

Magnetic Fields on Low Mass Ultra Fast Rotators using TESS and FORS2



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INTRODUCTION

Stars which are rapidly rotating are expected to show high levels of activity according to the activity-rotation relation. However, previous TESS studies have found groups of Ultra Fast Rotating (UFR) stars with periods less than one day displaying low levels of flaring activity. As a result, in this study, we are utilising VLT/FORS2 spectropolarimetric data of 10 low mass UFR stars all with $P_{\text{rot}} < 1$ day, to detect the presence of a magnetic field. We also have TESS 2-min lightcurves from cycles 1 & 3 allowing for the investigation of long-term variability in all of our targets.

2. OUR PILOT STUDY

TIC ID	NAME	P_{rot} (days)	MORE FLARE ACTIVE
425937691	UCAC3 53-724	0.10	✓
15859311	UCAC4 204-001345	0.154	
206544316	UPM J0113-5939	0.322	✓
156002545	2MASS J0033-5116	0.353	
248354845	GSC 04683-02117	0.522	✓
229142295	2MASS J0146-5339	0.447	
220539110	GSC 08859-00633	0.773	
166808151	EXO 0235.2-5216	0.740	✓
141807839	AL 442	0.839	✓
201861769	2MASS J0232-5746	0.862	

- ★ Obtained spectropolarimetric observations using the VLT/FORS2 instrument during December 2020.
- ★ Total of 5 period bins, each with one less active and one more active star taken from the larger sample of Doyle et al. (2019).

4. VARIATIONS BETWEEN TESS CYCLES

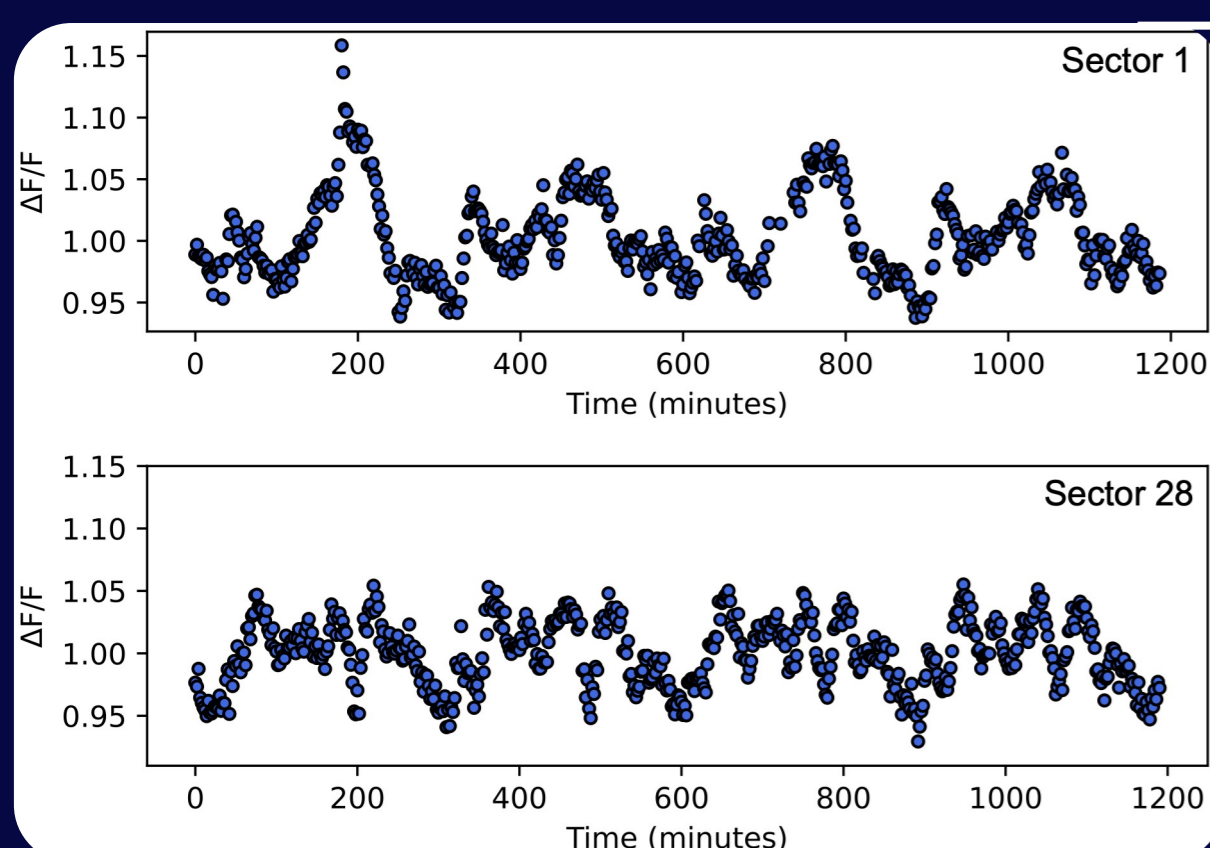
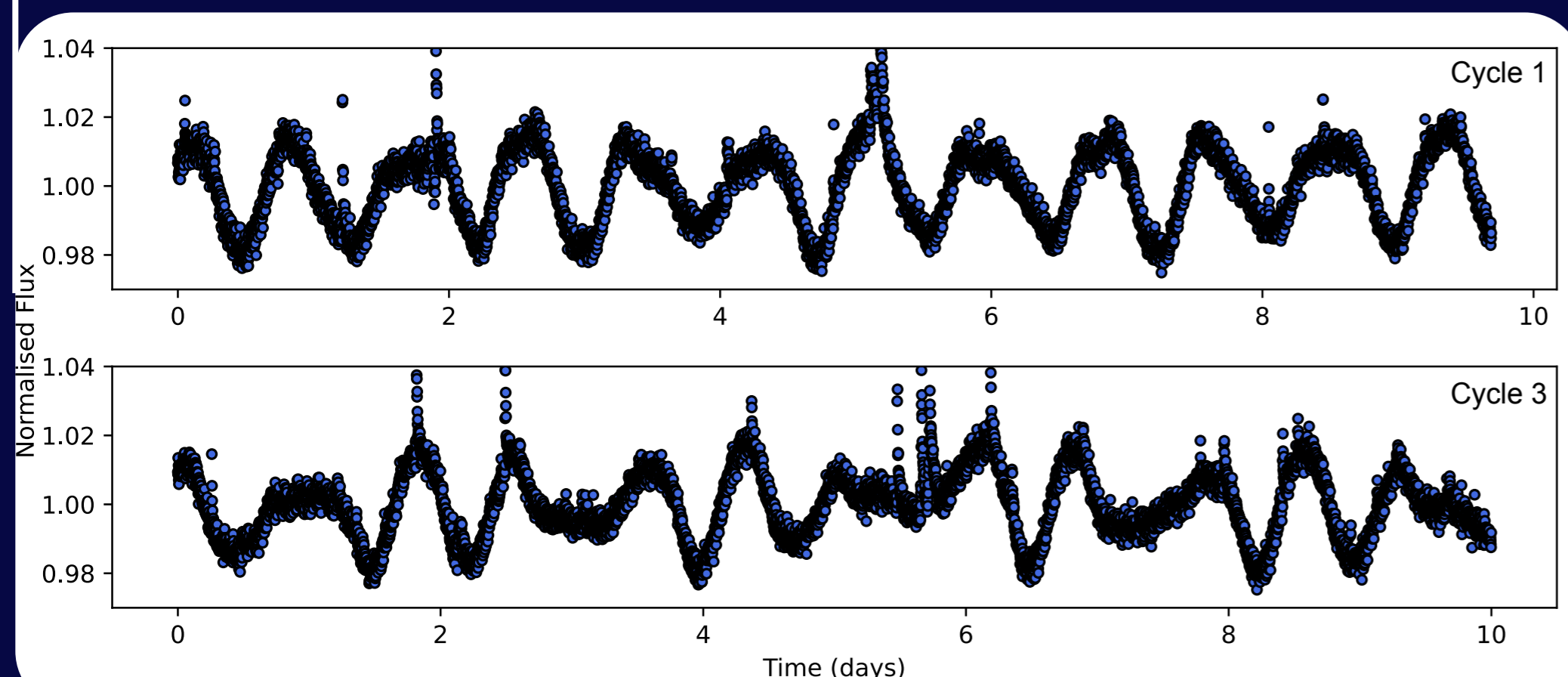


Figure 3: Two portions from TESS lightcurves of the M5.5 dwarf UCAC3 53-724 (TIC 425937691). The upper panel shows a section from sector 1 and the lower panel a section from sector 28, taken approximately 2 years apart.

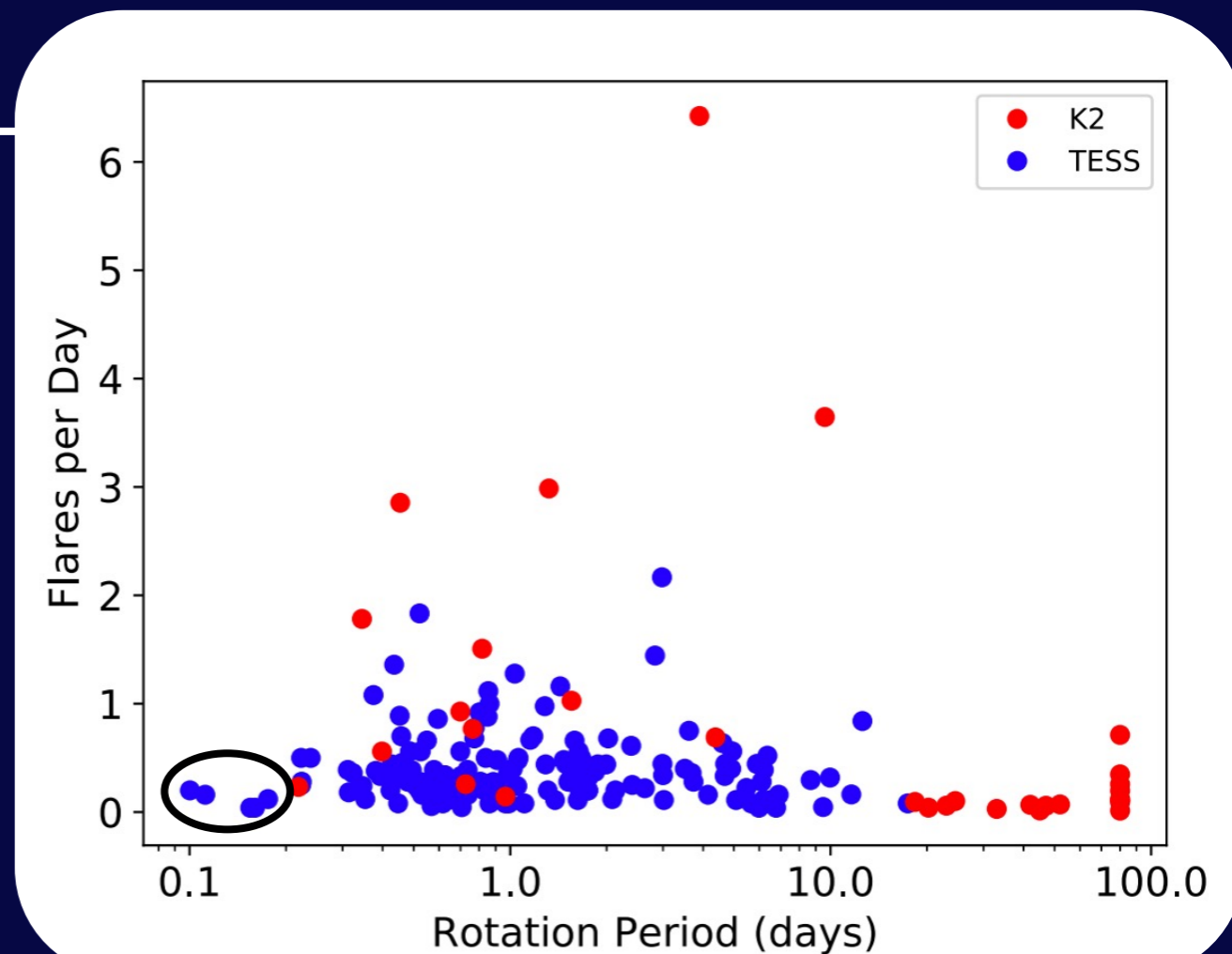
- ★ **TIC 425937691:** Change in the shape of the rotational modulation caused by manifesting spots resulting in a 10^{34} erg flare.
- ★ **TIC 141807839:** Changes in the shape of the modulation between cycles, no change in flare activity. Could this be migrating spots?

Figure 4: Two sections of TESS lightcurves from cycle 1 (top panel) and cycle 3 (bottom panel) of the M4.5 dwarf AL~442 (TIC 141807839).



1. PREVIOUS STUDIES

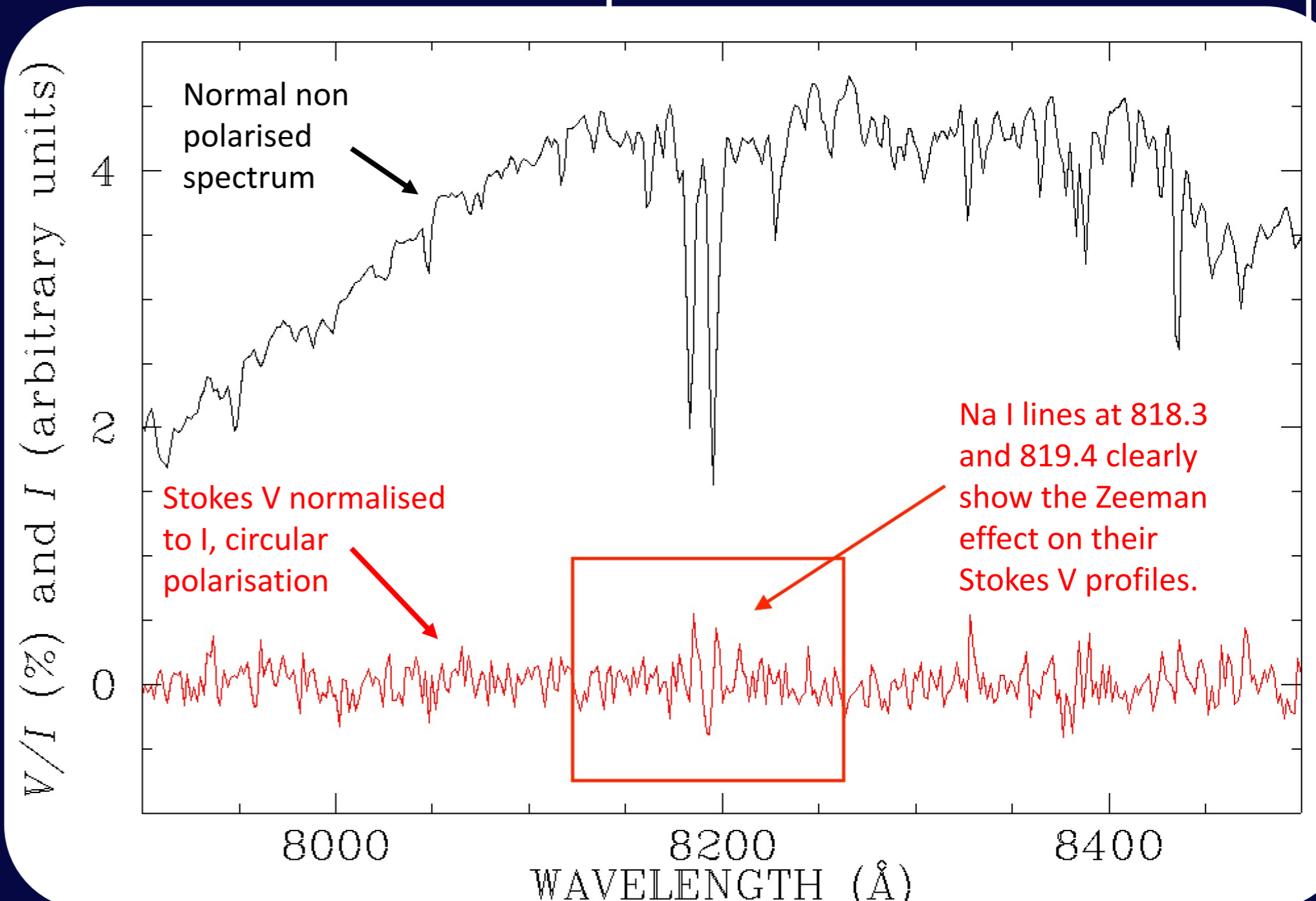
Figure 1: Normalised number of flares per day for each star as a function of rotation period. The red represent the stars from Doyle et al. (2018) using K2 short cadence data, and the blue the 149 targets from Doyle et al. (2019) using TESS 2-min cadence data.



- ★ In Doyle et al. (2019), we discovered 9 low mass UFRs (black circle in Fig. 1) in sectors 1-3 of TESS data with low levels of flaring activity, rotating with $P_{\text{rot}} < 0.3$ days.
- ★ Ramsay et al. (2020) investigated this further on 609 low mass stars using TESS data from sectors 1-13. The fraction of stars which show flares appears to drop significantly at $P_{\text{rot}} < 0.2$ days.
- ★ This is consistent with Gunther et al. (2020) who find tentative evidence for a drop-in flaring activity at $P_{\text{rot}} < 0.3$ days in the first two months of TESS data.

3. VLT/FORS2 RESULTS

Figure 2: The FORS2 spectra of AL 442.



- ★ Identified **5 stars** (50% of our sample) with a detectable magnetic field.
- ★ Of these, **four** were the **more active stars** in the period bins.
- ★ All magnetic fields detected have a strength < 1 kG.
- ★ We **do not** detect a magnetic field on our fastest rotating star UCAC3 53-724 which has a rotation period of 0.1 days.

5. CONCLUSIONS

- ★ We used TESS and FORS2 data to conduct a pilot study into the magnetic fields of low mass UFR stars. **50% of our sample showed evidence of a detectable field**, out of these four were the more active star in our period bin.
- ★ This tells us the **magnetic field configuration of these UFRs is not the key to solving the lack of their flaring activity!**
- ★ Two targets (TIC 425937691 and TIC 141807839) show changes in the shape of the rotational modulation and/or flare number between cycle 1 & 3, **indicative of long-term variability.**

References:

Doyle L., Ramsay G., Doyle J. G., Wu K., (2019), MNRAS, 489, 437 – 445 ; Doyle L., Ramsay G., Doyle J. G., Wu K., Scullion E., (2018), MNRAS, 480 (2), 2153 – 2164 ; Günther et al. (2020), AJ, 159, 60 ; Ramsay G., Doyle J.G., Doyle L., (2020), MNRAS, 497 (2), 2320-2326