A change in the relationship between chromospheric activity and the large-scale magnetic field for G stars on the main sequence

E. L. Brown[1], S. V. Jeffers[2], S. C. Marsden[1], J. Morin[3], S. Boro Saikia[4], P. Petit[5], M. M. Jardine[6], V. See[7,8], A. A. Vidotto[9,10], M. W. Mengel[1], M. N. Dahlkemper[11,12] and the BCool Collaboration

[1] University of Southern Queensland; [2] Max Planck Institut for Solar System Research, Göttingen; [3] Université de Montpellier, CNRS; [4] University of Vienna; [5] Université de Toulouse, CNRS; [6] University of St Andrews; [7] European Space Agency; [8] University of Exeter; [9] Trinity College Dublin; [10] Leiden University; [11] University of Göttingen; [12] CERN, Switzerland

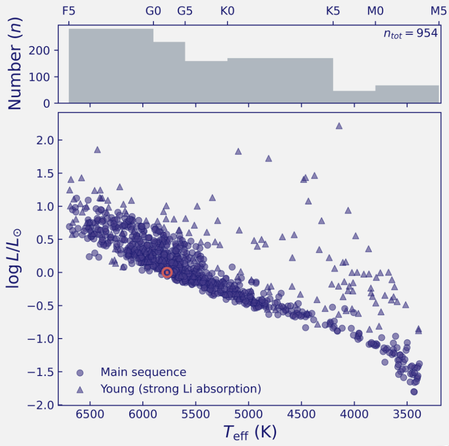
emma.brown@usq.edu.au Emma Brown The BCool Collaboration

We present a database of chromospheric activity and magnetic field strengths for 954 F-M dwarf stars

The internal magnetic fields of cool stars are known to power activity in stellar chromospheres, but there is still much to learn about the nature of this relationship and its dependence on stellar properties.

We draw on data from PolarBase, a rich legacy database of observations from the spectropolarimeters ESPaDOnS (CFHT) and NARVAL (TBL), to survey the chromospheric activity and large-scale magnetic field strengths for 954 F-M dwarf stars.

Our active sample complements previous chromospheric activity surveys that usually focus on inactive, planet search targets.

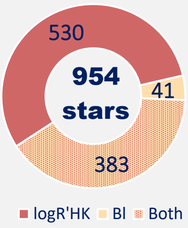


Method

We measure mean chromospheric activity, mean longitudinal field strength and their peak-to-peak variability amplitudes over time-scales of up to 15 yrs, and combine our data with archival activity data and published magnetic field geometries derived using Zeeman Doppler Imaging.

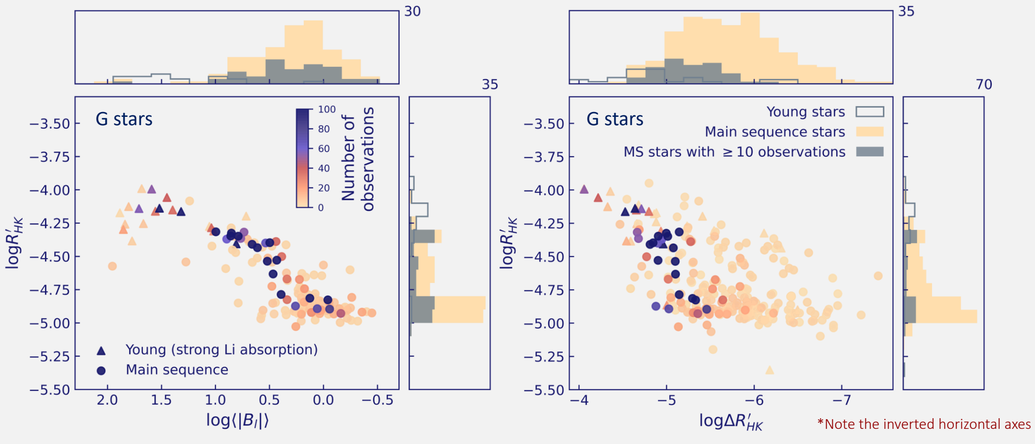
Chromospheric activity is measured as log R'_{HK} from the emissions in the cores of the CaII H and K lines [1,2,3,4].

Longitudinal magnetic field strength, B_l, is measured from high SNR, least-squares deconvolved spectral line profiles [5].



Key Findings

G stars with a high number of observations (red to dark blue markers) show an initial decrease in chromospheric activity, logR'_{HK}, with decreasing magnetic field strength, log$\langle|B_l|\rangle$, and chromospheric activity variability, log$\Delta R'_{HK}$. This is followed by an **abrupt drop in the mean chromospheric activity** from logR'_{HK} ~-4.4 to -4.8, with **little change in the mean magnetic field strength or the amplitude of chromospheric activity variability.** The relationships between activity, activity variability and magnetic field strength then appear to return to a gradually decreasing trend.



*Note the inverted horizontal axes

The drop in chromospheric activity on the main sequence **is not the same** as the **drop in activity between young and main sequence stars**, which occurs in the both the logR'_{HK} and log$\langle|B_l|\rangle$.

The **relationship change** for main sequence G stars occurs at a **rotation period of ~15 d**, and at a similar activity level as the **transition from mixed (poloidal and toroidal) to dominantly poloidal magnetic field geometries**.

F, K and M stars may show a comparatively smooth relation between chromospheric activity, magnetic field strength, and their variability amplitudes, but further data are required to confirm this.

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The takeaway

There is an **abrupt drop in chromospheric activity for G stars** on the main sequence but **no corresponding drop in magnetic field strength, nor activity variability**. The drop is therefore likely to be related to a change in the properties of the magnetic dynamo, rather than a rapid evolutionary phase.

Possibilities: a change in the area ratio of spots to plages?

References: [1] Vaughan et al., 1978, PASP, 90, 267; [2] Noyes et al., 1984, ApJ, 279, 763; [3] Marsden et al., 2014, MNRAS, 444, 3517; [4] Suarez Mascareno et al., 2015, MNRAS, 452, 2745; [5] Donati et al., 1997, MNRAS, 291, 658