Long-Term Stellar Activity Variation and its Influence on Radial-Velocity Measurements: The Case of M dwarfs

Centro de Astrofísica da Universidade do Porto

U.PORTO FACULDADE DE CIÊNCIAS UNIVERSIDADE DO PORTO

J. Gomes da Silva[1,2], N.C. Santos[1,2], X. Bonfils[3], X. Dumusque[1,4], X. Delfosse[3], T. Forveille[3], S. Udry[4]

Joao.Silva@astro.up.pt

[1]Centro de Astrofísica da Universidade do Porto, Rua das Estrelas, 4150-762 Porto, Portugal
[2]Departamento de Física e Astronomia, Faculdade de Ciências da Universidade do Porto, Portugal
[3]UJF-Grenoble 1 / CNRS-INSU, Institut de Planétologie et d'Astrophysique de Grenoble (IPAG) UMR 5274, Grenoble, F-38041, France
[4]Observatoire de Genève, 51 ch. des Maillettes, 1290 Sauverny, Switzerland

LAOG Laboratoire d'AstrOphysique de Grenoble

Observatoire de Genève Fondé en 1772

1 Motivation

- Other stars are known to have magnetic cycles simillar to that of the Sun (Baliunas et al. 1995)
- This can be a source of periodic long-term radial-velocity (RV) variations (Dravins 1985) that can interfer with the detection of long-period planets
- Recently we studied these signals for a small sample of K dwarfs with known activity cycles and found the signals to be stable at the ~1 m/s level (Santos et al. 2010)
- There are no compreensive studies about the influence of activity cycles on RV for M dwarfs

The aim of this study is to establish if it is possible for long-term cycle-type activity variations to induce RV signals

2 Sample & analysis

Sample:
- Observations using HARPS spectrograph (ESO 3.6-m, La Silla, Chile)
- Timespan of ~6 years
- 104 nearby M-dwarf stars from HARPS M-dwarf planet search program (Bonfils et al. 2005)

Parameters obtained:
- Four activity indices ($S_{\rm CaII}$, Hα, Na I, and He I)
- Precise radial-velocities at the ~1 m/s level
- CCF parameters: bisector inverse span (BIS), FWHM, and contrast

Data analysis:
- Bins of 150 days to average out short-timescale variations
- Each bin with at least 3 observations
- Selection of stars with more than 4 bins

Resulted in sample of 30 stars (M0-M5.5)

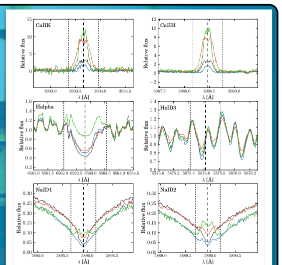

Fig. 1: Bands used to calculate the flux at the cores of the lines.

3 Correlation between activity indices (Gomes da Silva et al. 2011, submitted)

Data for $S_{\rm CaII}$ was selected with S/N > 2 (at spec. order 6):
- Subsample of 23 stars

Percentage of stars that passed variability F-tests (P < 0.05):
- $S_{\rm CaII}$: 39%
- Hα: 33%
- NaI: 37%
- HeI: 10%

Conclusions:
- ~36% of our sample show significant long-term variability
- HeI index not long-term variable for M dwarfs (not good to detect activity cycles)
- Activity cycles could be detected with either of the 3 other activity proxies

Correlation between the indices with FAP < 0.05:
- *S*-Hα: 26% (trend with average *S*)
- *S*-NaI: 70% (no trend with *S*,NaI or colour)
- *S*-HeI: 13% (trend with average *S*)

Conclusions:
- Hα and HeI have different behaviour than $S_{\rm CaII}$
- NaI index is a very good proxy of $S_{\rm CaII}$ long-term activity variations (as previously suggested by Díaz et al. (2007) for Hα emission stars)
- Should be preferred instead of *S* due to the better S/N at the spectral order

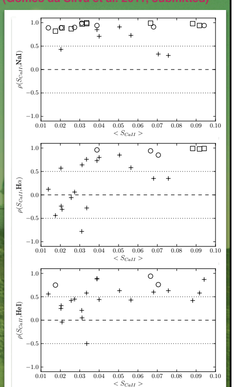

Fig. 2: Correlation coefficients versus average $S_{\rm CaII}$ for 23 stars. Open symbols have FAP < 0.05.

4 Correlation between activity and RV (Gomes da Silva et al. 2011, in prep.)

Added data obtained in 2010
Used NaI as activity indicator (better S/N)
All stars corrected for secular acceleration
All known planetary signals removed from RV

New selection criteria:
- Tspan > 3 yrs:
  - selection of 27 stars
- Variability F-tests for NaI with P(F) < 0.05:
  - selection of 14 stars

Results:
- 52% of stars show long-term activity variability (increase of 15% of variability due to one more year of observations)
- 36% of stars with long-term activity variability have significant correlation between activity and velocity (with FAP < 0.05)
- There is no dependence of the slope (RV,NaI) with colour or activity level
- Tendency for positive correlation coefficients
- No strong negative correlations found
- No significant correlations between RV and BIS, FWHM or contrast of the CCF
- 6 stars have significant correlation between NaI and FWHM (3 of them with strong correlation RV-NaI)

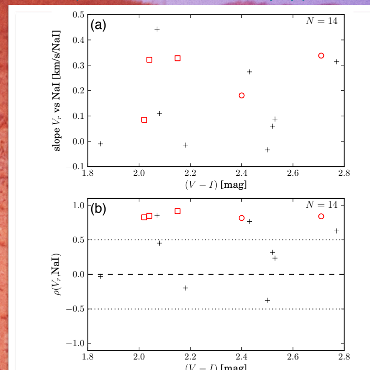

Fig. 3: (a) Slope of the correlation and (b) correlation coefficient between RV and Na I as a function of colour. Red points have FAP < 0.05 for the correlation coefficient.

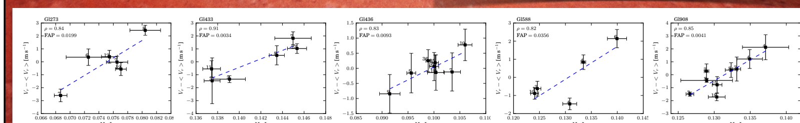

Fig. 4: Radial-velocity versus Na I index for the 5 stars with significant correlation. Blue line is best fit to data.

Conclusions

▼ We confirmed that, as recently demonstrated by Meunier et al. (2009) in their solar simulations, **the Hα index does not strictly follow the long-term activity as measured by $S_{\rm CaII}$** for the least active M dwarfs

▼ **The Na I index should be preferred** to the $S_{\rm CaII}$, Hα, or He I when analysing long-term activity of M dwarfs

▼ **Around half of the stars in our sample show long-term activity variability**

▼ **No general correlation between long-term activity and RV for M dwarfs** at the ~1 m/s level (as expected from Dumusque et al. 2011)

=> M dwarfs are good targets for long-period and low mass planet searches

▼ But, some particular cases appear to show RV influenced by long-term activity (with sig(RV) < 1.5 m/s)

▼ **Caution must be taken when looking for long-period planets around these stars - they should be analysed on an individual basis**

Acknowledgments

This work has been supported by the European Research Council/European Community under the FP7 through a Starting Grant, as well as in the form of a grant reference PTDT/CTE-AST/098528/2008, funded by Fundação para a Ciência e a Tecnologia (FCT), Portugal. J.G.S. would like to thank the financial support given by FCT in the form of a scholarship, namely SFRH/BD/64722/2009. N.C.S. would further like to thank the support from FCT through a Ciência 2007 contract funded by FCT/MCTES (Portugal) and POPH/FSE (EC).