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Activity–rotation calibrations in the space UV for FGK stars

C. Montez-Zavala, E. Bertone, and M. Chávez

Instituto Nacional de Astrofísica, Óptica y Electrónica – Luis Enrique Erro#1, CP 72840, Tonantzintla, Puebla, México, e-mail: montez@inaoep.mx

Abstract. We present the new Mg II hk surface flux vs. rotational period calibrations for F, G and K-type stars in main sequence phase. We used high resolution UV spectra, observed by IUE and HST/STIS, of 22 F-, 42 G- and 21 K-type stars. These calibrations curves can be used to derive stellar ages using gyrochronology equations.

1. Introduction

The age of stars is a fundamental parameter for understanding the evolutionary status of stellar systems and, therefore, for astrobiology studies, as many quantities (stellar luminosity and activity, habitability region limits, etc.) are time-dependent. However, age is quite difficult to derive with good precision in the case of field stars, especially during the main sequence (MS) phase.

One of the best methods to calculate the age of field stars is Gyrochronology (Soderblom 2010), that requires reliable determinations of stellar rotational periods ($P_{\rm rot}$), which can be indirectly derived using the correlation between stellar activity and $P_{\rm rot}$ (Noyes et al. 1984). One of the proxies for measuring stellar activity is the strenght of Mg II h (2803.53 Å) and k (2796.35 Å) emission lines. These space UV lines are stronger for older and hotter stars than the most popular Ca II HK lines (see Fig. 1 for the case of the 4.5 Gyr old Sun); they are, therefore, suitable features for improving the correlation stellar activity–$P_{\rm rot}$ for F-, G- and K-type stars.

2. The Mg II hk surface flux vs. rotational period calibration

We have collected a large sample of 271 FGK stars with luminosity class IV, IV-V and V that have been spectroscopically observed at high resolution around the Mg II hk lines. All data have been collected from the INES database of the International Ultraviolet Explorer (IUE) and from the Hubble Space Telescope (HST) database of STIS observations (Ayres 2010).

We measured the observed flux $f_{\rm hk}$ in emission of the Mg II hk lines of each star. To remove the contribution of the photospheric flux, we used the synthetic spectra database of Rodríguez-Merino et al. (2005). We then converted $f_{\rm hk}$ to the surface flux $F_{\rm hk}$, using the Oranje et al. (1982) relation: $\log F_{\rm hk}/f_{\rm hk} = 0.328 + 4 \log T_{\rm eff} + 0.4(V + BC)$.

In order to calibrate the relation between $F_{\rm hk}$ and $P_{\rm rot}$, we selected the stars whose $P_{\rm rot}$ has been directly obtained, either through the analysis of the photometric modulation of the visible flux, due to the uneven distribution of stellar spots on the surface, or through variability of the Ca II emission. We separately fitted the data of three subsamples (22 F, 42 G and 21 K stars) with an exponential function of the

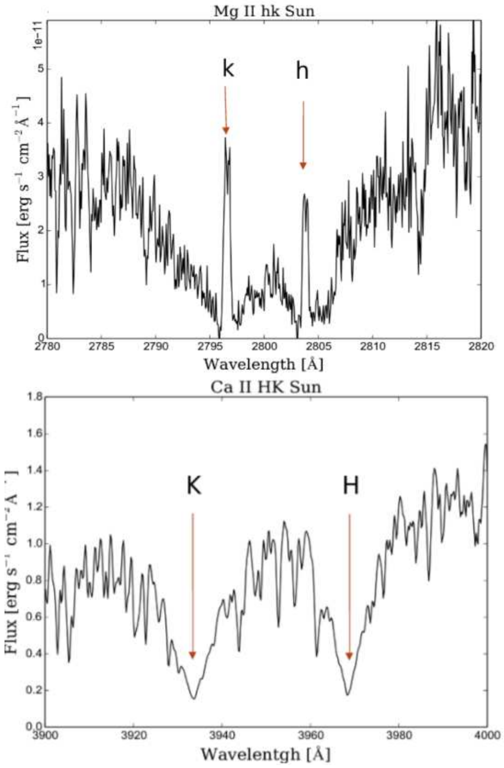

Fig. 1. Comparison of the Mg II hk and Ca II HK lines for the Sun.

form $\log F_{\rm hk} = A + Be^{\log P_{\rm rot}}$ and show the results in Fig. 2.

We have obtained, for the first time, the $F_{\rm hk}$–$P_{\rm rot}$ relations for F- and K-type stars, as previous works (e.g., Noyes et al. 1984) used mainly G stars as calibrators. We also improved the Olmedo et al. (2010) calibration for G stars. Our results can be employed to derive the stellar ages, using, for instance, the prescription of Barnes (2007).

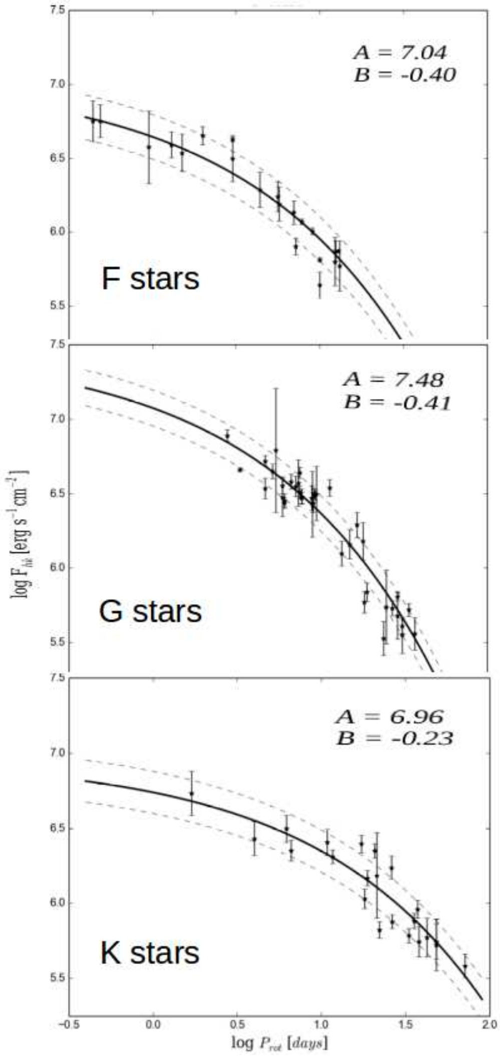

Fig. 2. Mg II h+k surface flux vs. $P_{\rm rot}$ calibrations for F-, G- and K-type stars. The solid line represents the best fit, while the dotted lines show the error at 1.5σ. The values of the correlation function parameters A and B are indicated in each panel.

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