Magnetic properties of low mass stars: new discoveries and future prospects

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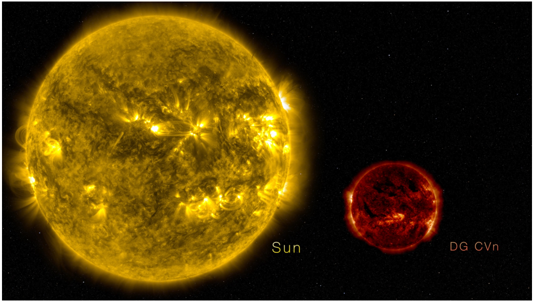
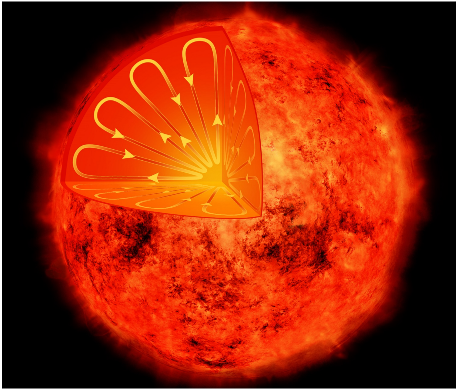
M dwarfs

- Cool MS stars
  $T_{\rm eff} = 2400 - 3800$ K
  $M = 0.6 - 0.1 M_\odot$
  70% by number
  40% by mass
- Solar like activity: X-ray, Hα, Ca II H & K
- Promising targets to search for Earth-size planets



M dwarfs

- Stellar dynamos
  Stars with $M < 0.35 M_\odot$ become fully convective (different dynamos?)



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Measuring magnetic fields: two approaches

- Polarimetry:
  Stokes-V: geometry, polarity (ZDI)
  Cannot detect small scale fields of opposite polarity
- Spectroscopy:
  Stokes-I: total magnetic flux density (Zeeman broadening)
  Cannot see polarity of the field

Polarimetry and spectroscopy provide important constraints for models of stellar dynamos.

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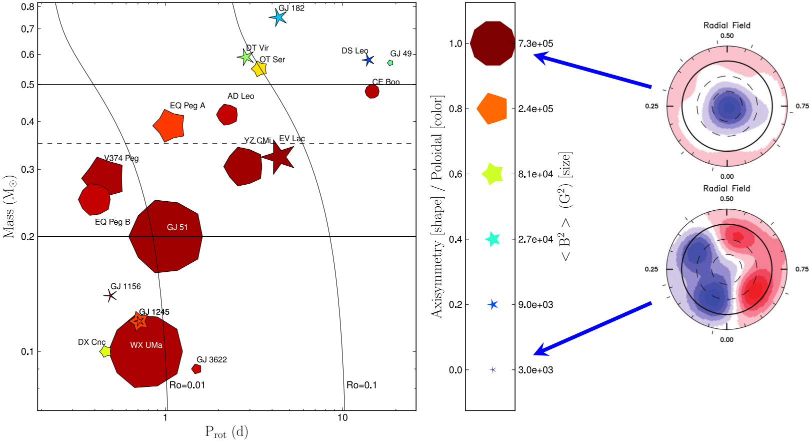
Results from polarimetry: confusogram



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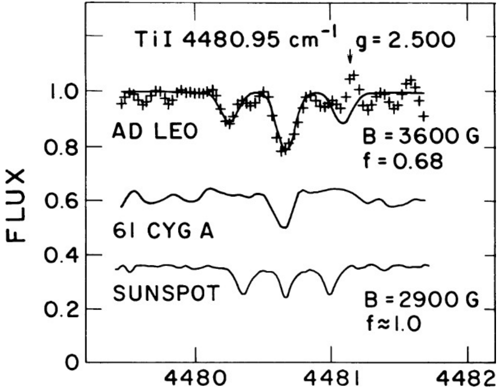
Spectroscopy

Saar & Linsky (1985)

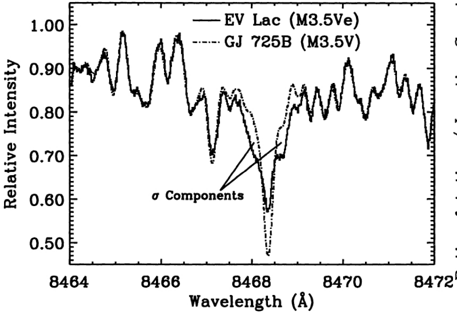
First detection of the magnetic field in an M dwarf star AD Leo

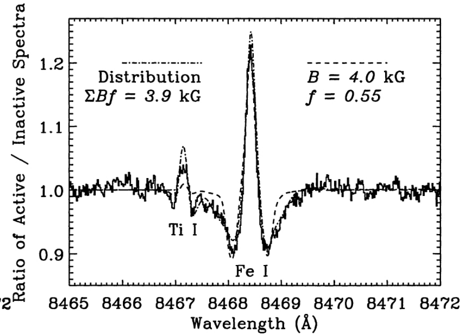


Spectroscopy

Johns-Krull & Valenti (1996, 2000)

Relative analysis of atomic line profiles (Fe I 8468.4 Å)

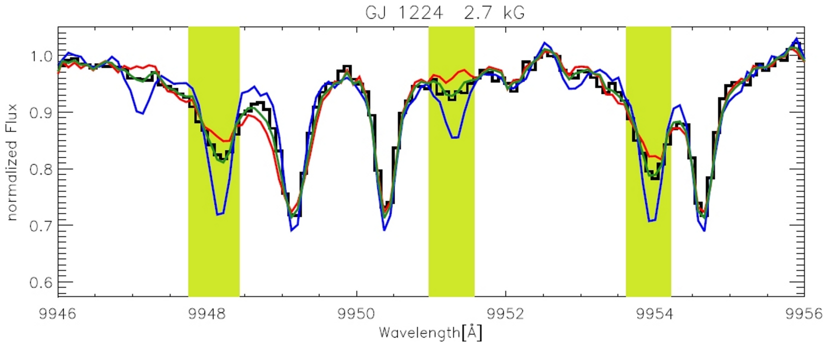




Spectroscopy

Reiners & Basri (2006, 2007)

Empirical analysis of FeH lines (without radiative transfer)
Simplest solution ever: estimate $\langle B \rangle$ by simple interpolation between the spectra of two reference stars with known $\langle B \rangle$



Spectroscopy

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Simplest solution ever: estimate $\langle B \rangle$ by simple interpolation between the spectra of two reference stars with known $\langle B \rangle$

These "known $\langle B \rangle$" are actually from Johns-Krull & Valenti (2000), i.e. derived from the relative analysis of line shapes and thus limited to the max. field of EV Lac (≈ 3.9 kG).

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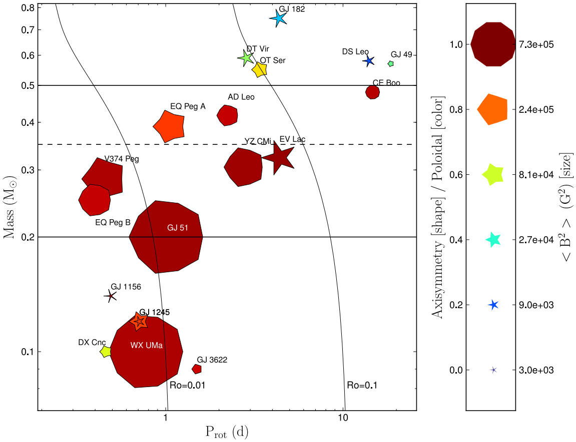
Combining Stokes-V and Stokes-I from POLARBASE



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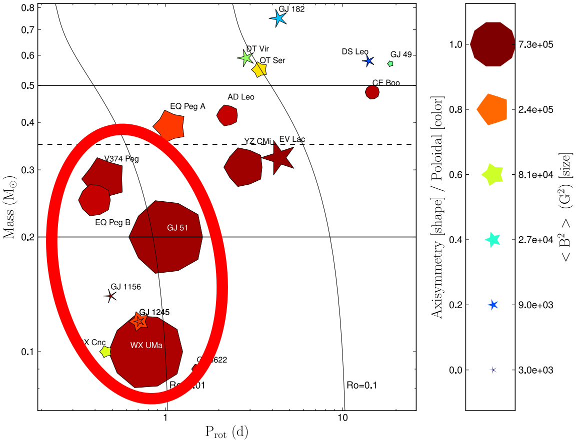

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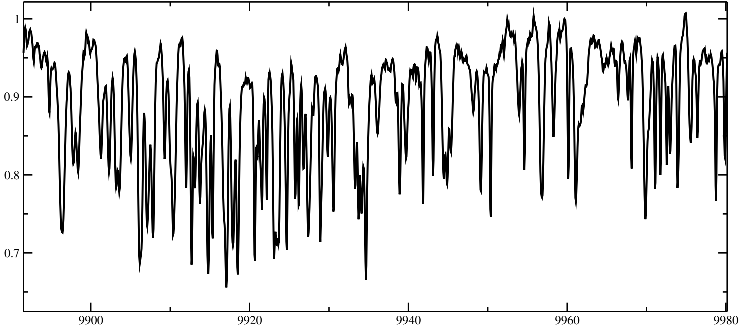
Main goal

Measure total (unsigned) magnetic flux from Stokes-I data

Wing-Ford $F^4\,\Delta - X^4\,\Delta$ transitions ($\lambda\lambda 990 - 995$ nm)

FeH



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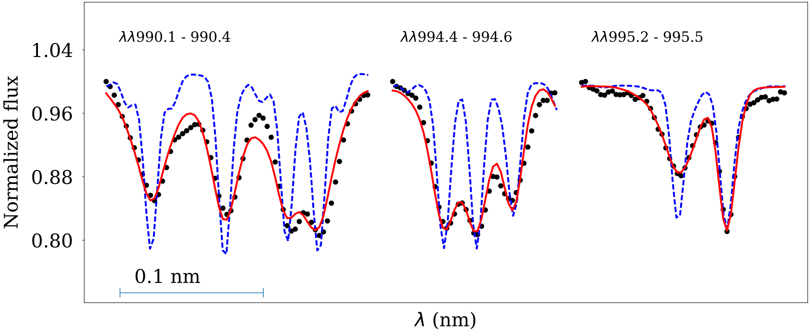

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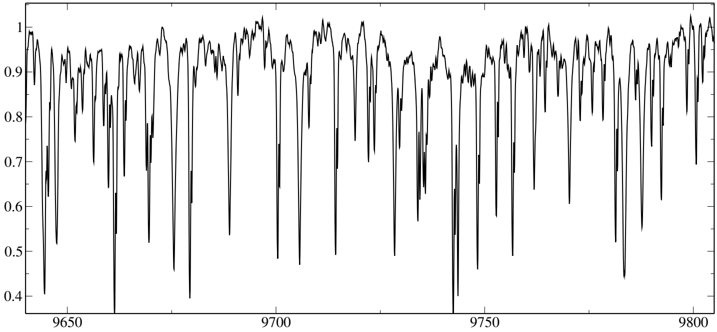

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Measure total (unsigned) magnetic flux from Stokes-I data

Remove telluric with MOLECFIT

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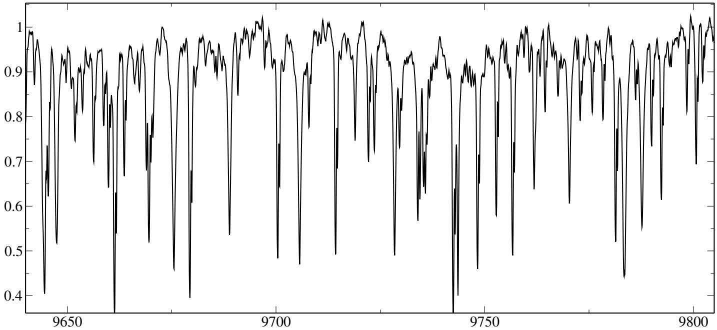

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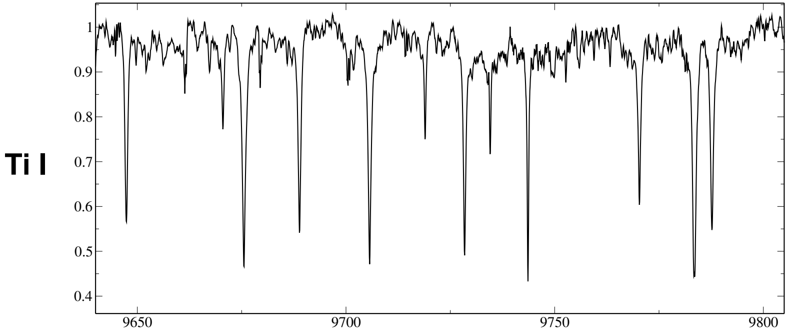
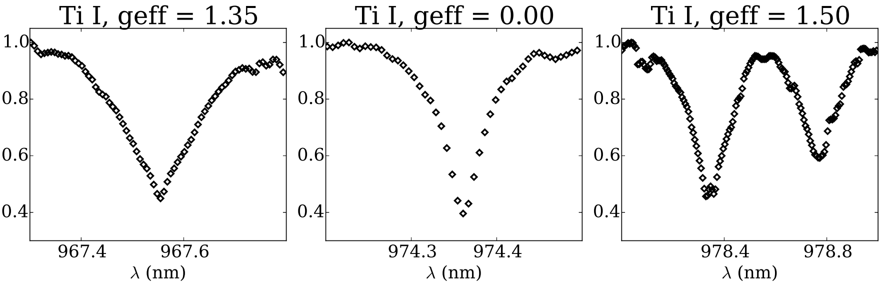


Ti lines in NIR

WX UMa, $\upsilon \sin i = 6$ km s^{-1}, $\langle B \rangle = 7.3 \pm 0.5$ kG



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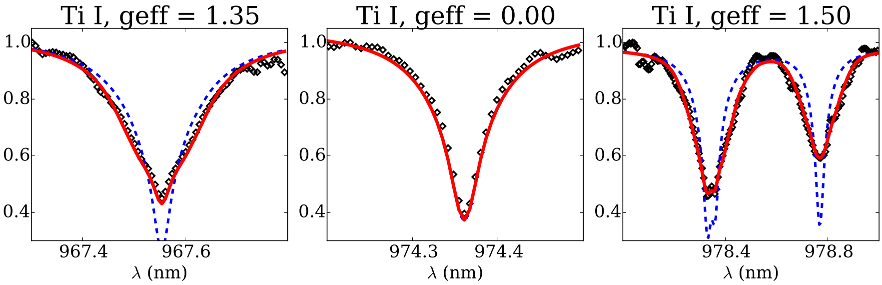

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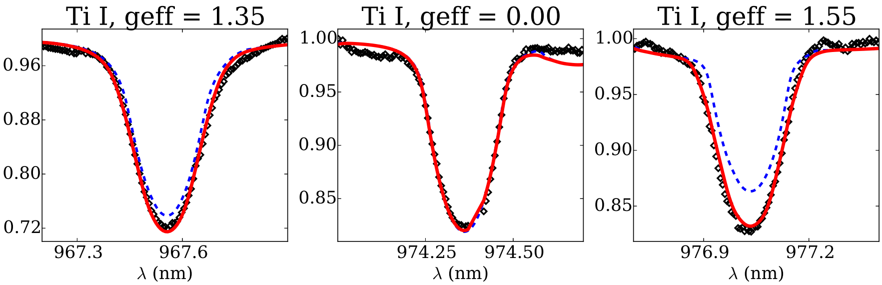
Ti lines in NIR

In stars with large $v \sin i$ we rely on the effect of magnetic intensification of spectral lines.

V374 Peg, $v \sin i = 35$ km s^{-1}, $\langle B \rangle = 5.2 \pm 1.0$ kG



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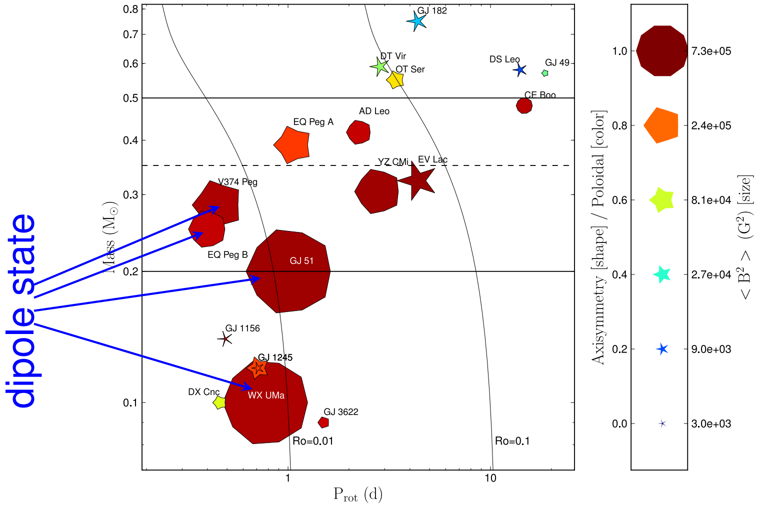
What is so peculiar about stars with strong fields?



Future work

Calar **A**lto high-**R**esolution search for **M** dwarfs with **E**xoearths with **N**ear-infrared and optical **E**chelle **S**pectrographs

carmenes

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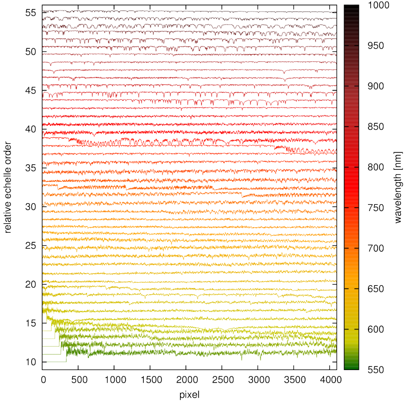
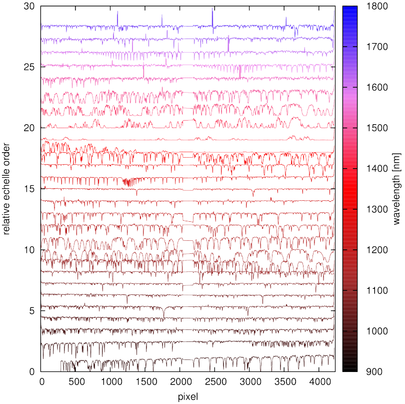
Future work

Stokes-I between 0.5 - 1.7μm ($R \approx 82\,000$)

VIS



NIR



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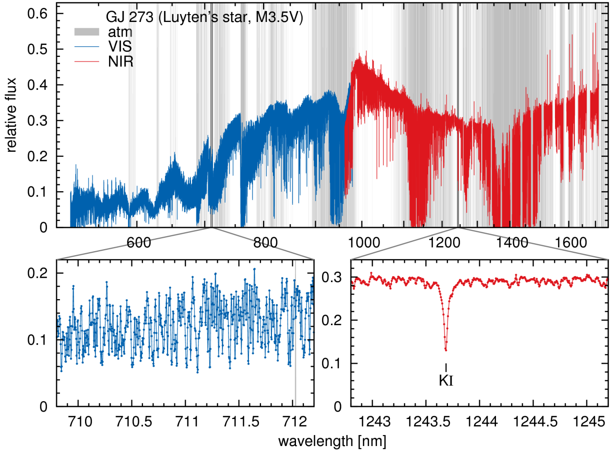

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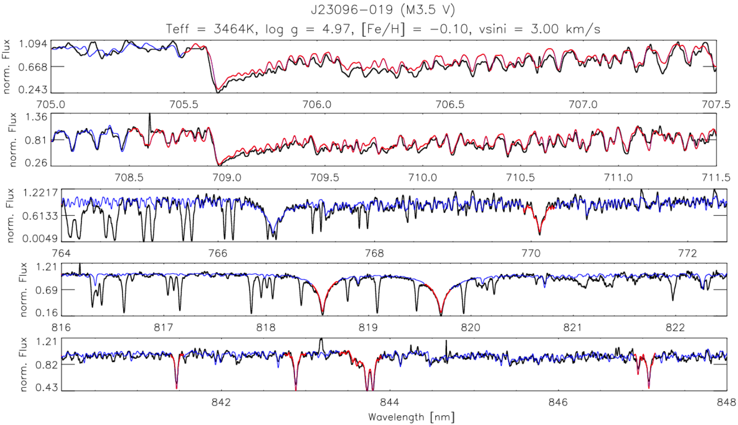
Future work

Derive stellar parameters for the whole sample.



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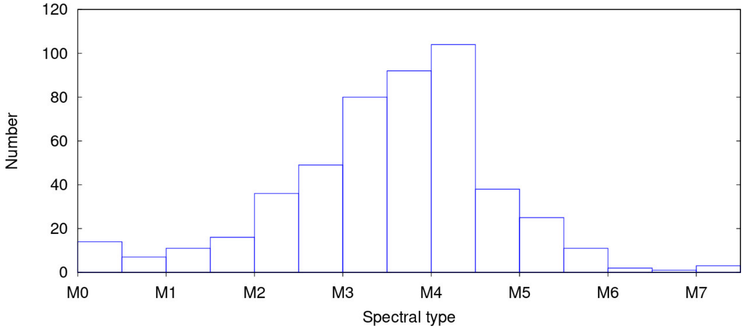
Future work

Sample of ≈300 M dwarfs, ≈70 transits per star.



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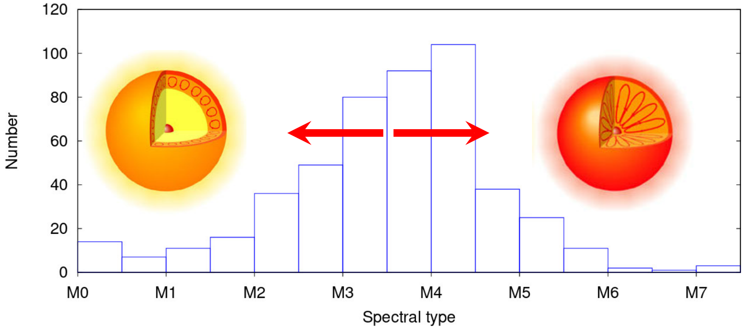

Summary

- Combining results from Stokes-V and Stokes-I.
- Observing dynamo bistability in both Stokes-I and Stokes-V (need to constrain better with larger sample).
- WX UMa managed to generate the strongest to date magnetic field of $\langle B \rangle \approx 7.0$ kG.
- Analysis of the full CARMENES sample.

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