Magnetic fields of cool active stars

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Stellar magnetic fields

✧ Wide variety of stars
  ✧ 85% cooler and less massive than the Sun

✧ Small fraction of the hot massive stars are magnetic
  ✧ Stable and dipole like
  ✧ Strong

✧ All cool low mass stars (M up to \( \sim 1.5M_\odot \)) are magnetic
  ✧ Complex and evolving
  ✧ Relatively weak
Zeeman effect – Line splitting

- Requires a magnetic field of several kG!

[Diagram showing line splitting with and without an external magnetic field]
Zeeman effect - Polarization

✧ Degree of polarization proportional to magnetic field strength
✧ Can be used to detect fields of ~0.1 G strength
✧ Stokes parameters IQUV
✧ Unpolarized light (I)
✧ Linear polarization (QU)
✧ Circular polarization (V)
Multi-line technique

✧ Weak field => weak polarization
✧ No visible polarization signatures in individual spectral lines
✧ Apply the multi-line technique least-squares deconvolution (LSD)

✧ All lines in the spectrum are scaled version of a mean profile
✧ Each line weighted by central depth, wavelength and magnetic sensitivity
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Polarization profile analysis

Stokes V

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Polarization profile analysis

Mean longitudinal magnetic field $<B_z>$

$<B_z>$ large

$<B_z> = 0$
Temperature mapping – Doppler imaging

✧ Stokes I
✧ Dark cool spot will cause bump in profile
✧ Each point in profile corresponds to longitude on the star
✧ Latitude is determined by where the corresponding bump is visible in the profile and how fast it moves across the profile
Cool stars in general have relatively weak magnetic fields
=> weak polarization
Circular polarization is up to 10 times stronger than linear polarization
Circular polarization sensitive to line-of-sight component of magnetic field vector
Magnetic fields of cool stars are currently studied using circular polarization only – not optimal
Linear polarization sensitive to transverse component of magnetic field vector
Zeeman Doppler imaging

Using Stokes I and V

Using Stokes IQUV

- Very accurate spot geometry and positioning
- Almost no crosstalk
New observations – II Peg

✧ Unique set of observations from CFHT
✧ 12 complete phases
✧ Continuously high activity

June 15 – July 1, 2013
Preliminary results – II Peg

ڀ More detailed structures when using all 4 Stokes parameters
Thank you!