

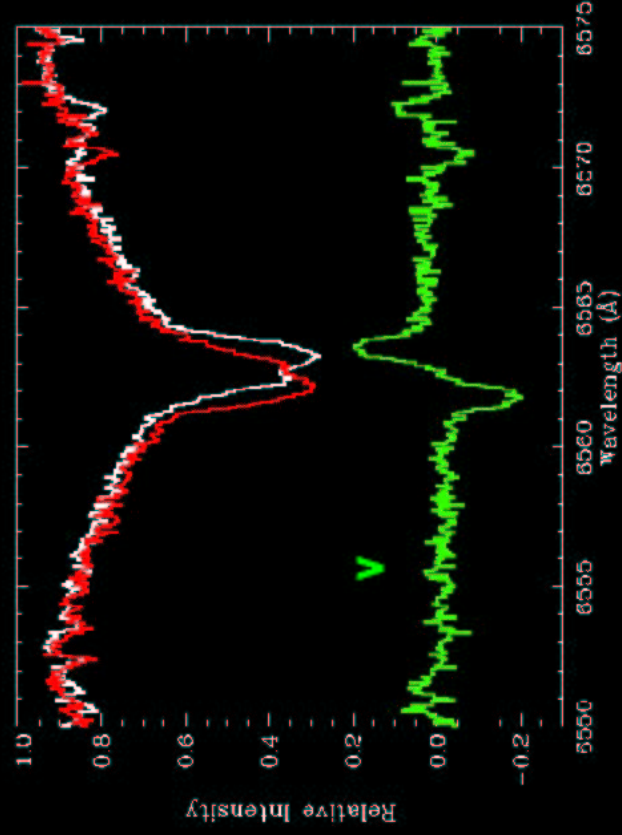
Stellar Magnetic Field Measurements

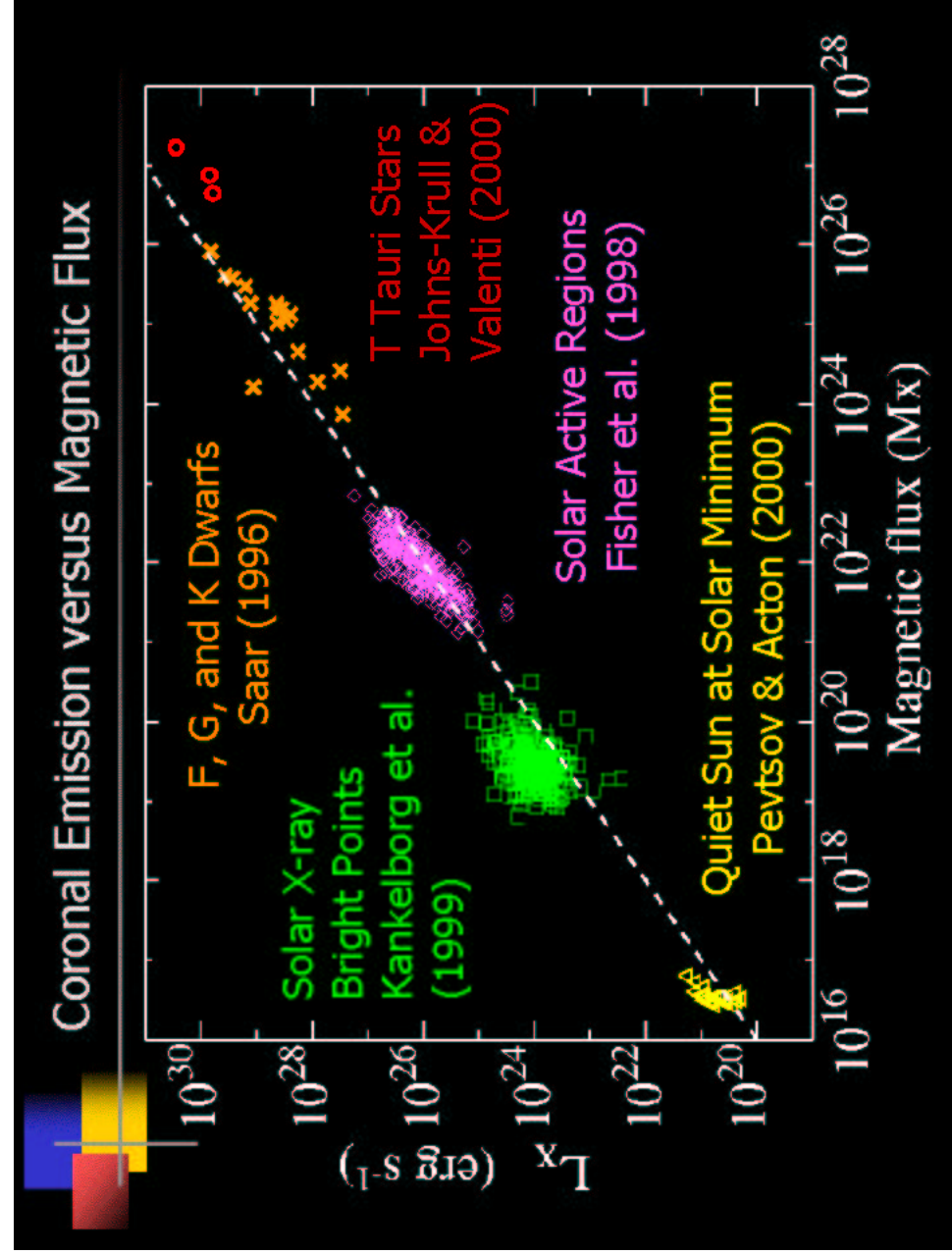
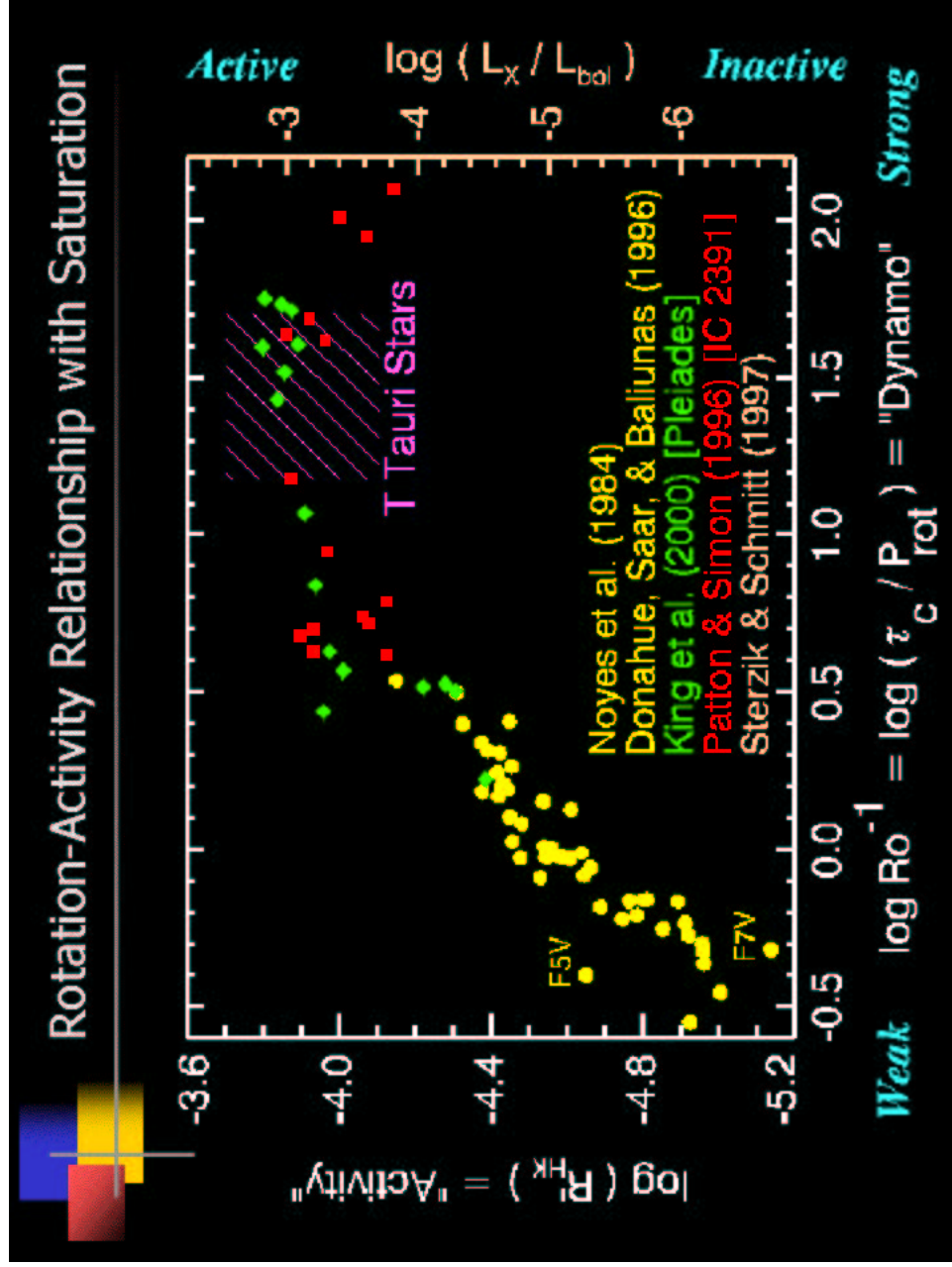
Christopher M. Johns-Krull
(Rice University)

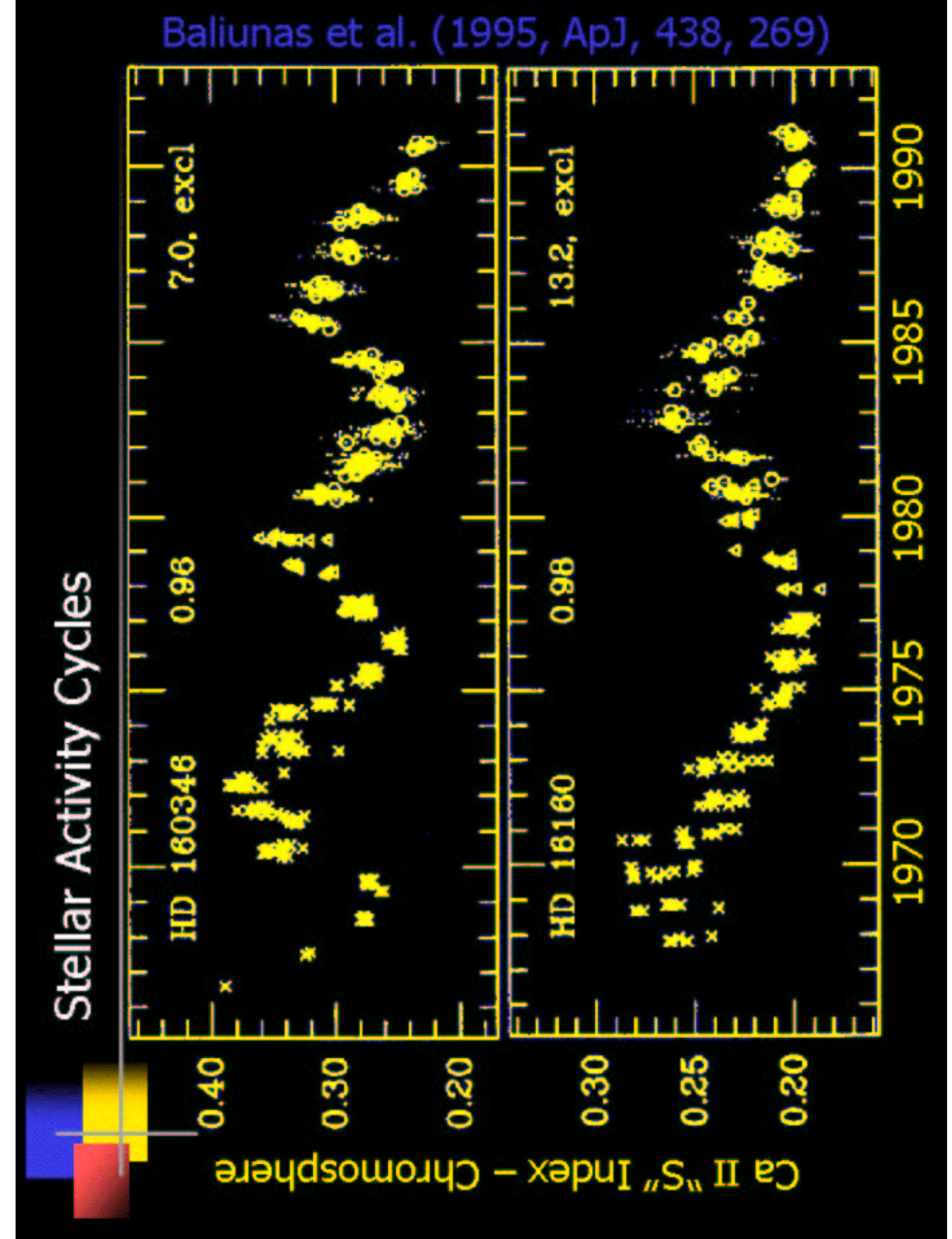
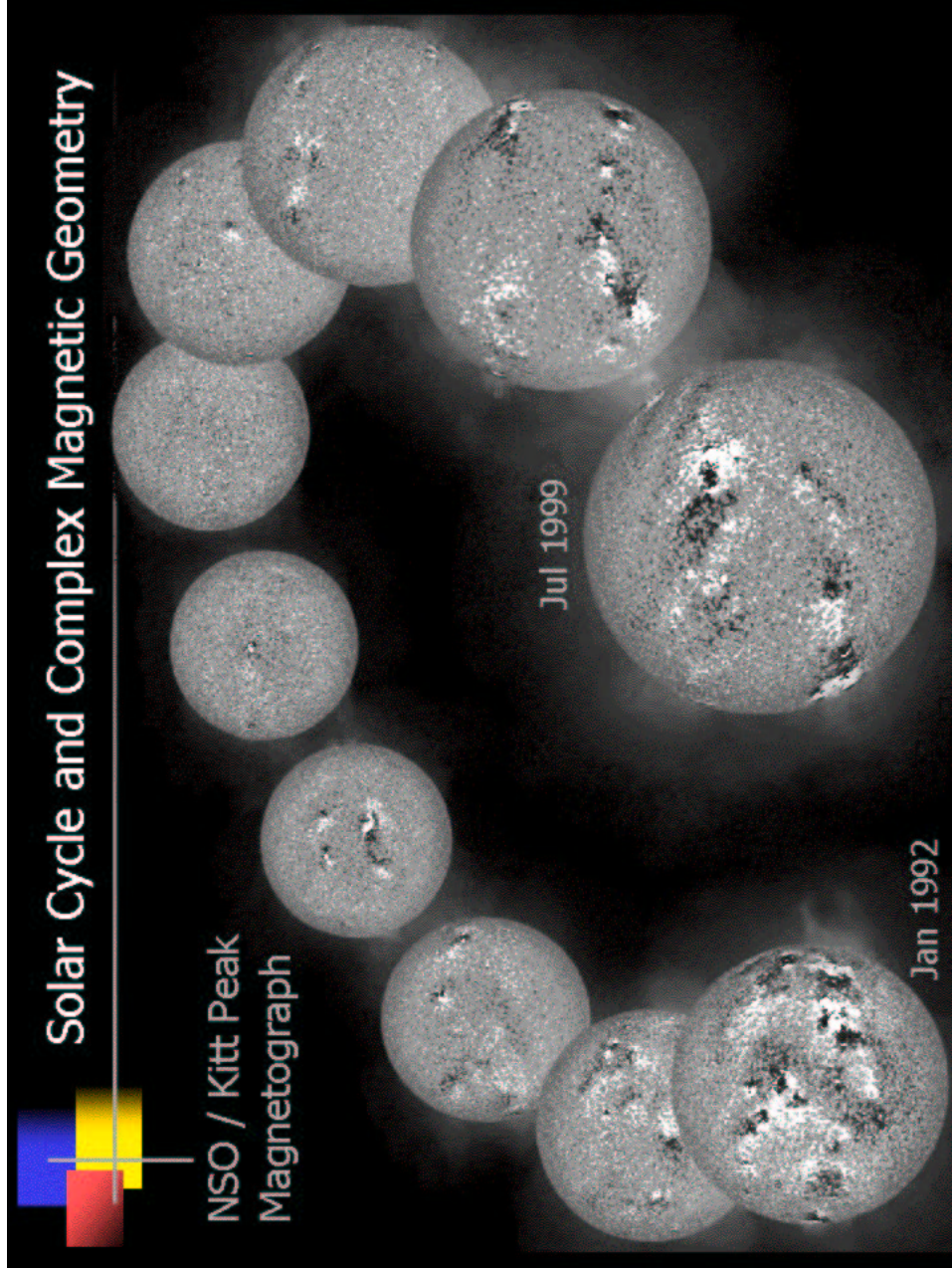
January 16, 2002

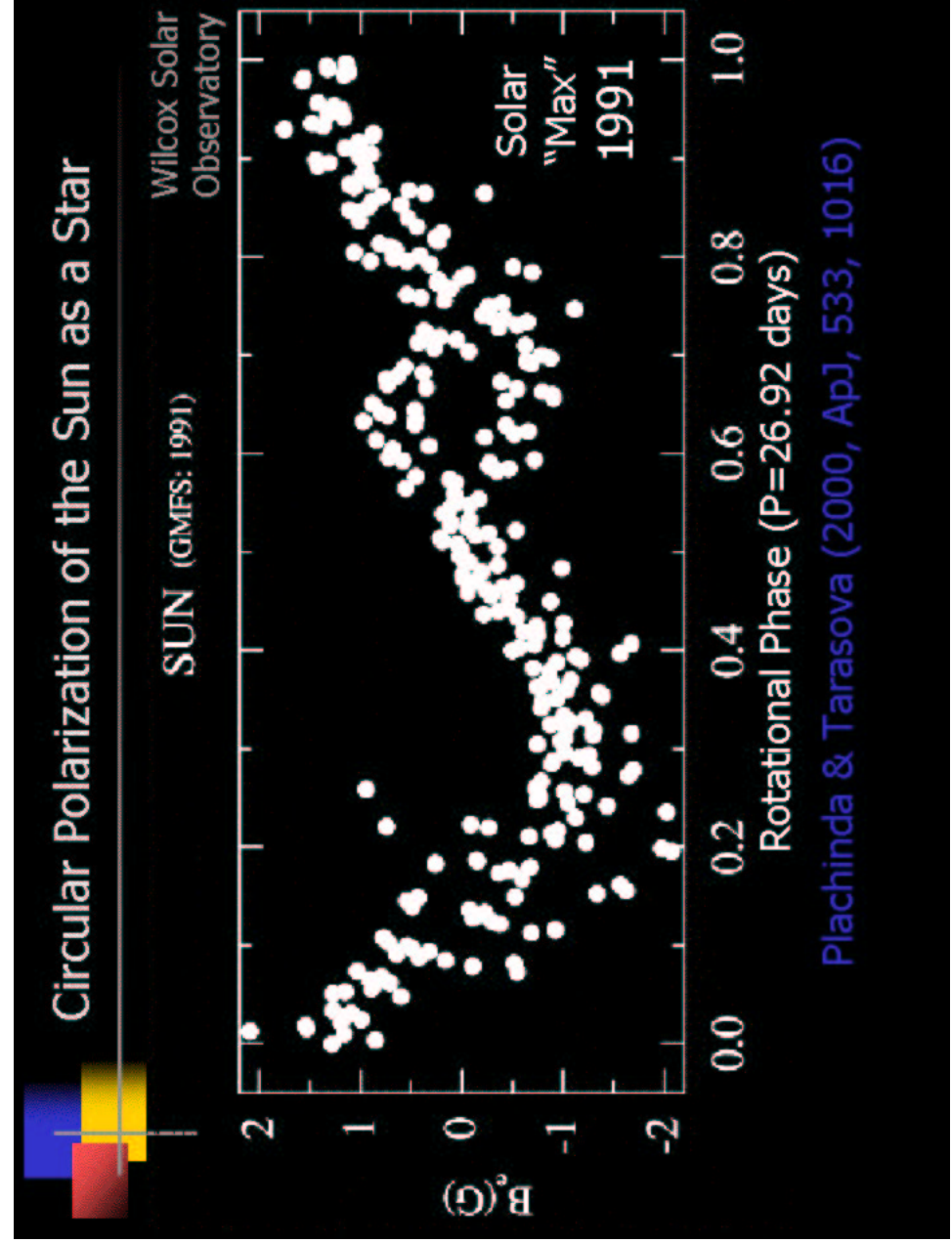
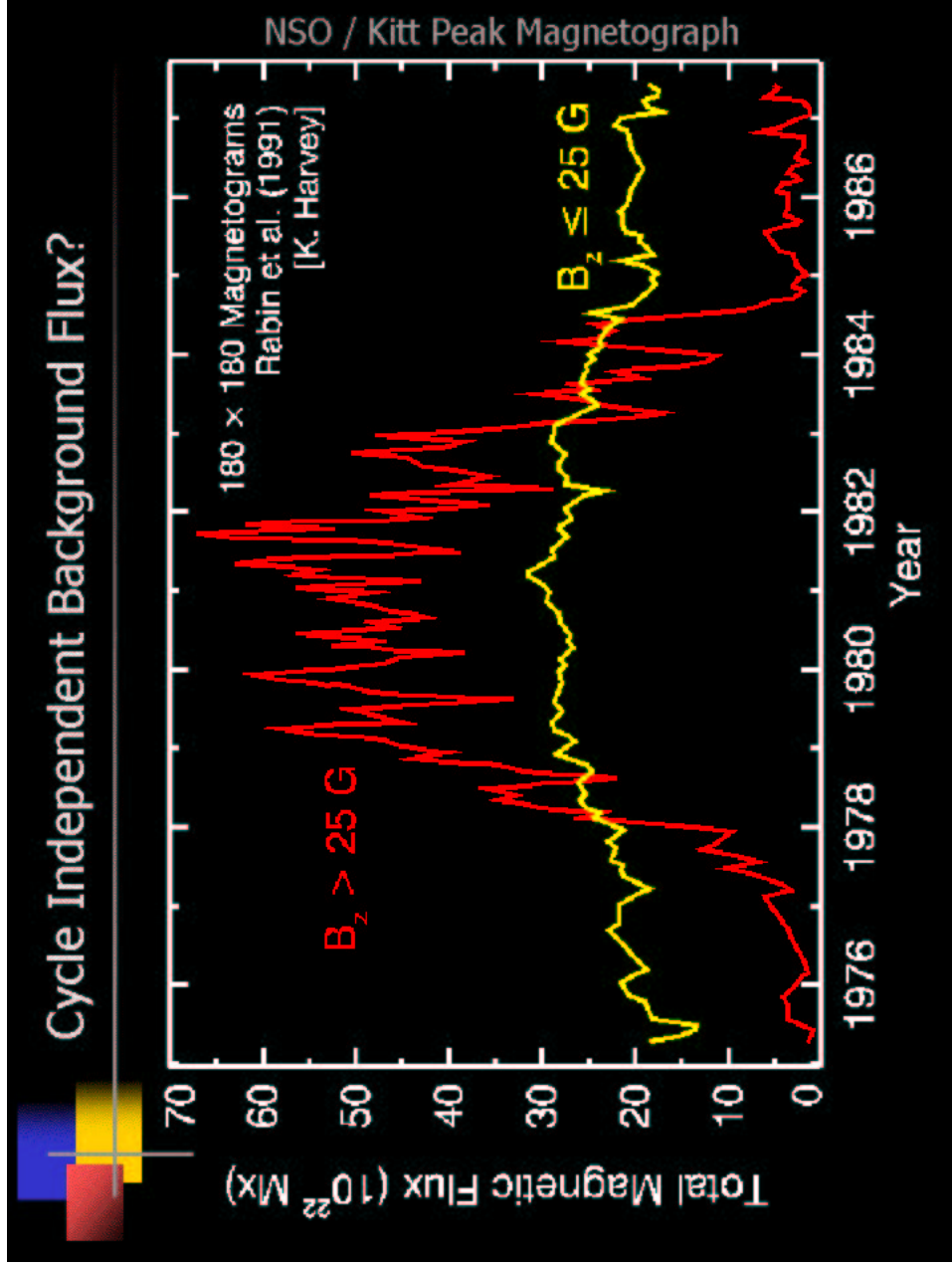
Ap Stars: Core Dynamo or Primordial Fields?

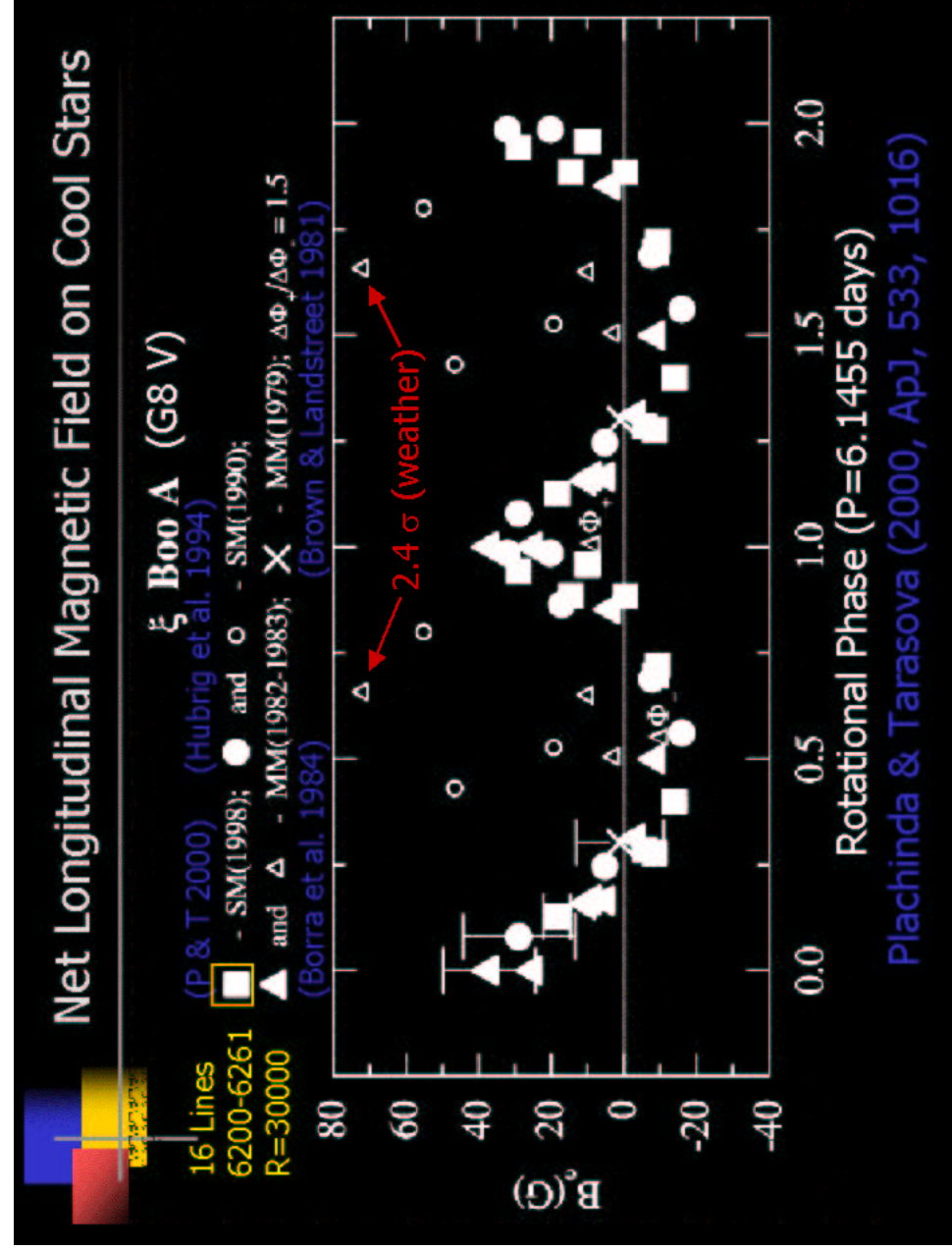
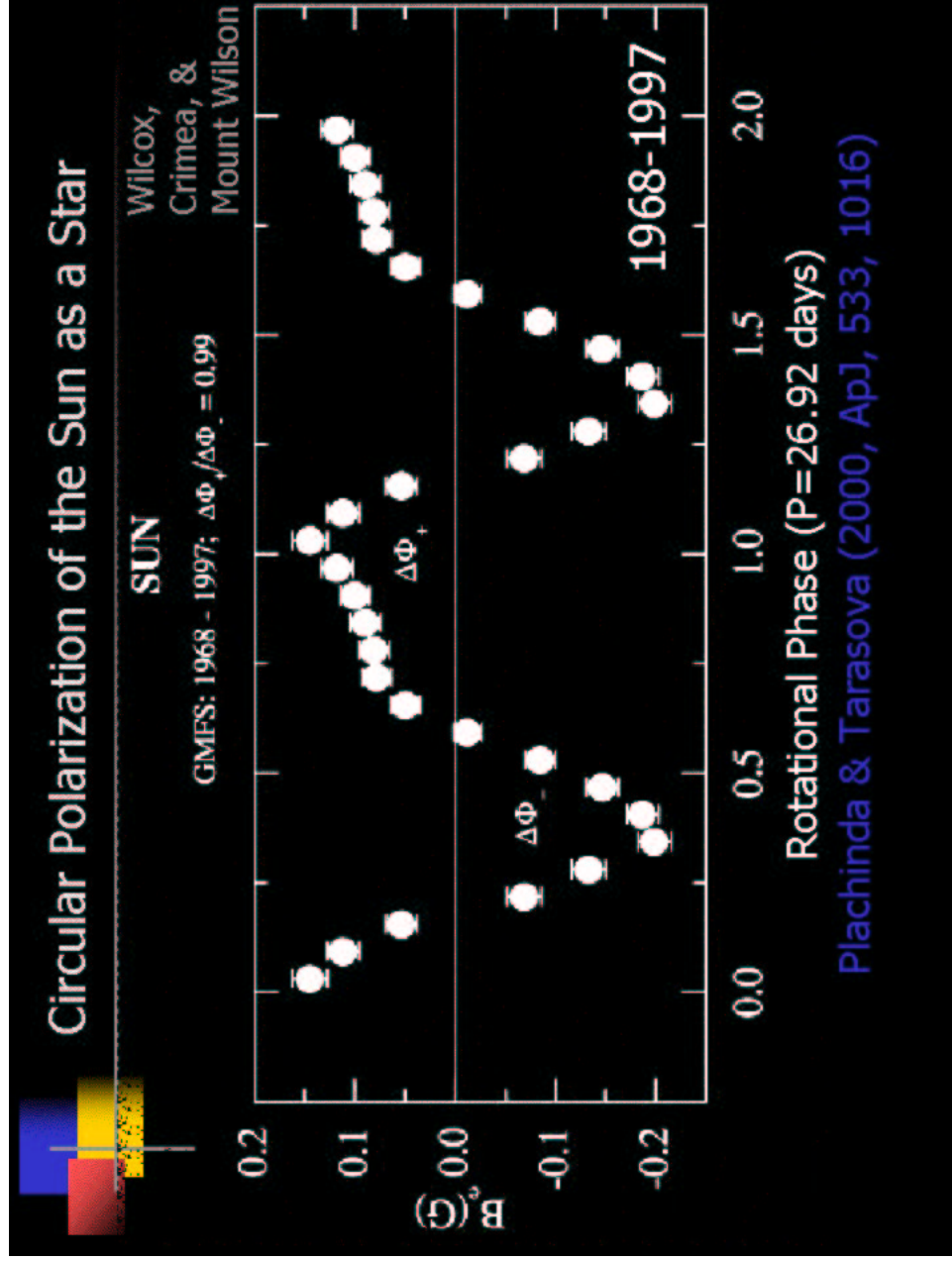
Babcock's Star - $H\alpha$: 34 kG Dipole-Like Field

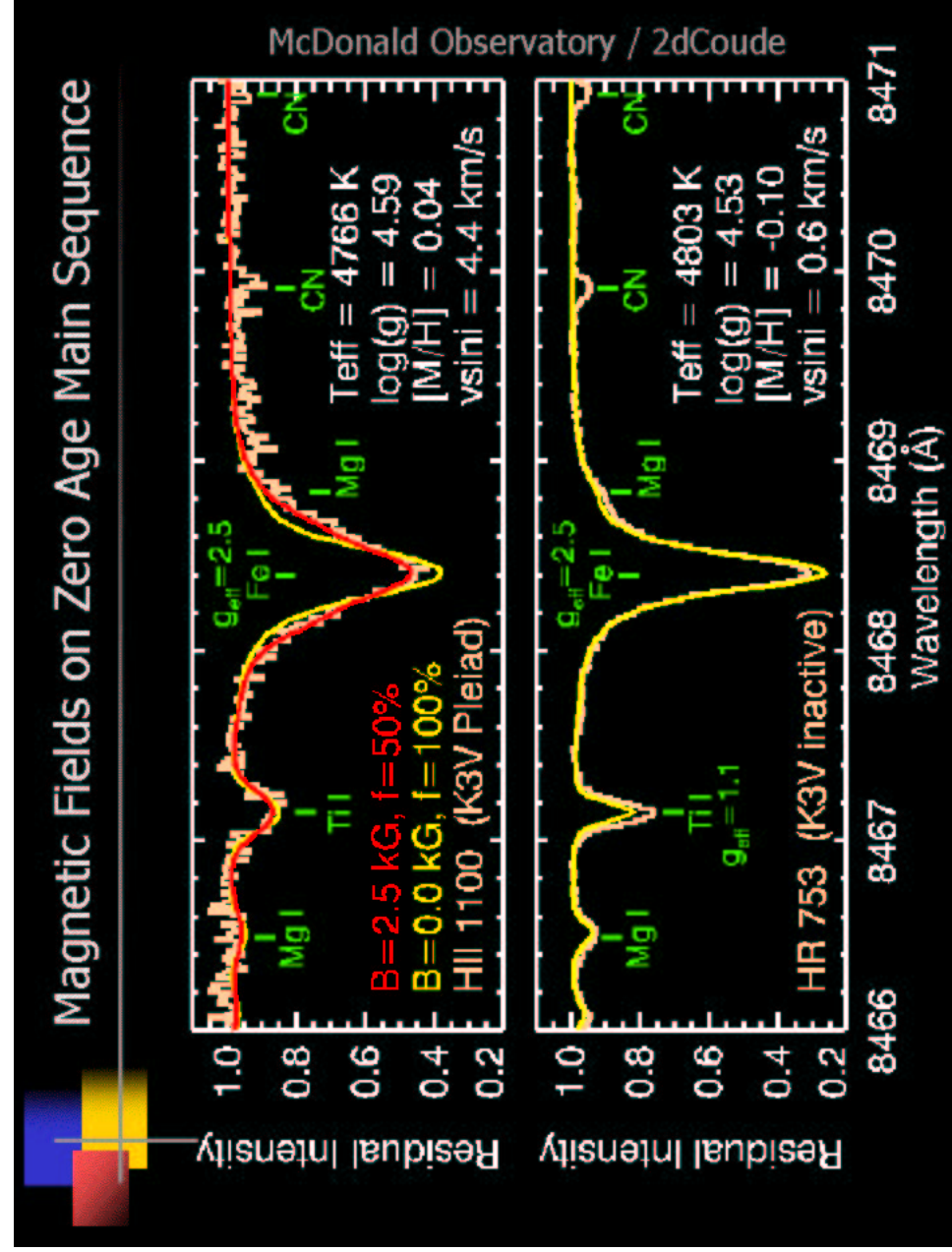
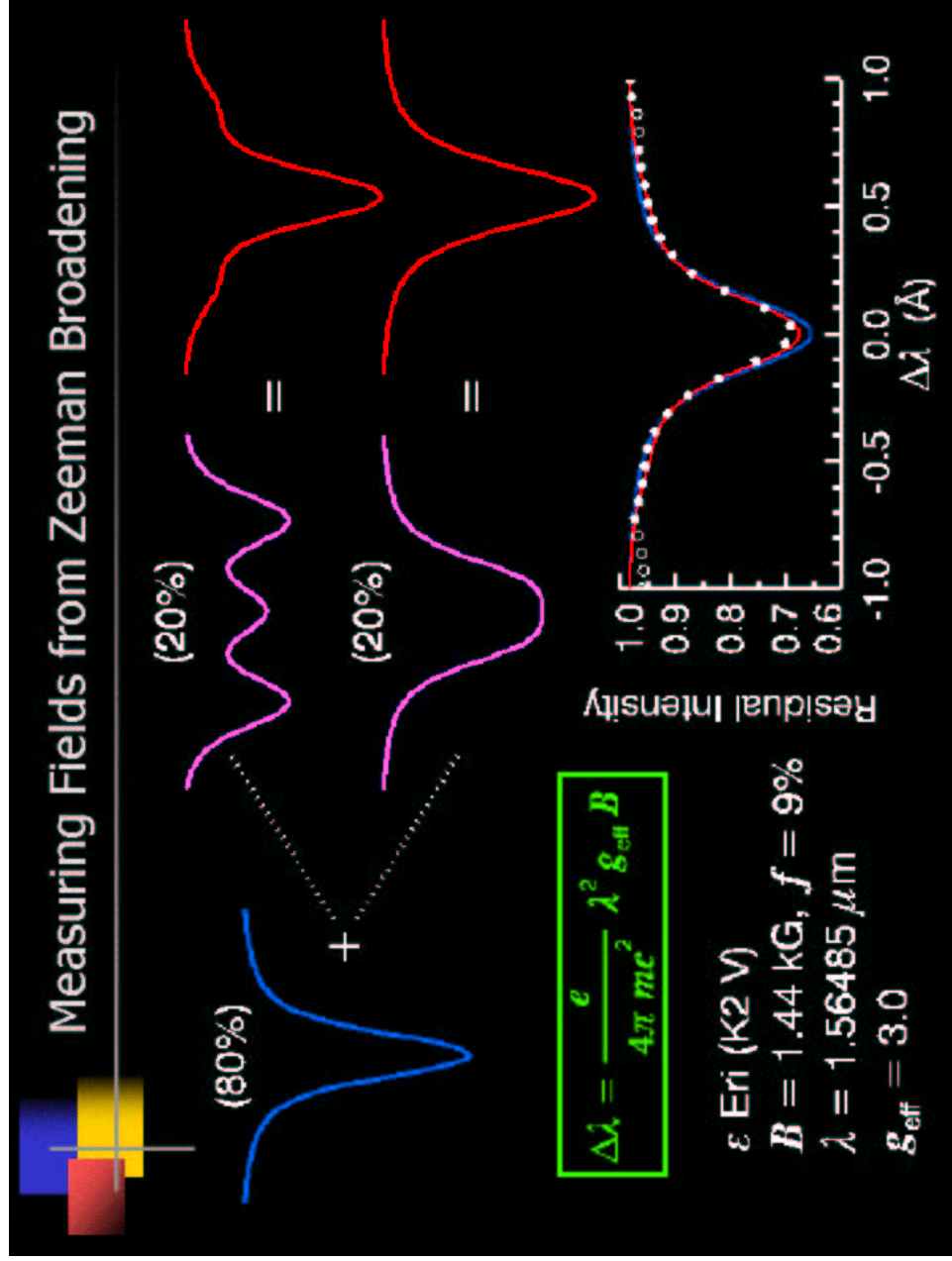


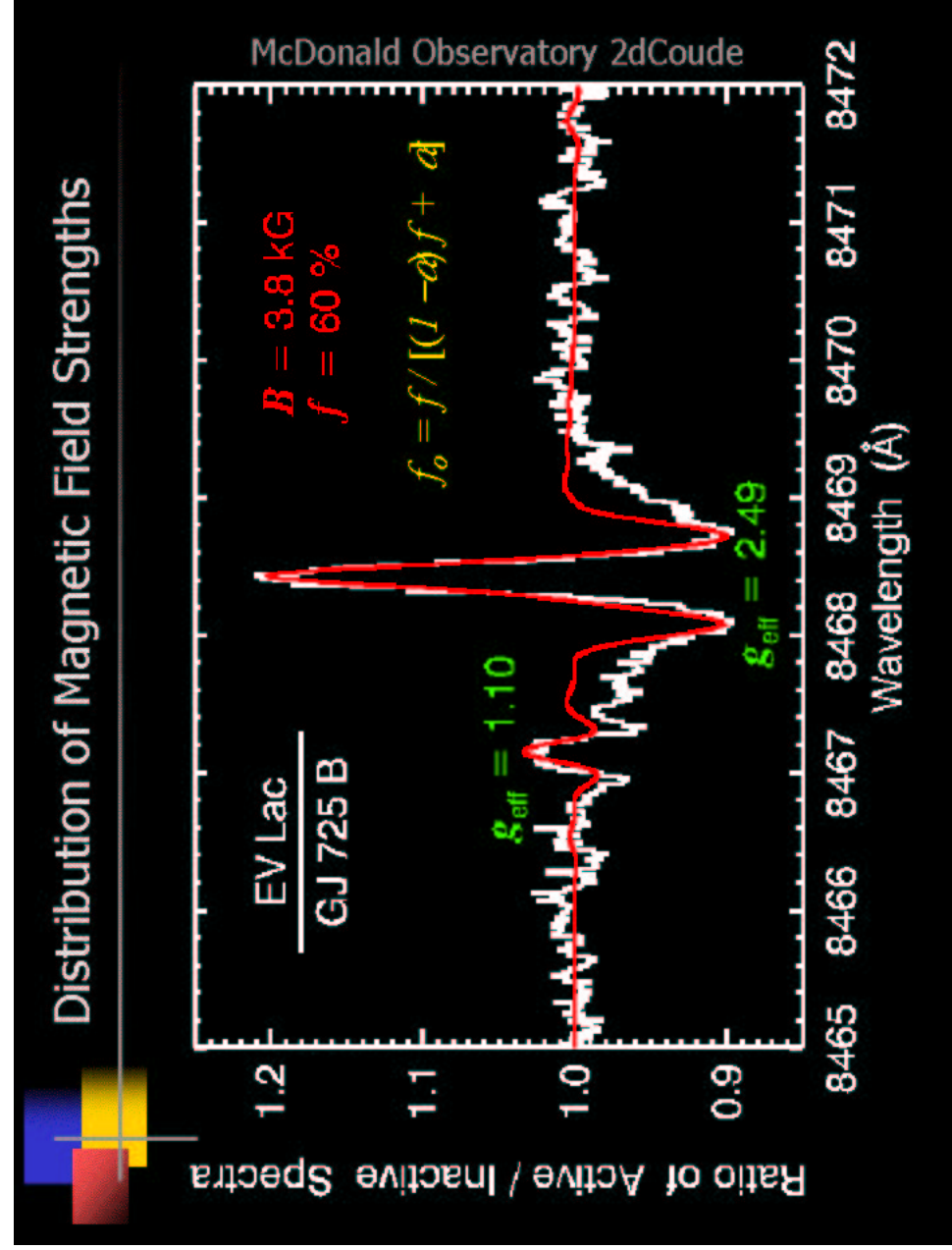
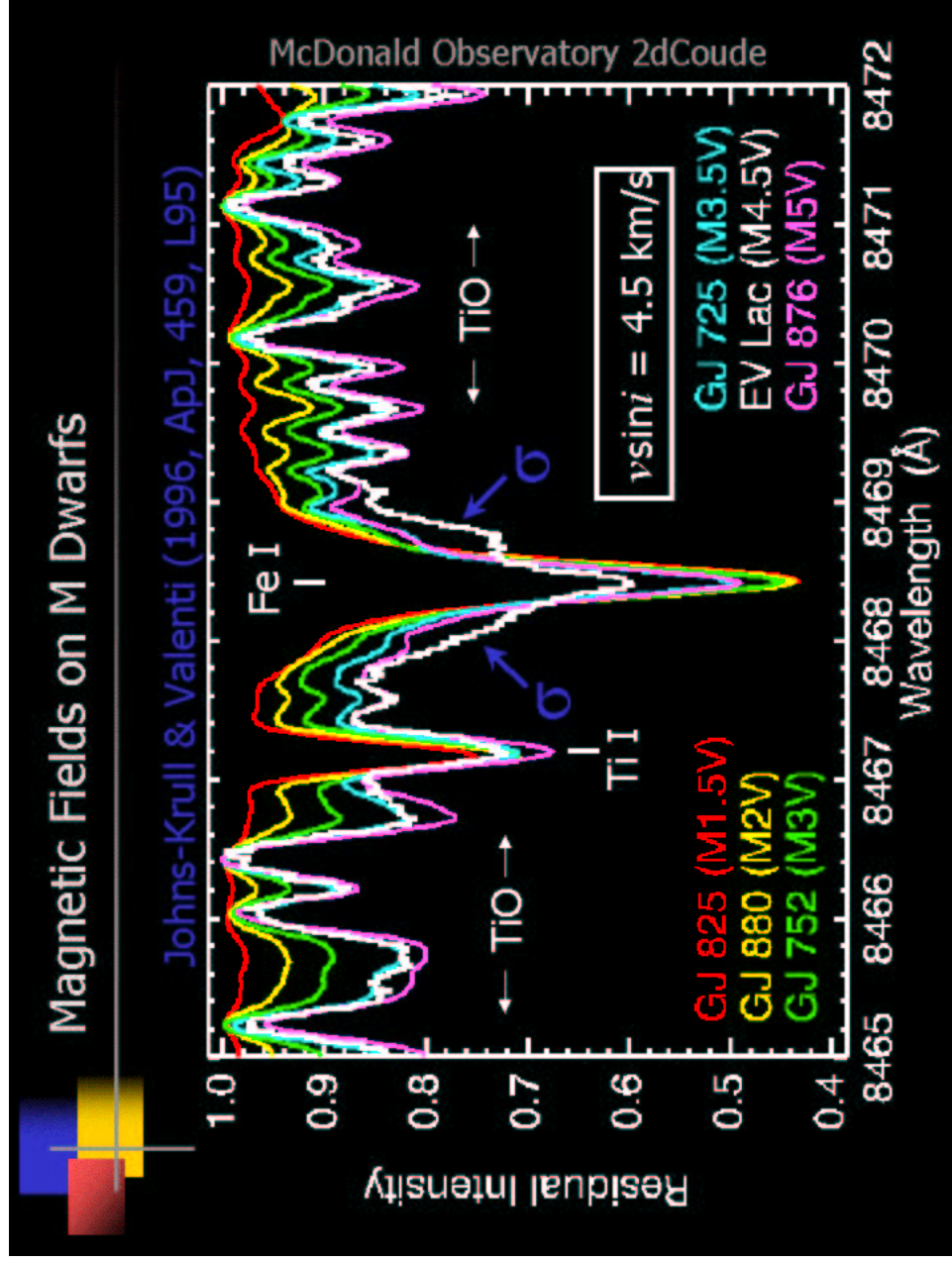








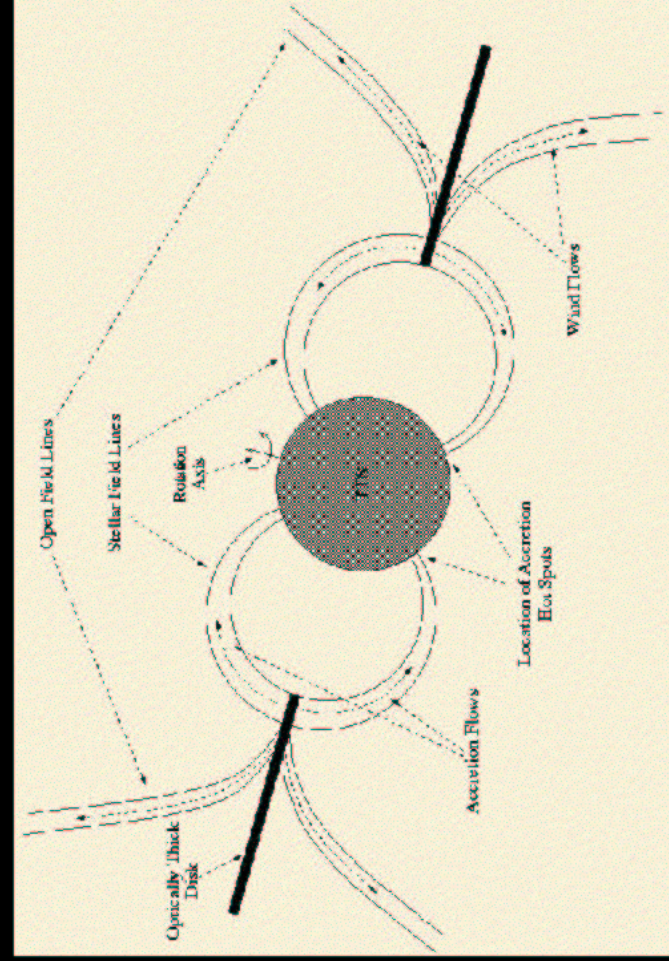


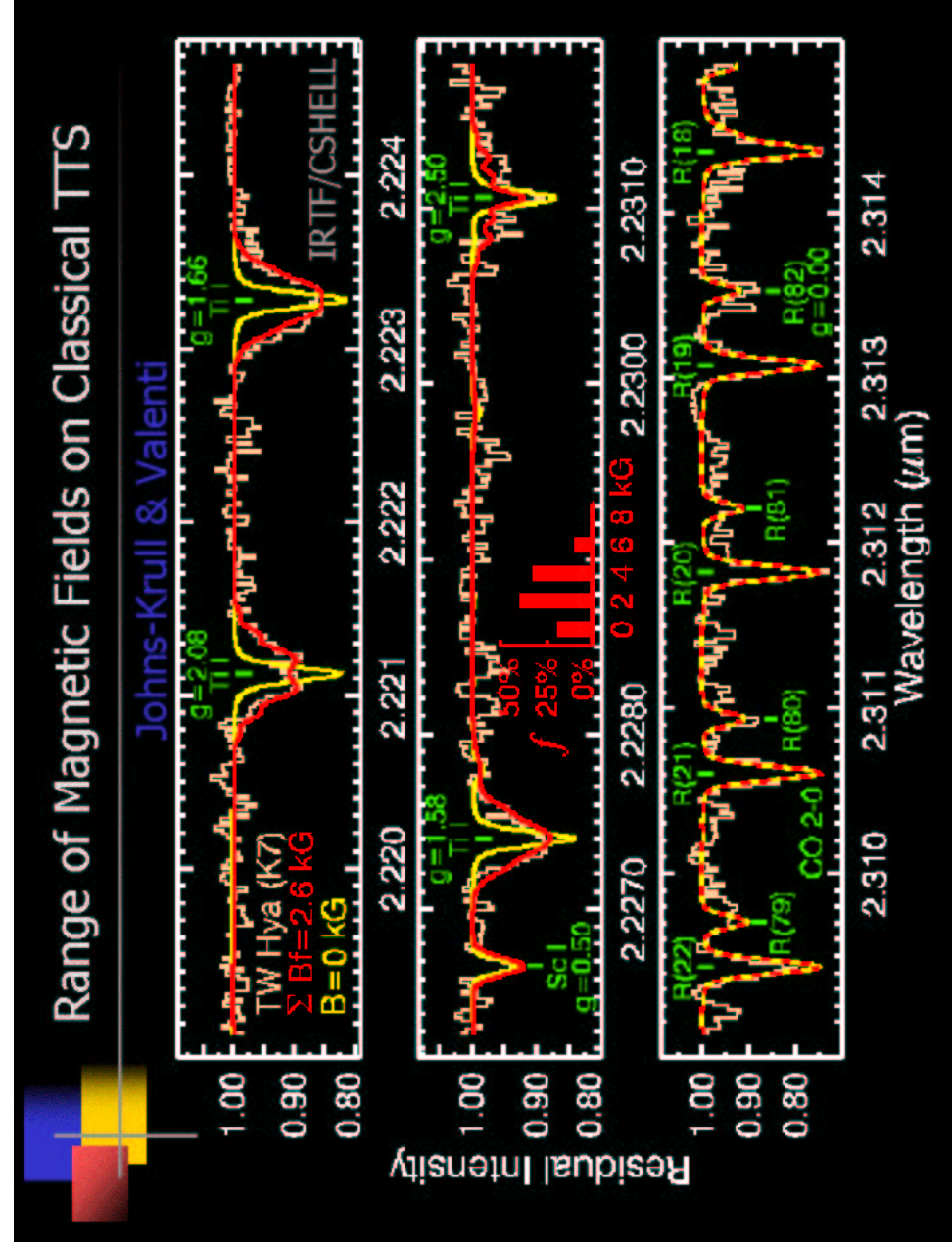
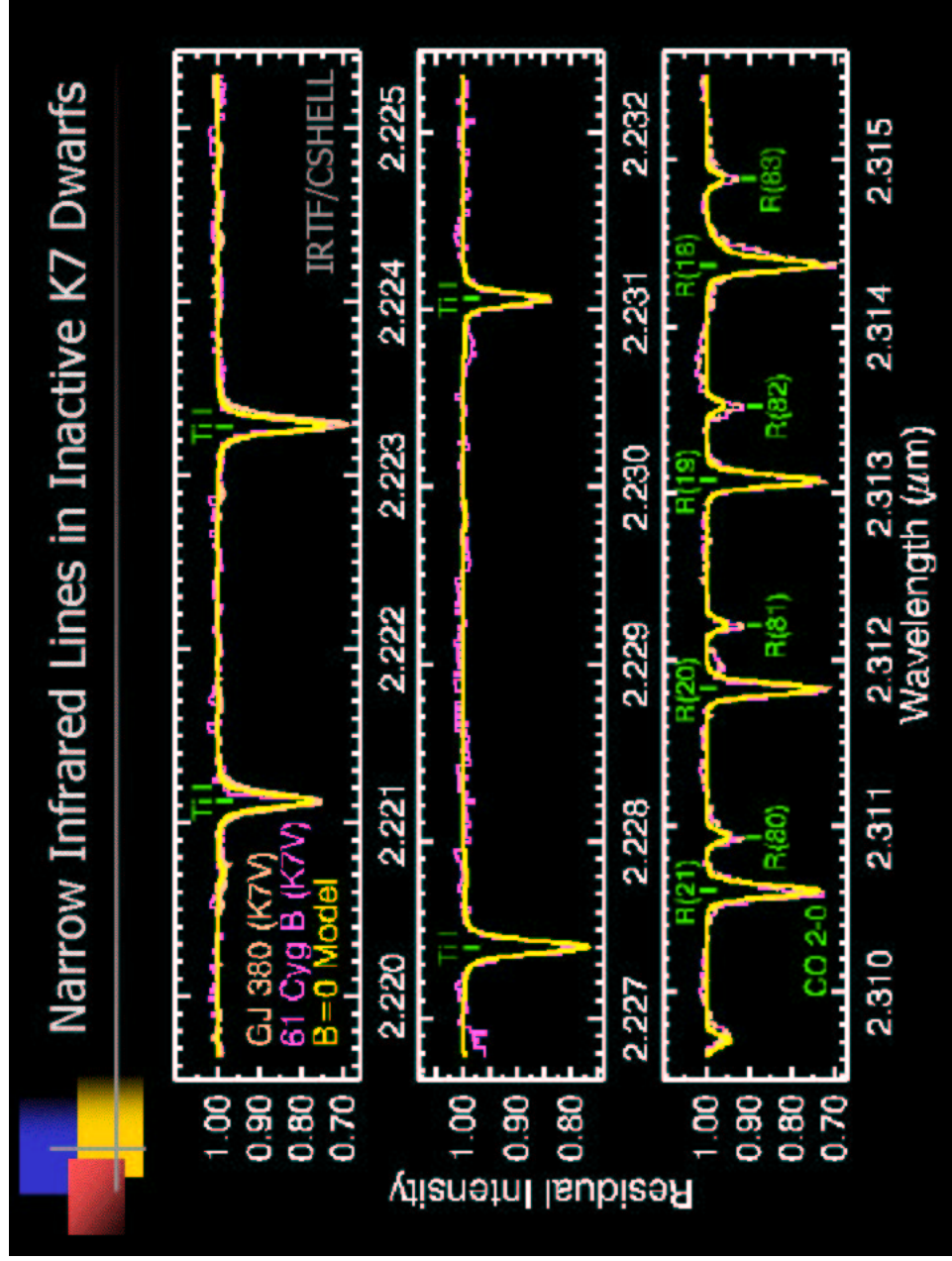


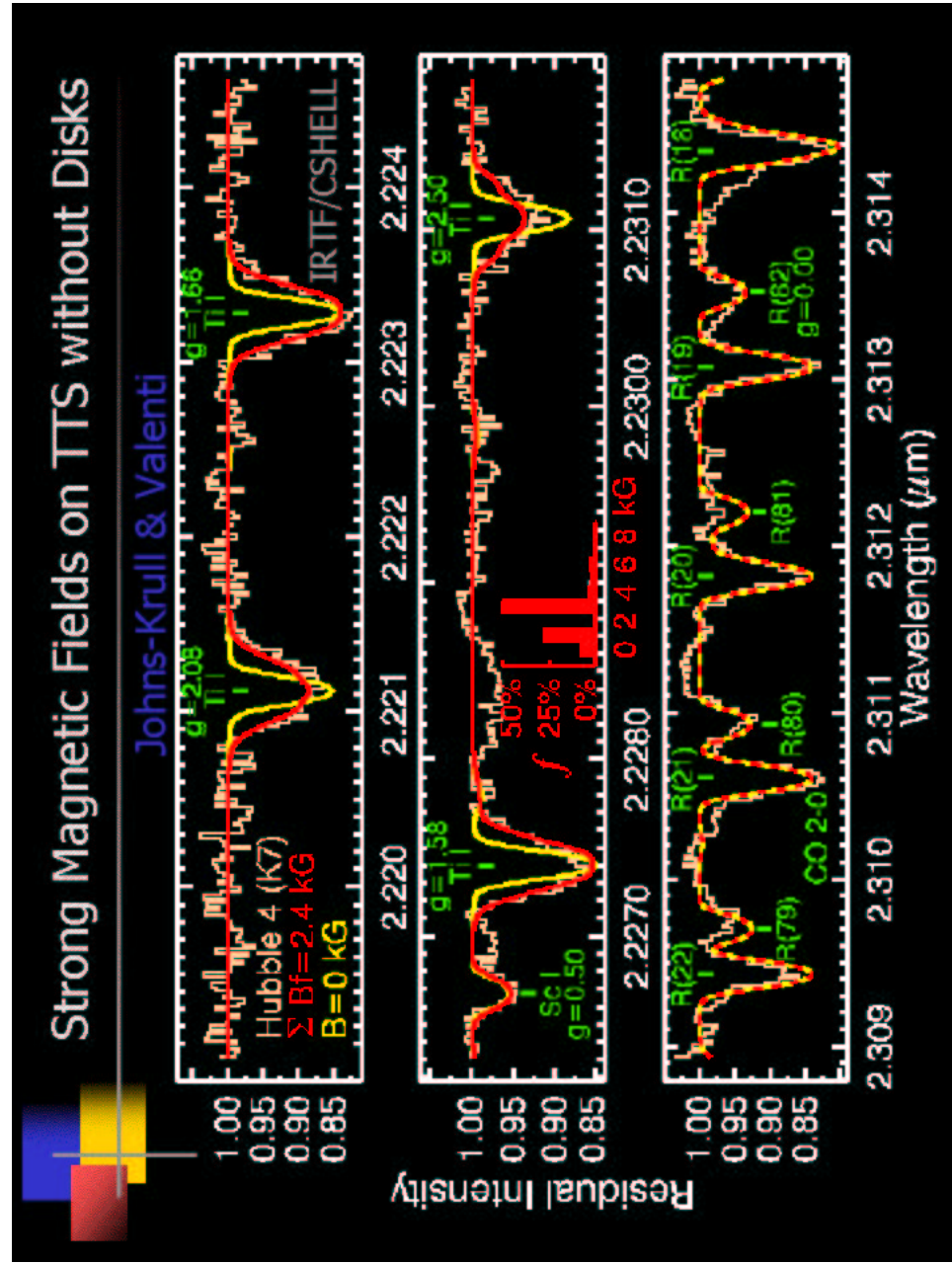
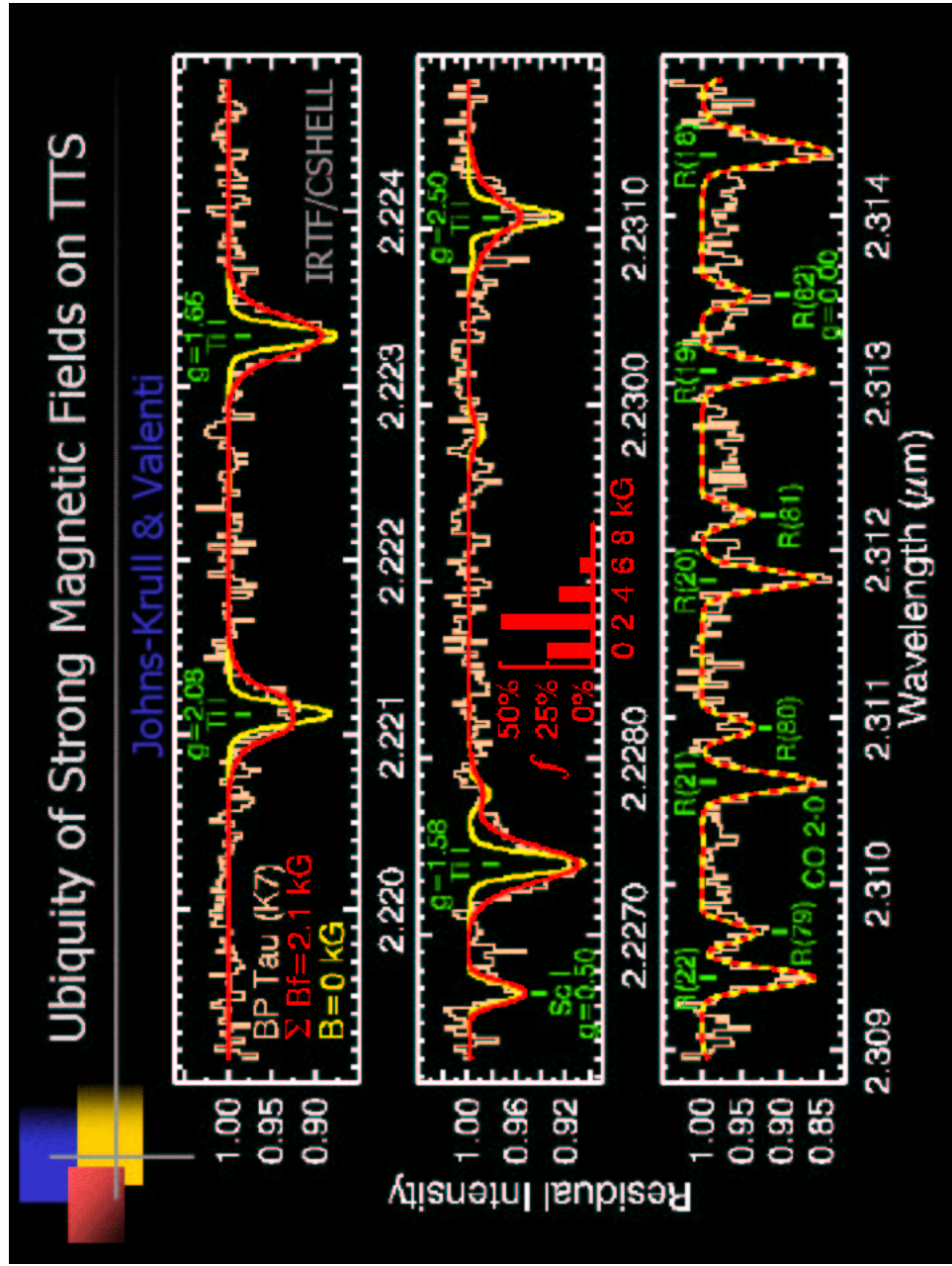
Lessons From M Dwarfs

- **Very strong (greater than convective collapse – Rajaguru et al. 2002) fields covering nearly the entire surface on fully convective stars**
- **Rotational dependence: yes and no**
- **No long term behavior, yet**

T Tauri Stars

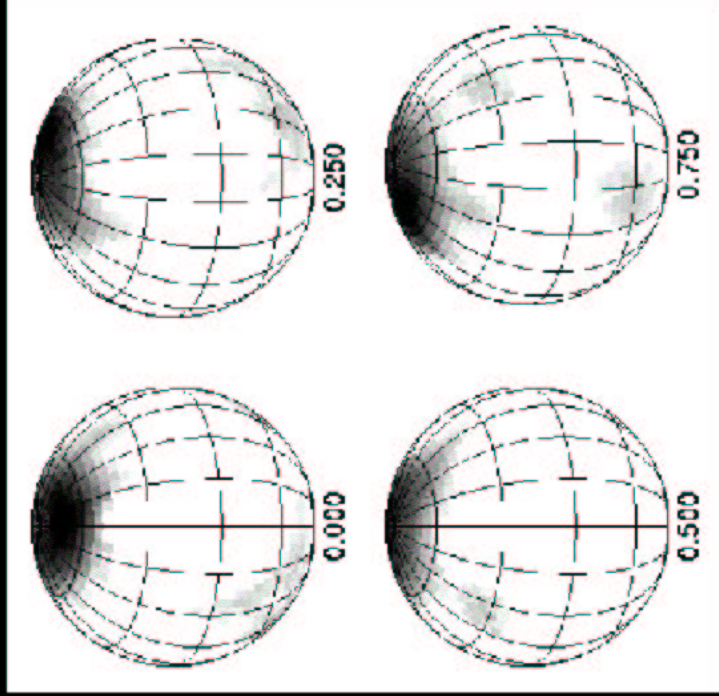




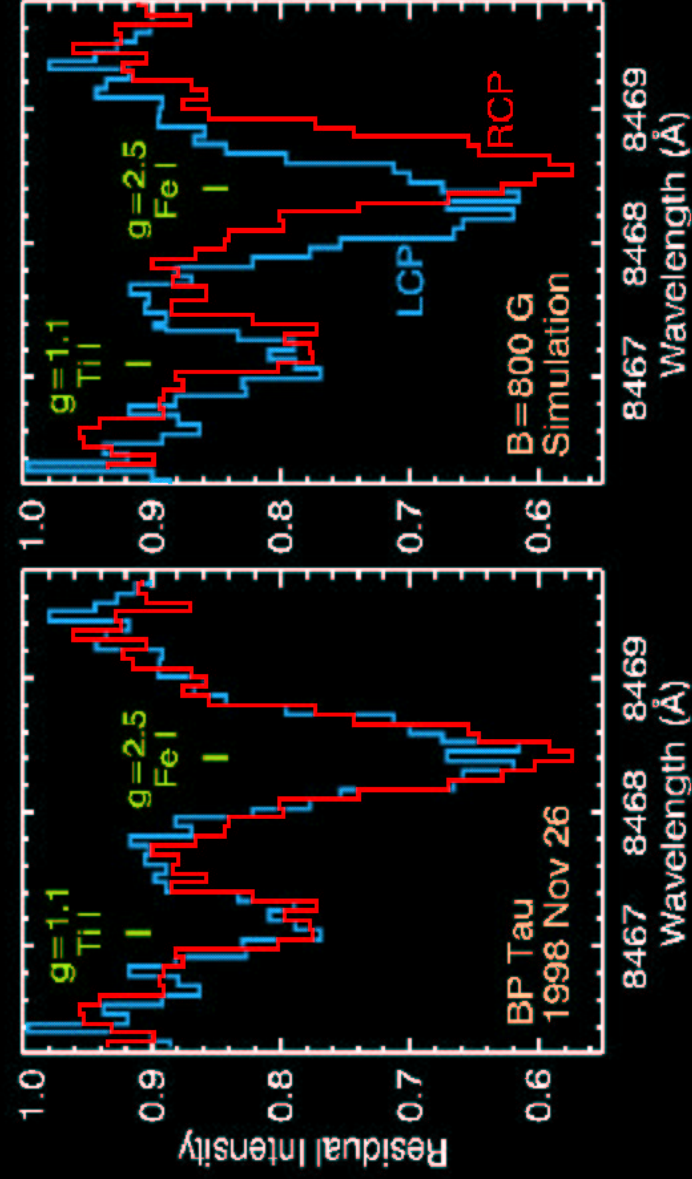


Spot Fields?

Johns-Krull & Hatzes (1997): Sz 68



Spot Fields?



Least-Squares Deconvolution of Stokes V

- References:
 - Donati, Semel, Carter, Rees, & Cameron (1997, MNRAS)
 - Donati & Collier Cameron (1997, MNRAS)
 - Donati, Collier Cameron, Hussain, & Semel (1999, MNRAS)

Universal Profile Shape

- Technique:
 - Find least-squares solution of: $V(v) = \sum_k g_k \lambda_k d_k Z(v)$

Stokes V

Lande g

Line

Depth

$$V_k(v) \propto g_k \lambda_k \frac{\partial I_k(v)}{\partial v}$$

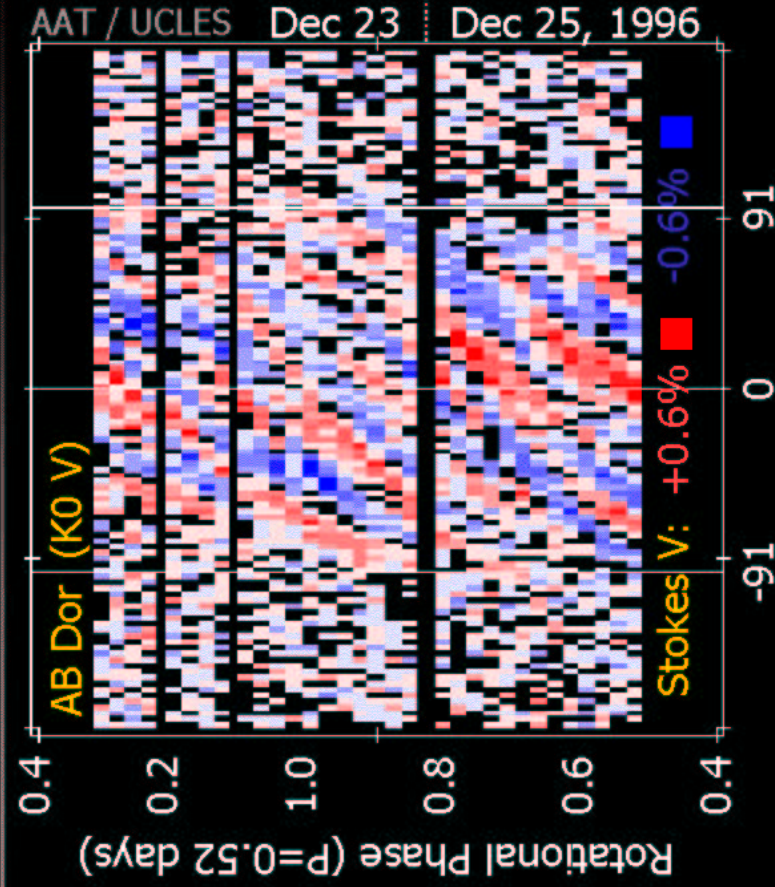
- Motivation:
 - Weak field approximation:

$$\frac{\partial I_k(v)}{\partial v} = d_k Z(v)$$

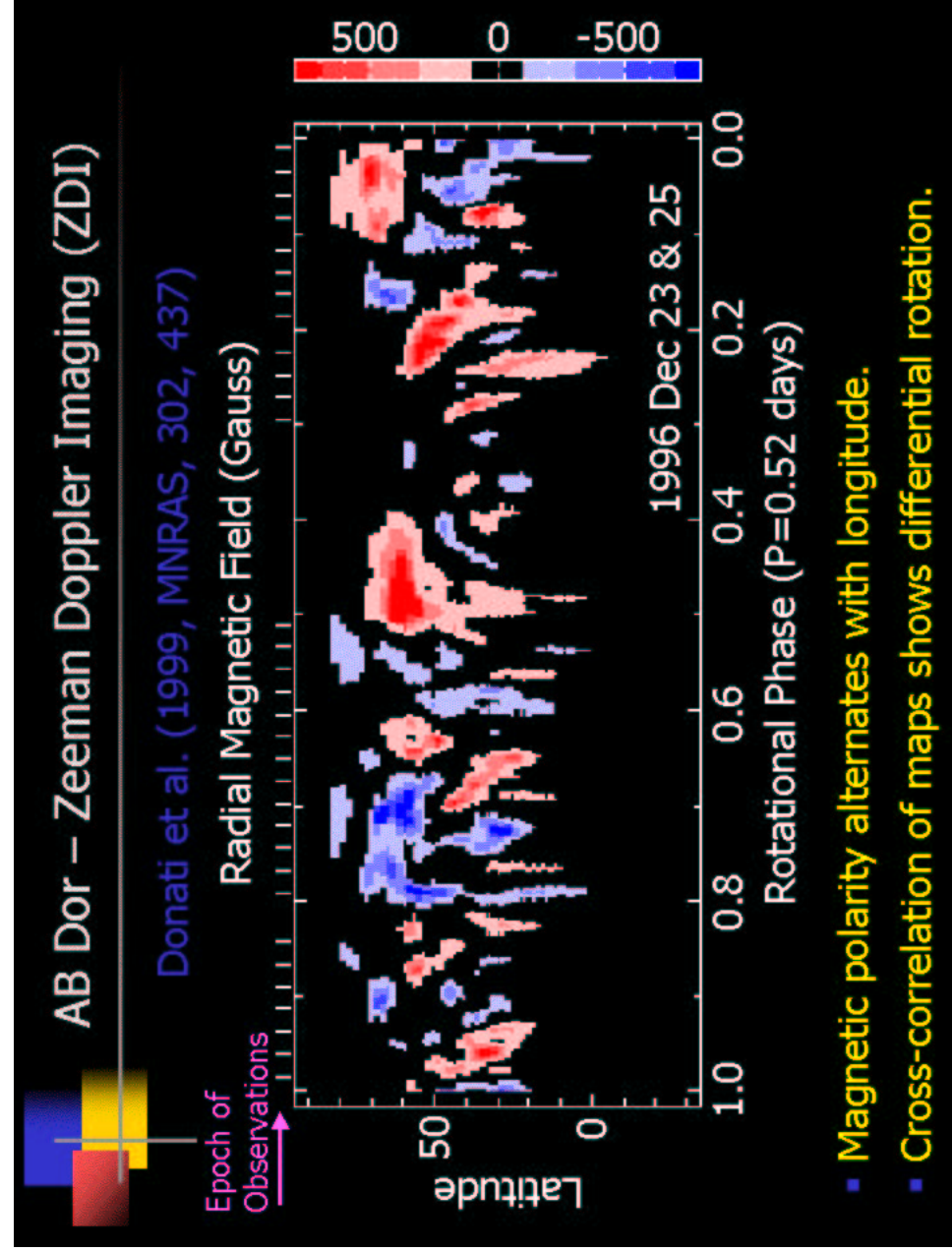
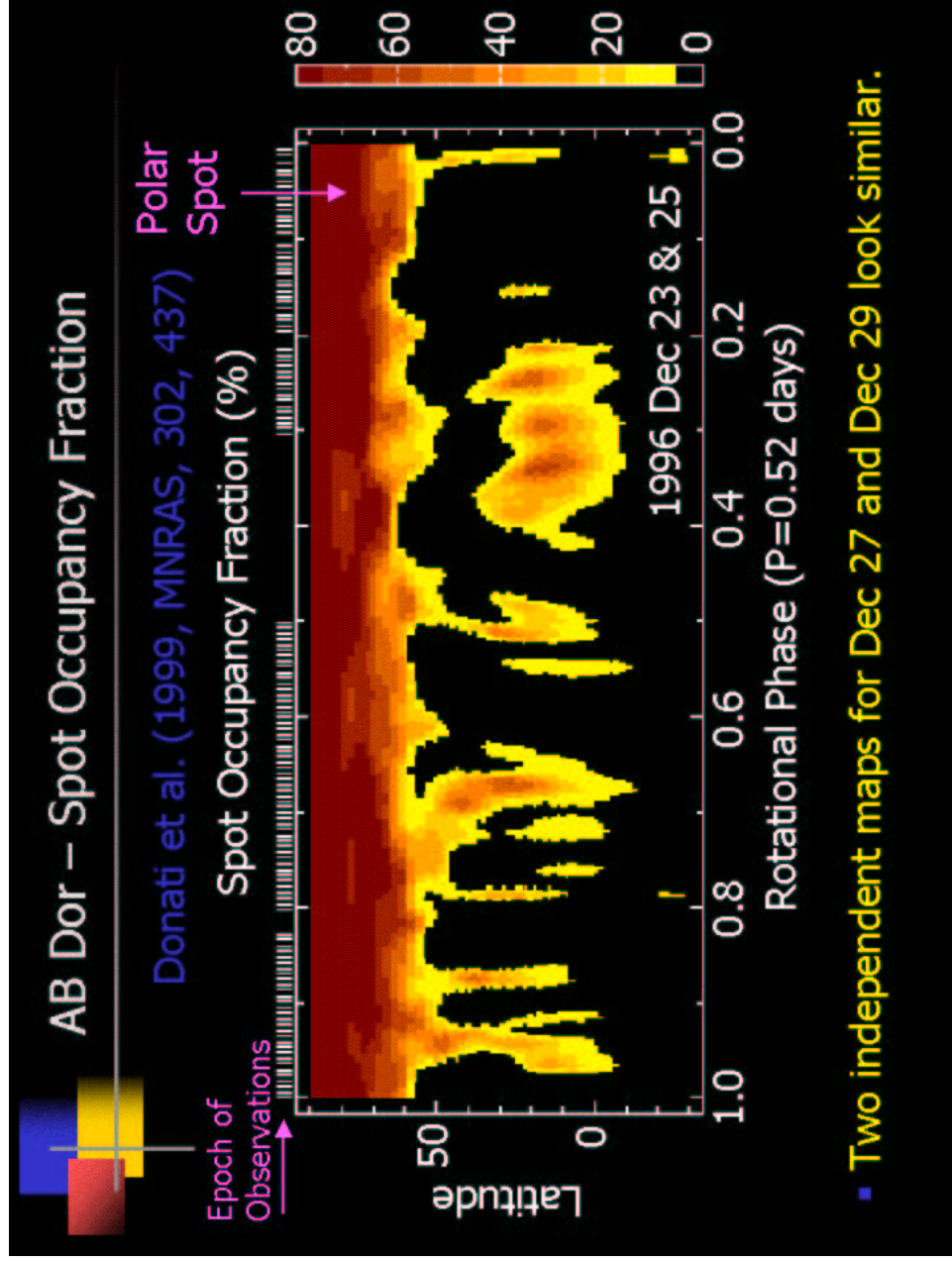
- Self-similar Stokes Intensity profiles:

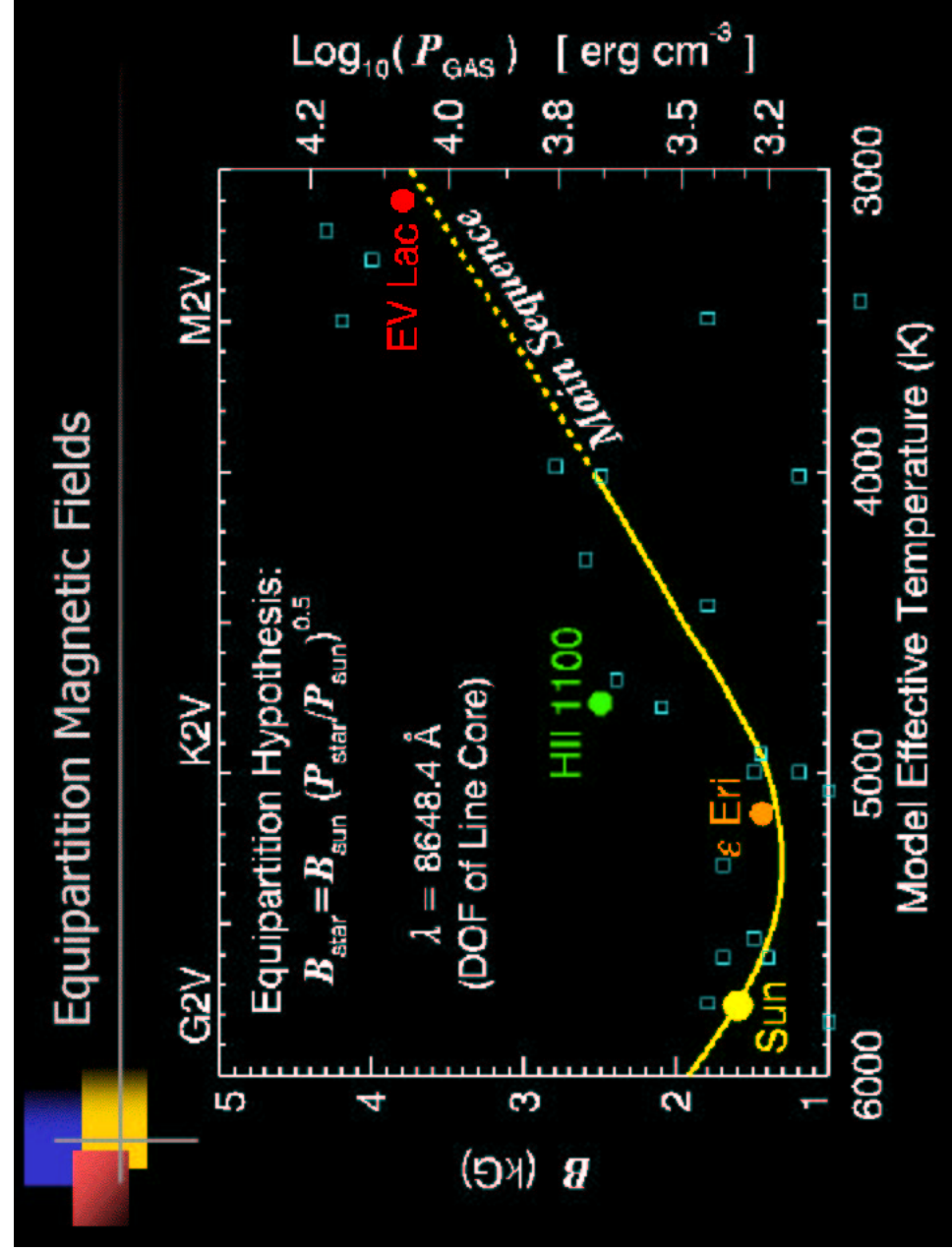
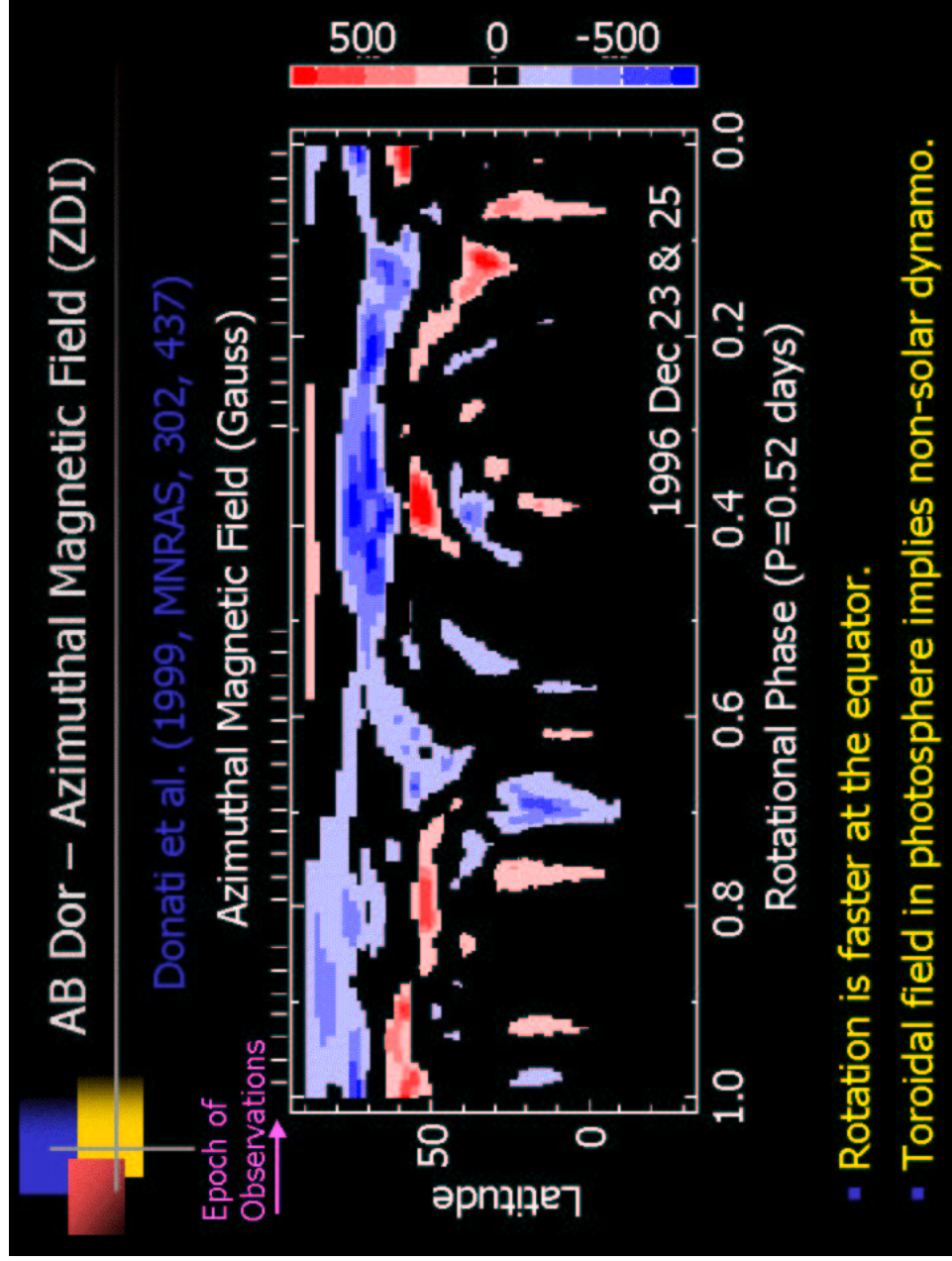
Circular Polarization of Rapid Rotators

Donati et al. (1999, MNRAS, 302, 437)

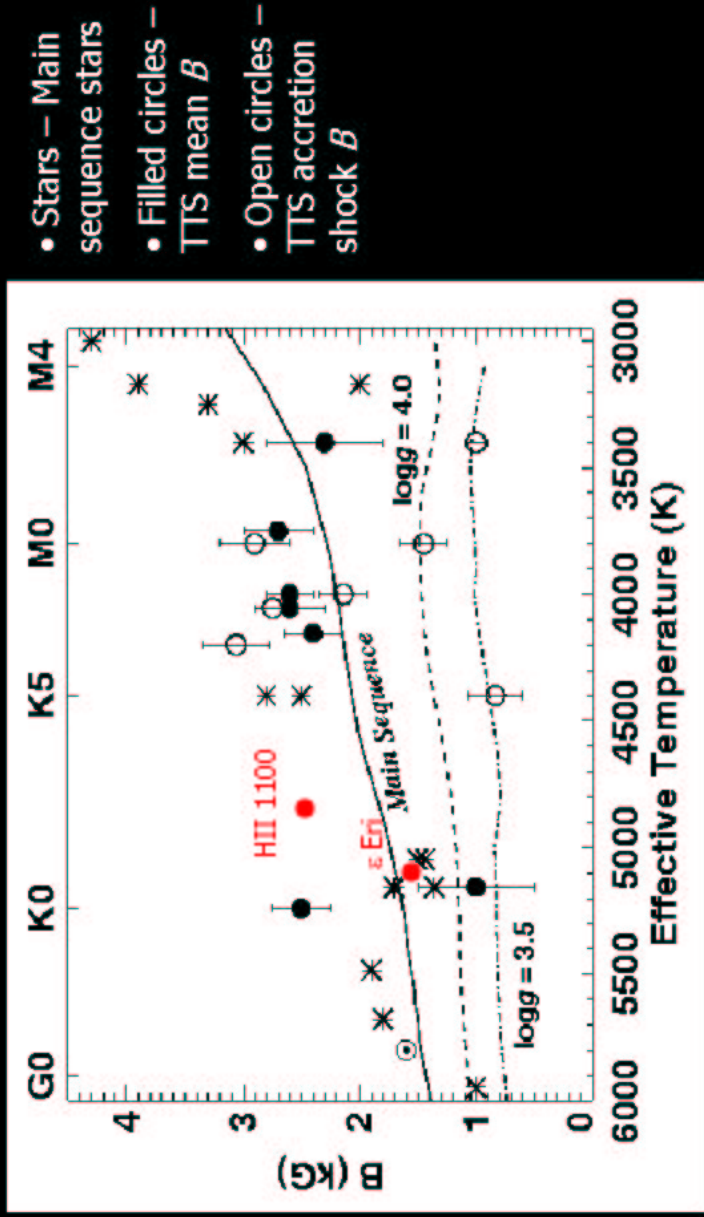


Least Squares Deconvolution (LSD) of ~1500 Spectral Lines



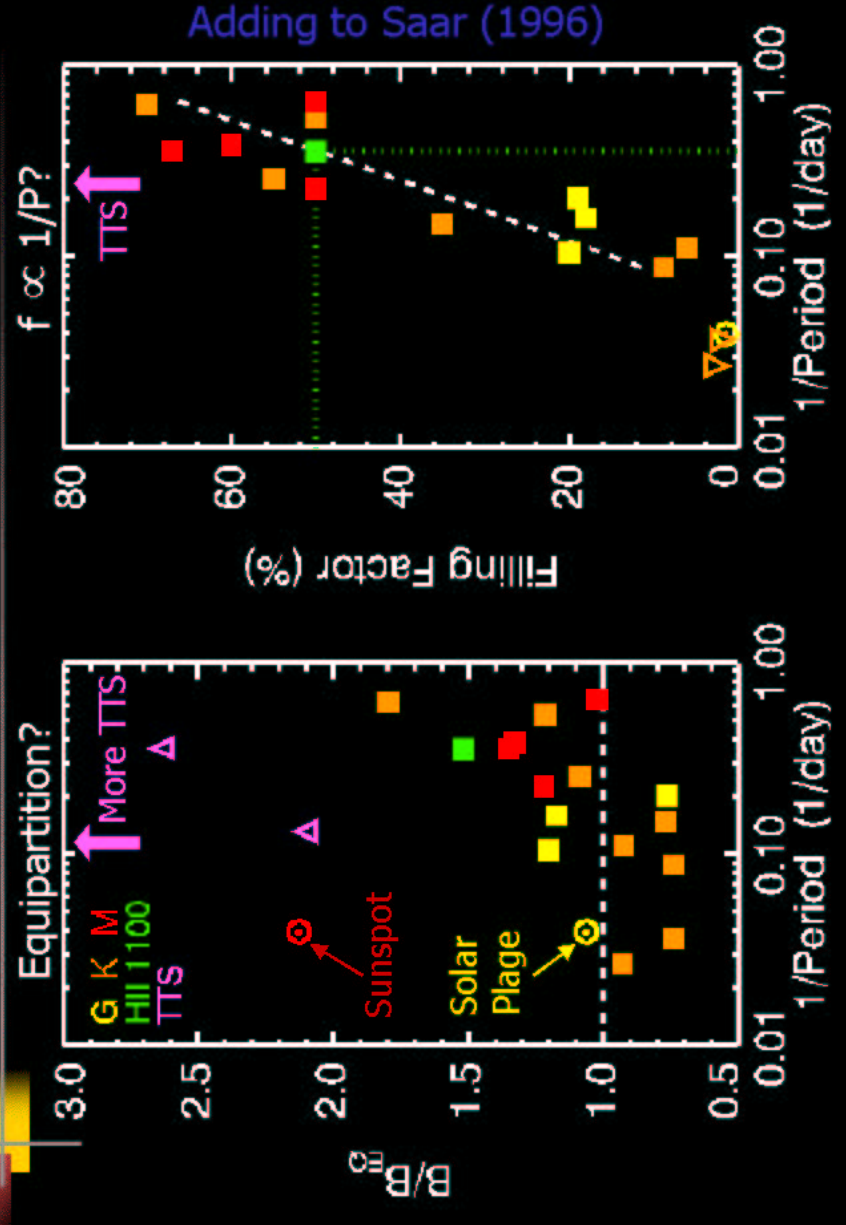


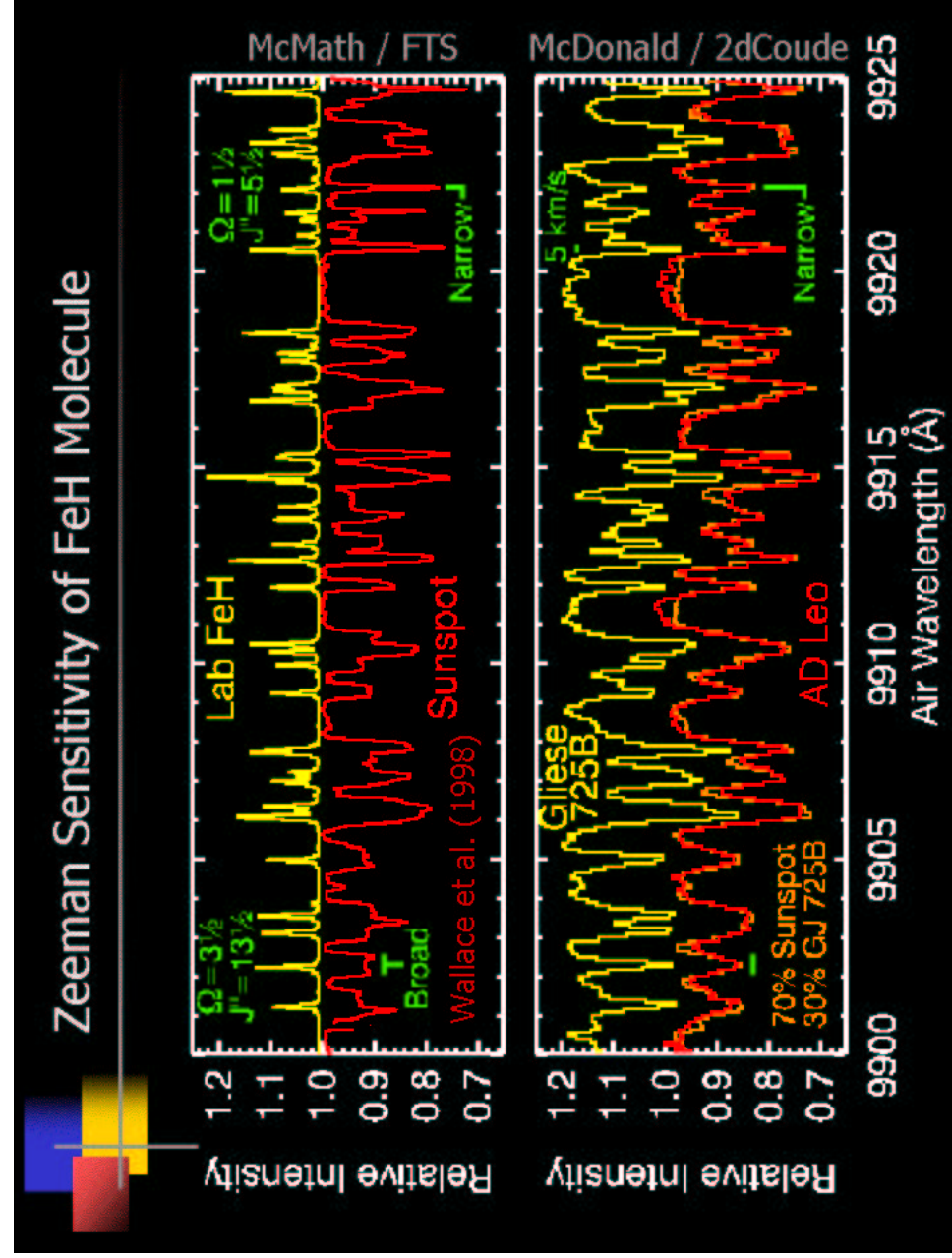
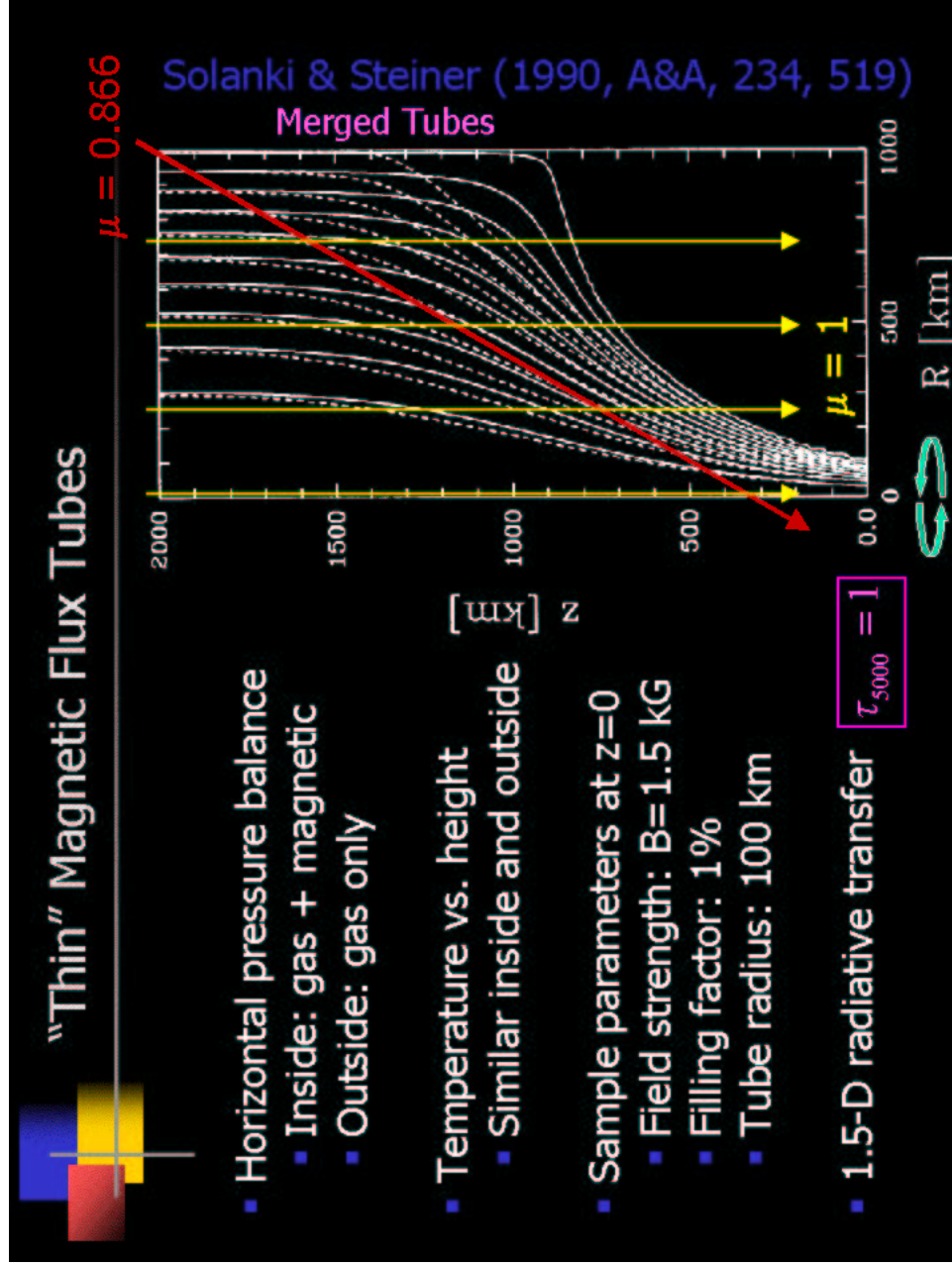
Equipartition Magnetic Fields



- Stars – Main sequence stars
- Filled circles – TTS mean B
- Open circles – TTS accretion shock B

Field Strength and Filling Factor vs. Rotation





Summary

- Cool stars: convective envelopes and rotation produce active dynamos and magnetic heating.
- Complex field geometries yields weak circular polarization.
 - Search for unresolved global fields (1 Gauss).
 - Measure field geometry on rapid rotators with ZDI.
- Fully convective stars (and Sun?) have second dynamo type.
- Measure fields on slow rotators with IR Zeeman broadening.
- Magnetic flux concentrated into flux tubes.
 - Pressure balance and tube size sets field strength.
 - Filling factor scales with dynamo productivity.
 - T Tauri stars violate these rules.