

Coronal magnetometry

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The challenge

- we wish to measure coronal magnetic fields, to address problems in storage and release of energy
 1. basic MHD of the corona (structure, stability, causes of dynamics, flares)
 2. the origins of space weather
 3. the role of the corona in the solar magnetic cycle
 4. coronal heating?
- the time is ripe to exploit **forbidden coronal lines** (1960s: Charvin, Harvey) [**permitted lines in prominences**- 1970s Leroy]
 1. signatures of the coronal magnetic field are weak ($I : P : V \approx 1 : 0.1 : 0.001$)
 2. ambiguities abound... models needed

Progress- theory

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- Lin, H. and Casini, R.: 2000, “A Classical Theory of Coronal Emission Line Polarization”, *Astrophys. J.* **542**, 528–534
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- Casini, R. and Lin, H.: 2002, “A Classical Model for the Damped, Magnetic Dipole Oscillator”, *Astrophys. J.* **571**, 540–544
- Penn, M. J., Lin, H., Tomczyk, S., Elmore, D., and Judge, P. G.: 2004, “Background induced measurement errors of the coronal intensity, density, velocity and magnetic field”, *Solar Phys.* **222**, 61–78



Progress- instrumental

Darnell, T., Tomczyk, S., Card, G., Judge, P. G., Casini, R., and Burkepile, J.: 2003, “**A Coronal Multi Channel Polarimeter For Magnetic Field Measurements**”, *AGU Fall Meeting Abstracts* B505

Kuhn, J. R., Coulter, R., Lin, H., and Mickey, D. L.: 2003, “**The SOLARC off-axis coronagraph**”, in *Innovative Telescopes and Instrumentation for Solar Astrophysics*. Edited by Stephen L. Keil, Sergey V. Avakyan . *Proceedings of the SPIE, Volume 4853, pp. 318-326 (2003).*, 318–326

Tomczyk, S.: 2003, “**Multi-Channel Polarimeter for Coronal Magnetic Field Measurements**”, *AGU Fall Meeting Abstracts* D3

Progress- observational

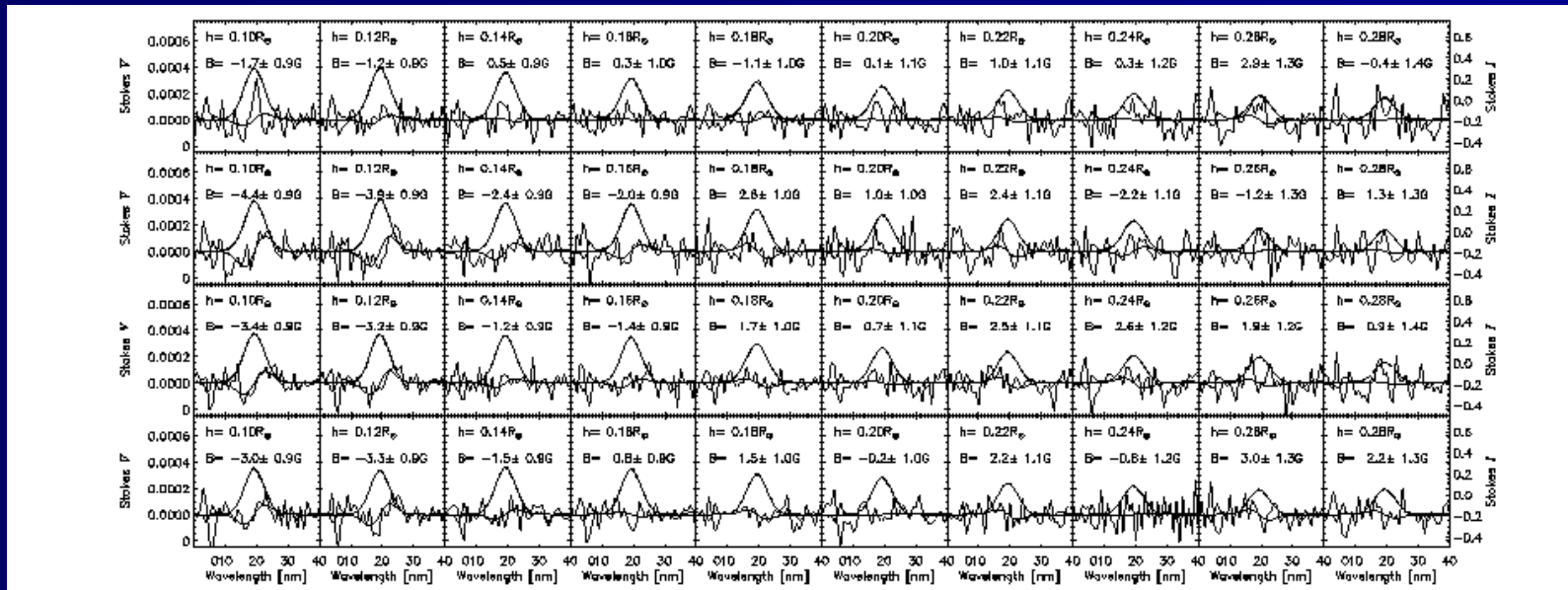
- Kuhn, J. R.: 1995, "Infrared Coronal Magnetic Field Measurements", in J. R. Kuhn and M. J. Penn (Eds.), *IR Tools for Solar Astrophysics: What's Next?*, No. 15 in NSO/Sacramento Peak Summer Workshop, World Scientific, Singapore, 89–93
- Kuhn, J., MacQueen, R. R., et al.: 1999, "Probable Discovery of a bright emission line of Si IX near 3.9 microns", *Astrophys. J.* 521, 478–482
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- Judge, P. G., Tomczyk, S., Livingston, W. C., Keller, C. U., and Penn, M. J.: 2002, "Spectroscopic Detection of the 3.934 Micron Line of Si IX in the Solar Corona", *Astrophys. J. Lett.* 576, L157–L160
- Lin, H., Kuhn, J. R., and Coulter, R.: 2004, "Coronal Magnetic Field Measurements", *Astrophys. J. Lett.* 613, L177–L180
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- Tomczyk, S.: 2004, "Magnetic Field Measurements from The Coronal Multi-Channel Polarimeter", *AGU Fall Meeting Abstracts* B4

SOLARC (Kuhn P.I., U. Hawaii)



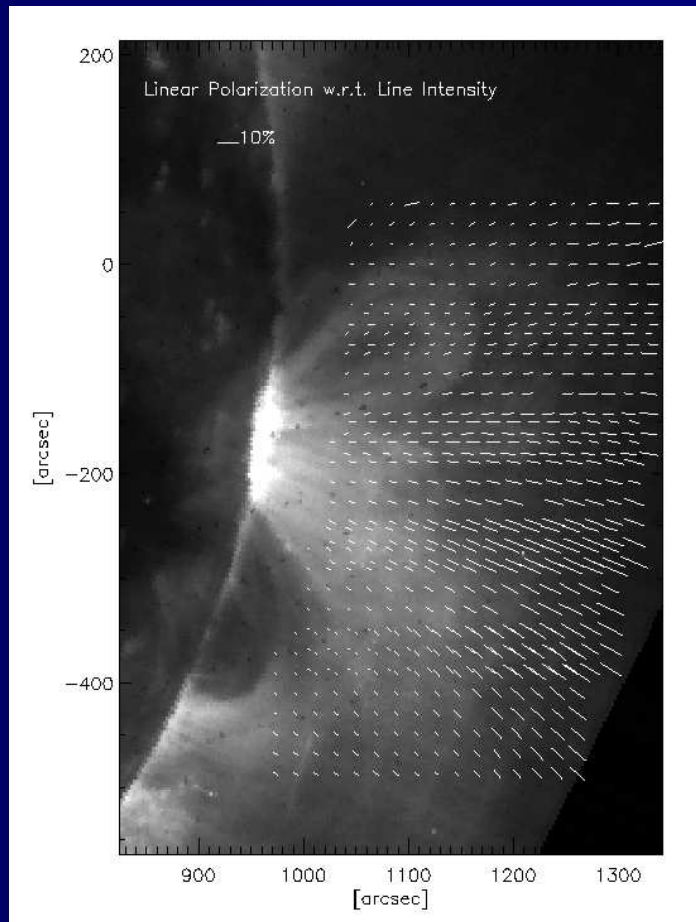
The SOLARC off-axis reflecting coronagraph. Gregorian, off-axis, “scatter free”.

SOLARC coronal data: I, V spectr

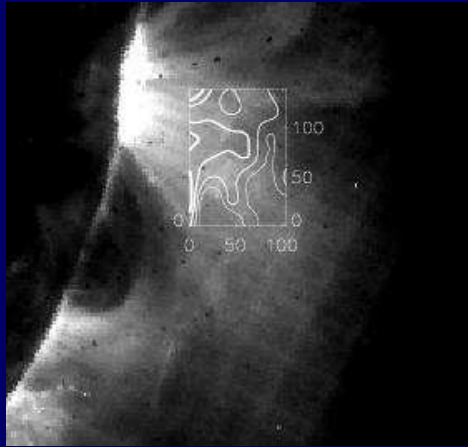


Feed to IR spectrograph. V changes sign at $h \approx 0.17R_{\odot}$: loops.

SOLARC coronal data: azimuth



SOLARC coronal data: B_{LOS}



SOLARC (contours of B_{LOS}), EIT (Intensity at 17.1 nm)

COMP (Tomczyk P.I., HAO)

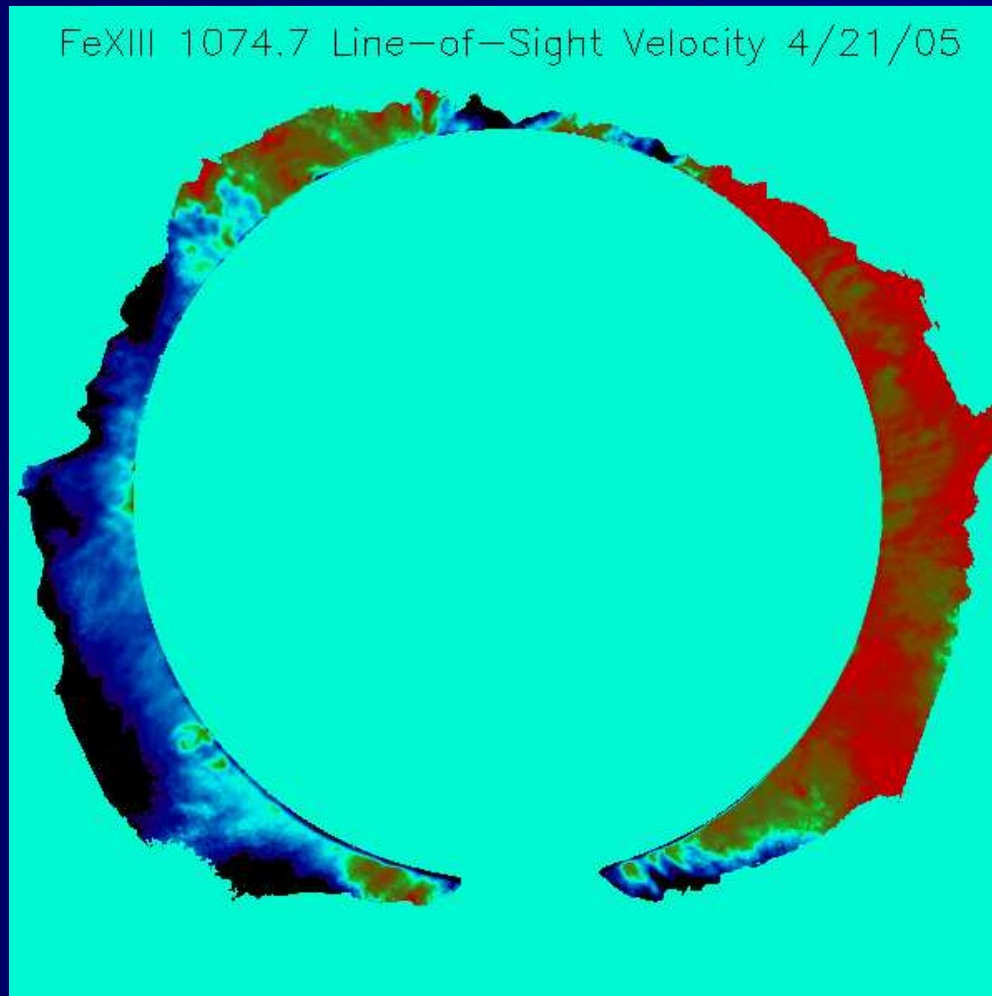


Multi-Channel Polarimeter for Coronal Magnetic Field Measurements.
Lyot filters ($\lambda/\Delta\lambda \approx 10^4$). Implemented at the 20cm “One-Shot” coronagraph on Sacramento Peak.

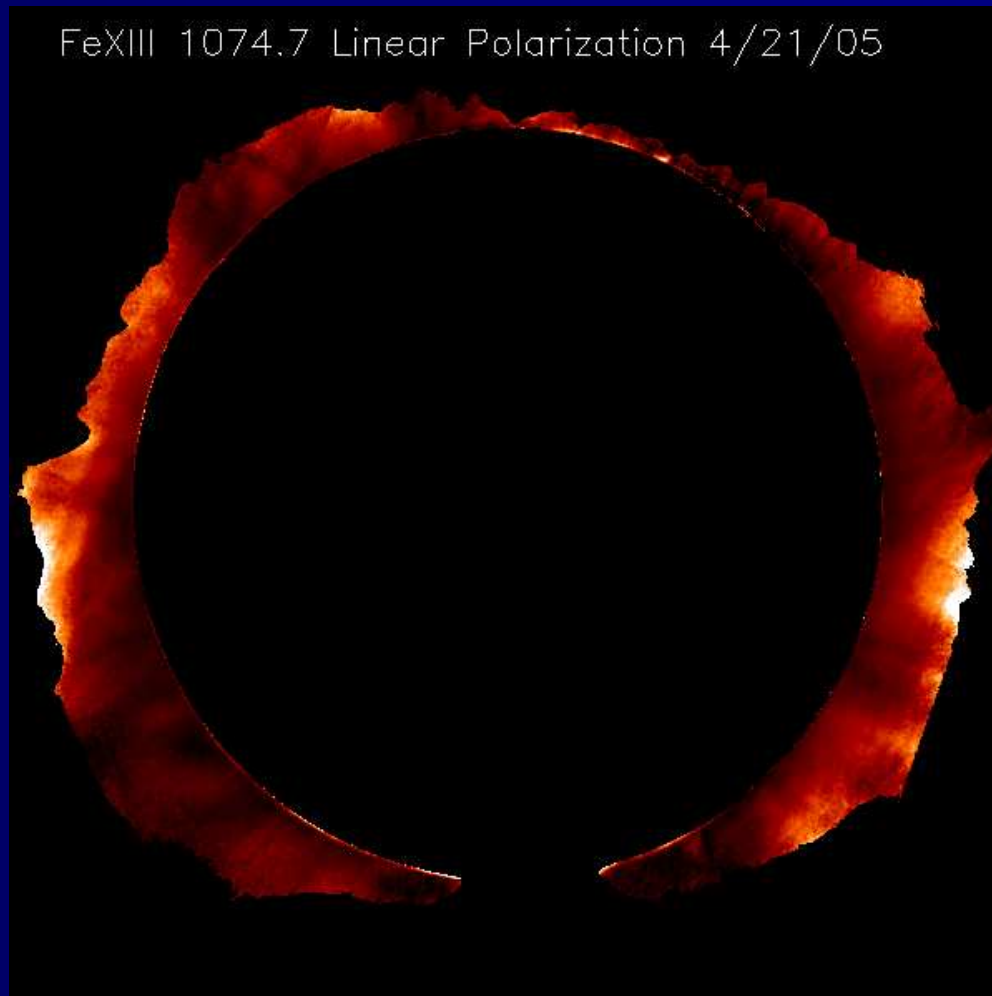
COMP coronal data: I



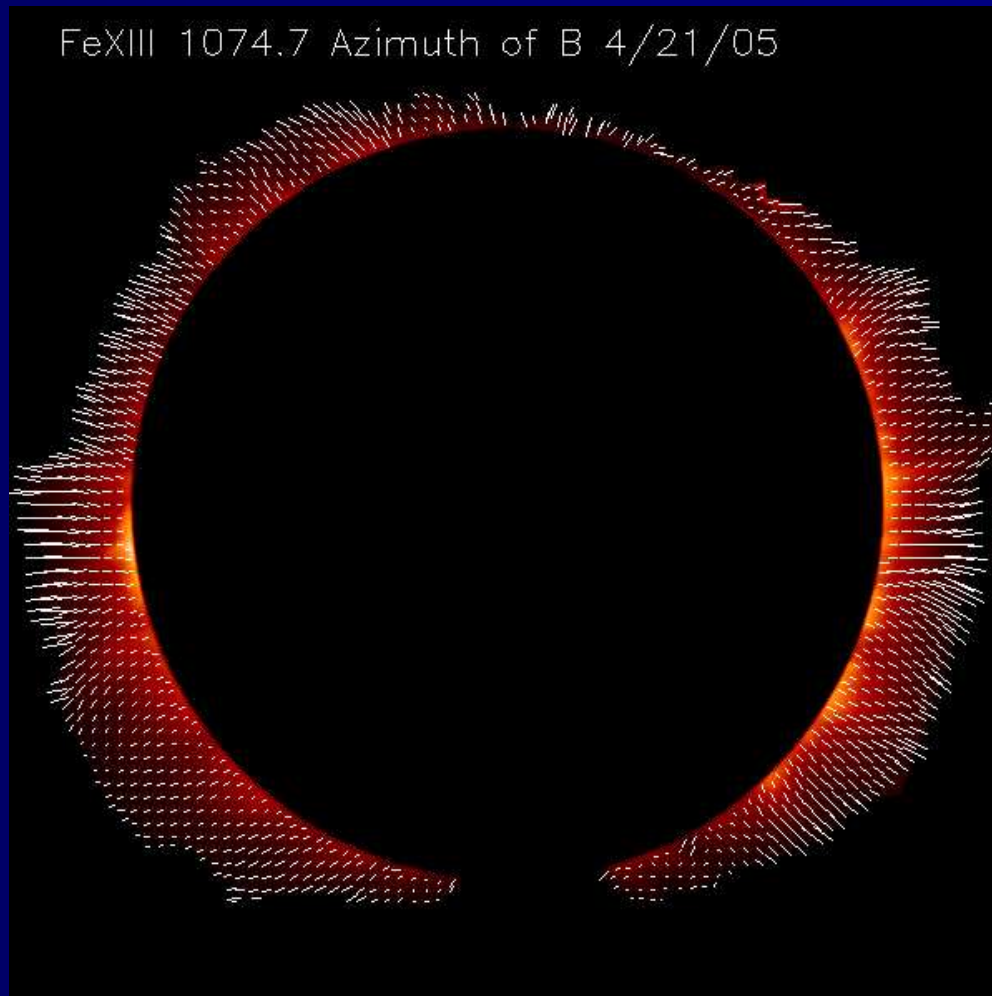
COMP coronal data: Velocity



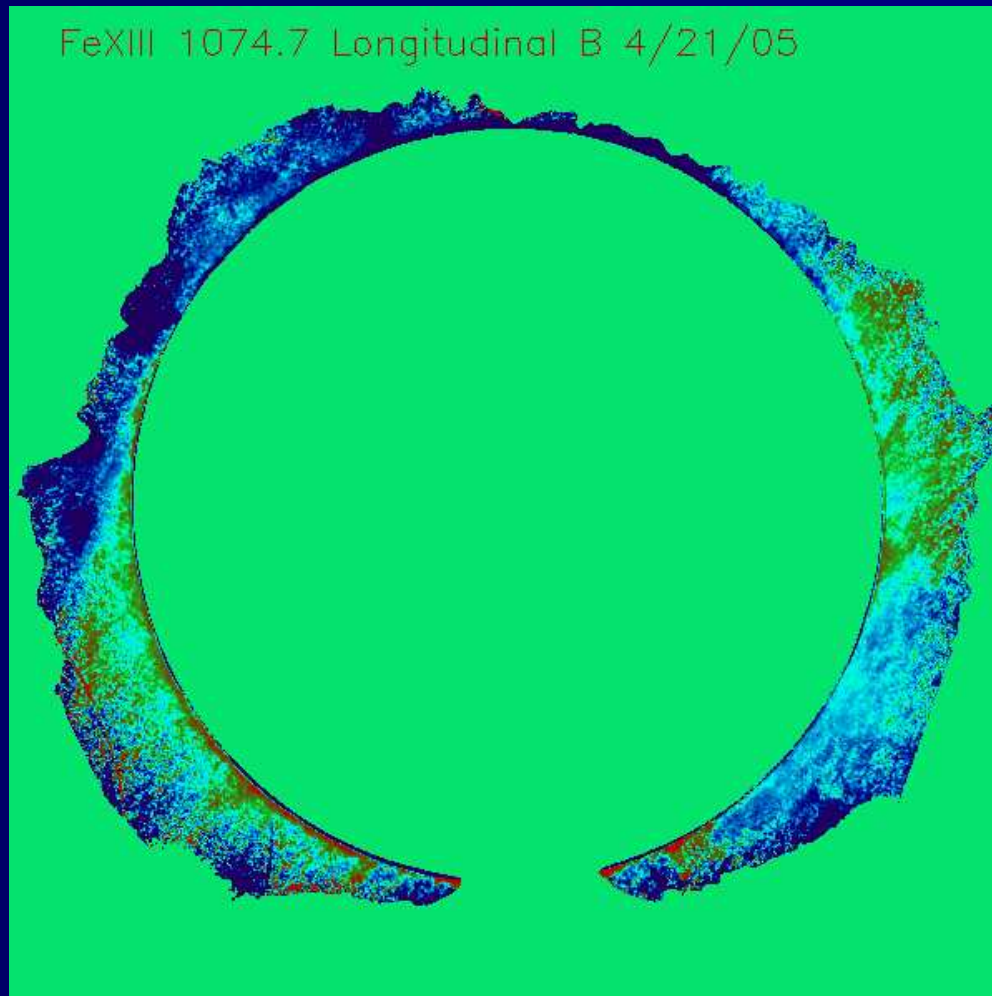
COMP coronal data: P/I



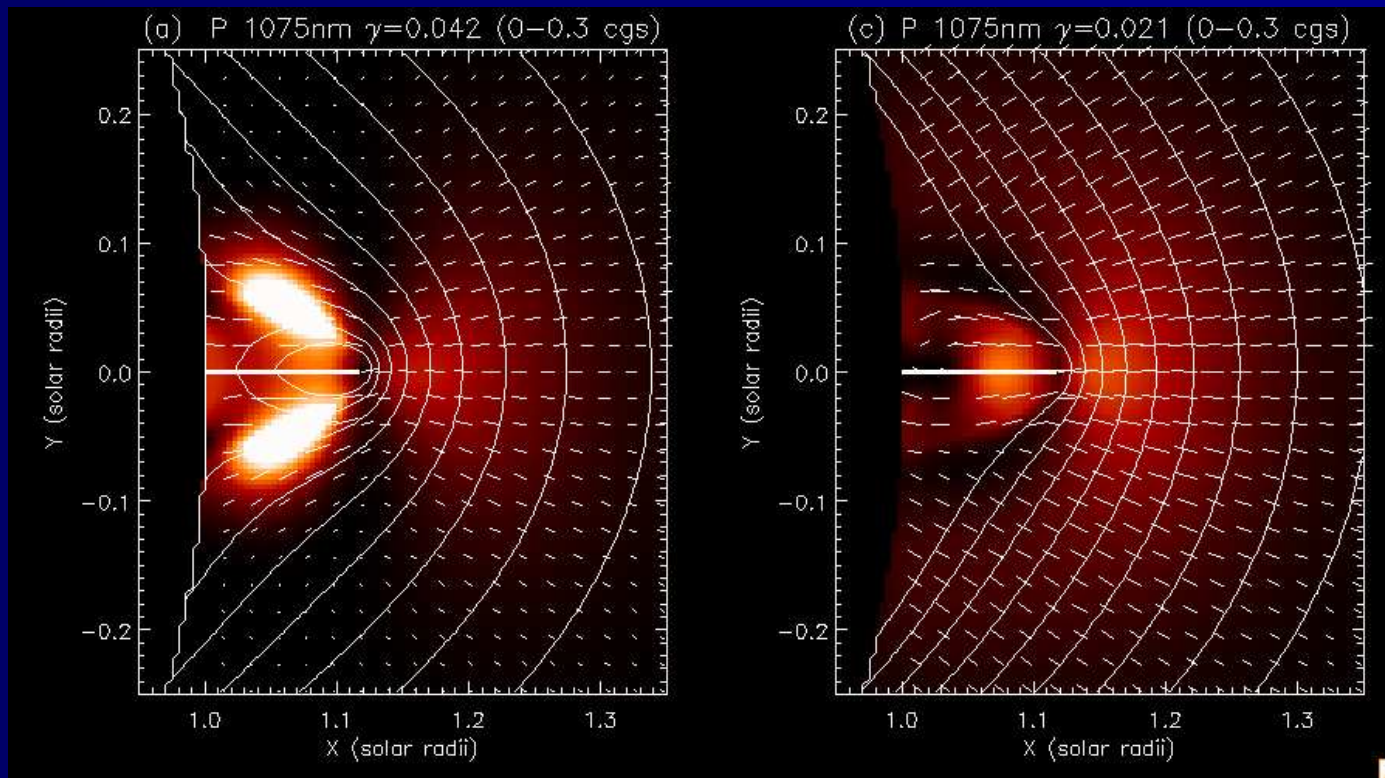
COMP coronal data: azimuth



COMP coronal data: B_{LOS}

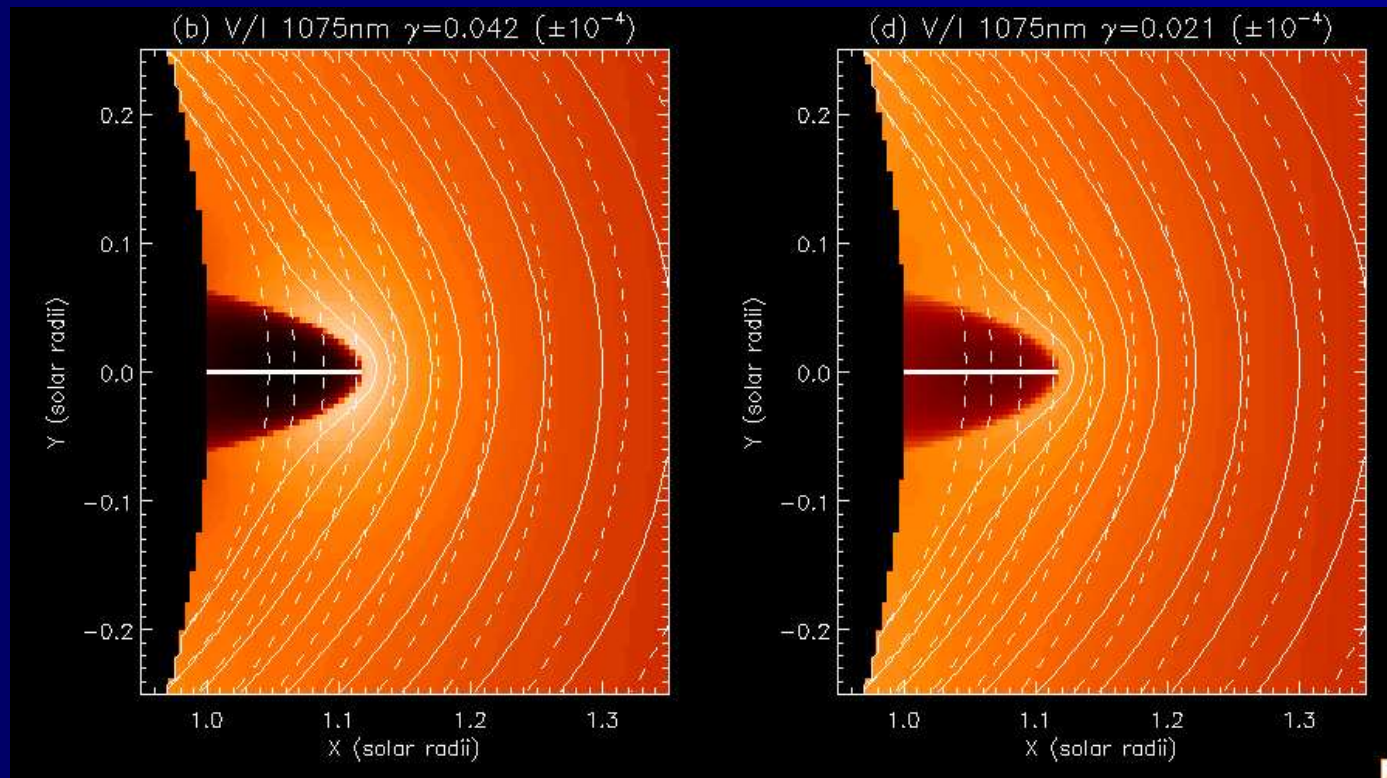


Synthetic linear poln. P



Low, Fong & Fan (2003) analytical current sheet. $\gamma = 0.042$: sufficient energy for opening field and driving CME. $\gamma = 0.021$: insufficient energy.

Synthetic circ. poln. $\text{abs}(V)/I$



Low, Fong & Fan (2003) analytical current sheet. $\gamma = 0.042$: sufficient energy for opening field and driving CME. $\gamma = 0.021$: insufficient energy.

Summary

- SOLARC spectra show definitive measurements of V : B_{LOS} (this is the **really difficult** measurement)
- COMP filter-based technique shows definitive measurements, is very efficient. Stokes V is being verified
- Synthetic data: COMP-like measurements can distinguish magnetic structures of real physical interest
- \Rightarrow the time is ripe for a concerted effort.

COSMO

- “COronal Solar Magnetic Observatory”
- a new \$20M project with Kuhn, Lin (U. Hawaii), Zurbuchen (U. Michigan)
- 1m-class coronagraph, great site
- coronal and prominence magnetic field sensors
- update of existing Mauna Loa facilities

COSMO status

- white paper draft sent to collaborators (7 Feb 2007)
- will be widely distributed to the community
- need science advisory team
- Engineer to be hired soon devoted to COSMO
- proposal to MRI funding agency early 2007?

In preparation

- COMP instrument paper (Tomczyk)
- COMP initial results paper (Tomczyk)
- Synthetic magnetic signatures of current sheets (Judge, Low, Casini)
- ...