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# Looking for Magnetic Fields in Kepler Red Giants

**J. Ballot[1], M. Aurière[1], S. Deheuvels[1], R. A. García[2], F. Lignières[1], S. Mathur[3], P. Petit[1]**

[1] IRAP, CNRS, Université de Toulouse, UPS-OMP, Toulouse, France

[2] AIM, CEA/DRF, CNRS, Univ. Paris Diderot, IRFU/SAp, Gif s/ Yvette, France

[3] Space Science Institute, Boulder, CO, USA

# In short...

- **We observed four $\ell = 1$ depressed red giants with the spectropolarimeters CFHT/ESPaDOnS and TBL/Narval in 2012 & 2013**
  - Circular polarization provides longitudinal magnetic field measurements through Zeeman effect
- **We detect a polarised signature in Droopy (KIC 8561221)**
  - This signature is compatible with a 4 G magnetic field
  - The signature is stable over 6 months
  - We put an upper limit of 2 or 3 G on others targets
- **This magnetic field intensity is compatible with red giants in the sample of Aurière et al. (2015)**

# Our sample

- **We choose 4 Kepler red giants with $\ell$=1 depressed modes at different evolutionary stages**

| | KIC | Name | V | $T_{\rm eff}$ [K] | $\nu_{\rm max}$ [μHz] | log $g$ | M/M$_\odot$ | |
|---|---|---|---|---|---|---|---|---|
| RG1 | 8561221 | BD+443149 | 10.08 | 5230 ± 70 | 495 ± 20 | 3.62 | 1.51 ± 0.19 | Droopy |
| RG2 | 9073950 | TYC 3541-1690-1 | 11.52 | 5280 ± 75 | 295 ± 22 | 3.40 | 1.46 ± 0.82 | |
| RG3 | 11973853 | TYC 3565-225-1 | 11.92 | 5220 ± 80 | 200 ± 10 | 3.23 | 1.74 ± 0.41 | |
| RG4 | 3443483 | TYC 3134-244-1 | 11.81 | 5100 ± 110 | 130 ± 7 | 3.05 | 1.80 ± 0.57 | |

- Low-amplitude $\ell$ = 1 modes were reported by Mosser et al. (2012) in a few percents of Kepler red giants.
- The youngest one is KIC 8561221 (Droopy) analysed by García et al. (2014)
- Recent studies by Fuller et al. (2015) explained this behaviour as the signature of a strong buried magnetic field

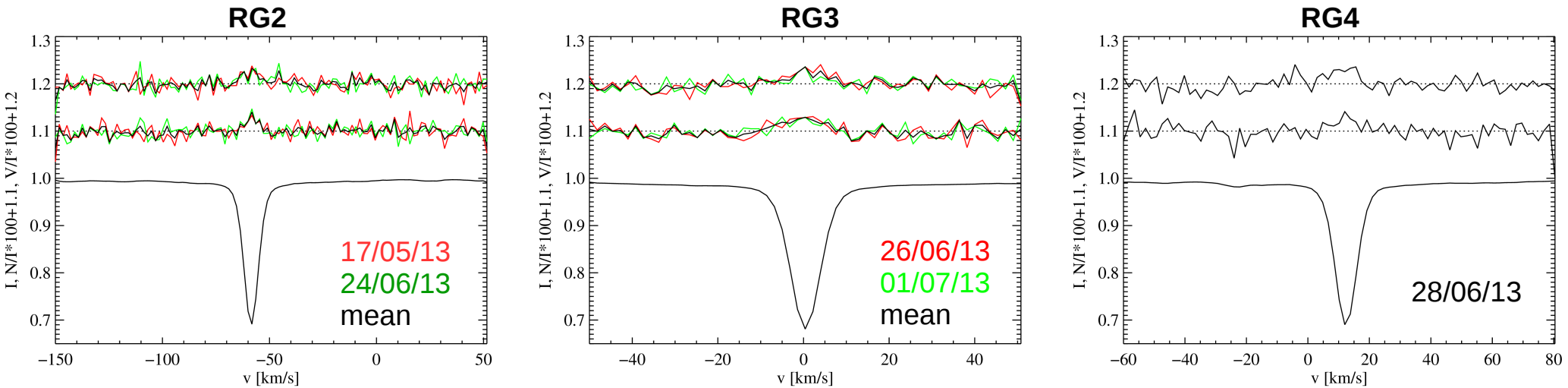
# Observations & methods

- **We observed our sample with CFHT/ESPaDOnS in 2013**
  - ESPaDOnS is a stellar spectropolarimeter installed at Canada-France-Hawaii Telescope (Mauna Kea Observatory, Hawaii)
  - We observed circularly polarized (Stokes V) spectra
  - All spectra are processed with the least-squares-deconvolution (LSD) technique (Donati et al. 1997) to extract a mean profile of absorption lines
  - Observation times are adjusted to reach a S/N of ~200

| Name | V | $T_{\rm eff}$ [K] | log $g$ | Observation sequence | Number of seq. | Total time |
|---|---|---|---|---|---|---|
| BD+443149 | 10.08 | 5230 | 3.62 | 4 × 450 s | 1 | 30 min |
| TYC 3541-1690-1 | 11.52 | 5280 | 3.40 | 4 × 675 s | 2 | 1hr 30 min |
| TYC 3565-225-1 | 11.92 | 5220 | 3.23 | 4 × 900 s | 2 | 2 hrs |
| TYC 3134-244-1 | 11.81 | 5100 | 3.05 | 4 × 900 s | 2 | 2 hrs |

# LSD profiles of RG2 – RG3 – RG4

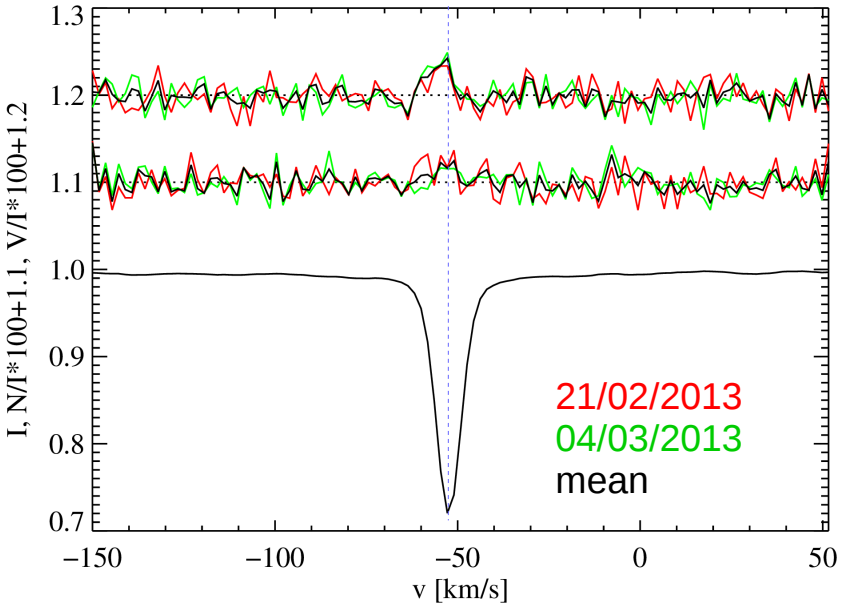
- **No significant polarimetric signature has been detected in KIC9073950, KIC11973853 & KIC3443483**
  - The longitudinal magnetic field is smaller than ~2-3 Gauss




*For each panel, from top to bottom: V/I LSD profile (circularly polarised spectra), Null LSD profile, and I (Intensity) LSD profile. RG2 & RG3 have been observed two nights. Individual spectra are shown in red and green, and the average is plotted in black*

# LSD Profiles of Droopy (1)

- **Observations**
  - Droopy has been observed two nights with ESPaDOnS:
    - 21/02/2013 (bad S/N)
    - 04/03/2013 (marginal detection)
- **The average of the two spectra provides us a *significant detection* in Stokes V in KIC 8561221**
  - Longitudinal magnetic field **B ~ 4 G**
  - The polarized signature is not purely antisymmetric as expected for a standard Zeeman effect.
    → it still has to be interpreted

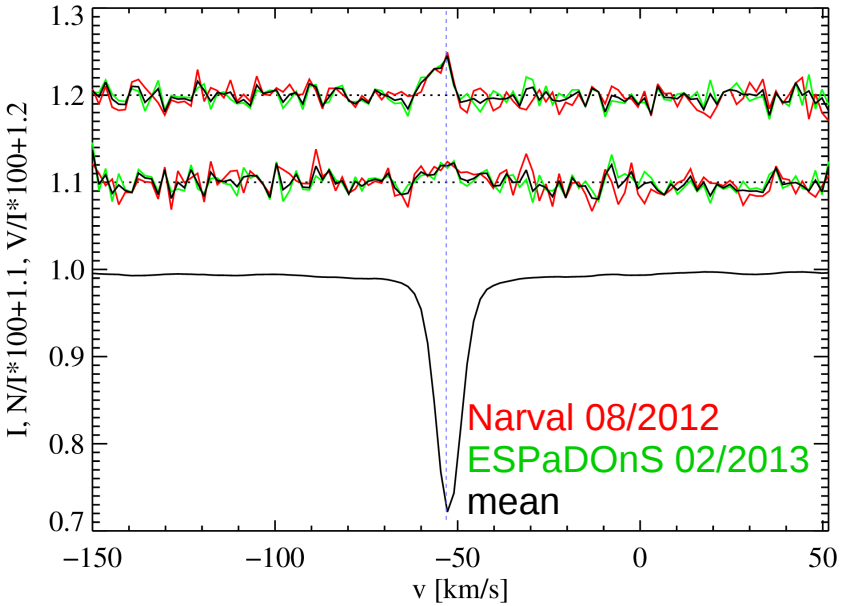



*See caption above. The first spectrum (21/02/2013) is too noisy to show a significant signature, the detection is marginal in the second one (04/03/2013), the average provides us a significant detection.*

# LSD Profiles of Droopy (2)

## Narval observations

- We also observed Droopy in 2012 with Narval, a twin spectropolarimeter of ESPaDOnS installed at Telescope Bernard Lyot (Pic du Midi Observatory, France)
- We observed Droopy 2 nights (14 & 23/08/2012) without detecting significant polarimetric signature.
- We detect a marginally significant signal in the average of the two spectra.




*See caption above. The average spectrum observed by Narval in summer 2012 and the one observed by ESPaDOnS in winter 2013 perfectly overlap, this indicates a stable signal.*

## Comparison between both epochs

- The signatures observed with 2 different instruments at 2 different epochs are very similar
  → ***stable signal***
  → similar rotation phase (?)

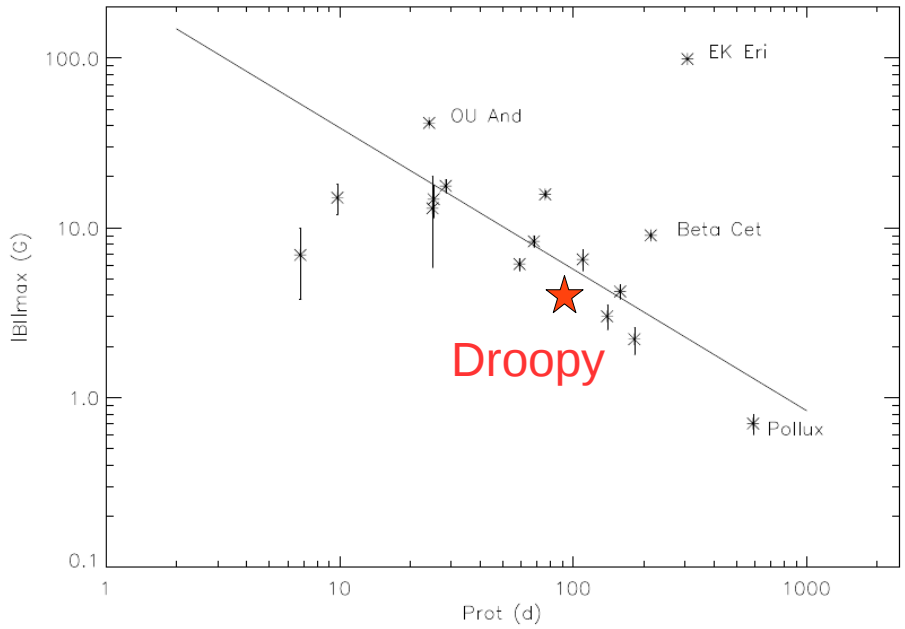
# Comparison with other red giants

## Sample of Aurière et al. (2015)

- Aurière et al. (2015) monitored a large sample of red giants looking after magnetic signature
- Some red giants show abnormally large magnetic fields, such as EK Eri. They are suspected to be the descendants of Ap stars
- The majority of objects follow a global trend compatible with a dynamo field generated in the convective envelope

## Droopy follows the normal trend

- By assuming a rotation period of 91 days (Garcia et al., 2014)




*After Aurière et al. (2015). Maximal longitudinal magnetic field observed in red giants as a function of rotation period. Droopy has been added as a red star.*

# References


- M. Aurière et al., A&A 574, A90 (2015)
- J. Fuller et al., Science 350, 423 (2015)
- R. A. García et al., A&A 563, A84 (2014)
- B. Mosser et al., A&A 537, A30 (2012)