Calibrating High-Resolution Four Stokes Parameter Observations of Magnetic Stars

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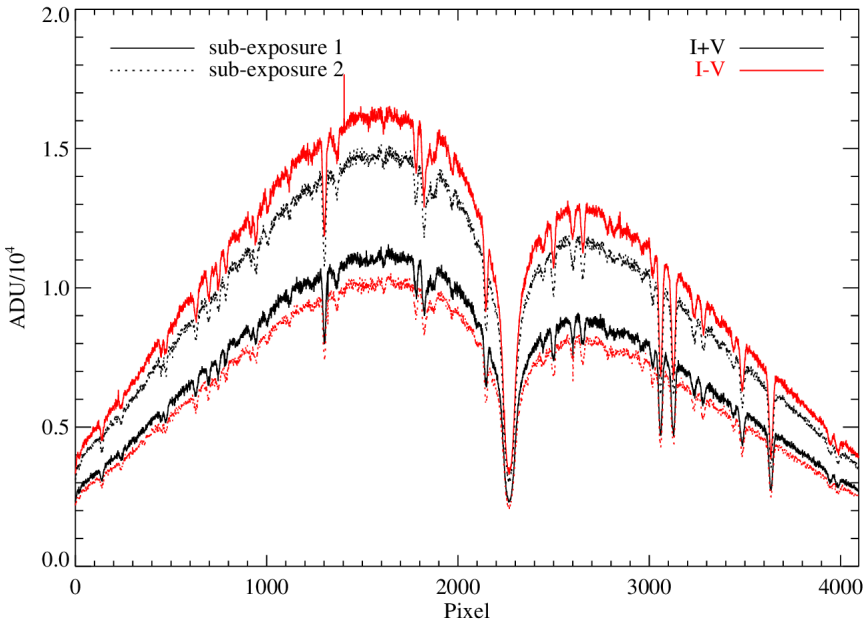
Calibration goals

- Verification of Stokes parameter signs
- Assessment of internal and external cross-talks
- Long-term monitoring of instrument stability
- Comparison between different instruments
- Testing methods to derive magnetic observables

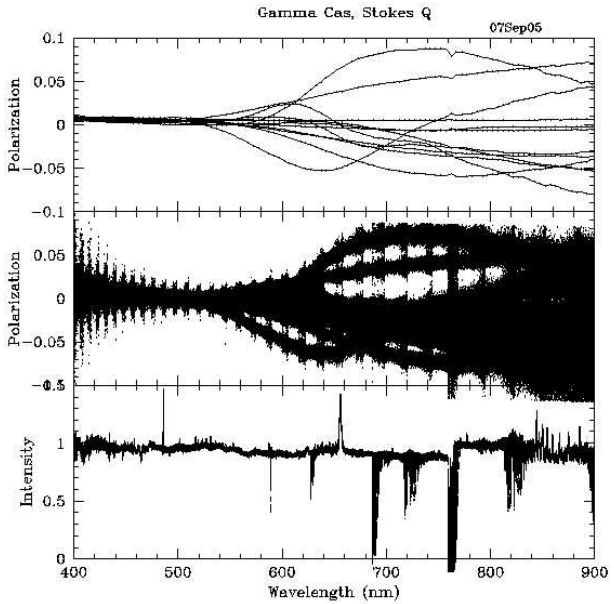
High-resolution spectropolarimetry

- Beam-exchange technique to derive Stokes *VQU* and null profiles
- Continuum polarization cannot be reliably measured

HARPSpol: large difference in fiber throughput



Espadons: guiding errors



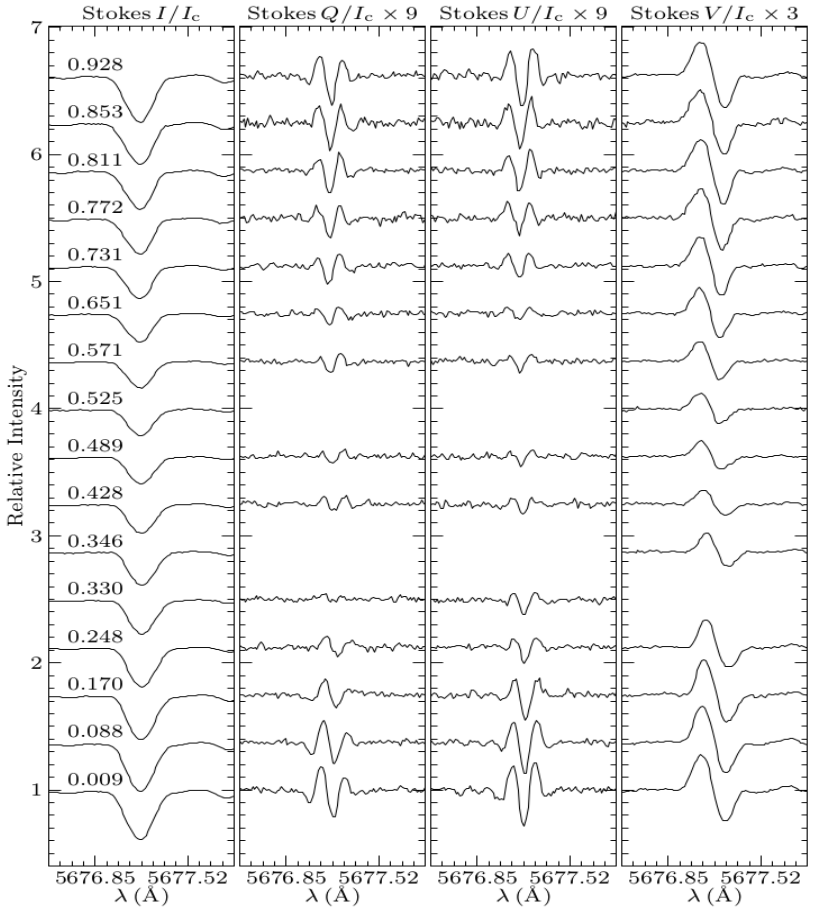
Usual continuum polarization standards cannot be used!

Ap stars as calibration targets

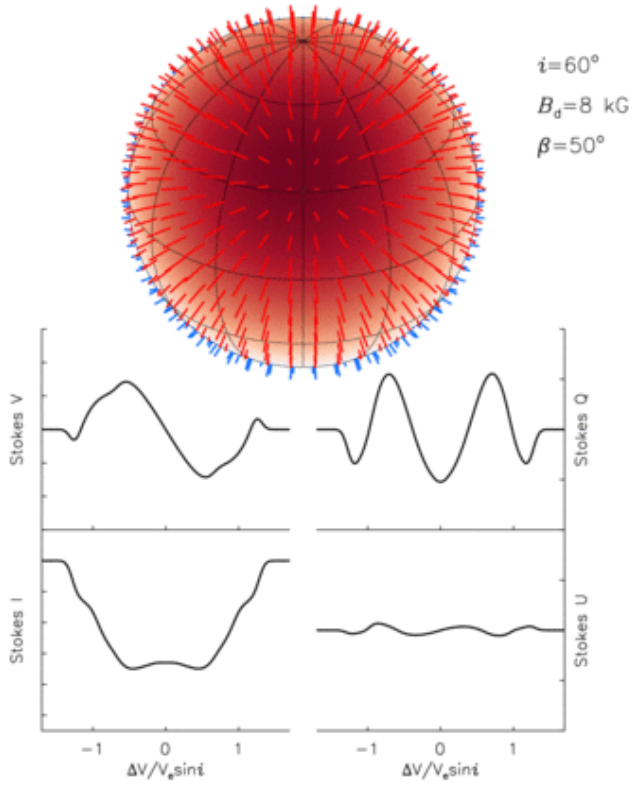
- Internal calibration:
  - *Bright stars with stable fields (Ap stars with $V < 6$)*
  - *Sharp spectral lines ($v_e \sin i < 10$ km/s)*
  - *Strong magnetic field ($B_d > 3$ kG)*

Oblique rotator variation of Ap stars

Nd III 5677 Å in HD 24712 (HARPSpol@3p6)



Simulation for dipolar field



Ap stars as calibration targets

- Internal calibration:
  - *Bright stars with stable fields (Ap stars with V < 6)*
  - *Sharp spectral lines ($v_e \sin i$ < 10 km/s)*
  - *Strong magnetic field (B_d > 3 kG)*

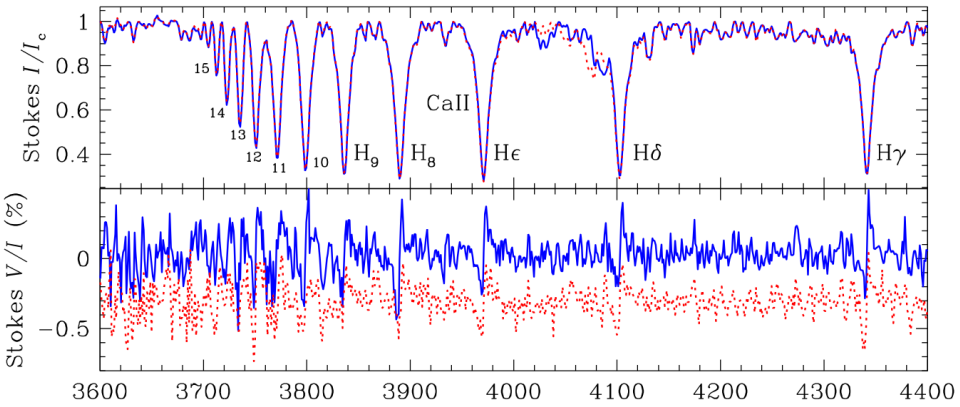
- External calibration and comparison:
  - *Constant shape and amplitude of polarization profiles:*

1) Small inclination and/or magnetic obliquity (i, β < 10°): HD 94660

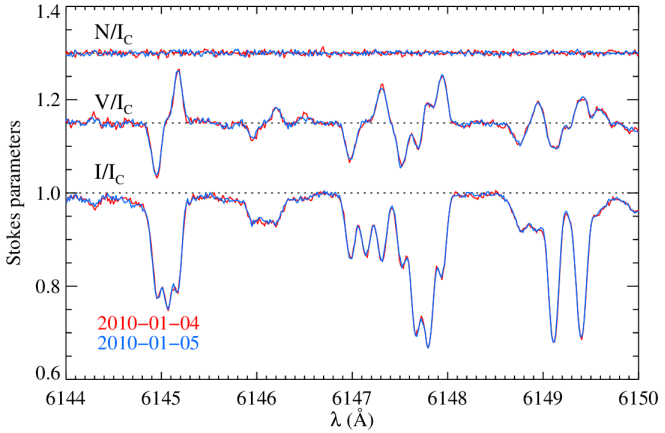
2) Very long rotation period (P_{rot} ≥ 10 yr): HD 201601=γ Equ

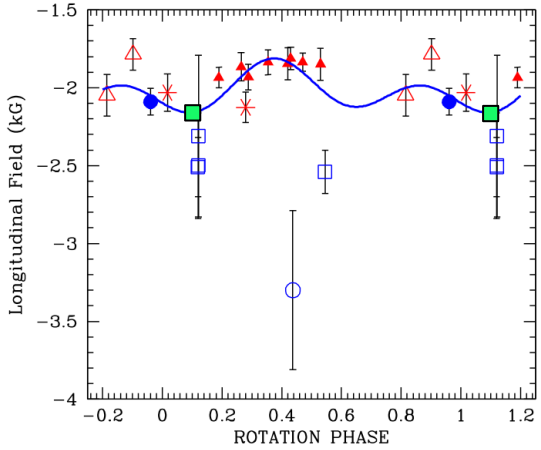
Circular spectropolarimetry

HD 94660 with FORS (Bagnulo et al. 2002)



HD 94660 with HARPSpol





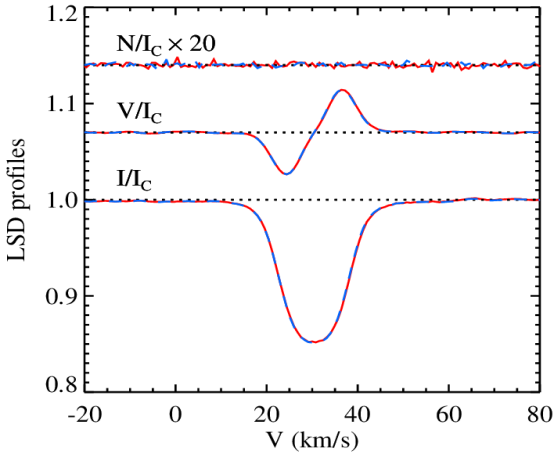
P_{rot}=7.6 yr

i = 47°, β = 5°

$\langle B_z \rangle \approx$ -2 kG

$\langle B \rangle \approx$ 6.2 kG

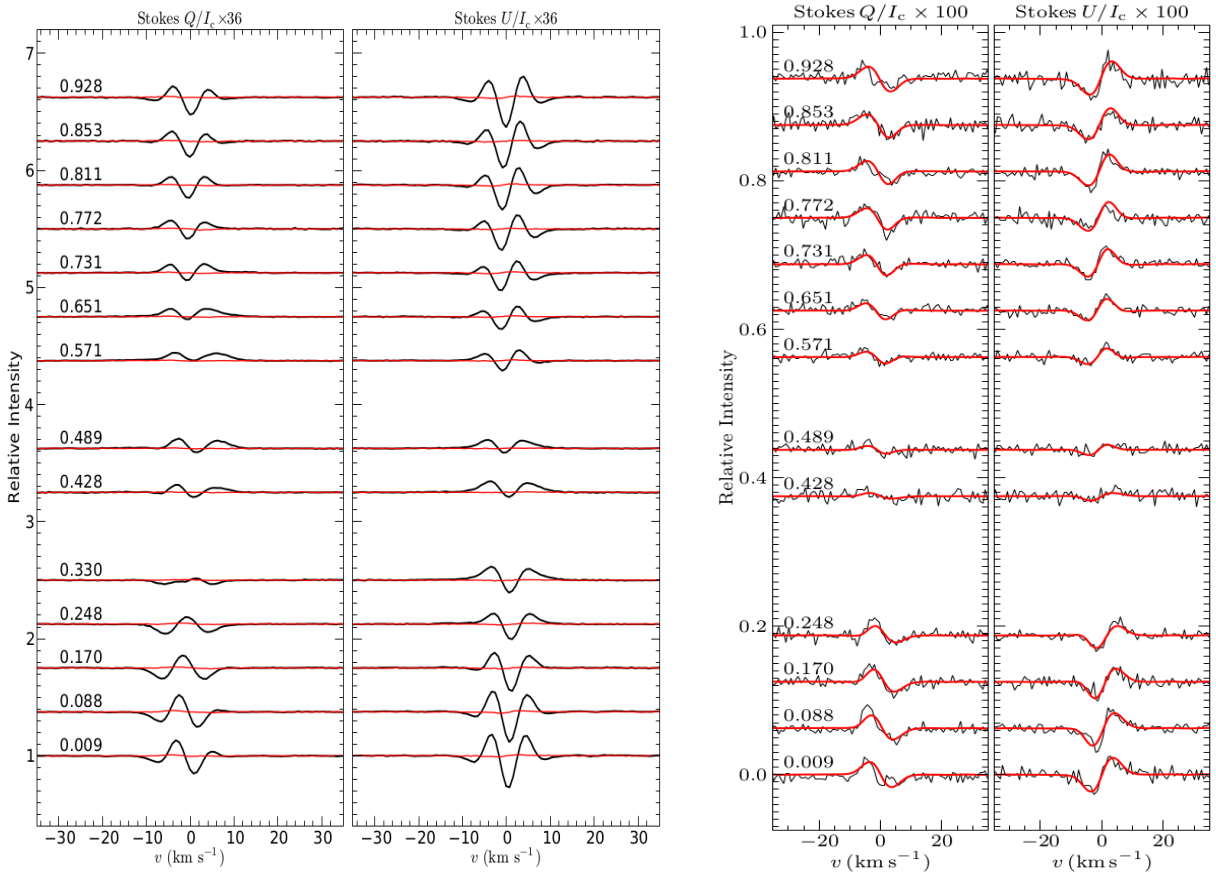
$\delta P/P \leq 10^{-3}$



Linear spectropolarimetry

Assessing internal cross-talk between Stokes parameters

LSD Stokes *QU* and null spectra (HD 24712 with HARPSpol)

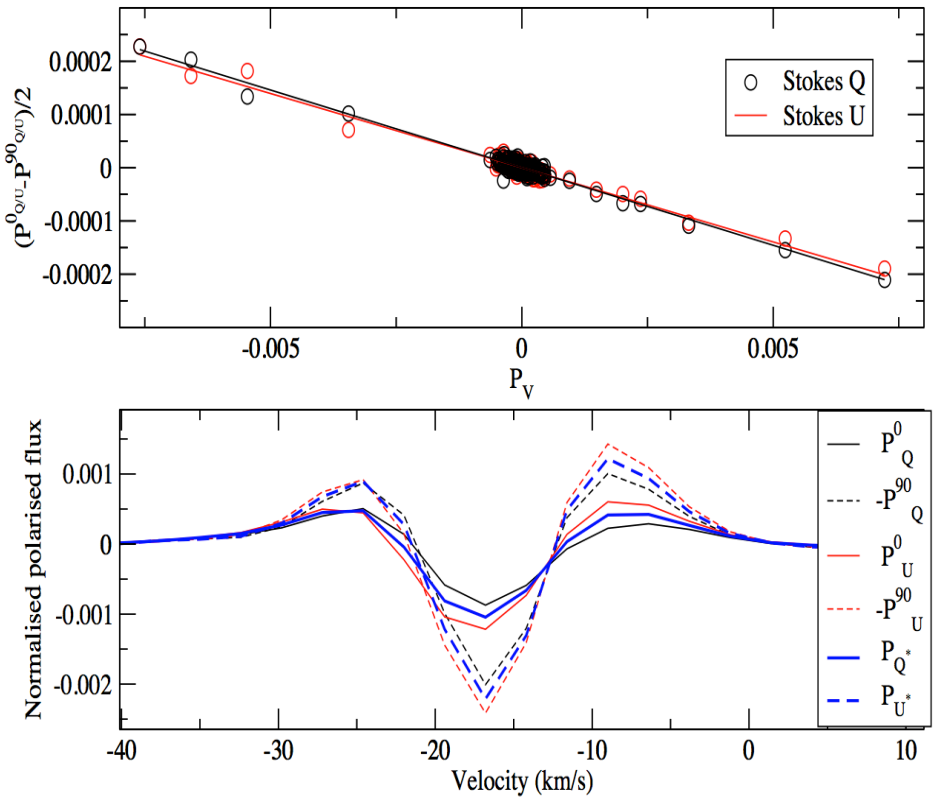


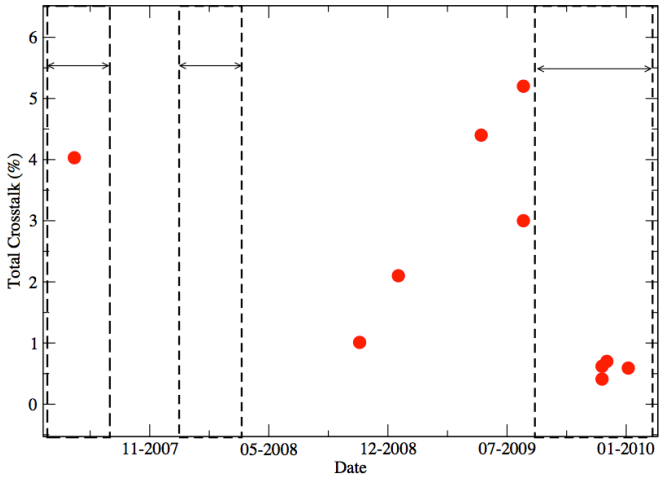
0.4-0.5% *V* to *QU* cross-talk

Linear spectropolarimetry

Assessing external cross-talk sources

β CrB with Espadons (Barrick et al.): cross-talk due to collimating lens and ADC

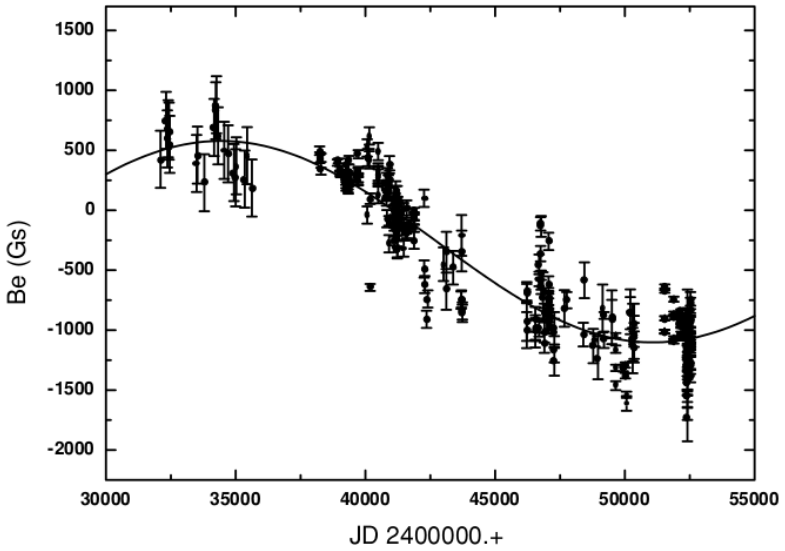




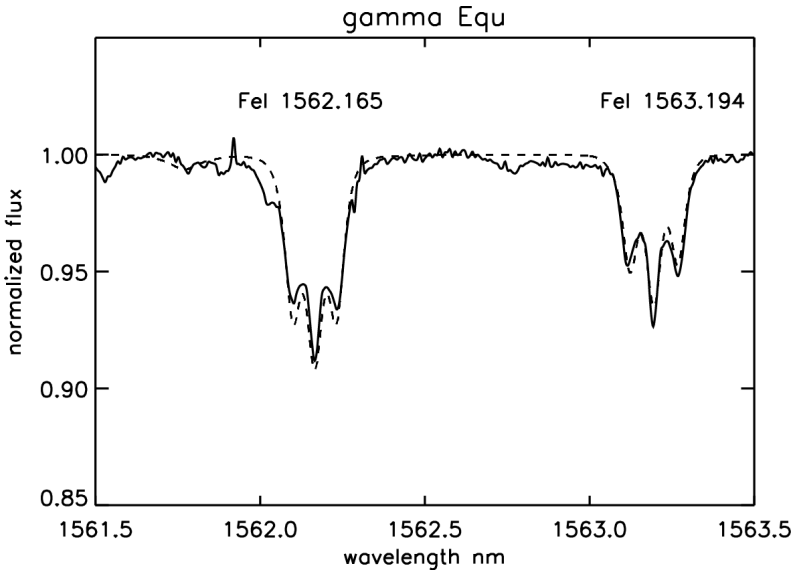
Linear spectropolarimetry

External comparison and cross-talk analysis requires Ap stars with stable polarization signatures

γ Equ (HD 201601), V=4.7, P_{rot}~100 yr, <B>~4 kG



Bychkov et al. (2006)

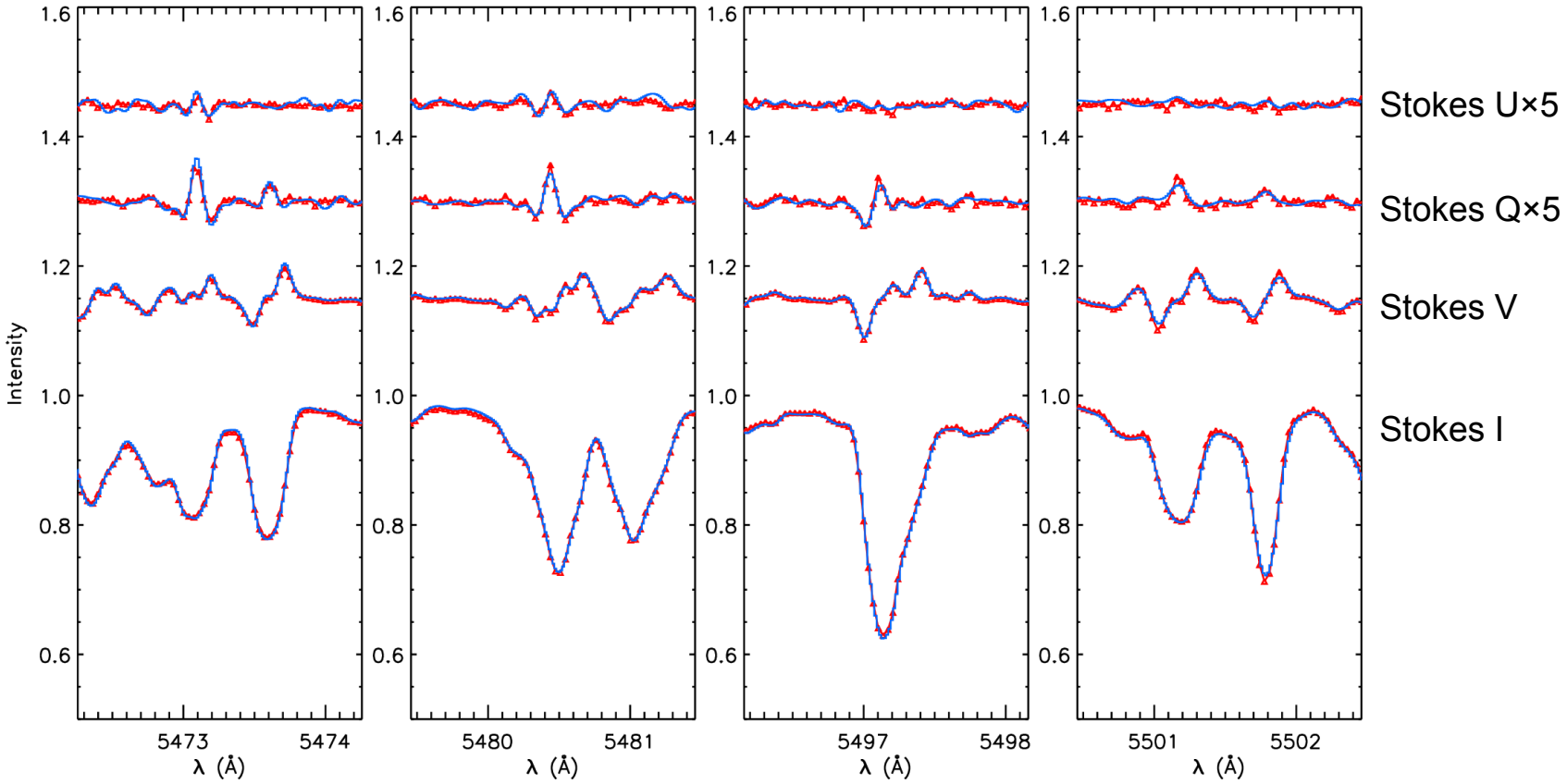


Hubrig et al. (2012)

Linear spectropolarimetry

Comparison between different instruments

γ Equ with Espadons (*R*=65,000) and HARPSpol (*R*=110,000)



Linear spectropolarimetry

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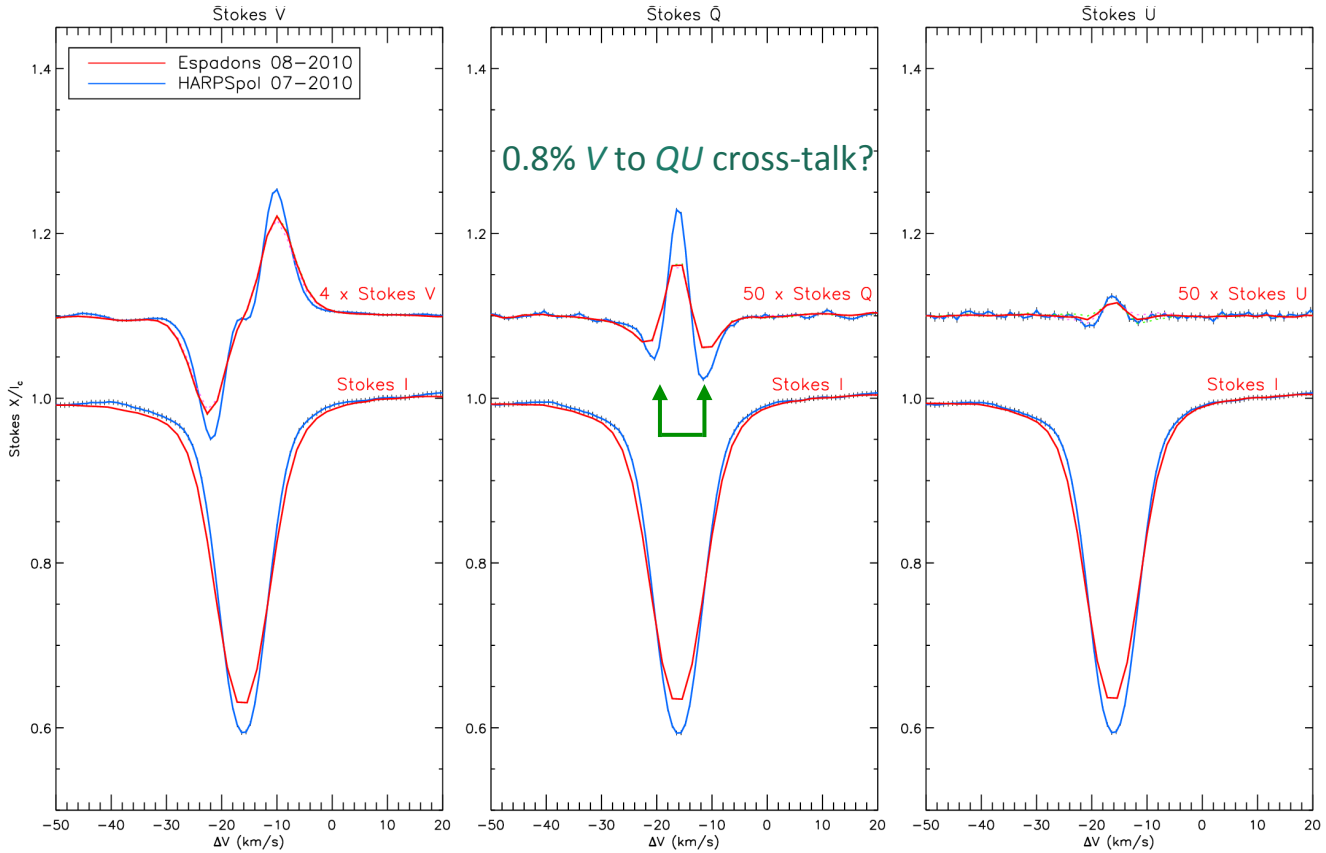

Conclusions

- Magnetic Ap stars are useful objects to calibrate high-resolution four Stokes parameter observations
- Very limited number of slowly rotating Ap stars suitable for external comparison and calibration are known
- Any other targets?