Library of medium-resolution fiber optic echelle spectra of F, G, K, and M field dwarfs to giants stars

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ABSTRACT

We present a library of Penn State Fiber Optic Echelle (FOE) observations of a sample of field stars with spectral types F to M and luminosity classes V to I. The spectral coverage is from 3800 Å to 10000 Å with nominal a resolving power 12000. These spectra include many of the spectral lines most widely used as optical and near-infrared indicators of chromospheric activity such as the Balmer lines (H\textalpha{} to H\textepsilon{}), Ca \textit{II} H & K, Mg \textit{i} b triplet, Na \textit{i} D\textsubscript{1}, D\textsubscript{2}, He \textit{i} D\textsubscript{3}, and Ca \textit{II} IRT lines. There are also a large number of photospheric lines, which can also be affected by chromospheric activity, and temperature sensitive photospheric features such as TiO bands. The spectra have been compiled with the goal of providing a set of standards observed at medium resolution. We have extensively used such data for the study of active chromosphere stars by applying a spectral subtraction technique. However, the data set presented here can also be utilized in a wide variety of ways ranging from radial velocity templates to study of variable stars and stellar population synthesis. This library can also be used for spectral classification purposes and determination of atmospheric parameters (T\textsubscript{eff}, log\textit{g}, [Fe/H]). A digital version of all the fully reduced spectra is available via ftp and the World Wide Web (WWW) in FITS format.

Subject headings: Atlases – stars: fundamental parameters – stars: general – stars: late-type – stars: activity – stars: chromospheres

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1. Introduction

Spectral libraries of late-type stars with medium to high resolution and large spectral coverage are an essential tool for the study of the chromospheric activity in multiwavelength optical observations using the spectral subtraction technique (see Barden 1985; Huenemoerder & Ramsey 1987; Hall & Ramsey 1992; Montes et al. 1995a, b, c, 1996a, b, 1997b, 1998). Furthermore, these libraries are also very useful in many areas of astrophysics such as the stellar spectral classification, determination of atmospheric parameters ($T_{\text{eff}}$, $\log g$, [Fe/H]), modeling stellar atmospheres, spectral synthesis applied to composite systems, and spectral synthesis of the stellar population of galaxies.

In previous work Montes et al. (1997a, hereafter Paper I) presented a library of high and mid-resolution (3 to 0.2 Å) spectra in the Ca II H & K, Hα, Hβ, Na I D1, D2, and He I D3 line regions of F, G, K, and M field stars. A library of echelle spectra of a sample of F, G, K, and M field dwarf stars is presented in Montes & Martín (1998, hereafter Paper II) which is an extension of Paper I to higher spectral resolution (0.19 to 0.09 Å) covering a large spectral range (4800 to 10600 Å).

The spectral library presented here expands upon the data set in Papers I and II. This library consists of echelle spectra of a sample of F, G, K, and M field stars, mainly dwarfs (V), subgiant (IV), and giants (III) but also some supergiants (II, I). The spectral resolving power is intermediate, nominally $R = 12000$ ($\approx 0.5$ Å in Hα), but the spectra have a nearly complete optical region coverage (from 3900 to 9000 Å). These regions includes most of the spectral lines widely used as optical and near-infrared indicators of chromospheric activity such as the Balmer lines (Hα to Hγ), Ca II H & K, Mg I b triplet, Na I D1, D2, He I D3, and Ca II IRT lines, as well as temperature sensitive photospheric features such as TiO bands.

Recently, Pickles (1998) has taken available published spectra and combined them into a uniform stellar spectral flux library. This library have a wide wavelength, spectral type, and luminosity class coverage, but a low spectral resolution ($R = 500$) and their main purpose is the synthesis and modeling of the integrated light from composite populations. However, for other purposes as detailed studies of chromospheric activity, stellar spectral classification, and determination of atmospheric parameters, libraries of higher resolution, as the presented in Paper I and II, Soubiran, Katz, & Cayrel (1998), and the library presented here are needed.

In Sect. 2 we report the details of our observations and data reduction. The library is presented in Sect. 3.

2. Observations and data reduction

The echelle spectra presented here were obtained during several observing runs with the Penn State Fiber Optic Echelle (FOE) at the 0.9-m and 2.1-m telescopes of the Kitt Peak National
Observatory (KPNO). The FOE is a fiber fed prism cross-dispersed echelle medium resolution spectrograph and is described in more detail in Ramsey & Huenemoerder (1986). It was designed specifically to obtain in a single exposure a wide spectral range encompassing all the visible chromospheric activity sensitive features. Typical data and performance of the FOE for the different observing runs are discussed in Ramsey et al. (1987); Huenemoerder, Buzasi, & Ramsey (1989); Newmark et al. (1990); Hall et al. (1990); Buzasi, Huenemoerder, & Ramsey (1991); Hall & Ramsey (1992); Welty & Ramsey (1995); and Welty (1995).

In Table 1 we give a summary of observations. For each observing run we list the date, the CCD detector used, the number of echelle orders included, the wavelength range covered ($\lambda_i-\lambda_f$) and the range of reciprocal dispersion achieved (Å/pixel) from the first to the last echelle orders. The Å/pixel value for each order can be found in the header of the spectra. The spectral resolution, determined by the FWHM of the arc comparison lines, ranges from 2.0 to 2.2 pixels. The signal to noise ratio is larger than 100 in all cases. Tables 2 gives for each observing run the spectral lines of interest in each echelle order.

The spectra have been extracted using the standard reduction procedures in the IRAF package (bias subtraction, flat-field division, and optimal extraction of the spectra). The wavelength calibration was obtained from concurrent spectra of a Th-Ar hollow cathode lamp. Finally, the spectra have been normalized by a polynomial fit to the observed continuum.

3. The library

As in Papers I and II, the stars included in the library have been selected as stars with low levels of chromospheric activity, that is to say, stars that do not present any evidence of emission in the core of Ca $\text{ii}$ H & K lines in our spectra (Montes et al. 1995c, 1996a), stars with the lower Ca $\text{ii}$ H & K spectrophotometric index S (Duncan et al. 1991; Baliunas et al. 1995), or stars known to be inactive and slowly rotating stars from other sources (see Strassmeier et al. 1990; Strassmeier & Fekel 1990; Hall & Ramsey 1992).

Table 3 presents information about the observed stars. In this table we give the HD, HR and GJ numbers, name, spectral type and luminosity class ($T_{\text{sp}}$), from the Bright Star Catalogue (Hoffleit & Jaschek 1982; Hoffleit & Warren 1991), the Catalogue of Nearby Stars (Gliese & Jahreiss 1991), and Keenan & McNeil (1989). The exception is some of the M dwarfs for which we list the more recent spectral type determination given by Henry, Kirkpatrick, & Simons (1994). In column (6) MK indicates if the star is a Morgan and Keenan (MK) Standard Star from García (1989) and Keenan & McNeil (1989). MK* indicates if the star is included in the list of Anchor Points for the MK System compiled by Garrison (1994). Column (7) give the metallicity [Fe/H].

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from Taylor (1994; 1995) or Cayrel de Strobel (1992; 1997) and column (8) rotational period ($P_{\text{rot}}$) and $v \sin i$ from Donahue (1993), Baliunas et al. (1995), Fekel (1997), and Delfosse et al. (1998). We also give, in column (9), the Ca II H & K spectrophometric index $S$ from Baliunas et al. (1995) and Duncan et al. (1991). In column (10) we list information about the observing run in which each star have been observed, using a code given in the first column of Table 1, the number between brackets give the number of spectra available. The last two columns indicate if the star was also included in Papers I and II.

Representative spectra (from F to M, dwarfs and giants stars) in different spectral regions are plotted in figures 1 to 4 in order to show the behaviour of the more remarkable spectroscopic features with the spectral type and luminosity class. In order of increasing wavelength we have plotted the following line regions: H$\beta$ (Fig. 1), Na i D$_1$, D$_2$, and He i D$_3$) (Fig. 2), H$\alpha$ (Fig. 3), and Ca II IRT $\lambda$8498, 8542 (Fig. 4). In each figure we have plotted main sequence stars (luminosity class V) in the left panel, and giants stars (III) in the right panel.

A total of 130 stars are included in this library. Many of them have been observed in several observing runs, and in some cases several nights during the same observing run being the total number of spectra 345. Using these spectra as well as those of Papers I and II a study of possible short and long term spectroscopic variability of some of the multiply observed stars is possible.

A description of the spectral lines most widely used as optical and near-infrared indicators of chromospheric activity, as well as other interesting spectral lines and molecular bands present in the spectral range covered by the spectra can be found in Papers I and II and references therein.

As an illustration of the use of these spectra and those of Papers I and II we intend to analyze temperature sensitive lines in order to improve the actual line-depth ratio temperature calibrations (Gray & Johanson 1991, Gray 1994) and spectral-class/temperature classifications (Strassmeier & Fekel 1990), as well as the determination of fundamental atmospheric parameters $T_{\text{eff}}$, $\log g$, [Fe/H] (Katz et al. 1998 and Soubiran et al. 1998). This will be the subject of forthcoming papers.

In order to enable other investigators to make use of the spectra in this library for their own purposes, all the final reduced (flattened and wavelength calibrated) multidimensional spectra containing all the echelle orders of the stars listed in Table 3 are available at the CDS in Strasbourg, France, via anonymous ftp to cdsarc.u-strasbg.fr (130.79.128.5). They are also available via the World Wide Web at:

http://www.ucm.es/info/Astrof/fgkmsl/FOEfgkmsl.html.

The data are in FITS format with pertinent header information included for each image. In order to further facilitate the use of this library one dimensional normalized and wavelength calibrated spectra, for the orders containing the more remarkable spectroscopic features, are also available as separate FITS format files.

In addition this library as well as the libraries presented in Papers I and II will be included in the Virtual Observatory (see http://herbie.ucolick.org/vo/). This is a project to establish a new spectroscopic database which will be contained digitized spectra of spectroscopic plates as well
as spectra observed digitally from different observatories. Virtual Observatory is an International Astronomical Union (IAU) initiative through its Working Group for Spectroscopic Data Archives.

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Fig. 1.— Spectra in the Hβ line region of stars with representative spectral types. Main sequence stars (V) are plotted in the left panel, and giants stars (III) in the right panel.
Fig. 2.— As Fig. 1 in the Na 1 D, D, He 1 D line region.
Fig. 3.— As Fig. 1 in the Hα line region.
Fig. 4.— As Fig. 1 in the Ca II IRT ($\lambda\lambda 8498, 8542$) line region.
Table 1: Summary of Observations

| O | Date   | CCD Detector   | N. Or. | \(\lambda_i - \lambda_f\) | \(\Delta/\text{pixel}\) |
|---|--------|----------------|--------|-----------------------------|--------------------------|
| 1 | 1994/12| T1KA (1024x1024)| 34     | 3875-9400                   | 0.123-0.296              |
| 2 | 1994/05| T1KA (1024x1024)| 33     | 3875-9000                   | 0.124-0.284              |
| 3 | 1993/12| T1KA (1024x1024)| 34     | 3875-9400                   | 0.121-0.288              |
| 4 | 1992/11| T2KB (2048x2048)| 36     | 3700-9050                   | 0.113-0.276              |
| 5 | 1991/09| T13 (800x800)    | 34     | 3810-8950                   | 0.077-0.180              |
| 6 | 1991/05| TEK2 (512x512)   | 32     | 3950-8975                   | 0.152-0.310              |
| 7 | 1990/10| RCA1 (512x512)   | 40     | 3690-10700                  | 0.130-0.378              |
| 8 | 1989/12| TI2 (800x800)    | 15     | 7250-9000                   | 0.130-0.158              |
| 9 | 1989/04| RCA3 (512x512)   | 34     | 3890-9350                   | 0.151-0.359              |
|10 | 1988/09| RCA3 (512x512)   | 33     | 3880-8950                   | 0.150-0.344              |
|11 | 1987/03| RCA1 (512x512)   | 33     | 3880-8950                   | 0.151-0.346              |
Table 2: Lines included in FOE spectral orders in each observing run.

| Or. No. | 1, 2, 3, 10, 11 | 4, 7 | 5 | 6 | 9 | 8 |
|---------|-----------------|-----|---|---|---|---|
| 1       | Ca II K         |     |   |   |   |   |
| 2       | Ca II H         |     |   |   |   |   |
| 3       | Ca II H         | Ca II H | Hδ | Ca II IRT |
| 4       | Hδ              | Ca II K |     |     |     |     |
| 5       | Ca II H         | Hδ     |     |     |     |     |
| 6       | Hγ              | Hδ     |     |     |     |     |
| 7       | Hγ              |         |     |     |     |     |
| 8       |                 |         |     |     |     |     |
| 9       |                 |         |     |     |     |     |
| 10      | Hγ              | Hγ     |     |     |     |     |
| 11      |                 |         |     |     |     |     |
| 12      | Hβ              | Hβ     |     |     |     |     |
| 13      |                 |         |     |     |     |     |
| 14      | Mg i b          | Mg i b |     |     |     |     |
| 15      |                 |         |     |     |     |     |
| 16      | Na i D          | Mg i b |     |     |     |     |
| 17      | Na i D          |         |     |     |     |     |
| 18      |                 |         |     |     |     |     |
| 19      |                 |         |     |     |     |     |
| 20      | Na i D          |         |     |     |     |     |
| 21      |                 | Mg i b |     |     |     |     |
| 22      |                 |         |     |     |     |     |
| 23      | Na i D          | Na i D | Hα | Hβ |
| 24      |                 |            |     |     |     |     |
| 25      | Li i            | Li i     |     |     |     |     |
| 26      |                 | Li i     |     |     |     |     |
| 27      | Hα              | Li i     |     |     |     |     |
| 28      | Li i            |         |     |     |     |     |
| 29      |                 |         |     |     |     |     |
| 30      |                 |         |     |     |     |     |
| 31      | Ca II IRT       | Ca II IRT | Hδ |     |     |     |
| 32      |                 | Ca II IRT | Ca II H |     |     |     |
| 33      |                 | Ca II IRT | Ca II K |     |     |     |
| 34      |                 | Ca II IRT |         |     |     |     |
| 35      | Ca II IRT       |         |     |     |     |     |
| 36      |                 |         |     |     |     |     |
Table 3: Stars

| HD    | HR  | GJ  | Name        | T<sub>sp</sub> | MK           | [Fe/H] (dex) | P<sub>rot</sub> (days) | v sin i (km s<sup>-1</sup>) | S | Obs. | Pap. (I, II) |
|-------|-----|-----|-------------|---------------|--------------|--------------|---------------------|------------------------|---|-----|-------------|
| 58946 | 2852| 274 | Aρ Gem     | F0 V (SB?)    | MK           | -            | -                   | 68                     | - | 8   |             |
| 15257 | 717 | -   | 12 Tri     | F0 III        | -            | -            | 78                  | -                      | - | 8   |             |
| 1457  | -   | -   | SAO 11104  | F0 Iab       | -            | -            | -                   | -                      | 3 | 8   |             |
| 128167| 5447| 557 | σ Boo      | F2 V         | MK           | -0.387       | 7.8                | 0.190                  | 11|     |             |
| 210027| 8430| 848 | t Peg      | F5 V (SB1)   | MK           | -0.079       | -                   | -                      | 5 |     |             |
| 87141 | 3954| -   | BD+54 1348 | F5 V         | 0.047        | -            | 10                  | -                      | 8 |     |             |
| 55052 | 2706| -   | 48 Gem     | F5 III-IV    | -            | 74           | -                   | 11                     |   |     |             |
| 20902 | 1017| -   | α Per      | F5 Ib: MK*   | -            | 18           | -                   | -                      | 8 |     |             |
| 76572 | 3563| -   | 61 Cnc     | F6 V         | -            | <10          | 0.148               | 11                     |   |     |             |
| 11443 | 544 | 78.1| α Tri     | F6 IV (SB)   | 0.000        | 93           | 0.275               | 5                      |   |     |             |
| 8992  | -   | -   | SAO 22328  | F6 Ib       | -            | -            | -                   | -                      | 3 |     |             |
| 187013| 7534| 767.1| 17 Cyg   | F7 V         | -0.109       | -            | 10.0                | 0.154                  | 2, | 11(2)| I           |
| 222368| 8969| 904 | t Pac      | F7 V (SB?)   | MK           | -0.127       | 5.6                 | 0.153                  | 4 |     |             |
| 187691| 7560| 768.1| α Aql   | F8 V         | 0.059        | -            | 3.1                 | 0.148                  | 1, 2, 3, 6(2), 7, 11(2)| I |
| 142373| 5914| 602 | χ Her      | F8 V         | -0.431       | -            | 2.4                 | 0.147                  | 6, | 11  | I, II       |
| 9826  | 458 | 61  | v And      | F8 V         | -0.14        | -            | 8                   | 0.154                  | 5 |     |             |
| 45067 | 2313| -   | BD-00 1287 | F8 V         | -0.16        | < 15         | 0.141               | 11                     | I |     |             |
| 107213| 4688| -   | 9 Com      | F8 V         | 0.154        | -            | 10.0                | 0.135                  | 11|    |             |
| 122563| 5270| -   | BD+10 2617 | F8 IV        | 0.274        | -            | -                   | -                      | 6 |     |             |
| 102870| 4540| 449 | β Vir      | F9 V (SB?)   | MK           | 0.180        | -                   | 4.5                    | - | 11 |             |
| 22484 | 1101| 147 | 10 Tau     | F9 IV-V (SB?)| -0.106       | -            | 2.8                 | 0.147                  | 4, | 8   |             |
| 114710| 4983| 502 | β Com      | F9.5 V       | MK           | 0.135        | 12.35               | 4.3                    | 0.201                  | 2, | 11(2)| I, II       |
Table 3: Continue

| HD   | HR  | GJ  | Name             | T<sub>sp</sub> | MK  | [Fe/H] | P<sub>rot</sub> | v sin i | S     | Obs.          | Pap. (I, II) |
|------|-----|-----|------------------|----------------|-----|--------|----------------|---------|-------|---------------|-------------|
| **G stars** |
| 39587 | 2047 | 222 | AB χ¹ Ori        | G0- V (SB1)    | MK  | -0.084 | 5.36           | 8.6     | 0.325 | 10(6)         | I, II       |
| 143761| 5968 | 606.2| ρ CrB           | G0+ Va         | MK  | -0.185 | 5.0            | 5.0     | 0.150 | 11            | I           |
| 13974 | 660  | 92  | δ Tri           | G0.5 V (SB2)   | MK  | -0.444 | 10.0           | 0.232   | 1(2), 3, 4, 5, 10 | I           |
| 26630 | 103  | -   | μ Per           | G0 Ib (SB)     | MK  | -0.32  | -              | 14      | 0.362 | 8             |             |
| 126053| 5384 | 547 | BD+01 2920 G1 V |                | MK  | -      | -              | 1       | 0.165 | 6, 11         |             |
| 95128 | 4277 | 407 | 47 UMa          | G1- V          | MK  | 0.026  | -              | <3      | 0.165 | 8             |             |
| 67228 | 310  | -   | μ² Cnc          | G1 Ivb         | MK  | 0.052  | -              | 3.0     | 0.138 | 1(2), 6, 11   |             |
| 84441 | 3873 | -   | ε Leo           | G1 II          | MK  | 0.17   | -              | <17     | -     | 9(6), 11(2)   |             |
| 185758| 7479 | -   | α Sge           | G1 II          | MK  | -      | -              | 6.0     | -     | 2(2)          |             |
| -    | -    | -   | Sun             | G2 V           | MK  | 0.00   | 25.72         | <1.7    | 0.179 | 1             | I           |
| 1835 | 88   | 17.3| 9 Cet           | G2.5 V         | MK  | 0.050  | 7.7            | 6       | 0.349 | 1, 3, 4(2), 5 |             |
| 221170| -    | -   | BD+29 4940 G2 IV|                | MK  | -      | -              | -       | 0.106 | 2, 3, 5       |             |
| 196755| 7896 | -   | κ Del           | G2 IV          | MK  | -0.02  | -              | 2.7     | 0.152 | 1, 2(2), 3, 4, 5 |             |
| 218658| 8819 | -   | π Cep           | G2 III (SB)    | MK  | 0.01   | -              | 22      | 0.237 | 1, 2          |             |
| 161239| 6608 | -   | 84 Her          | G2 IIIb        | MK  | -      | -              | 6.0     | 0.138 | 11(2)         |             |
| 11544 | -    | -   | SAO 22740 G2 I b|                | MK  | -      | -              | -       | 1, 3  |               |             |
| 223047| 9003 | -   | ψ And           | G3 Ib-II       | MK  | 0.10   | -              | <19     | 0.385 | 8             |             |
| 117176| 5072 | 512.1| 70 Vir          | G4 V           | MK  | -0.035 | -              | 1.2     | 0.142 | 6, 11(2)      |             |
| 123  | 5    | 4.1 A| V640 Cas        | G5 V           | MK  | -      | -              | -       | -     | 3, 5, 11      |             |
| 20630 | 996  | 137 | κ¹ Cet          | G5 V (SB?)     | MK* | 0.133  | 9.24           | 3.9     | 0.366 | 1(3), 4, 7    | I, II       |
| 59058 | -    | -   | BD+38 1771 G5 V |                | MK  | -      | -              | -       | -     | 8             |             |
| 86873 | -    | -   | BD+32 1970 G5   |                | MK  | -      | -              | -       | -     | 8             |             |
| 161797| 6623 | 695 A| μ Her A         | G5 IV          | MK* | 0.242  | -              | 1.2     | 0.136 | 5, 6          |             |
| 71369 | 3323 | -   | o UMa           | G5 III         | MK  | -0.21  | -              | 3.4     | 0.120 | 1             |             |
| -    | -    | -   | κ Her           | G5 III         | MK  | -      | -              | -       | -     | 2             |             |
| 20825 | -    | -   | 62 Ari          | G5 III         | MK  | -0.14  | -              | -       | -     | 4, 5          |             |
| 190360| 7670 | 777 A| BD+29 3872 G6 IV+M6 V | | MK* | 0.308  | -              | -       | 0.146 | 5, 6          |             |
| 221115| 8923 | -   | 70 Peg          | G7+ III        | MK  | -0.03  | -              | <19     | 0.147 | 2             |             |
| 101501| 4496 | 434 | 61 UMa          | G8 V           | MK* | -0.070 | 16.68         | 2.3     | 0.311 | 6, 11(2)      | I           |
| 103095| 4550 | 451 A| BD+38 2285 G8 Vp|                | MK* | -1.266 | -              | 2.2     | 0.188 | 11            |             |
| 188512| 7602 | 771 A| β Aql           | G8 IV          | MK* | -0.30  | -              | 1.4     | 0.136 | 1, 2, 4, 5, 7 | I           |
| 73593 | 3422 | -   | 34 Lyn          | G8 IV          | MK  | -      | -              | -       | 0.117 | 3, 11(3)      |             |
| 218935| 8827 | -   | 60 Peg          | G8 III-IV      | MK  | -      | -              | -       | 0.120 | 5             |             |
| 113226| 4932 | -   | ε Vir           | G8 IIab        | MK* | 0.00   | -              | 3.2     | -     | 1(3), 2(6), 3, 9(6), 11(6) |             |
| 16161 | -    | -   | ν Cet           | G8 III         | MK  | -0.38  | -              | <17     | 0.111 | 4, 5          |             |
| 104979| 4608 | -   | o Vir           | G8 IIIa        | MK  | -0.33  | -              | 2.5     | -     | 6, 11(2)      |             |
| 191026| 7689 | -   | 27 Cyg          | G8.5 IVa       | MK  | -0.10  | -              | -       | -     | 4             |             |
| 108225| 4728 | -   | 6 Cvn           | G9 III         | MK  | -0.11  | -              | <19     | -     | 6             |             |
| 76294 | 3547 | -   | ζ Hyα           | G9 IIIa        | MK  | -0.21  | -              | -       | -     | 1, 3          |             |
| 4128  | 188  | 31  | β Cet           | G9.5 III       | MK  | 0.13   | -              | 4.0     | 0.187 | 10            |             |
| HD    | HR  | GJ  | Name      | T<sub>sp</sub> | MK     | [Fe/H] (dex) | P<sub>rot</sub> (days) | v<sub>sin i</sub> (km s<sup>-1</sup>) | S  | Obs. |
|-------|-----|-----|-----------|--------------|--------|-------------|-----------------------|-------------------------------|-----|------|
| 185144| 7462| 764 | σ Dra     | K0 V         | MK*    | -0.045      | -                     | 0.6                          | 0.215 | 2    |
| 3651  | 166 | 27  | 54 Psc    | K0+ V        | MK     | -0.003      | 48.00                 | 2.2                          | 0.176 | 1, 3, 4, 5, 8 |
| 198149| 7957| 807 | η Cep     | K0 IV        | MK     | -0.32       | -                     | 0.6                          | -    | 1, 2 |
| 6734  | -   | -   | 29 Cet    | K0 IV        | MK     | -0.25       | -                     | -                            | 0.131 | 3    |
| 168723| 6869| 711 | η Ser     | K0 III-IV    | MK     | -0.42       | 2.6                   | 0.122                         | 6, 11(3) | |
| 45410 | 2331| -   | 6 Lyn     | K0 III-IV    | MK     | -           | -                     | -                            | 0.127 | 11   |
| 28    | 3   | -   | 33 Psc    | K0 III-IV (SB1) | MK     | -0.31      | <17                   | -                            | -    | 5    |
| 188947| 7615| -   | η Cyg     | K0 III       | MK     | -0.09       | 1.8                   | 0.103                         | 2(2), 8 | |
| 197989| 7949| 806.1| ε Cyg    | K0 III       | MK*    | -0.18       | 2.0                   | 0.104                         | 4(2) | |
| 19476 | 941 | -   | κ Per     | K0 III       | MK     | 0.04        | <17                   | 0.110                         | 5    | |
| 182272| 7359| -   | BD+33 3434| K0 III      | MK     | -           | -                     | -                            | 0.105 | 4, 5 |
| 19787 | 951 | -   | δ Ari     | K0 III       | MK     | -0.03       | <17                   | 0.110                         | 5    | |
| 8512  | 402 | -   | θ Cet     | K0 IIIb      | MK     | -0.22       | <17                   | 0.105                         | 4, 5 | |
| 12014 | -   | -   | SAO 22820 | K0 Iib      | MK*    | -           | -                     | -                            | -    | 3    |
| 10476 | 493 | 68  | 107 Psc   | K1 V        | MK     | -0.123      | 35.2                  | 0.6                          | 0.198 | 4(2), 5, 7(2) |
| 155885| 6011| 663 B| 36 Oph B | K1 V        | MK     | -0.305      | 22.9                  | 0.084                         | 11   | |
| 142091| 5901| -   | κ CrtB    | K1 IVa       | MK     | -0.04       | 0.6                   | -                            | 6, 11 | |
| 138716| 5777| -   | 37 Lib    | K1 III-IV    | MK     | -0.12       | <19                  | -                            | 11   | |
| 203504| 5133| -   | 1 Peg     | K1 III       | MK     | -0.14       | <17                  | 0.103                         | 2(2) | |
| 124897| 5340| 541 | α Boo     | K1.5 III     | MK     | -0.47       | 3.3                   | 0.144                         | 6(5), 9(3), 11(6) | |
| 6805  | 334 | -   | η Cet     | K2- III      | MK     | 0.04        | <17                   | 0.112                         | 4    | |
| 210745| 8465| -   | ζ Cep     | K1.5 I fb    | MK     | 0.75        | <17                   | 0.293                         | 8    | |
| 166620| 6806| 706 | BD+38 3095| K2 V        | MK     | -0.114      | 42.4                  | 0.6                          | 0.190 | 1(3), 2, 3, 4(2), 6, 11(2) |
| 4628  | 222 | 33  | BD+04 123 | K2 V        | MK     | -0.235      | 38.5                  | -                            | 0.230 | 4, 5, 10 |
| 22049 | 1084| 144 | ε Eri     | K2 V        | MK*    | -0.165      | 11.68                 | 2.0                          | 0.496 | 5, 7 |
| 149661| 6171| 631 | 12 Oph    | K2 V        | MK     | -0.004      | 21.3                  | 0.6                          | 0.339 | 6, 11(2) |
| 201196| 8088 | - | 15 4340 | K2 IV       | MK     | -           | -                     | -                            | 1(2), 2, 3(3), 4(2) | |
| 153210| 6299| -   | κ Oph     | K2 III       | MK*    | -0.03       | <17                   | 0.102                         | 6    | |
| 161096| 6603| -   | β Oph     | K2 III       | MK     | 0.00        | -                     | 2.5                          | 0.103 | 9, 10(4) |
| 194317| 7806| -   | 39 Cyg    | K2.5 III     | MK     | -0.17       | <19                   | 0.148                         | 2(2), 4, 8 | |
| 16160 A| 753 | 105 A| BD+06 398 | K3- V       | MK*    | -0.297      | 48.0                  | -                            | 0.226 | 1, 3, 4(3), 5, 7 | |
| 160346 | - | 688 | BD+03 3465| K3- V       | MK     | -           | 33.5                  | -                            | 0.300 | 11(3) | |
| 219134| 8832| 892 | BD+56 2966| K3 V        | MK     | -0.017      | 2.1                   | 0.230                         | 8    | |
| 3627  | 165 | -   | δ And     | K3 III (SB) | MK     | 0.04        | ≤3                    | -                            | 5    | |
| 136514| 5710| -   | 6 Ser     | K3 III      | MK     | -0.14       | <17                   | -                            | 6    | |
| 186791| 7525| -   | γ Aql     | K3 II       | MK     | -0.29       | <17                   | -                            | 7(3) | |
| 131156 B| 5544 B| 566 B| ξ Boo B   | K4 V       | MK     | 0.19        | 12.28                 | 20                           | 1.381 | 11   | |
| 201091| 8085| 820 A| 61 Cyg A  | K5 V        | MK*    | -0.06       | 35.37                 | 0.6                          | 0.658 | 1(2), 2(2), 3, 4(6), 5, 8 |
| 156026 | - | 664 | 36 Oph C  | K5 V        | MK     | -0.279      | 18.0                  | 2.2                          | 0.770 | 11(2) | |
| 29139 | 1457| 171.1| α Tau     | K5+ III     | MK     | -0.16       | <17                   | -                            | 1(5), 3, 4(2), 5(4), 8 | |
| 11800 | -   | -   | BD+59 363 | K5 I fb    | MK     | -           | -                     | -                            | -    | 3    | |
| 216946| 8726| -   | BD+48 3887| K5 I fb    | MK     | -0.03       | -                     | -                            | 8    | |
| 201092| 8086| 820 B| 61 Cyg B  | K7 V        | MK     | -0.10       | 37.84                 | 1.4                          | 0.986 | 1(2), 2(2), 3, 4(2), 5, 8 | |
| 80493 | 3705| -   | α Lyn     | K7 IIIab    | MK     | -0.26       | -                     | -                            | 8    | |
Table 3: Continue

| HD   | HR  | GJ | Name       | T_{sp}   | MK | [Fe/H] (dex) | P_{rot} (days) | v sin i (km s^{-1}) | S | Obs. | Pap. |
|------|-----|----|------------|----------|----|--------------|-----------------|-------------------|---|------|------|
| M stars |     |    |            |          |    |              |                 |                   |   |      |      |
| -    | -   | 906| V347       | M0 V (K5)| -  | -            | -               | -                 | 8 |      |      |
| 89758 | 4069|    | µ UMa      | M0 III (SB)| MK | -            | -               | -                 | 1, 11(2) |      |      |
| 6860 | 337 | 53.3| β And     | M0+ IIIa | MK*| -0.10        | -               | 0.319             | 4(2), 5, 8 |      |      |
| 4 B  | BD+45 4408 B | M0.5 V (K7)| - | - | - | - | - | 8 | | |
| 232979 | - | 172| BD+52 857 | M0.5 V (K8)| MK | - | - | 1.909 | 1 | II |
| 1326 A | - | 15 A| GX And    | M1.5 V (1) (M2 V)| MK | - | < 2.9 | - | 1, 2(2), 3, 8 | II |
| 218329 | 8795| - | 55 Peg    | M1 IIIab | MK | - | - | 0.234 | 1 |      |      |
| 206330 | 8284| - | 75 Cyg    | M1 IIIab | MK | - | - | - | 8 | | |
| 39801 | 2061| - | α Ori     | M1-M2 Ia-Iab | MK*| - | - | - | - | 11(2) | |
| 95735 | - | 411| BD+36 2147 | M2+ Ve (1)| MK | -0.20 | - | < 2.9 | 0.424 | 11 | |
| 206936 | 8316| - | µ Cep     | M2- Ia | MK*| - | - | - | 8 | | |
| 133216 | 5603| 574.1| σ Lib     | M2.5 III | MK | - | - | - | 11(2) | | |
| 42995 | 2216| - | η Gem     | M2.5 III | MK | - | - | - | 11(2) | | |
| 2411 | 103 | - | TV Psc    | M3 III | MK | - | - | 0.211 | 2(2) | | |
| 44478 | 2286| - | µ Gem     | M3 IIIab | MK | 0.11 | - | - | 8 | | |
| 14270 | - | - | AD Per    | M3 Iab | MK | - | - | - | 3 | | |
| -    | - | 273| BD+05 1668 | M3.5 V (1)| MK | - | - | < 2.4 | 1(2) | II |
| 55583 | 2717 | - | 51 Gem    | M4 IIIab | MK | - | - | - | 1, 11(2) | | |
| 214665 | 8621| - | BD+56 2821 | M4+ III | MK | - | - | 0.259 | 8 | | |
| 120323 | 5192| - | 2 Cen     | M4.5 III | MK | - | - | - | 11 | | |
| 130144 | 5512| - | BD+15 2758 | M5 III | MK | - | - | - | 11 | | |
| 94705 | 4267| - | VY Leo    | M5.5 III | MK | - | - | - | 11 | | |
| 33664 | 1693| - | RX Lep    | M6 III | MK | - | - | - | 11(2) | | |
| 84748 | 3882| - | R Leo     | M8 IIIe | MK | - | - | - | 1(2) | I | |

(1): Henry et al. (1994)

SB: Spectroscopic Binary (Duquennoy & Mayor 1991)