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Gaia DR3 BPRP spectra of stars from the MILES library

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Abstract

Here some coordinate errors for stars included in the MILES library are reported. The errors were found while crossmatching the MILES catalog with the Gaia DR3 catalog. I found some literature reporting the same issue, however, the notification did not reach CDS. I advise you to further check my notes, which of course could also contain some imprecisions.

Key words: stars: evolution — stars: supergiants — stars: massive

1 Our Gaia matches to the Miles library

The MILES library comprises 985 spectra (Sánchez-Blázquez et al. 2006). The spectra cover from 3525 to 7500 Å at the resolution of 2.3 Å. The coordinates here adopted are from the file "catalog.dat" included within the spectra distribution.

Five catalog stars appear to have coordinates unrelated to the given alias names, and were removed: HD000249, HD151217, BD+090352, HD152601, and BD+195116B. The coordinates of the binary HD219617 are 10″ offsets (and it is not clear which component was observed).

The stars in clusters are listed with names that do not precisely coincide with SIMBAD names. For example, NGC288-77 is Cl* NGC 288 ALC 77; M79_153 is NGC 1904 153; M79_160 is NGC 1904 160; M3_IV-25 is Cl* NGC 5272 S I-IV-25; M3_III-28 is Cl* NGC 5272 S I-III-28; M3_398 is NGC 5272 398.

There may be a few imprecisions for the binaries system, sometimes the name refers to the system, and sometimes to the component A. For example, HD206826 refers to the HD206826A component of the DMS system, HD210595 is the HD210595A component of the DMS system. HD219916 is omi Cep A (A component). We assume that HD201889 is HD201889A (the secondary is only 1.″43 away), that HD198183 is HD198183A, that HD223385 is HD223385A, that HD 194943 is 194943A.

901 Gaia DR3 matches are automatically found in the Gaia DR3 catalog by searching per position and/or 2MASS_ID. By searching on SIMBAD the remaining stars, additional Gaia DR3 matches are found (the latter being mostly binaries or high-velocity stars). In conclusion 965 (out of 985) secure Gaia DR3 counterparts are found, of which 759 have BP/RP spectra.

Of the 20 stars not associated with a Gaia DR3 match, six have wrong coordinates, ten do not have Gaia counterparts in DR3 (HD029139, MS0515.4-0710, HD039801, HD054605, HD081797, HD089484, HD124897, HD164058, HD206778, and HD020902), and four are cluster members with uncertain coordinates.

1.1 Issues with the coordinates of cluster members

The catalog coordinates appear to be all, but those of M71 stars, in the FK5 system, epoch=2000 and equinox 2000. For the stellar cluster members, the MILES catalog lists the stellar evolutionary phase, which facilitates the identification. By using the celestial coordinates given in the catalog, only four stars of the M71 clusters are correctly retrieved with equinox=2000. 21 stars can be retrieved by assuming equinox=1950 and are the first or second SIMBAD entries (always within 13″). M71 1-

95, M71 1-66, and M71 1-107 are more uncertain and we do not match them.

In the original Arp's paper, the coordinates of M5 are listed as offsets from the cluster center. The counterparts to M5 members are displaced by 13″ and some others by 49″.

Yan et al. (2019) report that "for four of the stars(BD+090352, HD000249, HD151217, HD152601), the coordinates provided are in error. For 23 of the 28 stars in the cluster M71, the coordinates are given in Equinox B1950 rather than J2000." However, the online VIZIER catalog J/MNRAS/371/703/catalog listed wrong coordinates for stars in M71 (assumed epoch 2000). We have forwarded this list of corrections to CDS.

2 MILES spectra and BPRP spectra

Here the link to the webpage with the spectra https://lamortadella.github.io/BPRPlibraries/MILESbprp/index.html. The original MILES spectra are plotted in cyan and overlaid in black the Gaia BP/RP spectra. A rebinned version of the MILES spectra is over-plotted in red matching the resolution of the Gaia data.

The MILES spectra cover from 3525 to 7500 Å, while the Gaia low-resolution spectra cover from 3360 to 10200 Å. The spectral segments from 400.0 nm to 700.0 nm were used to estimate the Gaia median flux density and the MILES median flux density. 759 MILES spectra could be flux calibrated by rescaling them with the two estimated medians.

As for the other libraries, the two parameters, ChiT and Chi2 were calculated to evaluate the quality of the spectral matches (rebinned MILES spectra and BPRP spectra), as shown in Fig. 1.

The distribution of the ChiT values is shown in Fig. 2. The ChiT are plotted versus the Gmag and the BP-RP colors in Figs 3 and 4, while the ratioT values are plotted versus the BP-RP values in Fig. 5. As expected, data points with available Gaia DR3 BPRP spectra have N_{BP} and N_{RP} larger than 15, see Figs. 6 7.

A best sample of 154 spectra is selected by requiring: ChiT < 0.1,
0.99 <ratioT< 1.01,
quality flag from SIMBAD = "OK",
has_xp_continuous eq 'True',
phot_variable_flag ne 'VARIABLE',
non_single_star eq 0,
phot_g_mean_mag gt 4.5,
where ratioT is the mean ratio between the flux densities of the Gaia DR3 BPRP spectrum and the flux densities of the MILES spectrum between 400 and 740 nm.

The wavelength range of the MILES library does not cover the entire Gaia BP-filter range, as it startes at 353.6 nm rather than 325 nm. The spectral range from 353.6 and to 400 nm was further explored to check for the systematics. In Figs 8 and 9, the same trends seen with the CALSPEC and SPSS libraries appear. The average flux ratio between the BPRP spectrum and the MILES spectrum (in the indicated range) grows with increasing BP-RP colour, as well as its standard deviation. There is no clear trend with the G-mag.

section**References**

Sánchez-Blázquez, P., Peletier, R. F., Jiménez-Vicente, J., et al. 2006, MNRAS, 371, 703

Yan, R., Chen, Y., Lazarz, D., et al. 2019, ApJ, 883, 175

Table 1. This is the list of M71 cluster members matched with Gaia DR3 using the FK5, equinox=1950,epoch=1950 coordinates system.

Gaia DR3	fits	Name	2MASS_ID	sep [″]	Nstar
1821608471955735296	s0944.fits	M71_A9	19533747+1844596	4.71	1
1821608575035068544	s0945.fits	M71_1-109	19533857+1846304	2.83	1
1821620463505562880	s0948.fits	M71_1-75	19534157+1847430	2.76	1
1821608708141023488	s0949.fits	M71_1-73	19534253+1847083	3.13	1
1821608300156977792	s0950.fits	M71_KC-147	19534318+1845067	8.74	1
1821608708141030784	s0951.fits	M71_1-71	19534373+1847336	0.84	1
1821608712439851264	s0952.fits	M71_KC-263	19534468+1847072	1.70	1
1821608403236183168	s0953.fits	M71_1-87	19534561+1845502	2.71	1
1821608643754392320	s0955.fits	M71_1-65	19534573+1847012	1.26	1
1821608712484571392	s0956.fits	M71_1-64	19534615+1847261	5.84	1
1821608433263145088	s0958.fits	M71_1-21	19534750+1846169	3.87	1
1821609021711485696	s0959.fits	M71_1-37	19534802+1847086	3.96	1
1821609017378698496	s0960.fits	M71_1-41	19534766+1847188	1.43	1
1821608437595882496	s0961.fits	M71_1-09	19534905+1846003	3.98	2
1821609021711481728	s0962.fits	M71_1-39	19534874+1847174	1.28	1
1821609021711456256	s0963.fits	M71_1-34	19534986+1847003	1.79	1
1821609223559201792	s0964.fits	M71_1-53	19535064+1849075	1.69	1
1821607612962061184	s0965.fits	M71_KC-169	19535474+1844577	13.40	1
1821607608629456512	s0966.fits	M71_A2	19535419+1845327	5.79	1
1821609090431005696	s0957.fits	M71_1-63	19534656+1847441	2.83	1
1821620424811789952	s0967.fits	M71_1-77	19533757+1847286	3.78	2
1821608300156977792		M71_KC-147		8.74	1
1821608712439851264		M71_KC-263		1.70	1

sep=separation between the position given in the MILES catalog and the position assigned by SIMBAD to that NAME (when using epoch=1950, equinox=1950).

Nstar= position of the assigned star in the SIMBAD list obtained with the position given in the MILES catalog (when using epoch=1950, equinox=1950).

Table 2. This is the list of M71 and NGC288 cluster members matched with Gaia DR3 using the FK5, equinox=2000, epoch=2000 coordinates system.

Gaia DR3	fits	Name	2MASS_ID	sep [″]	Nstar	
1821620424811789568	s0968.fits	M71_1-78	19533717+1847201	0.38	1	2000
1821606783990508288	s0969.fits	M71_S	19533986+1843530	2.08	1	2000
1821608265797235456	s0970.fits	M71_X	19534108+1844112	1.54	1	2000
1821608609394653696	s0971.fits	M71_I	19534477+1846349	0.47	1	2000
2342904488170510592		NGC288-77		0.76	1	2000

sep=separation between the position given in the MILES catalog and the position assigned by SIMBAD to that NAME (when using epoch=2000, equinox=2000).

Nstar= position of the assigned star in the SIMBAD list obtained with the position given in the MILES catalog (when using epoch=2000, equinox=2000).

Table 3. Uncertain

Name	DR3	sep	Nstar	Comments	Epoch
M5_IV-19	4421477829743733248	43.65	16		2000
M5_IV-87	4421568848693436800	13.81	1		2000
M5_IV-86	4421568848693437952	13.77	1		2000
M5_II-53	4421573246740330112	49.71	44		2000
M5_II-51	4421620182142956672	49.66	28		2000
M5_II-76	4421620182139717120	49.25	20		2000
M5_III-03	4421479204133344128	48.85	25		2000
M67_F-108/NGC 2682 108	none	12.94	2		2000
M71_1-95/19534103+1846056	none	10.56	3		1950
M71_1-66/NGC 6838 1066	none	7.38	3		1950
M71_1-107/19534288+1846374	none	36.31	25		1950

sep=separation between the position given in the MILES catalog and the position assigned by SIMBAD to that NAME (when using epoch=2000, equinox=2000).

Nstar= position of the assigned star in the SIMBAD list obtained with the position given in the MILES catalog (when using epoch=2000, equinox=2000).

Table 4. Stars without a match in Gaia DR3

fits	Name	V [mag]
s0157.fits	HD029139	0.86
s0175.fits	MS0515.4-0710	
s0199.fits	HD039801	0.42
s0242.fits	HD054605	1.84
s0347.fits	HD081797	1.97
s0382.fits	HD089484	1.98
s0501.fits	HD124897	−0.05
s0650.fits	HD164058	2.23
s0814.fits	HD206778	2.39
s0898.fits	HD020902	1.79

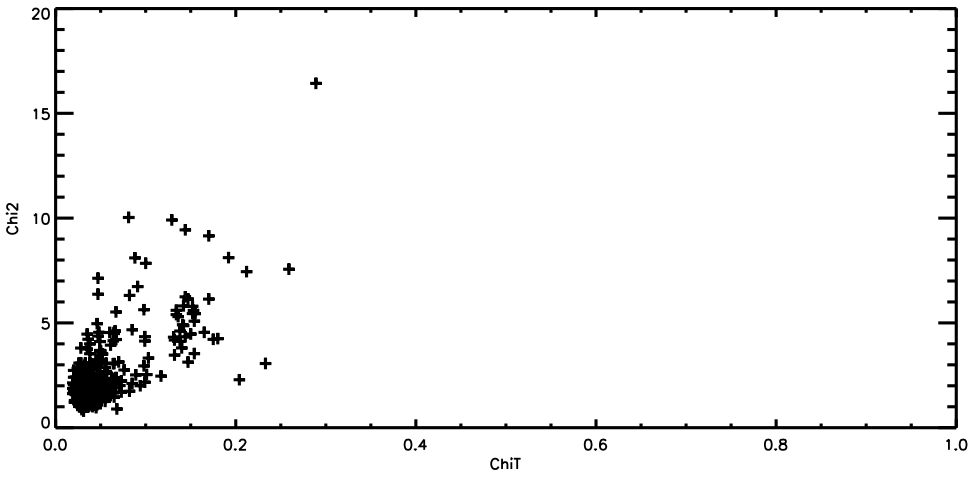

Fig. 1. MILES: the chiT versus the chi2 values (black plus signs). Only datapoints with comment="OK" and with full coverage from 400.0 nm to 740.0 nm are used.

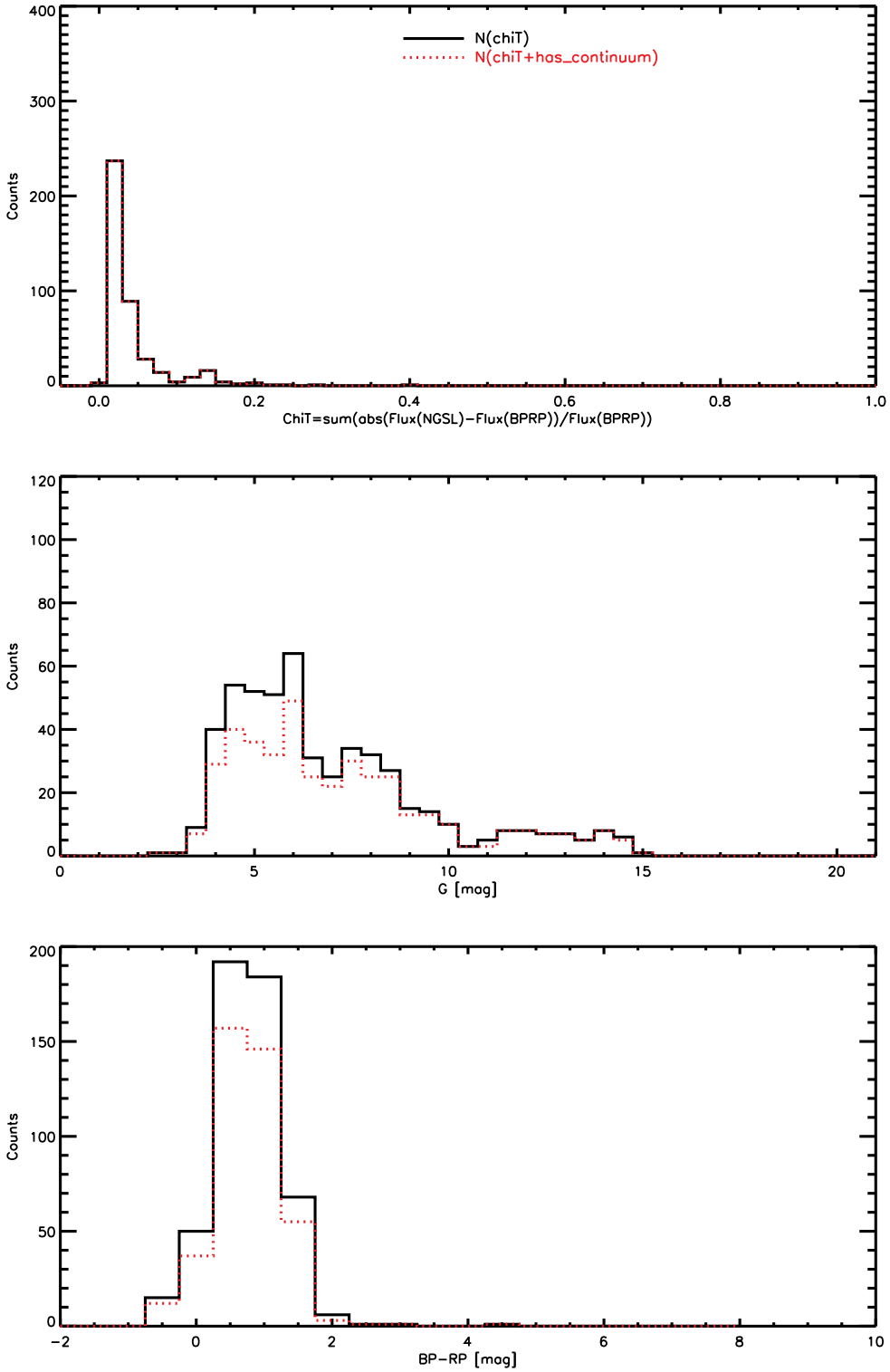

Fig. 2. MILES spectra: *Top panel:* Histogram of the chiT parameter in black or in red when only considering the data points with has_xp_continuous='True'. *Middle panel:* Histogram of the G magnitudes. In red the histograms of those sources with has_xp_continuous='True'. *Lower panel:* Histogram of the BP-RP colors. In red the histograms of those sources with has_xp_continuous='True'.

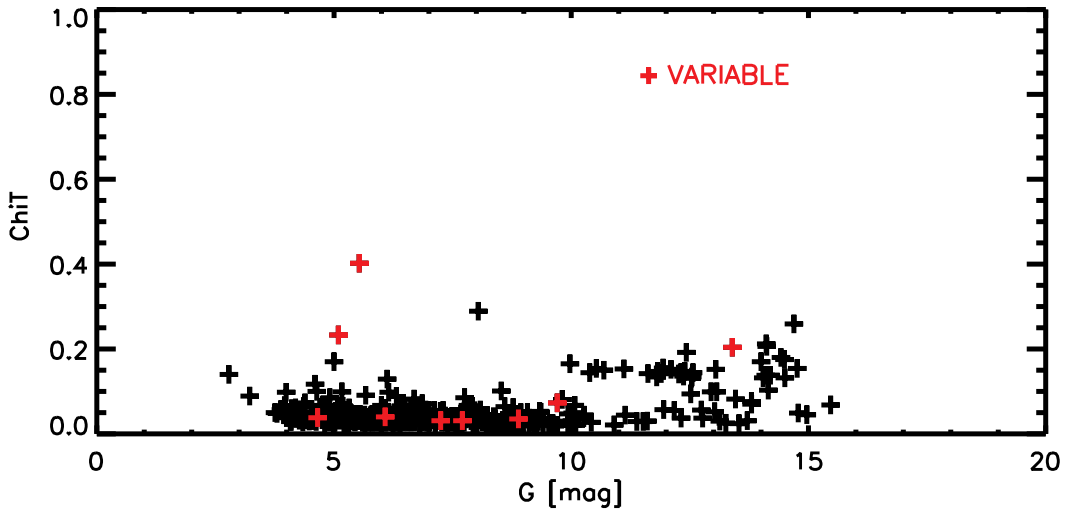

Fig. 3. *Upper panel:* chiT versus Gmag of the MILES stars. Only datapoints with comment="OK" and with full coverage from 400.0 nm to 740.0 nm are used.

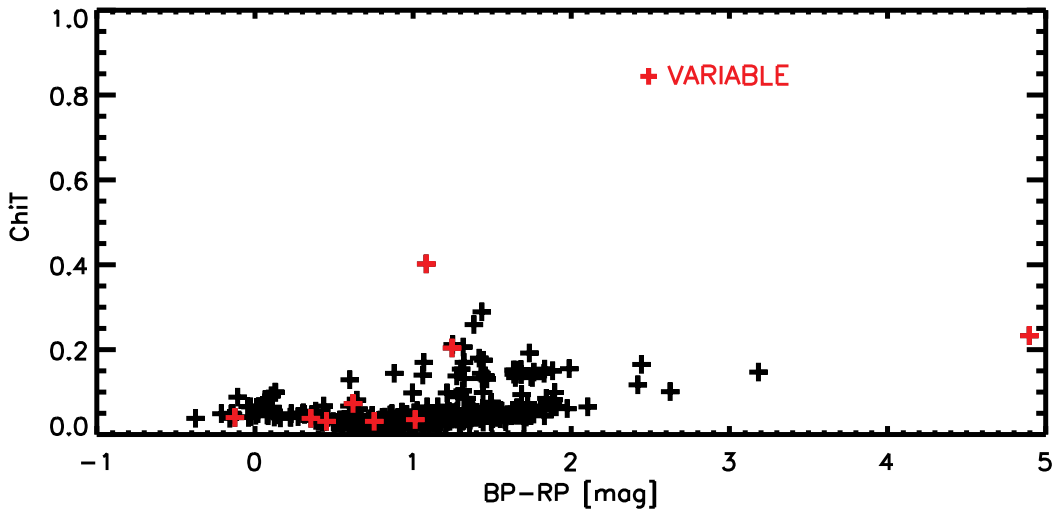

Fig. 4. chiT versus BP-RP mag of the MILES stars. Only datapoints with comment="OK" and with full coverage from 400.0 nm to 740.0 nm are used.

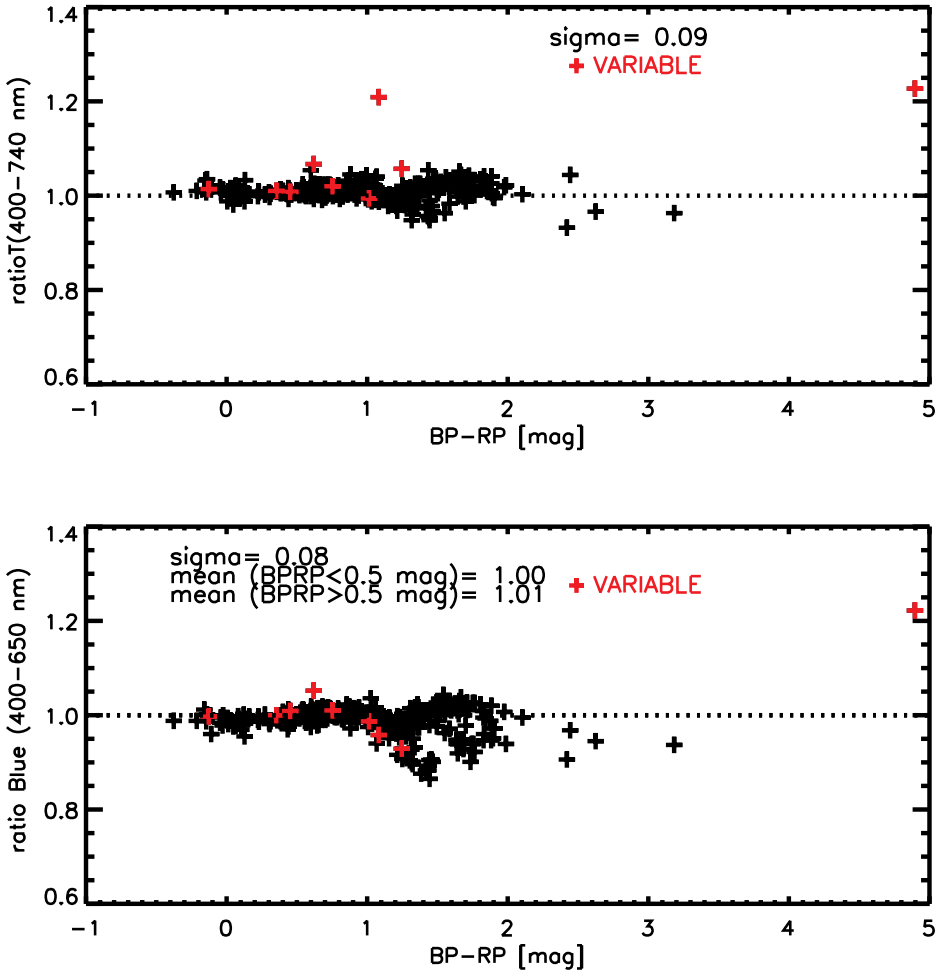

Fig. 5. MILES spectra: Only datapoints with comment="OK", and with full coverage from 400.0 nm to 740.0 nm are used.

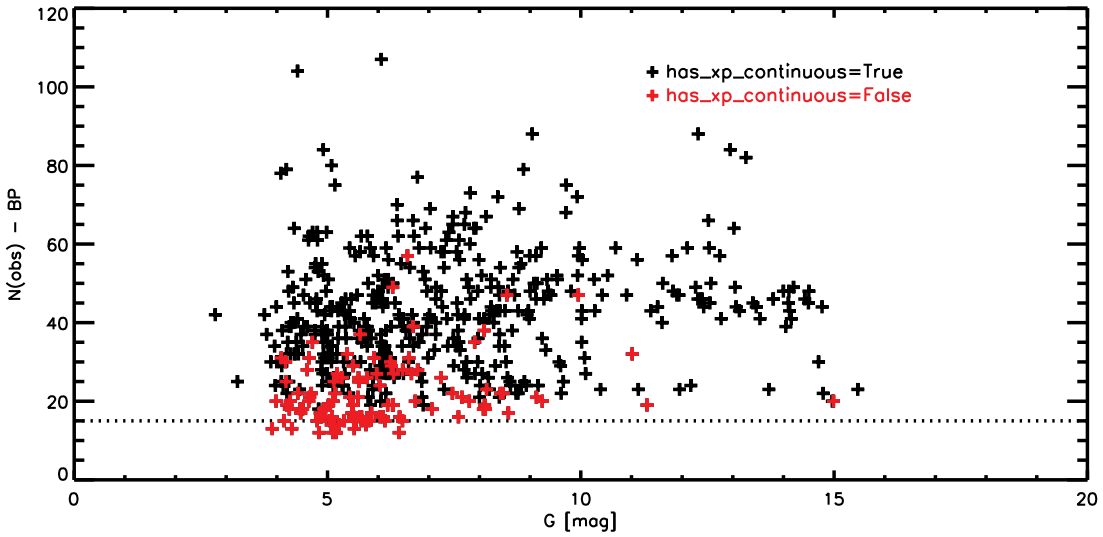

Fig. 6. MILES stars: Number of observations in BP-band versus Gmag. Only datapoints with comment="OK" and with full coverage from 400–740 nm are plotted.

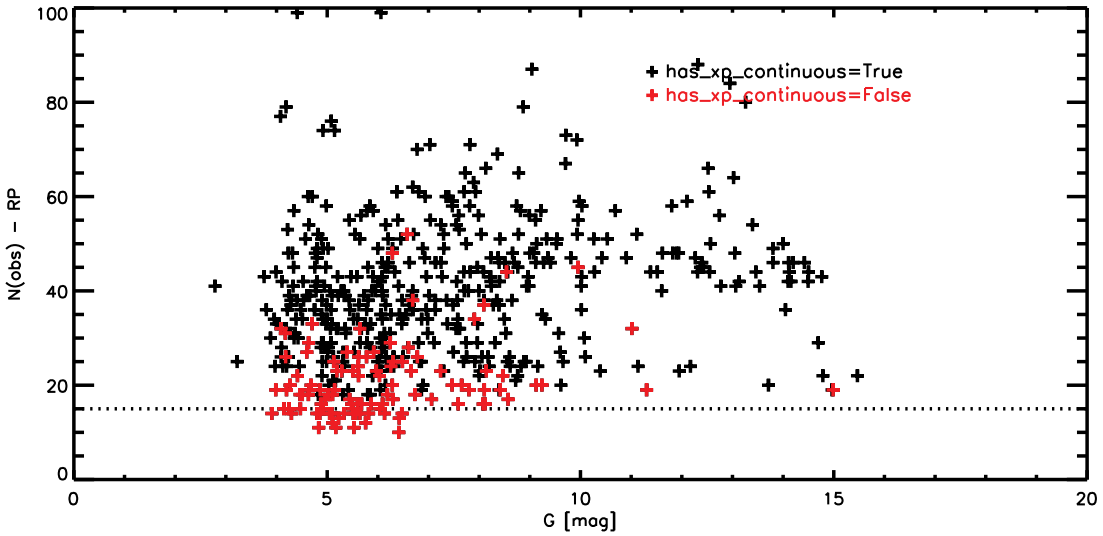

Fig. 7. MILES stars: Number of observations in RP-band versus Gmag. Only datapoints with comment="OK" and with full coverage from 400–740 nm are plotted.

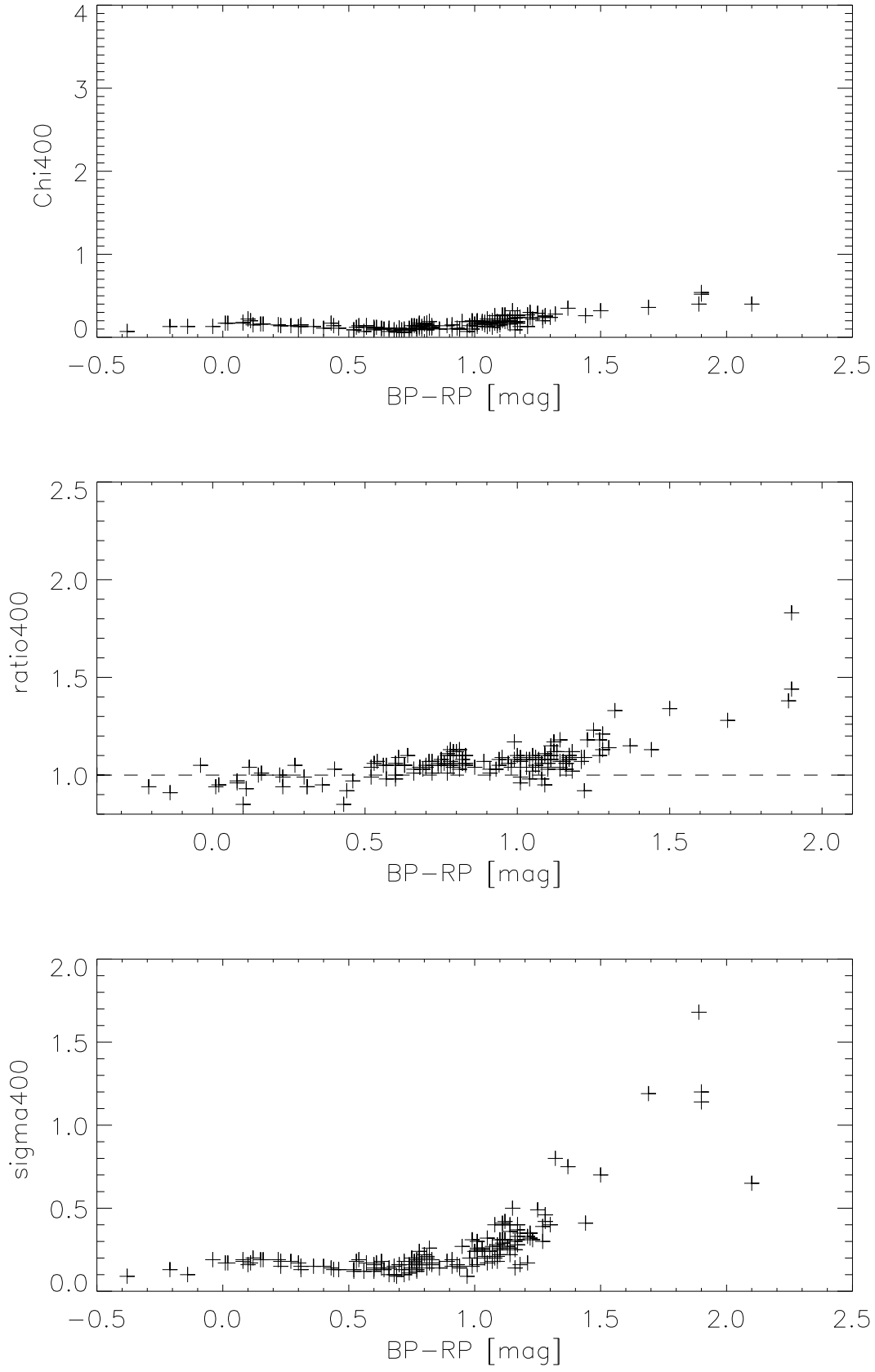

Fig. 8. MILES stars: Using the best sample of MILES spectra (with adjusted slope), the performance of the fit below 400 nm is analyzed.

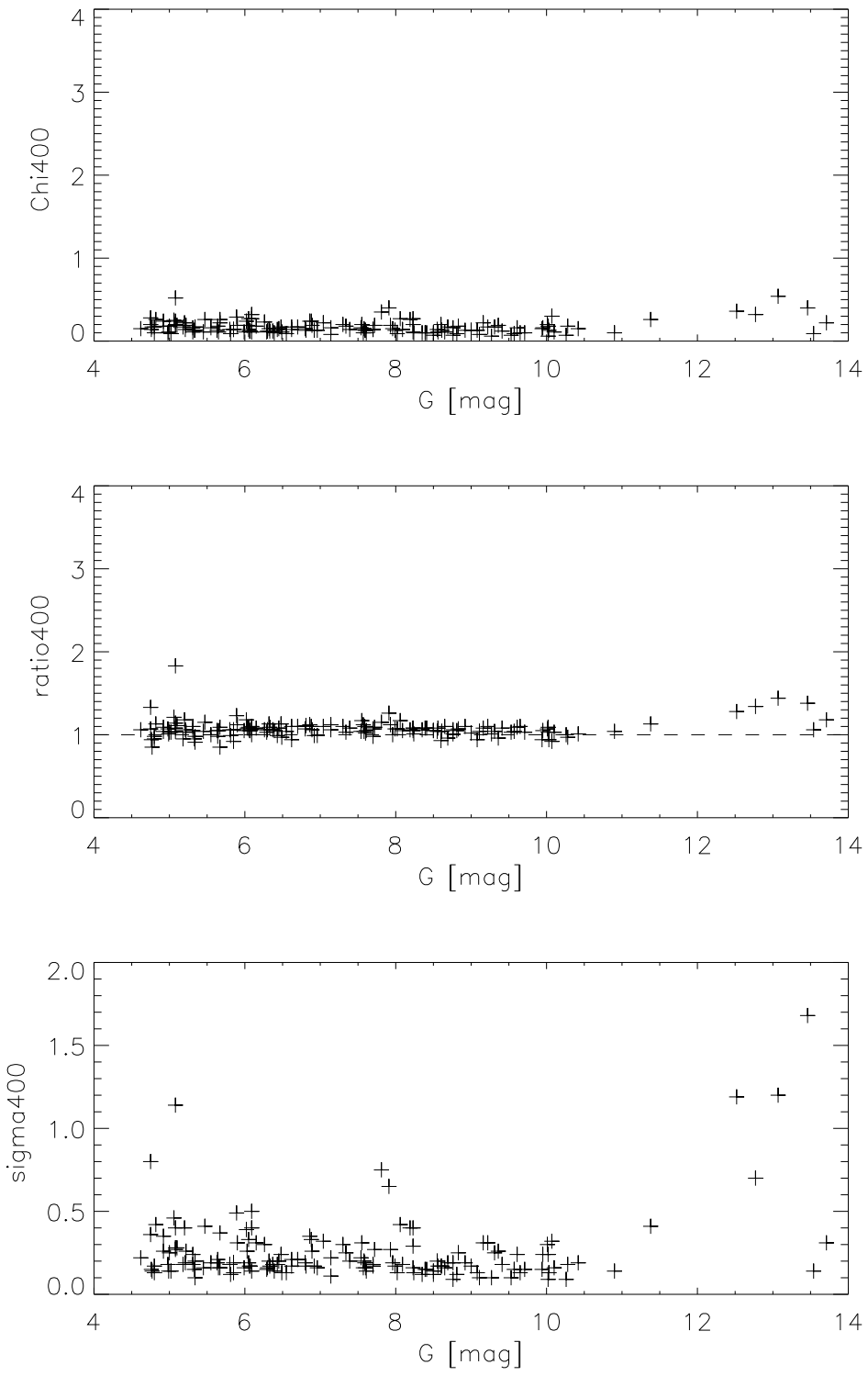

Fig. 9. Distribution of the G-mag of stars in the MILES library.

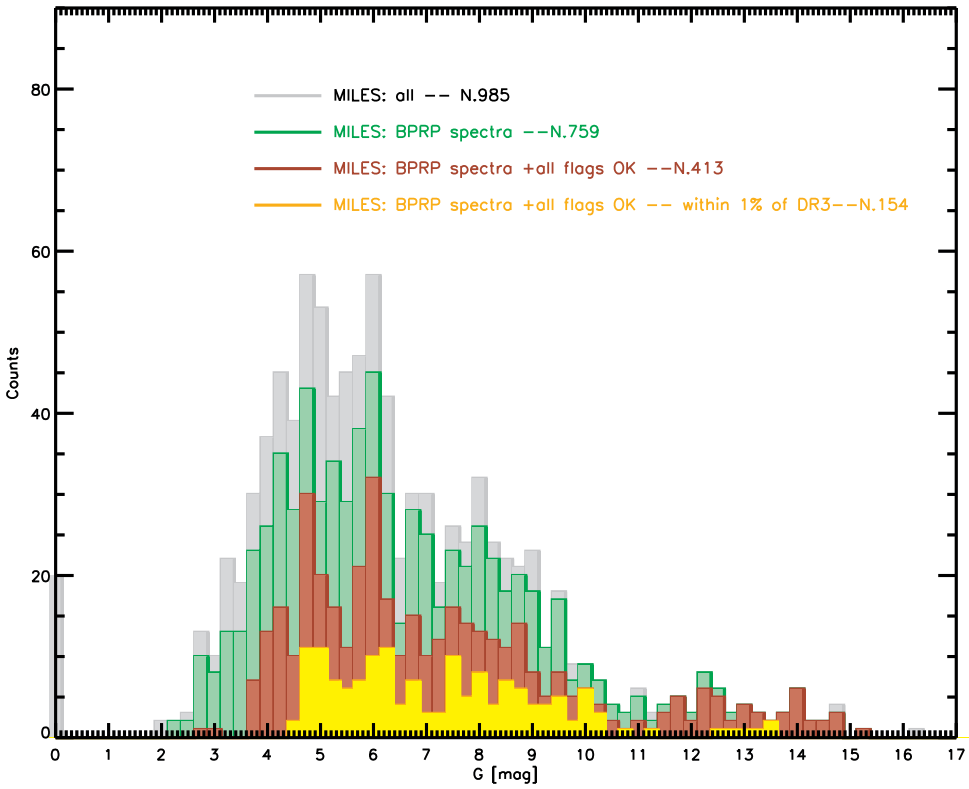

Fig. 10. G-mag values versus BP−RP values of stars in the MILES library.

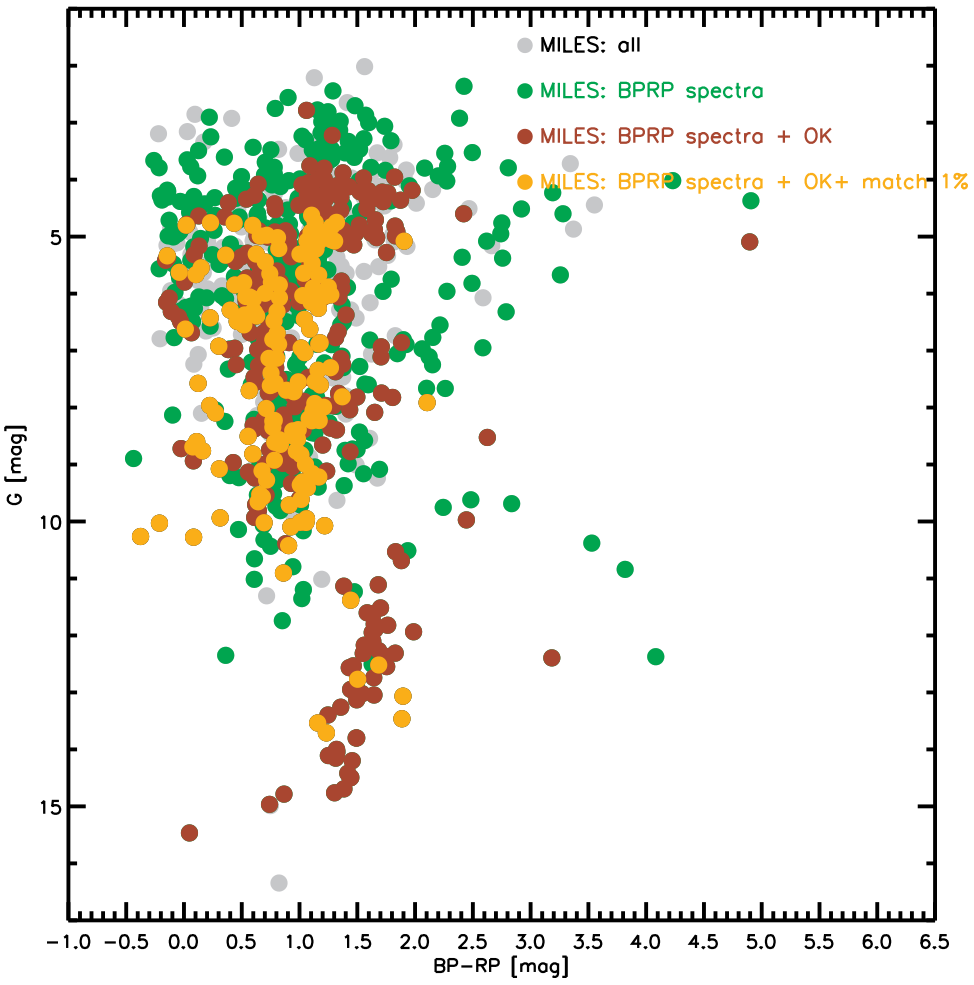

Fig. 11. MILES spectra.