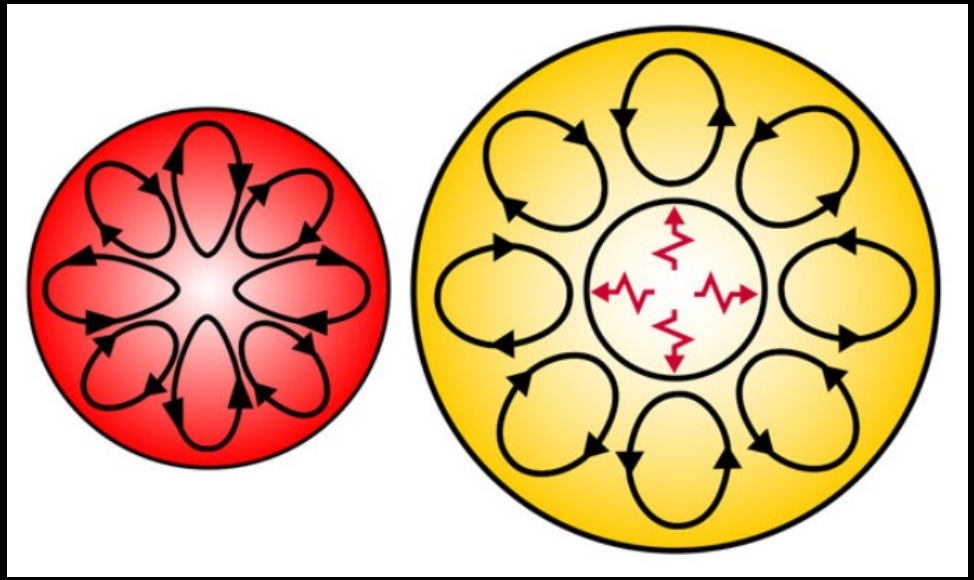
The large-scale magnetic field of the M dwarf double-line spectroscopic binary FK Aqr

S. Tsvetkova, J. Morin, C.P. Folsom, J.-B. Le Bouquin, E. Alecian, S. Bellotti, G. Hussain, O. Kochukhov, S. Marsden, C. Neiner, P. Petit, G.A. Wade
and the BinaMIcS collaboration

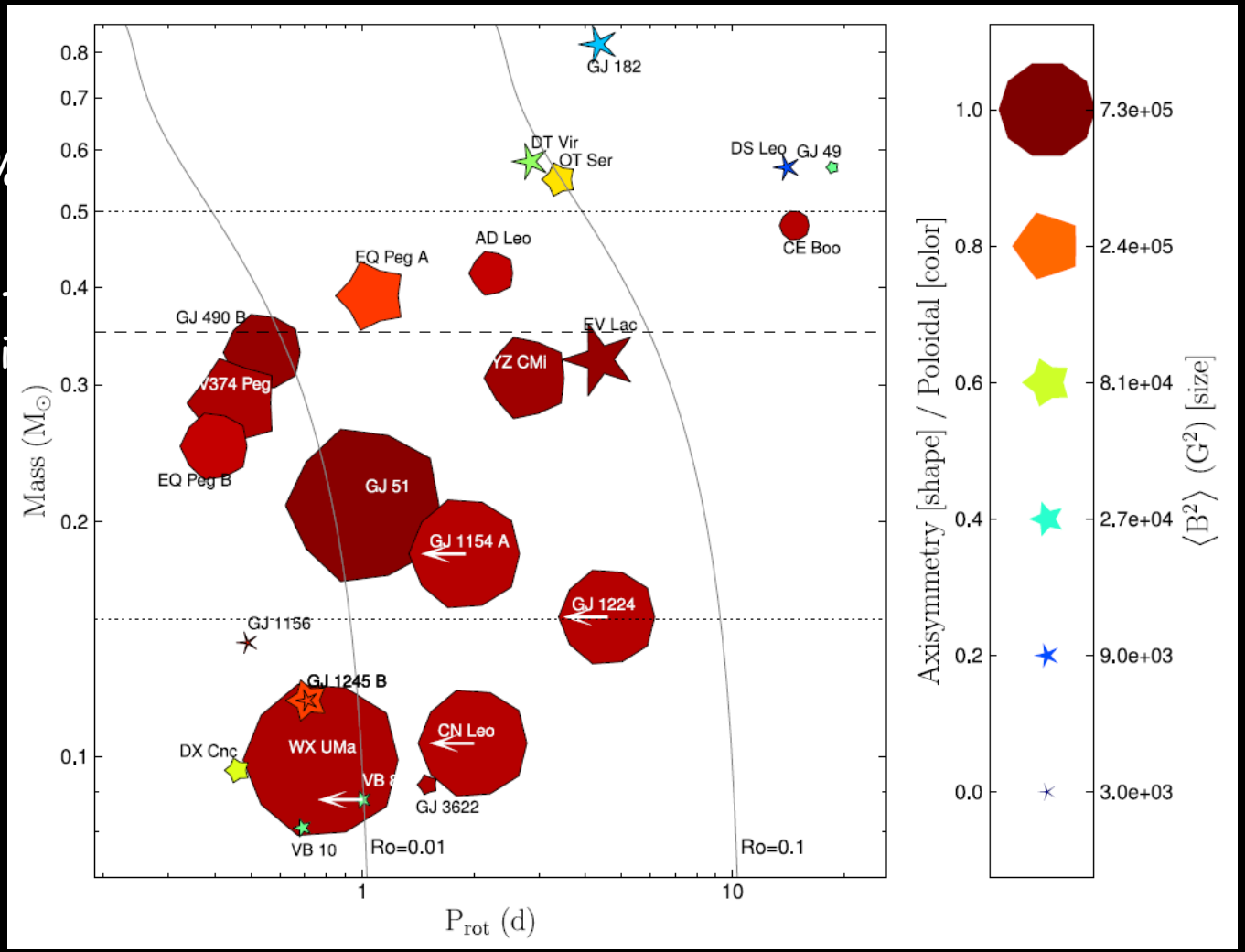
M dwarfs

- ~ 75% of all stars in the solar neighbourhood
- Mass – 0.08 – 0.60 Msun
- Teff – 2500 – 4000 K
- transition of the internal structure at M ≈ 0.35 Msun (spectral class M3/M4)



M dwarfs

- ~ 75%
- Mass
- Teff
- transi



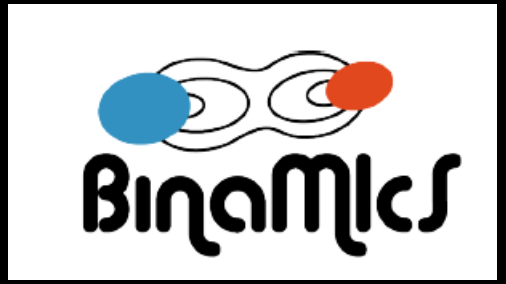
J. Morin+ 2010, 2012

BINAMICS

- Binarity and Magnetic Interactions in various classes of stars

- The goals of the project are to understand the impact of magnetic fields on stellar formation and evolution, of tidal effects on fossil and dynamo magnetic fields, of magnetism on angular momemtum and mass transfers between binary components, as well as magnetospheric interactions

- Spectropolarimetric observations with Espadons@CFHT and Narval@TBL
- Higher-mass binaries – O, B, A, Ap stars
- Binaries with cool components – RS Cvn, W UMa, BY Dra, M-dwarfs
- ~ 150 systems



FK Aqr

The system

- M1-2 Ve
- P = 4.08322 d
- e = 0.01
- Mass ratio q = 0.8
  M1 = 0.54 Msun, M2 = 0.44 Msun

Observations

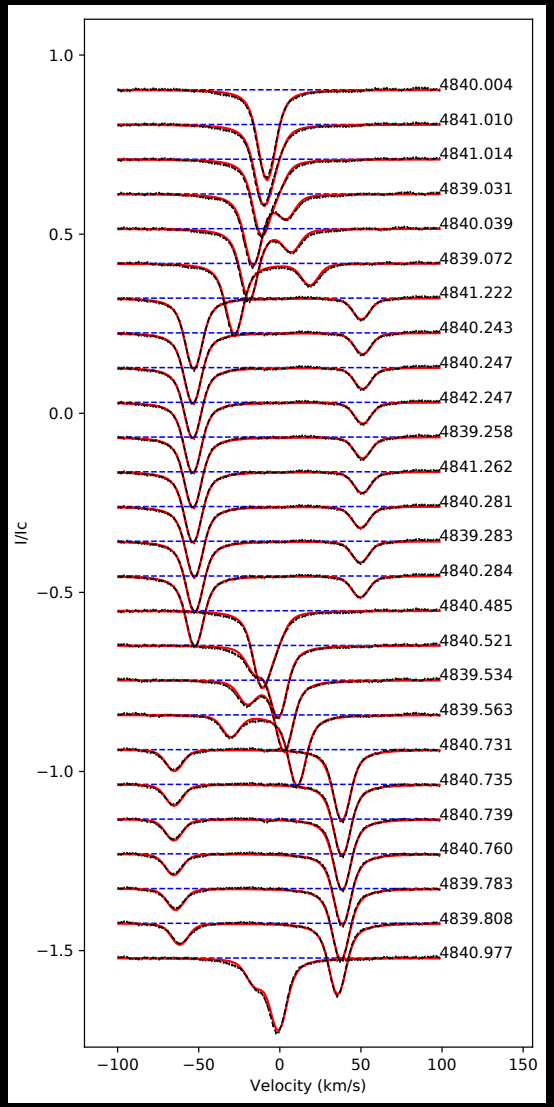
- 26 spectra
- 3 – 16 September 2014
- Espadons@CFHT - 3.6 m, spectrum coverage from 370 nm to 1050 nm

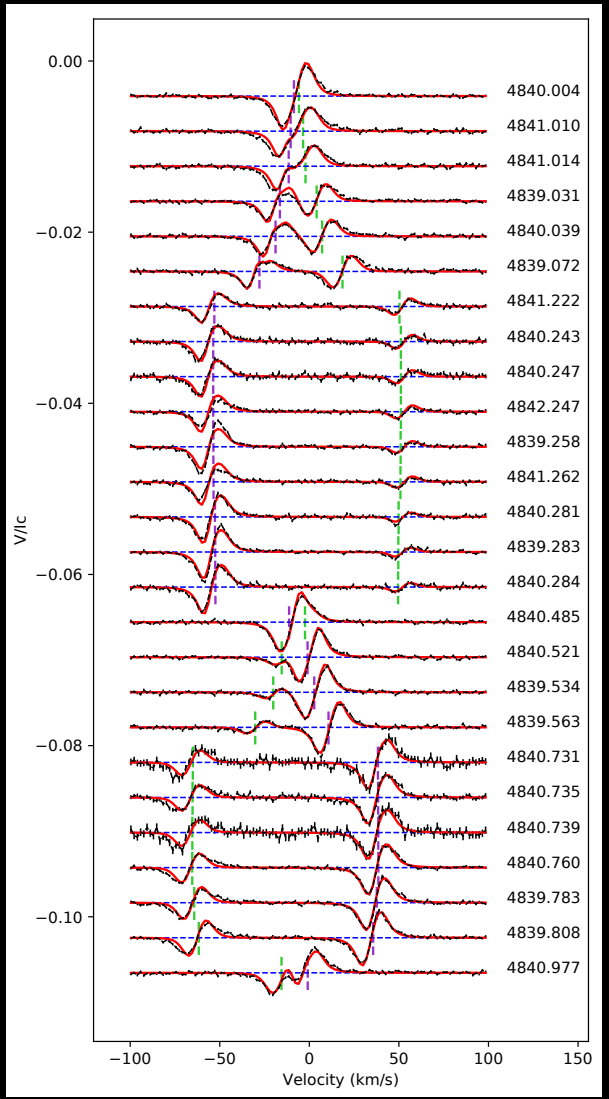
Analysis

- LSD method
- Radial velocities
- Orbital parameters – PHOEBE
- Bl, Hα, CaII H&K, CaII IRT
- ZDI technique

FK Aqr - LSD

- Least-squares deconvolution method (J.-F. Donati+ 1997)





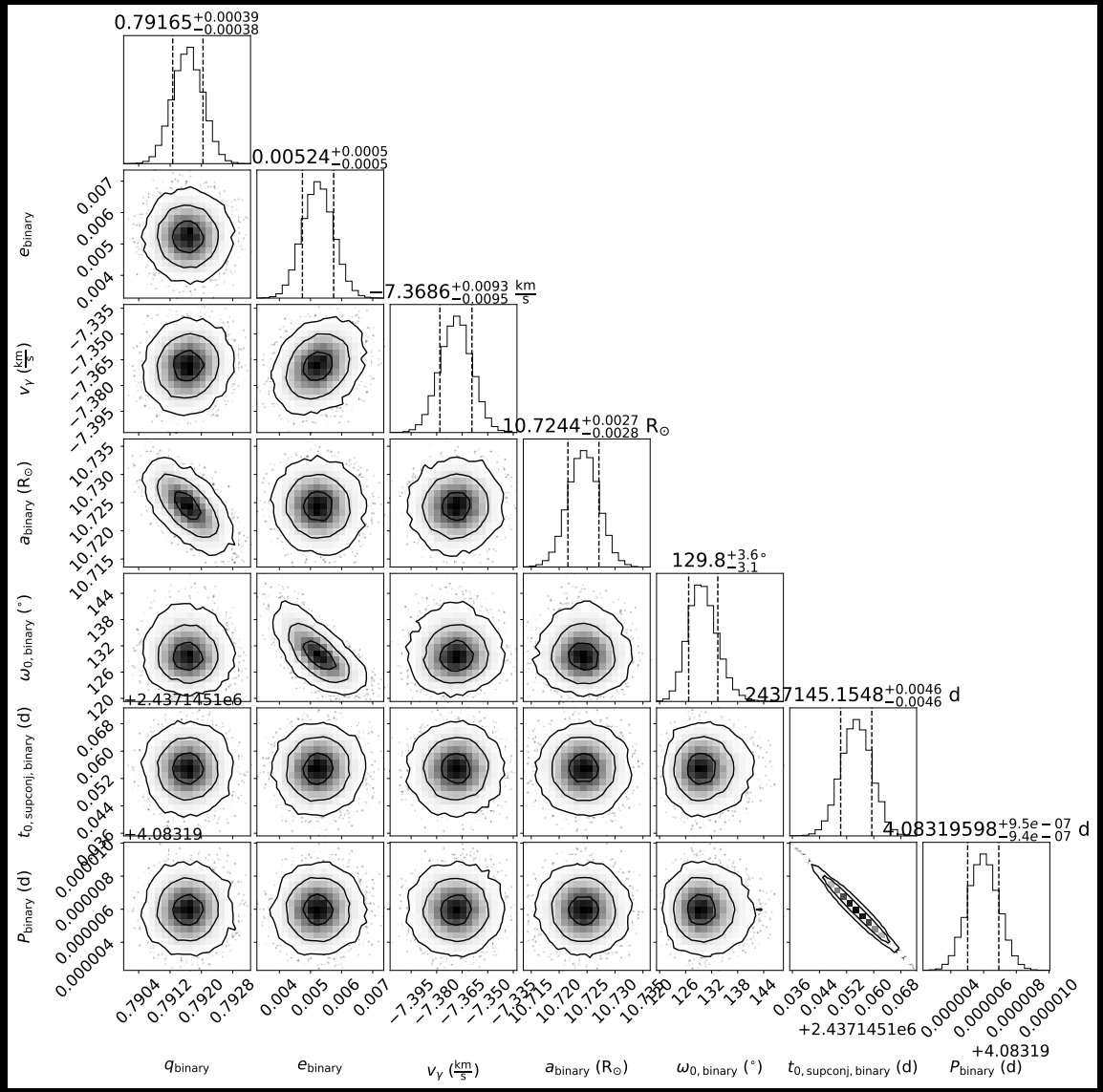
FK Aqr - RV

- Radial velocities are measured from Stokes I profiles.
- Combined with measurements from G.H. Herbig & J.M. Moorhead 1965

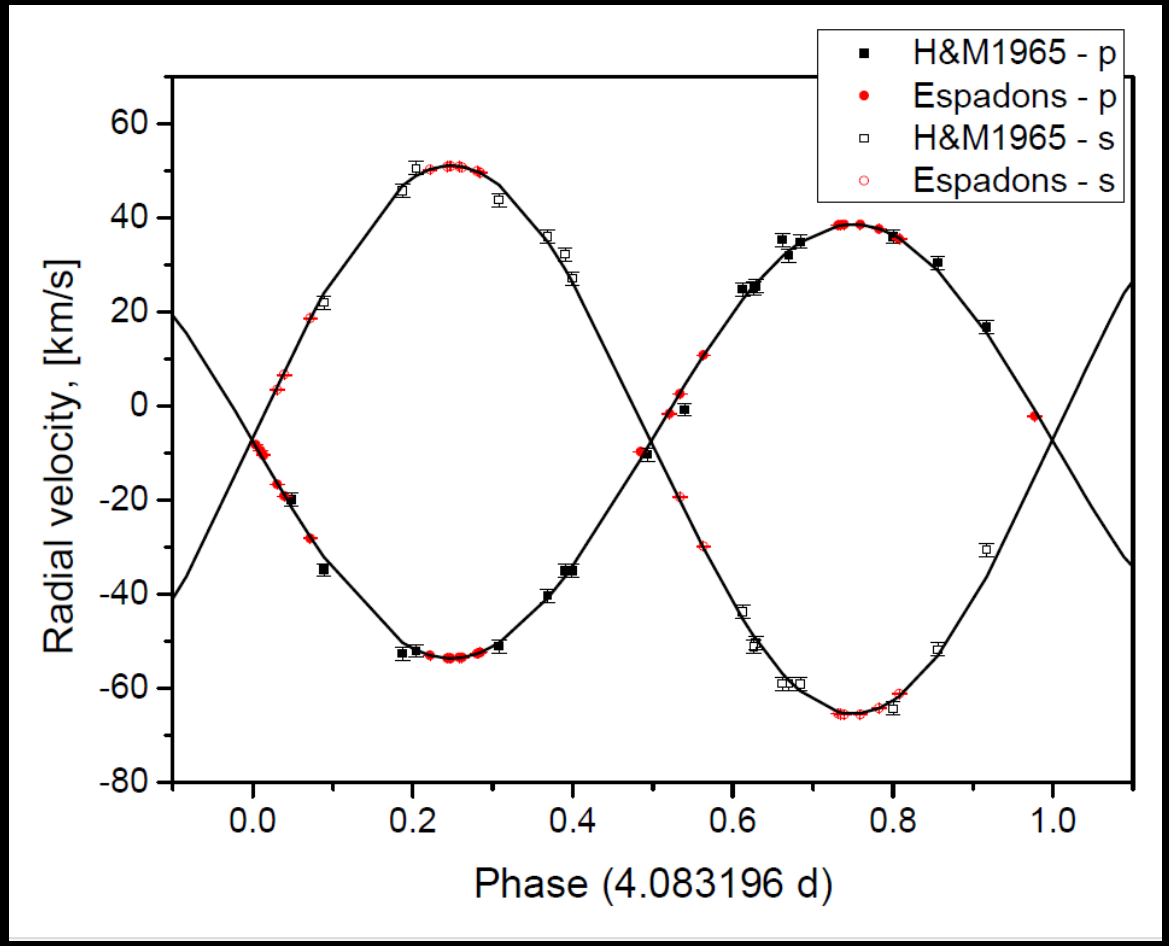
FK Aqr - PHOEBE

- Binary modeling code (Prsa & Zwitter 2005, Prsa+ 2016)
- MCMC sampler
- 30 walkers, 50 000 iterations

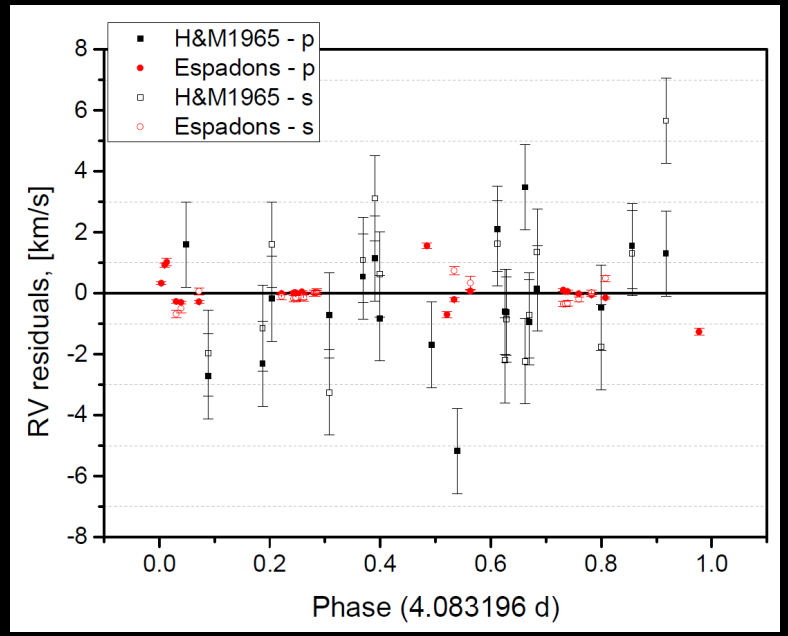
FK Aqr - PHOEBE



FK Aqr - PHOEBE

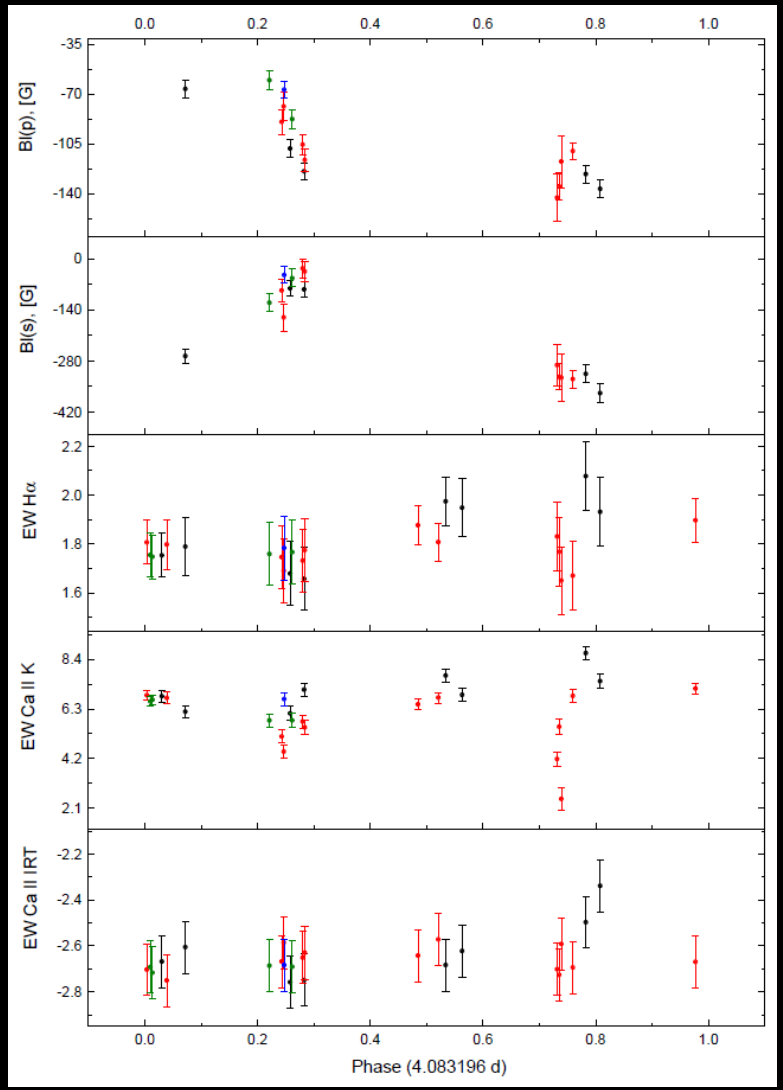


RV residuals



$X^2 = 1.3$ (p)

$X^2 = 1.5$ (s)

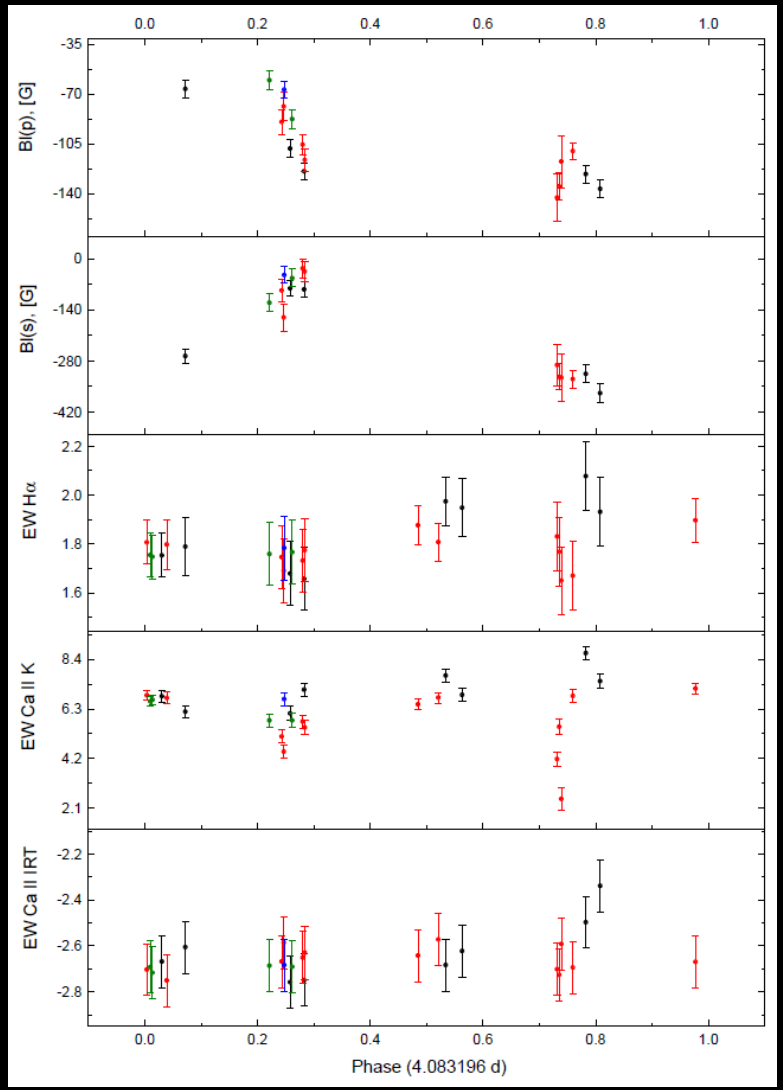


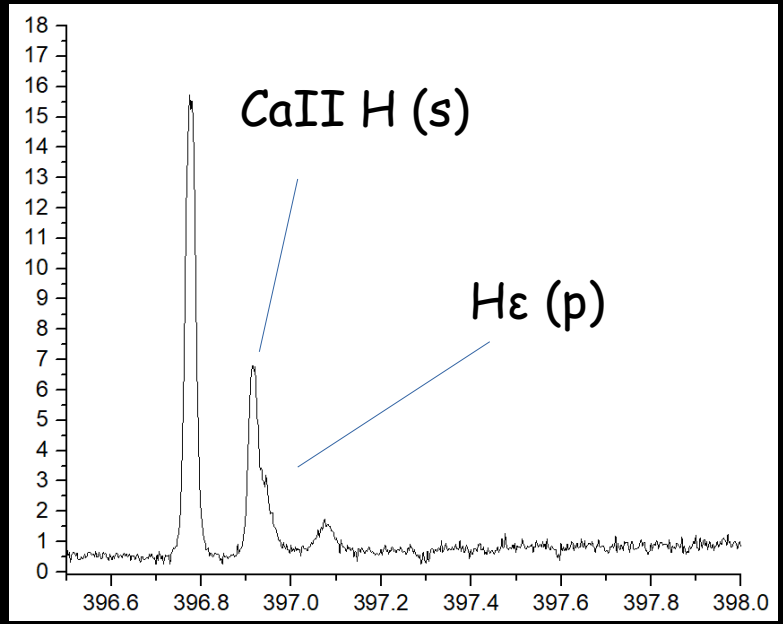
FK Aqr – Bl, Hα, CaII H&K, CaII IRT

Primary : (-143) - (-60) *G*

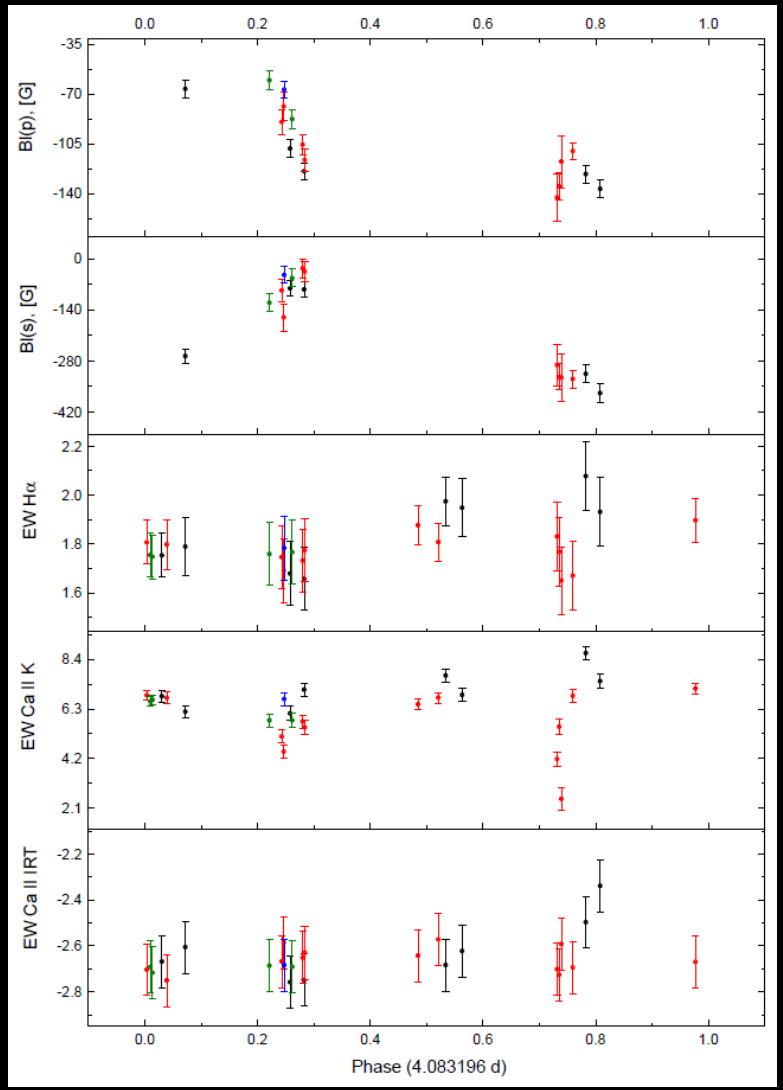
Secondary : (-368) - (-27) *G*

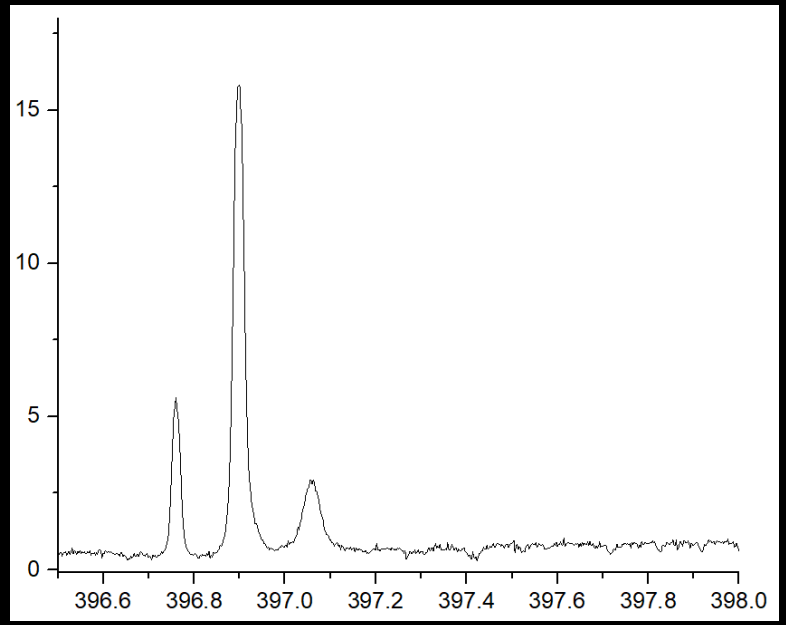
FK Aqr – Bl, Hα, CaII H&K, CaII IRT

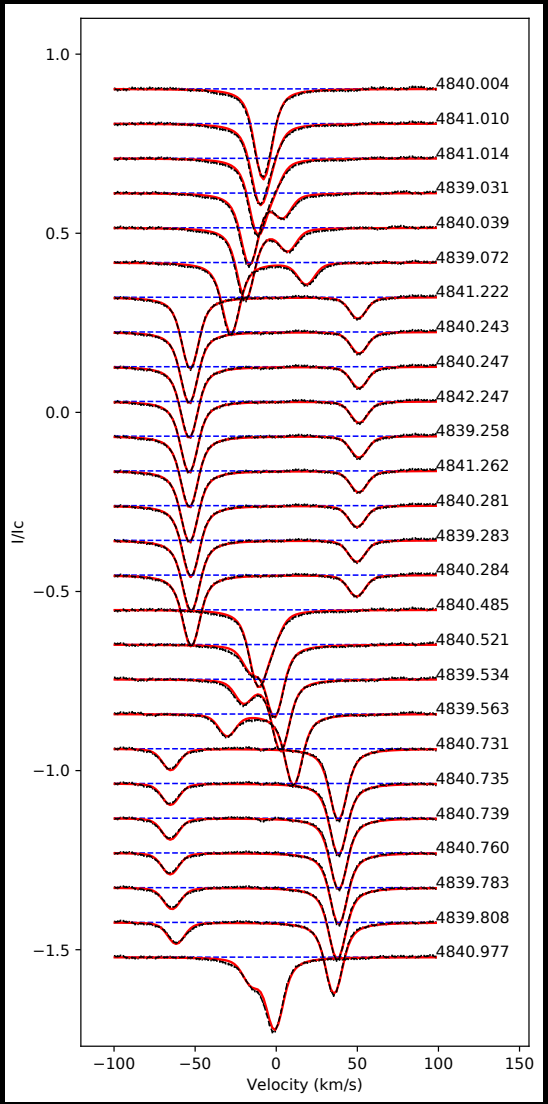


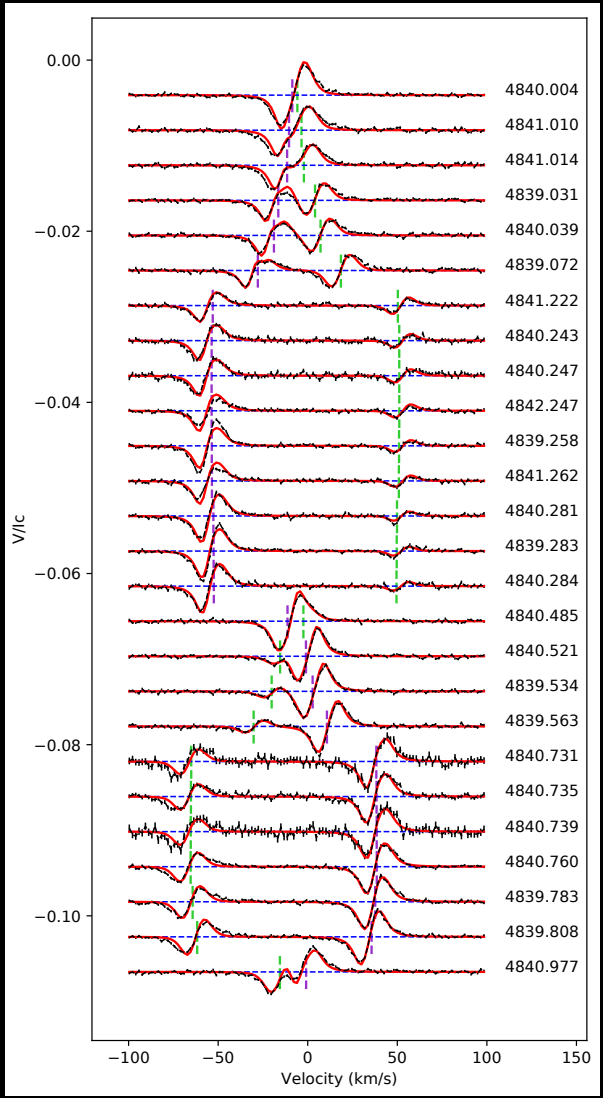


FK Aqr – Bl, Hα, CaII H&K, CaII IRT



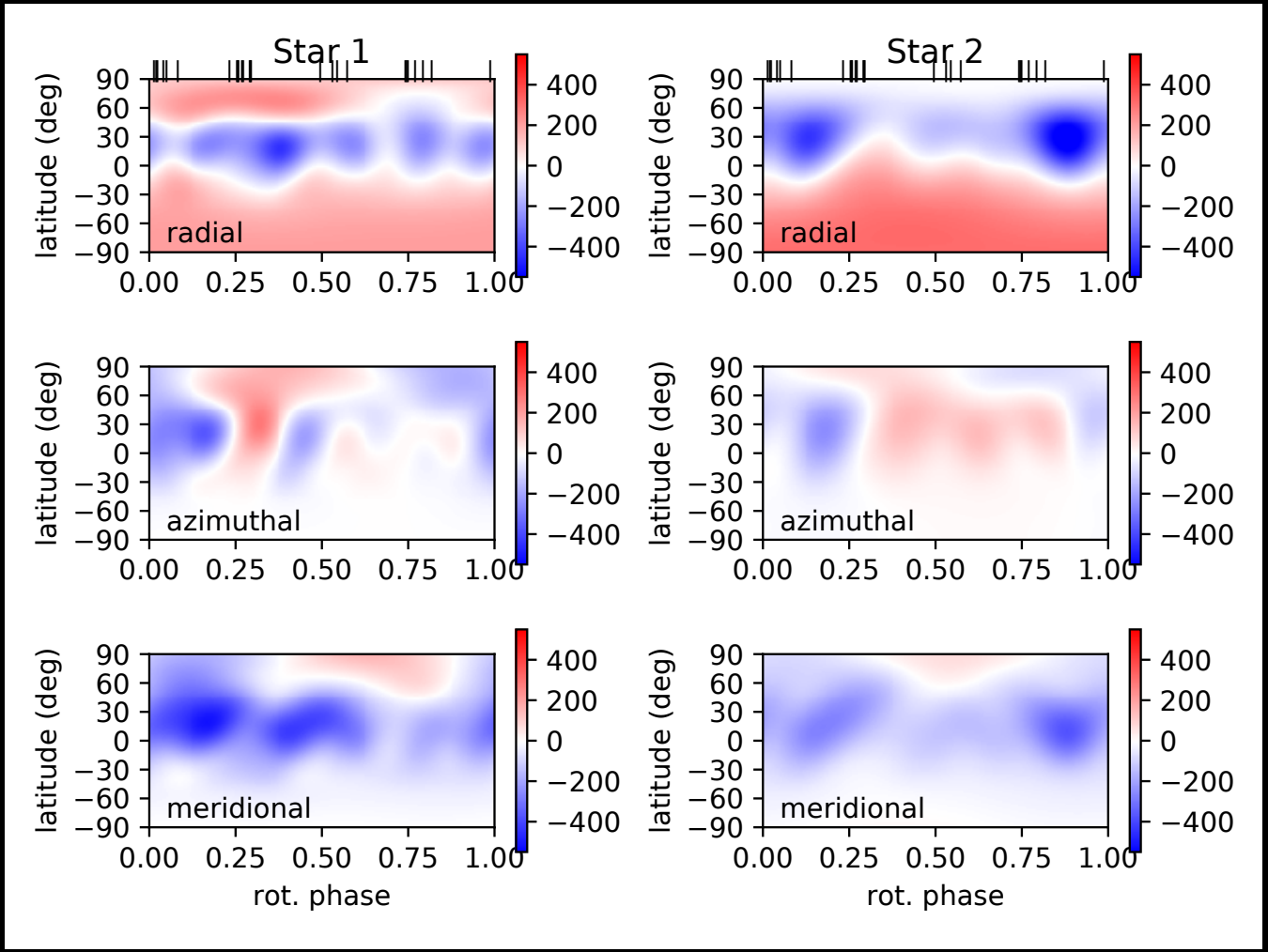






FK Aqr – ZDI

- Zeeman Doppler Imaging tomographic method (Semel 1989, Donati & Brown 1997, Donati+ 2006)
- $X^2 = 1.7$
- The strength, Gauss & Lorentz widths : intervals 0.5 – 5.0 with a step of 0.1



FK Aqr - ZDI

- Zeeman Doppler Imaging tomographic method (Semel 1989, Donati & Brown 1997, Donati+ 2006)
- $X^2 = 1.7$

FK Aqr - ZDI

Table 4. The magnetic analysis of the components of FK Aqr.

component	B_{mean} [G]	B_{max} [G]	poloidal [% tot]	toroidal [% tot]	dipole [% pol]	quadrupole [% pol]	octopole [% pol]	axisymmetric [% tot]
primary	248.8	675.4	89.6	10.4	56.8	22.1	13.0	72.1
secondary	250.8	702.8	95.9	4.1	78.5	9.6	7.5	70.4

Thank you for your attention!