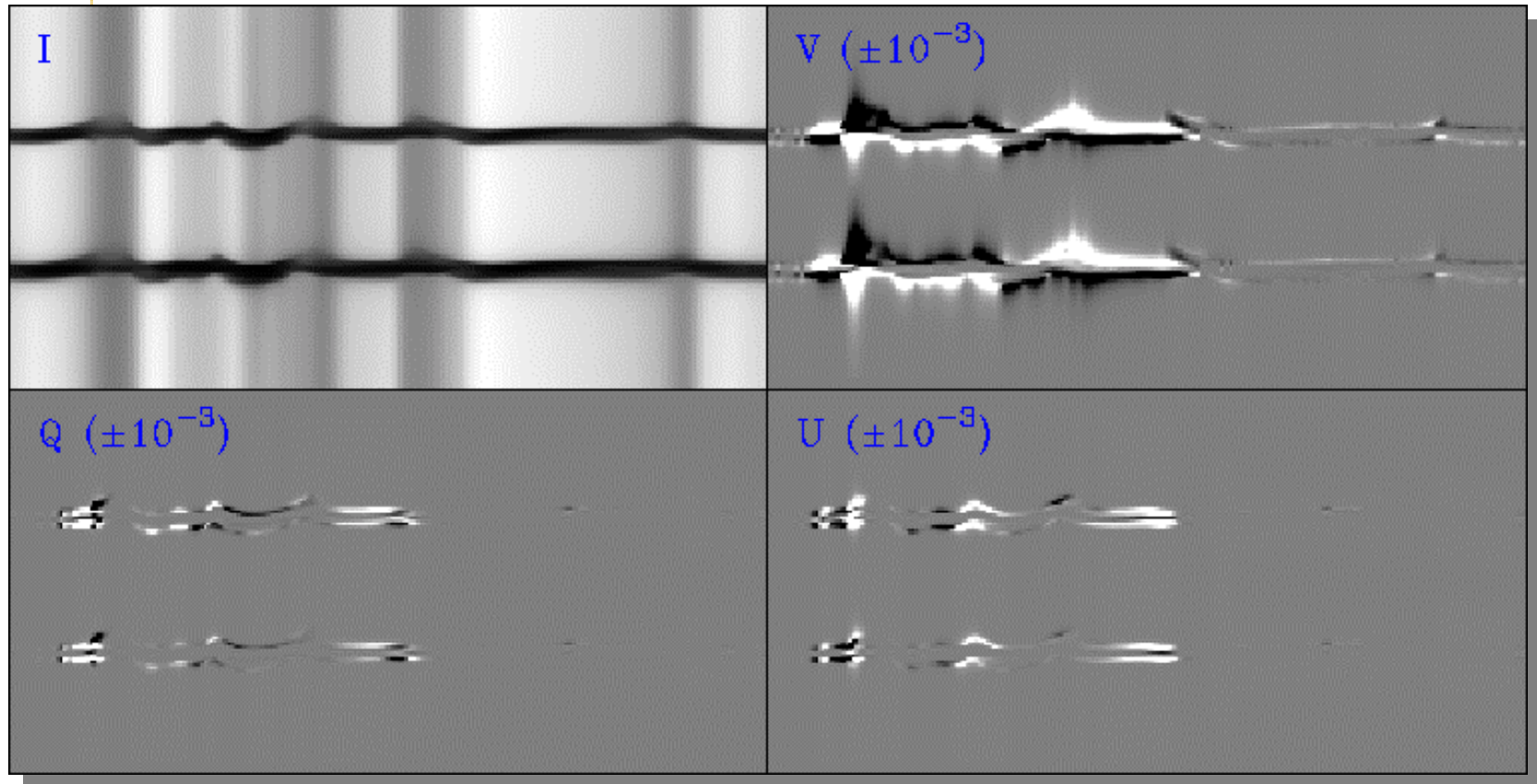


**Kitt Peak Vacuum Telescope, original data courtesy Karen Harvey**

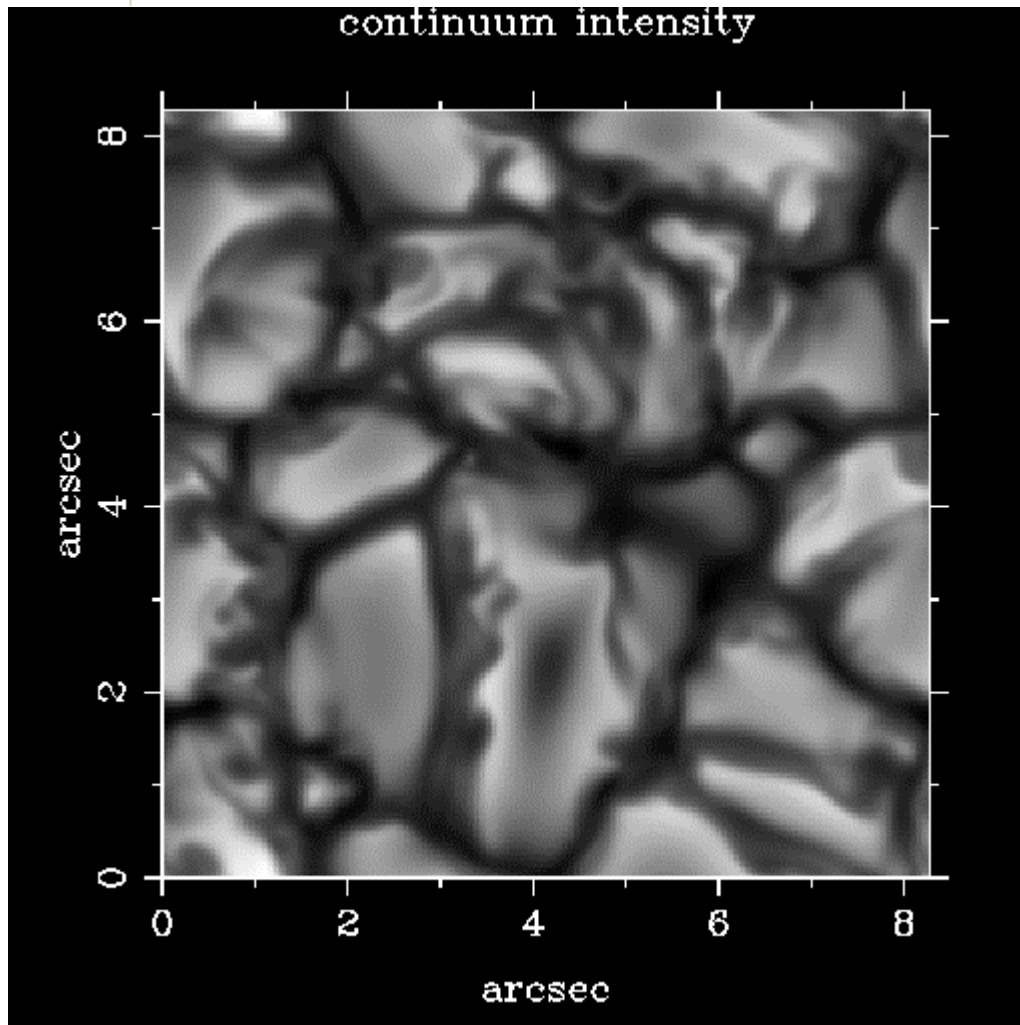
- ❑ Smallest features are not noise
- ❑ Magnetic field everywhere!
- ❑ Quiet sun magnetic field contains more flux than all active regions together
- ❑ Apparently 'emerging' flux rate 2 orders of magnitude larger than in ephemeral regions (Zirin 1987)
- ❑ Small-scale surface dynamo (Cattaneo 1999) ?
- ❑ Leftovers of active region decay?
- ❑ Small-scale global dynamo?
- ❑ Compare (realistic) simulations with observations!

- ❑ Calculations by Bob Stein and Åke Nordlund
- ❑ Start with snapshot of fully developed hydrodynamic convection
- ❑ Impose 30G horizontal seed field
- ❑ Top boundary: potential field
- ❑ Bottom boundary: inflows advect 30G horizontal field
- ❑ 6 by 6 by 3 Mm
- ❑ 24 km horizontal grid spacing
- ❑ Fluxtube formation

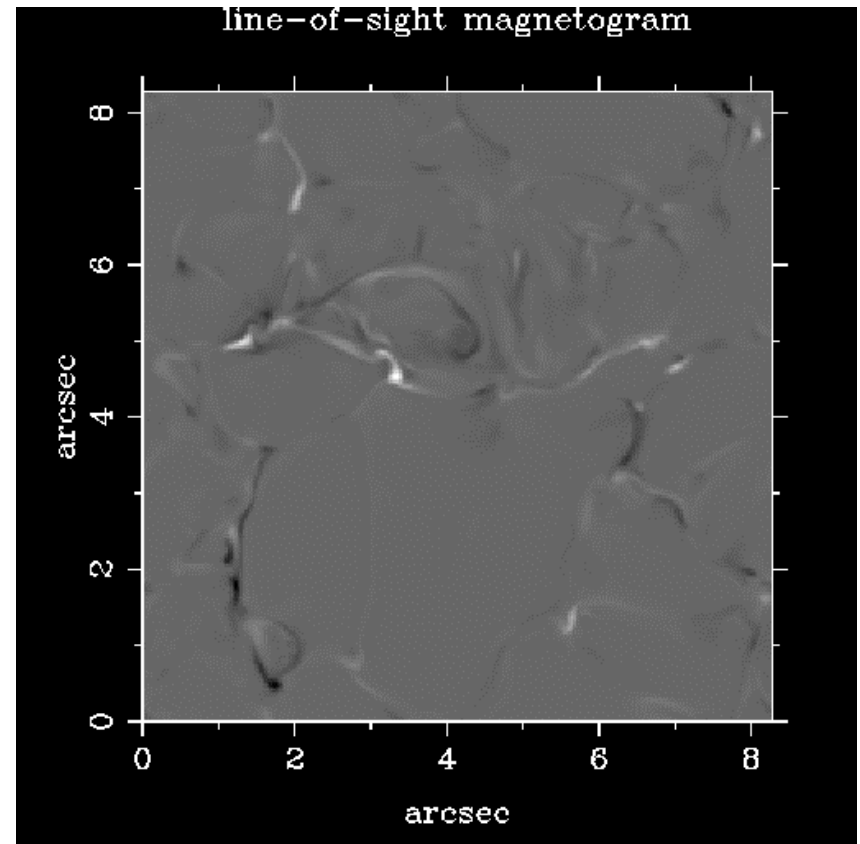
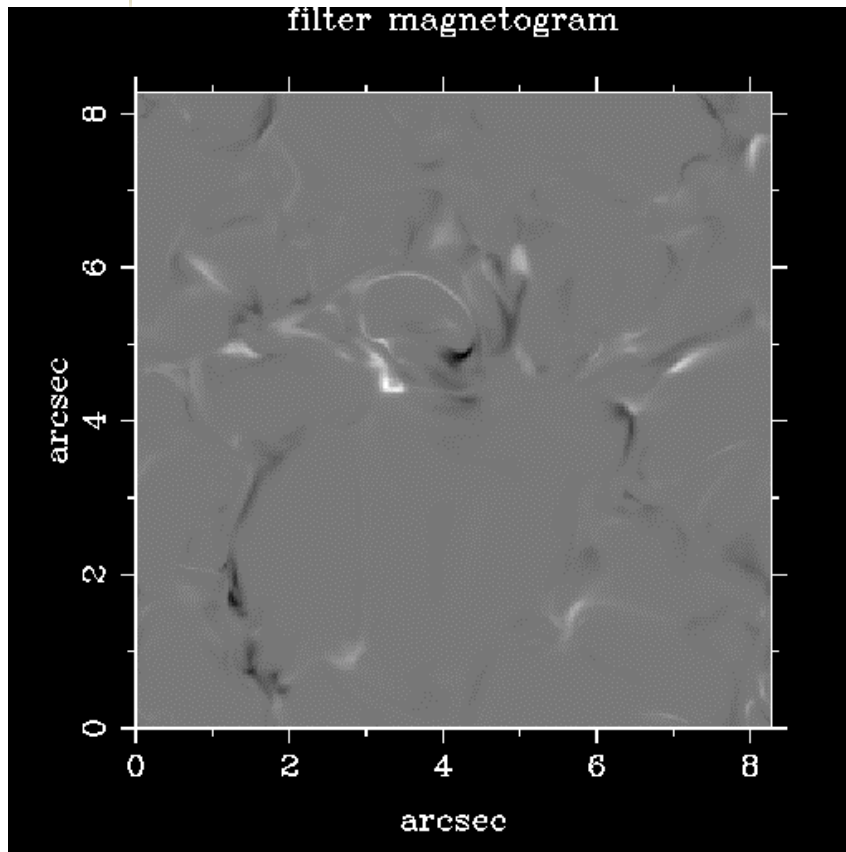




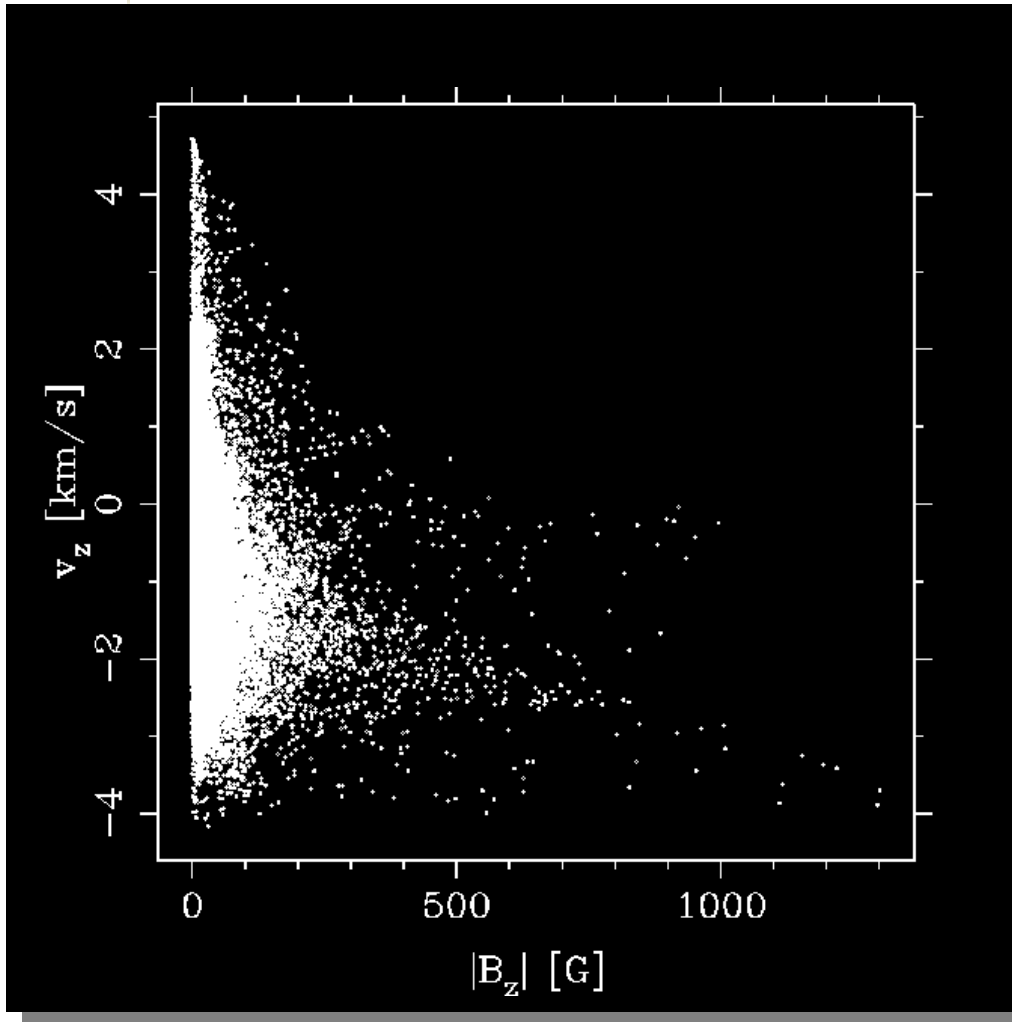
- ❑ 1-D LTE polarized radiative transfer, no spatial smearing, no diffraction
- ❑ FeI 630.15 and 630.25 nm without telluric lines, Zeeman effect only
- ❑ Complicated profiles require robust parameter extraction



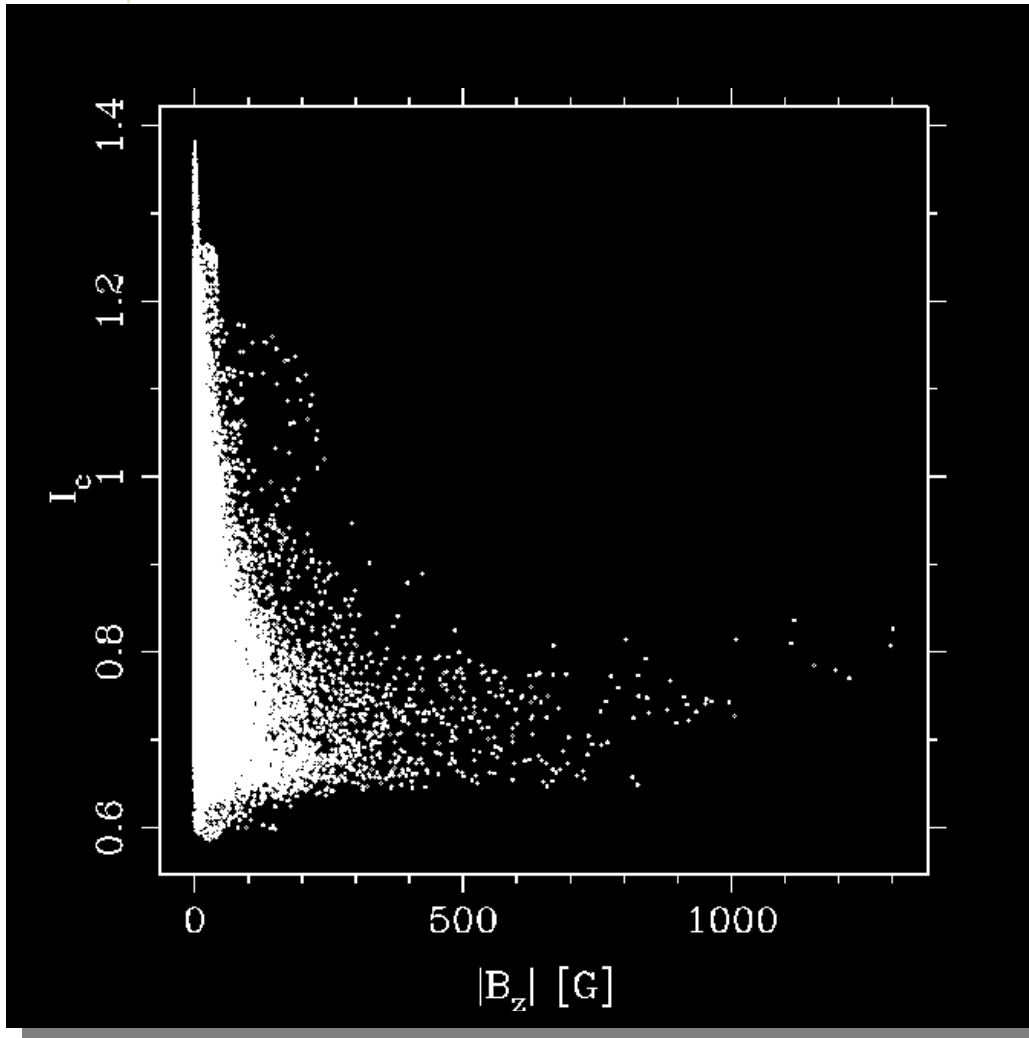
- ❑ Continuum intensity
- ❑ Line-of-sight magnetogram with center-of-gravity method
- ❑ Line-of-sight velocity with center-of-gravity method
- ❑ Concentrate on Stokes V because signals are larger than in Q and U



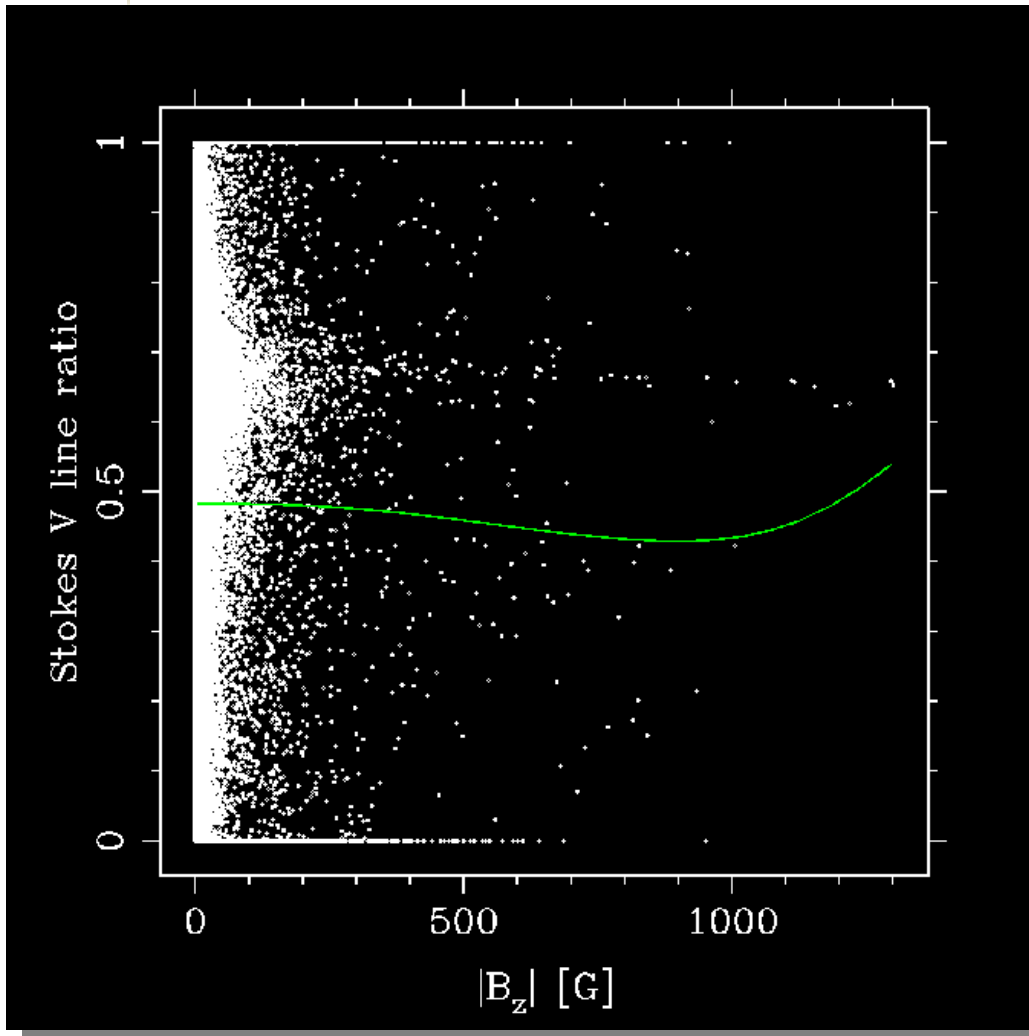
- ❑ Important to choose observables that are related to physical parameters in 'clean' way
- ❑ Full Stokes profiles need to be analyzed to achieve this



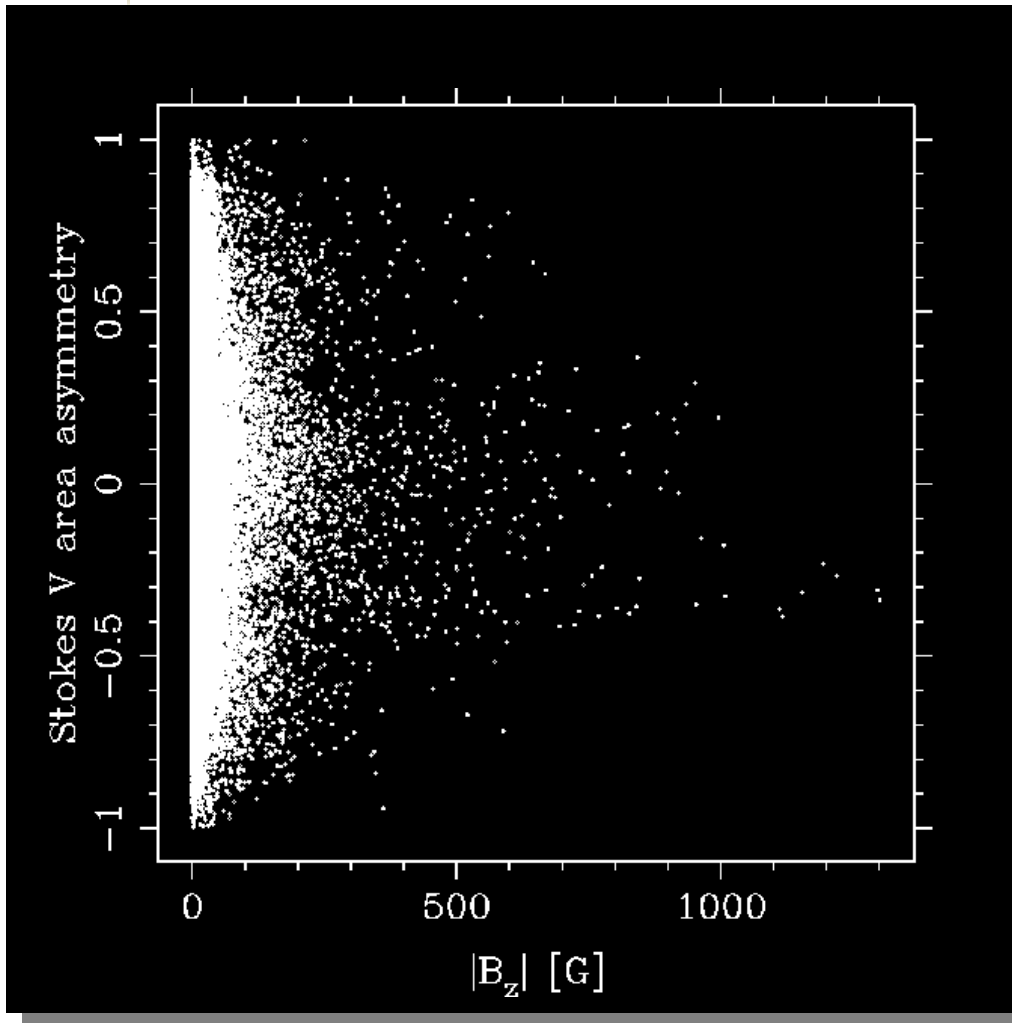
- Most line-of-sight magnetic flux in downflows
- But also some line-of-sight magnetic flux in upflows



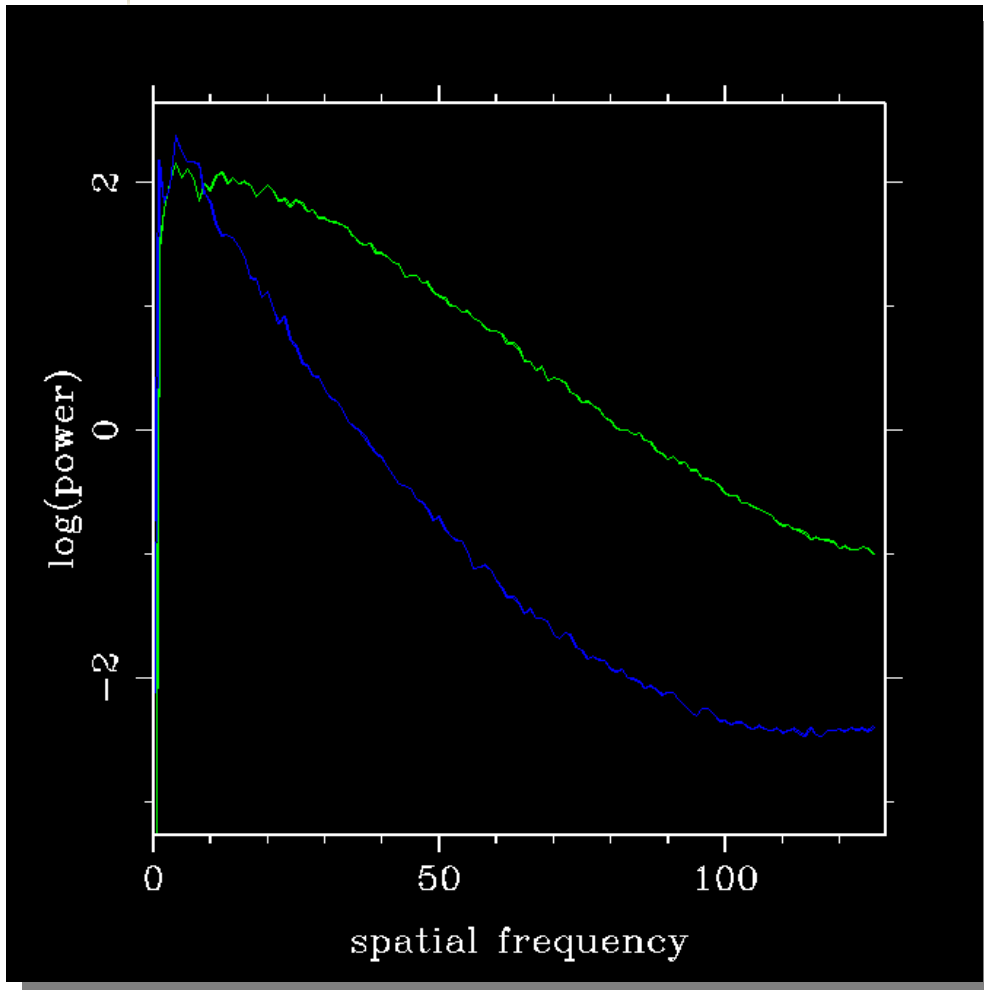
- Most line-of-sight magnetic flux in 'dark' regions



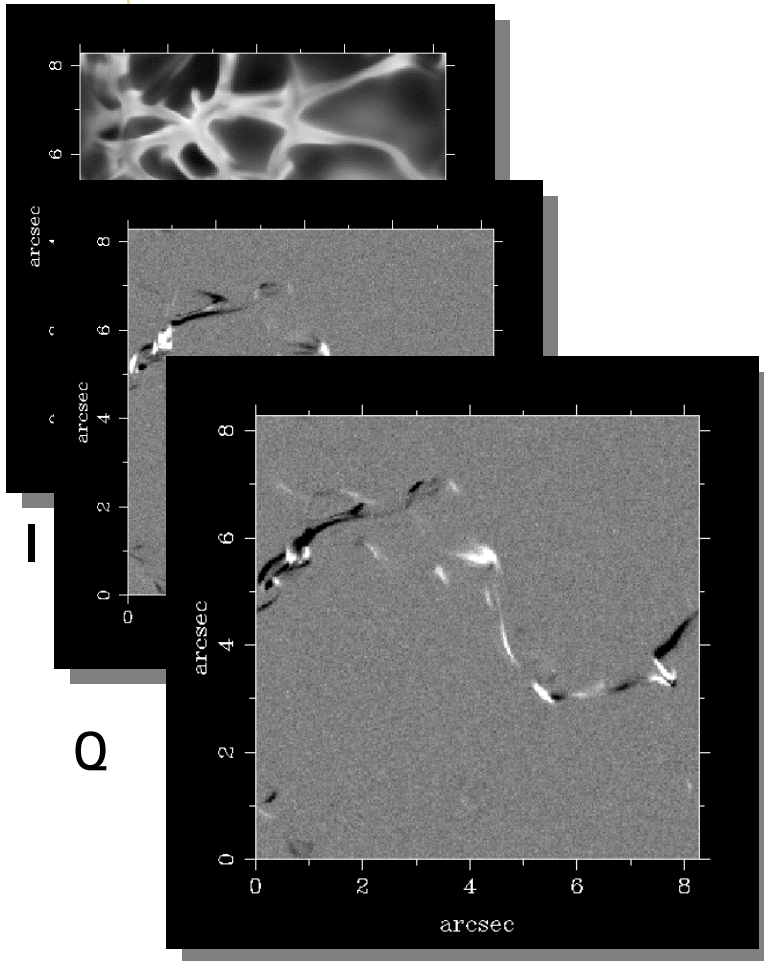
- ❑ Green line is theoretical line ratio for a vertical field that is constant with height
- ❑ Spread in 'observed' Stokes V amplitude ratio is much larger than its sensitivity on field strength
- ❑ Stokes V line ratio is most likely not a good indication for field strength
- ❑ Stokes V amplitude ratios are dominated by other effects



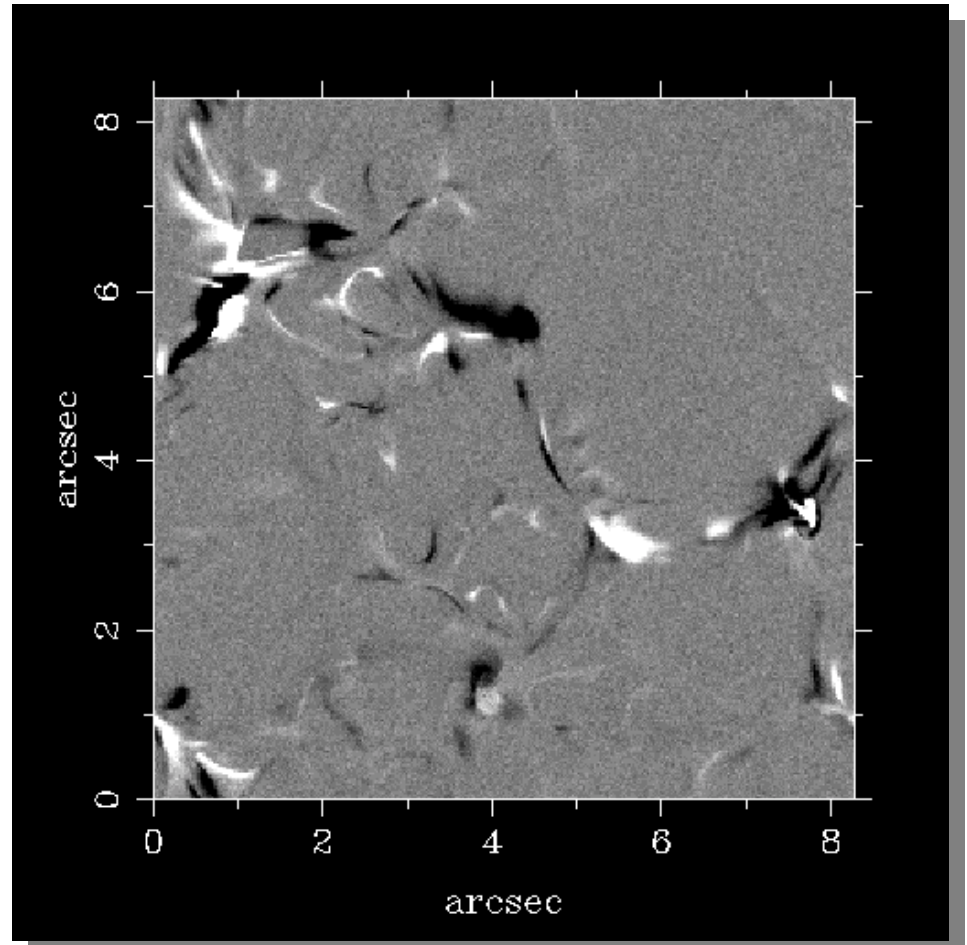
- Large spread for small field strengths indicates complex Stokes profiles
- Slightly negative asymmetry for large field strengths is consistent with observations



- Azimuthally averaged 2-D power spectra
- Green: line-of-sight magnetogram
- Blue: line-of-sight velocity
- Turbulent MHD theory can make prediction of slopes and relation of peak locations



U



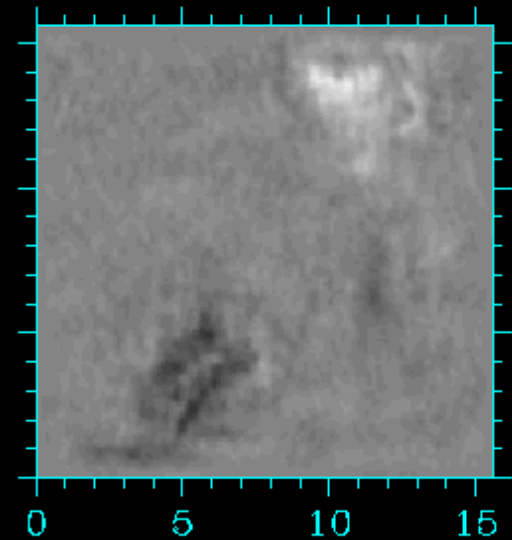
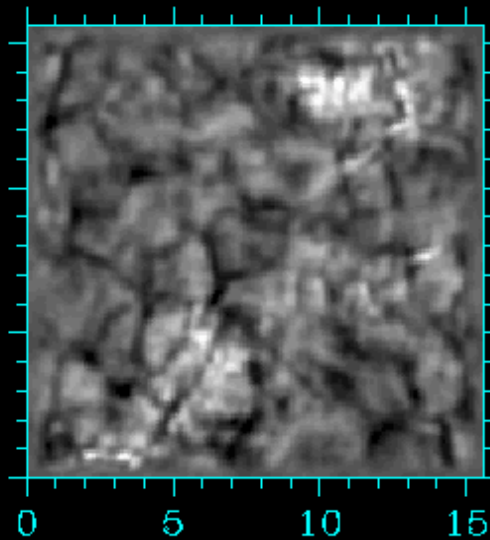
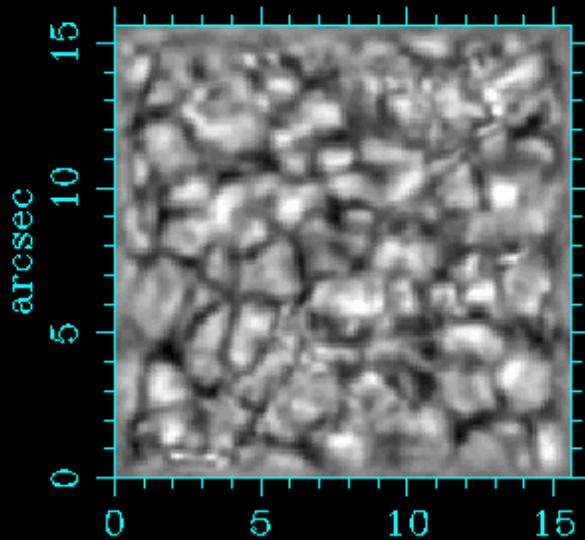
V

- ❑ More spectral lines that might provide better diagnostics
- ❑ Different wavelength regimes such as near-infrared to obtain 'cleaner' diagnostics
- ❑ Full Stokes vector inversions
  - ρ Comparison with model field vector
  - ρ Helicity
- ❑ Static center-to-limb variation
- ❑ Make use of temporal evolution in simulations:
  - ρ Flow fields in intensity and magnetogram
  - ρ Vorticity
- ❑ Design and build ATST with a full suite of instruments

white line

CaI 6103Å line wing

CaI 6103Å Stokes V



NSO/ERIM

arcsec

time: 0 min

- Quiet network observed with Dunn Solar Telescope, Phase Diverse Speckle (PDS) and speckle deconvolution reconstructions (no adaptive optics)

With R. Paxman, D. Carrara, A. Basu, T. Rimmele