Boletim da Sociedade Astronômica Brasileira, **32**, no. 1, 19-20

The temperature scale and the classification of stars

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Abstract. In this work, we present an updated temperature scale calibration of different spectral types (O, B, A, F, G, K, M) and different luminosity classes, from dwarfs of the main sequence to subgiants, giants, supergiants and luminous supergiants.

Resumo. Neste trabalho, apresentamos uma escala de temperaturas atualizada para estrelas de diferentes tipos espectrais (O, B, A, F, G, K, M) e diferentes classes de luminosidade, desde anãs da sequência principal, subgigantes, gigantes, supergigantes até supergigantes luminosas.

Keywords. Stars: fundamental parameters – Methods: data analysis – Subdwarfs – Supergiants

1. Introduction

Previous works about spectral class versus stellar temperature are not up to date, or they do not cover all spectral types or luminosity classes . Noticing this need, thia work intends to provide an updated temperature scale for different spectral types and luminosity classes , including also their average surface gravity as an additional parameter.

Throughout the years our group SAMPA (Stellar Atmospheres, Planets and Abundances) has gathered a database of atmospheric parameters (metallicity, surface gravity and temperature) for thousands of stars. For many of those, there are spectral types, obtained through the group's original works or the SIMBAD database.

From that sample we selected those whose metallicities were about the Sun's, and then we calculated their medium values of temperature and surface gravity. Then, we divided the sample in spectral subtypes and luminosity classes. We present in this work the correlations between spectral types, luminosity classes and effective temperature and surface gravity, for O, B, A, F, G, K and M stars.

2. Methodology and results

We calculated the median values of the atmospheric parameters of temperature and superficial gravity and then, the sample was divided in spectral types and luminosity classes. It has been defined an arbitrary numerical spectral type, starting with 0 to M9, then 1 to M8, 2 to M7 until 69 for O0 spectral type.

In this work, we show a correlation between the spectral types, luminosity classes and effective temperature and surface gravity for O, B, A, F, G, K, M stars.

We made polynomial adjustments to obtain the expected (smooth) values of effective temperature and surface gravity for each spectral type, as shown in "Fig.1", "Fig.2", "Fig.3", "Fig.4" and "Fig.5", below. In the end, we compared our results with Allen's Astrophysical Quantities tables.

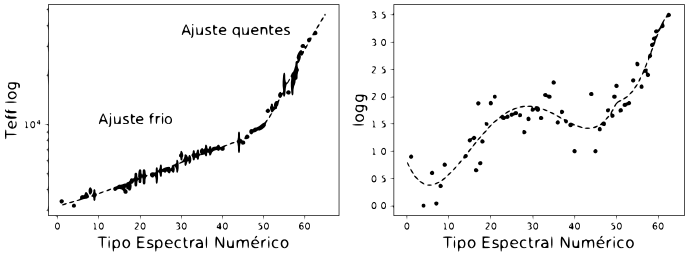

Figure 1: Effective Temperature and Surface Gravity as a function of the numerical spectral types for luminous supergiants (Luminosity class I). For "Ajuste Frio" we have the coldest stars and for "Ajuste Quente" we have the hottest ones.

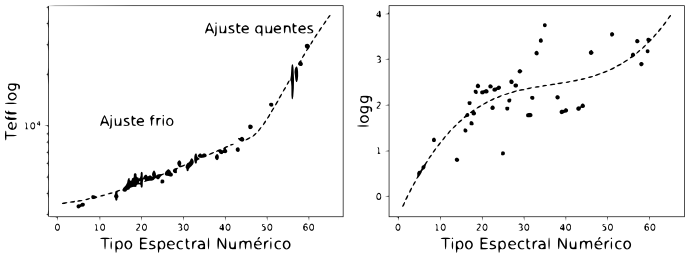

Figure 2: Effective Temperature and Surface Gravity as a function of the numerical spectral types for supergiants (Luminosity class II). For "Ajuste Frio" we have the coldest stars and for "Ajuste Quente" we have the hottest ones.

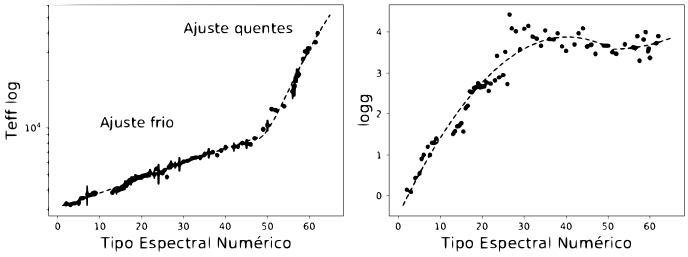

Figure 3: Effective Temperature and Surface Gravity as a function of the numerical spectral types for giants (Luminosity class III). For "Ajuste Frio" we have the coldest stars and for "Ajuste Quente" we have the hottest ones.

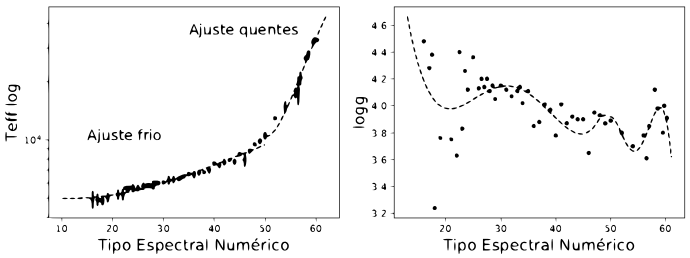

FIGURE 4: Effective Temperature and Surface Gravity as a function of the numerical spectral types for subgiants (Luminosity class IV). For "Ajuste Frio" we have the coldest stars and for "Ajuste Quente" we have the hottest ones.

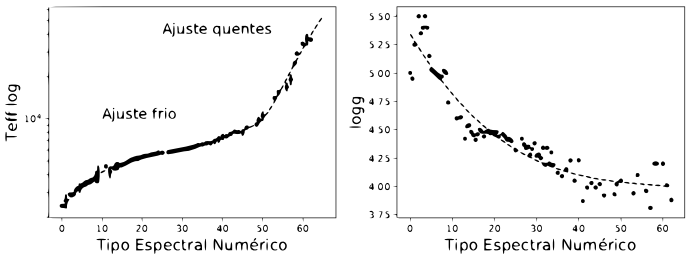

FIGURE 5: Effective Temperature and Surface Gravity as a function of the numerical spectral types for dwarfs of the main sequence (Luminosity class V). For "Ajuste Frio" we have the coldest stars and for "Ajuste Quente" we have the hottest ones.

Table 1: Values of Teff, logg and sigma obtained through the polynomial adjustments and Allen tables, for Luminosity V.

Luminosity V						
TE	Teff Allen	Teff	σ	logg Allen	logg	σ
M5	3170	3162	95	–	–	–
M2	3520	3713	111	–	–	–
M0	3840	4028	559	–	–	–
K5	4410	4668	292	–	–	–
K2	4830	4975	128	–	–	–
K0	5150	5158	231	4.49	4.48	0.73
G8	5310	5330	157	–	–	–
G5	5560	5576	220	4.49	4.35	0.45
G2	5790	5823	146	–	–	–
G0	5940	5998	144	4.39	4.25	0.22
F8	6250	6185	153	–	–	–
F5	6650	6500	175	4.34	4.17	0.22
F2	7000	6873	167	–	–	–
F0	7300	7161	347	4.34	4.11	0.25
A5	8180	8056	189	4.29	4.07	0.12
A2	9000	8738	471	–	–	–
A0	9790	9565	496	4.14	4.04	0.18
B5	–	–	–	4.04	4.02	0.49
B3	–	–	–	3.94	4.02	0.19
B2	20900	21931	1601	–	–	–
B0	–	–	–	3.94	4.01	0.23
O9	34000	31542	150	–	–	–

3. Comparison with literature

We compare our results of the polynomial adjustments with the values in the fourth edition of Allen's Astrophysical Quantities book as shown in the tables bellow.

Table 2: Values of Teff, logg and sigma obtained through the polynomial adjustments and Allen tables, for Luminosity III.

Luminosity III						
TE	Teff Allen	Teff	σ	logg Allen	logg	σ
M5	3380	3383	91	–	–	–
M2	3540	3599	561	–	–	–
M0	3690	3755	167	1.34	1.26	0.38
K5	4050	4187	230	1.74	2.03	0.65
K2	4390	4474	217	–	–	–
K0	4660	4678	151	2.14	2.66	0.34
G8	4800	4891	177	–	–	–
G5	5050	5229	754	2.54	3.16	0.64
G0	–	–	–	2.94	3.54	0.81

Table 3: Values of Teff, logg and sigma obtained through the polynomial adjustments and Allen tables, for Luminosity I.

Luminosity I						
TE	Teff Allen	Teff	σ	log g Allen	logg	σ
M2	3370	3613	159	-0.06	0.40	0.23
M0	3620	3746	277	0.14	0.50	0.38
K5	3990	4130	61	0.34	0.92	0.37
K2	4310	4396	181	–	–	–
K0	4550	4588	407	0.94	1.39	0.7
G8	4700	4792	486	–	–	–
G5	4930	5120	546	1.14	1.72	0.63
G2	5190	5475	221	–	–	–
G0	5370	5726	469	1.34	1.82	0.94
F8	5750	5989	475	–	–	–
F5	6370	6406	437	1.44	1.72	0.84
F2	7030	6849	422	–	–	–
F0	7460	7159	265	1.74	1.52	0.81
A5	8610	7987	1130	2.04	1.42	0.94
A2	9380	9452	285	–	–	–
A0	9980	9615	163	2.14	1.74	0.83
B8	11100	10792	141	–	–	–
B5	13600	14461	594	2.44	2.12	0.24
B2	17600	20413	2465	–	–	–
B0	–	–	–	2.84	2.97	0.13

4. Discussions

For the most of compare spectral types it was possible to see that they are compatible in the most of the values. However, there are spectral types which the effective temperature or the surface gravity obtained through the polynomial adjustments are not compatible with Allen's book values. Likely our results are more reliable, as is based on recent works in the literature, and is based on a large sample of stars. For future works, we pretend to include new stars in the sample and improve this method to calibrate the temperature and gravity scales.

References

Allen, C. W. 2000, Allen's Astrophysical Quantities, (New York: Springer)