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Determination of the spectral type of 60 stars from the catalog SDSS

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Abstract. Our task consisted in selecting a certain amount of stars from a catalog in order to identify which spectral type they belong to. Our work was divided into two main phases: at first, we created a graph with the spectrum for each star and then compared them with the spectra taken from a list of stars of known spectral type to find the one that best matches our stars. After this, we were able to assign a spectral type to all the stars we examined.

1. Introduction

Stars are characterized by many physical and chemical parameters such as temperature, colour, luminosity and chemical composition.

A stellar spectrum shows the energy flow emitted by a star at different wavelengths. Thanks to the work of some physicists like Planck and Wien, today we are aware that the shape of the spectral curve is related to the temperature of the star, while the negative peaks, that represent the absorption lines, are due to the elements in its atmosphere. Thanks to this, analysing the spectrum of a star, its temperature and the chemical composition of its atmosphere can be inferred.

Regarding the classification of the stars according to their spectral characteristics, it is generally used in astronomy the Harvard classification, which divides the stars into seven main classes, from the hottest ones to the coldest ones:

O: blue stars with a temperature between 50000K and 25000K;
B: blue stars with a temperature between 25000K and 12000K;
A: white stars with a temperature between 12000K and 7500K;
F: white stars with a temperature between 7500K and 6000K;
G: yellow stars with a temperature between 6000K and 5000K (like the Sun);
K: red stars with a temperature between 5000K and 3000K;
M: red stars with a temperature of about 3000K.

Moreover each class is divided into other ten groups, from 0 to 9, with decreasing temperature.

2. Observational Data

The stars we chose for our project were selected from the Sloan Digital Sky Survey (SDSS) archive, which contains photometric observations and spectra of objects in more than 35% of the sky. This survey is based on observations made with the 2.5-m wide-angle optical telescope and 0.5-m Photometric Telescope at the Apache Point Observatory in New Mexico.

We started selecting 5000 stars, among the point-like sources, having different right ascension (RA) and declination (DEC), and high quality in the SDSS archive.

3. Work description

The first phase of our work consisted in selecting the stars to be processed. Our purpose was to get as many spectral types as possible, therefore we searched for stars with different characteristics. In order to do this, we created a two colours plot by using the TOPCAT software (an interactive graphical viewer and editor for tabular data).

We tried to combine different colour indexes in order to have the best linear distribution. At the end we obtained the relation in Fig. 1, which shows the distribution of the stars with different colours and therefore different temperatures.

Then we proceeded choosing 60 objects in the graph, trying to cover up the best distribution of stars on the diagram. After this, we downloaded the spectra for the selected objects from the SDSS catalogue. We elaborated the spectra using the package IRAF (Image Reduction and Analysis Facility). We obtained all the information connected with each star's spectrum we analysed. This was necessary to find the average value

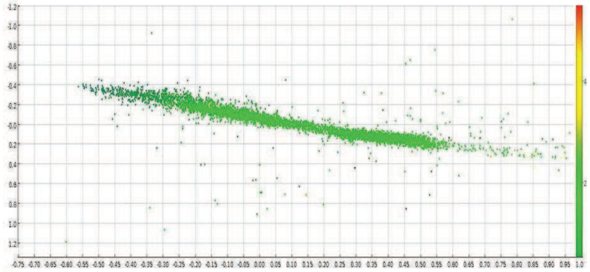

Fig. 1. Graph obtained selecting 5000 stars from the SDSS catalogue. On the x-axis there is the colour index $g - r$, on the y-axis the colour index $i - r$, and on the third axis (the color bar) the colour index $u - g$.

of the spectra at a certain wavelength (5500 Å), that was used to normalize the spectra and therefore make them comparable with the spectra of the library. This was done using IRAF again and dividing the spectra by the above mentioned value.

After that, using TOPCAT, we compared our spectra with those of known spectral type taken from the Jacoby catalogue, trying to overlap the graph as best as we could. This allowed us to identify the spectral type that best fitted the stars we had selected and to create a list of all the 60 stars, with the corresponding spectral type. The list of all the 60 stars with the corresponding spectral type is given in Table 1. In Figs. 2-7 are shown some of the comparisons we made.

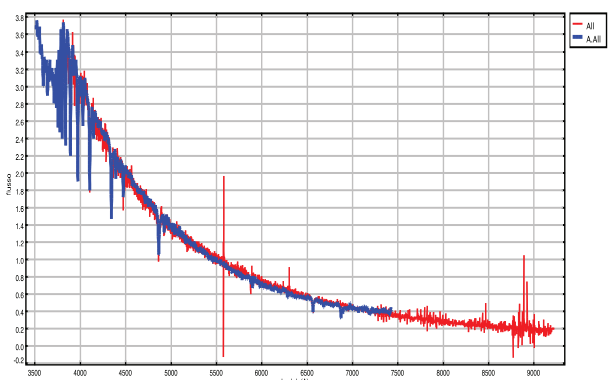

Fig. 2. This is a star (red line) that was classified as B1.5 after the comparison with the corresponding spectrum taken from the Jacoby catalogue (blue line).

In the last phase of our work we assigned a progressive number to every spectral type, from O0 = 1 to M9 =70. In Fig. 8 we plotted the number of the spectral type versus the colour index ($g - r$), for all the stars we had examinated. This plot allowed us to link the colour with the spectral type of the stars.

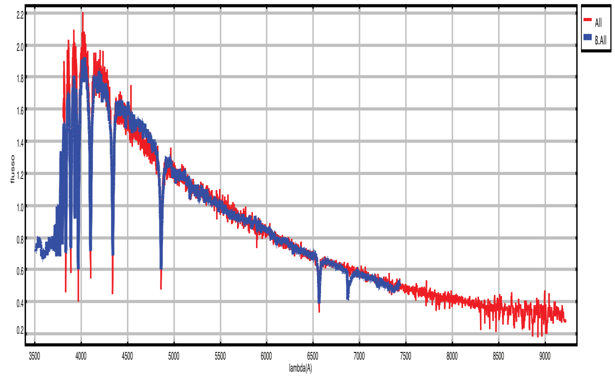

Fig. 3. The same as Fig. 2 for a star classified as A7.

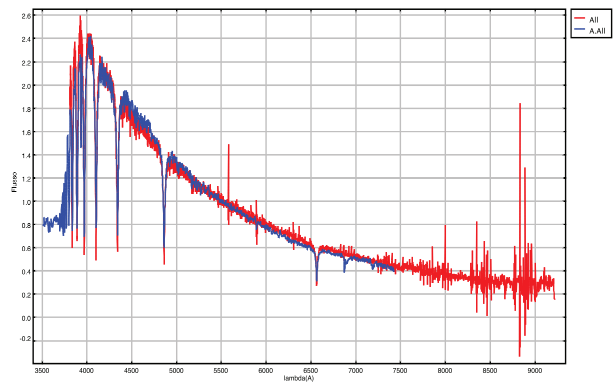

Fig. 4. The same as Fig. 2 for a star classified as A2.

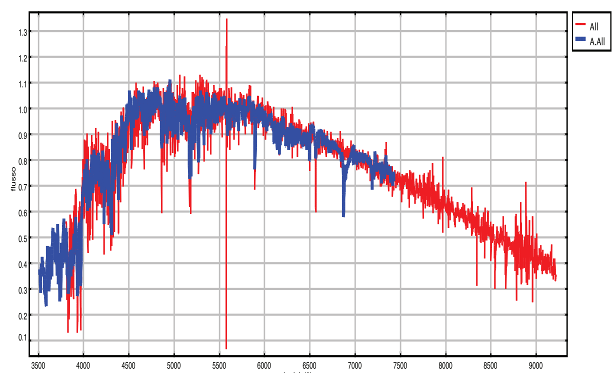

Fig. 5. The same as Fig. 2 for a star classified as K0.

4. Results

We identified 59 spectral types out of 60 (see Table 1) with good approximation for stars of B, A, F, and G type. On the other hand, we found more difficulties to identify K and M type stars, and this is probably due to the fact that these stars are cooler and therefore their spectra have lower quality. We can notice that most of the stars (15 out of 59) belong to the spectral class A, 11 to the class M, 10 to the class K, 8 to the class G and 8 to the class F. We did not find any star belonging to the spectral type O and we found only 7 stars

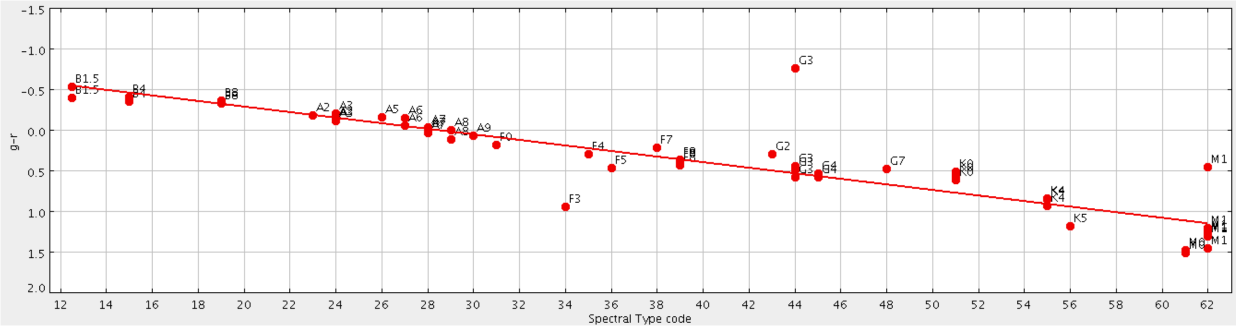

Fig. 8. The final diagram shows the linear relation (dashed line) between the colour $(g - r)$, on y-axis, and the spectral type code of the stars, on the x-axis. The spectral classification is also reported in the plot.

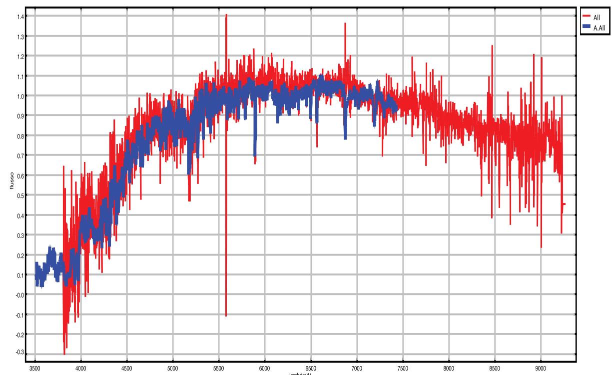

Fig. 6. The same as Fig. 2 for a star classified as K5.

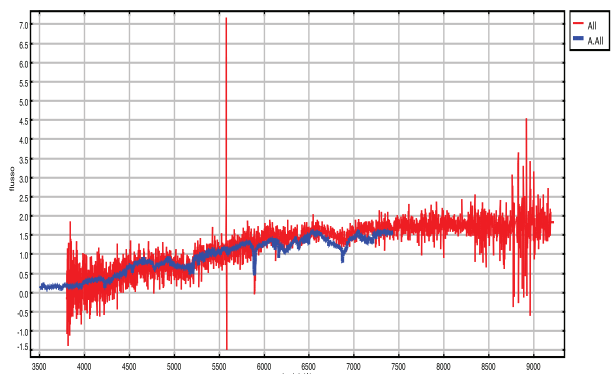

Fig. 7. The same as Fig. 2 for a star classified as M0.

of class B, probably because these kinds of stars are very hot and thus quite uncommon. Regarding the star whose spectral type was not determined, we might consider the hypothesis of some error in the data processing. In fact, its spectrum appears almost flat, therefore we can suppose that this is the combination of two different spectra. As for the last graph (Fig. 8), we found a relation between the colour and the spectral type. In fact, by tracing the linear regression using the ordinary least squares method, we obtained a linear relation. We can also notice that for "cool" spectral types the values are slightly positive and the colour of the stars verges to red, as stated by the Harvard classification, while for "hot" spectral types the values are slightly negative and the colour of the stars verges to yellow.

References

[1] A library of stellar spectra, G.H. Jacoby, D.A. Hunter and C.A. Christian, 1984, ApJS, 56, 257
[2] UBV Photoelectric Photometry of Open Cluster M35, H. Sung and S.-W. Lee, 1992, JKAS, 25, 91

Table 1. Summary results

No	Object name SDSS Catalog	RA	DEC	Spectral Type	Mag g	Mag r	color $(g-r)$
1	J151817.20+573142.5	229.572	57.528	B8	19.13	19.49	-0.355
2	J085713.70+215705.5	134.307	21.952	A2	17.42	17.60	-0.182
3	J123224.37+411237.4	188.102	41.210	A3	20.13	20.32	-0.197
4	J111711.31+293419.2	169.297	29.572	G3	17.72	17.13	0.589
5	J142343.56+024801.0	215.932	2.800	M1	17.60	16.31	1.284
6	J021500.27+135748.1	33.751	13.963	K4	18.85	18.00	0.858
7	J173853.68+545255.2	264.724	54.882	M1	18.23	17.78	0.455
8	J205835.61-051558.4	314.648	-5.266	A8	17.61	17.60	0.011
9	J171246.87+300608.6	258.195	30.102	F4	25.10	24.80	0.296
10	J083528.55+540347.6	128.869	54.063	K4	17.71	16.86	0.853
11	J075305.22+460538.4	118.272	46.094	F8	16.39	15.95	0.436
12	J130514.46+030221.7	196.310	3.039	G4	17.53	22.75	-5.216
13	J105711.59+321313.3	164.298	32.220	B4	19.24	19.59	-0.348
14	J150212.12-024557.7	225.551	-2.766	A7	14.87	14.86	0.007
15	J163809.33+345046.6	249.539	34.846	F0	18.44	18.25	0.191
16	J215840.78+003334.6	329.670	0.560	M1	19.82	18.61	1.211
17	J134723.64+013541.6	206.848	1.595	M1	17.44	16.17	1.265
18	J160104.31+551305.1	240.268	55.218	F3	18.58	17.63	0.948
19	J084118.27+274627.1	130.326	27.774	A6	15.53	15.58	-0.048
20	J085422.39+013650.9	133.593	1.614	A5	15.98	16.13	-0.149
21	J073925.43+341845.2	114.856	34.313	M1	18.34	16.88	1.457
22	J160810.63+103211.6	242.044	10.537	B8	17.09	17.45	-0.356
23	J215227.25+115726.6	328.114	11.957	B1.5	17.44	17.83	-0.396
24	J082428.16+175213.3	126.117	17.870	A7	18.94	18.97	-0.028
25	J090123.05+075037.2	135.346	7.844	K0	17.83	17.32	0.519
26	J141028.63+024424.3	212.619	2.740	M1	17.10	15.80	1.299
27	J113836.32+475510.0	174.651	47.919	B1.5	17.52	18.05	-0.524
28	J002649.20-091145.6	6.705	-9.196	K5	25.09	19.76	5.330
29	J153920.68+022057.6	234.836	2.349	M1	16.48	18.39	-1.910
30	J223404.42-081218.8	338.518	-8.205	K0	17.66	17.09	0.566
31	J145929.25+003320.3	224.872	0.556	B4	18.97	19.37	-0.398
32	J084818.90+185314.1	132.079	18.887	A3	15.89	15.99	-0.107
33	J170028.23+635037.2	255.118	63.844	K5	20.57	19.39	1.183
34	J150348.50+005403.7	225.952	0.901	F5	17.66	17.19	0.468
35	J013347.55-090812.1	23.448	-9.137	A9	17.52	17.45	0.069
36	J095253.47+550957.4	148.223	55.166	F8	17.89	17.53	0.364
37	J131721.60+610700.7	199.340	61.117	K4	19.20	18.35	0.846
38	J171837.36+534623.9	259.656	53.773	A8	19.71	19.59	0.124
39	J173147.94+581619.0	262.950	58.272	A3	19.59	19.72	-0.134
40	J162010.12+191258.1	245.042	19.216	A6	17.97	18.11	-0.137
41	J123657.67+262449.9	189.240	26.414	A6	17.72	17.86	-0.143
42	J100707.23+232301.4	151.780	23.384	A7	17.56	17.59	-0.033
43	J144040.54+000806.2	220.169	0.135	F7	15.28	15.06	0.224
44	J223439.76+143614.6	338.666	14.604	G4	18.03	17.49	0.539
45	J224734.23-011007.0	341.893	-1.169	G4	18.17	17.58	0.583
46	J152355.90+022826.6	230.982	2.474	G3	17.11	17.87	-0.759
47	J161210.54+114535.7	243.044	11.760	B8	18.08	18.40	-0.321
48	J093404.58+304739.6	143.519	30.794	G2	15.68	15.38	0.303
49	J235157.31+135731.9	357.989	13.959	G3	18.27	17.81	0.454
50	J145800.15-004509.3	224.501	-0.753	A7	19.34	19.30	0.044
51	J154949.75+460012.9	237.457	46.004	F8	17.67	17.28	0.395
52	J161334.19+114944.2	243.392	11.829	G3	17.64	17.15	0.493
53	J093911.44+175540.9	144.798	17.928	M1	19.23	17.92	1.307
54	J134723.64+013541.6	206.849	1.595	M1	17.44	16.17	1.265
55	J163135.42+162509.0	247.898	16.419	K4	17.74	16.80	0.941
56	J032334.20-073404.7	50.893	-7.568	M0	21.24	19.76	1.482
57	J221213.32+132928.1	333.056	13.491	K0	25.11	18.64	6.473
58	J135640.16+014719.9	209.167	1.789	M0	20.78	19.26	1.522
59	J082255.27+440317.6	125.730	44.055	G7	18.05	17.56	0.487
60	J230929.85+142724.1	347.374	14.457	K0	17.98	17.34	0.617