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THE IMPACT OF REDDENING ON THE OBSERVED FLUXES OF A STARS

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ABSTRACT We compare observed ultraviolet and visible flux distributions, for a sample of A-type stars, with computed fluxes obtained with version 9 of the ATLAS code (Kurucz, 1970) in order to asses the impact of reddening. We also make a comparison between determinations of reddening from UV colour indices and visible wide band (Johnson) and intermediate band (Strömgren) colour indices. We discuss the implications on the study of slightly reddened high galactic latitude stars.

INTRODUCTION

The first step in the abundance analysis is to select a model atmosphere. The first parameters to be fixed are the effective temperature and the surface gravity. Methods which may be used to fix them are usually based on the comparison between observed quantitites and those computed from model atmospheres such as: continuum fluxes as derived from spectrum scans in the visible or UV or both; colours; features in the line spectrum.

The first two comparisons are affected by reddening. In this paper we investigate the impact of reddening on the estimates of effective temperature and we address the problem of how reddening can be reliably determined.

THE PROGRAM STARS

We selected a sample of 9 B8–A3 type stars, six Pop II HB stars and three standard Pop I stars for which visible fluxes are available either in the Breger catalogue (Breger, 1976) or from Philip and Hayes (1983), and UV fluxes observed with IUE (low resolution, large aperture) are available in the ULDA

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TABLE I Data for the program stars

Star (1)	Sp (2)	V (3)	(B-V) (4)	(U-B) (5)	(b-y) (6)	m1 (7)	c1 (8)	β (9)	T_{eff} (10)	$log\ g$ (11)	[M/H] (12)	Ref* (13)
CD-34 12784†	B9.5III	1.85	-0.03	-0.13	0.016	0.102	1.176	2.778	9300	4.00	0.0	12,2,14
CD-26 10505‡	A0V	8.12	0.08	0.05	0.067	0.105	1.268	2.84	8300	3.45	-2.5	4,2,5
BD-17 3883‡	B9 IV/V	9.053	0.063	0.102	0.062	0.117	1.202	2.845	8500	3.75	-2.0	6,2,7
BD-06 86‡	A2	9.98	0.19	0.35	0.135	0.113	1.212	2.683	7500	2.50	-2.0	1,2,3
BD+13 3899†	A0V	2.99	0.01	-0.01	0.012	0.147	1.080	2.878	9680	4.27	0.0	12,2,15
BD+15 2383†	A3V	2.14	0.08	0.07	0.044	0.210	0.975	2.90	8600	4.20	0.0	12,2,13
BD+25 3344‡	sdA2	6.928	0.147	0.138	0.133	0.110	1.207	2.780	7450	2.93	-1.5	10,2,9
BD+30 2431‡	B8p	10.055	-0.135	0.632	-0.062	0.104	0.320	2.696	17500	4.20	0.0	6,2,11
BD+39 2031‡	A1V	7.26	0.04	0.10	0.023	0.158	1.198	—	8700	3.70	-0.5	8,2,9

* The first number is the reference for UBV colours, the second number is the reference for uvbyβ colours, the third number is the reference for atmospheric parameters.

†Population I stars

‡Population II stars

1 Carney (1983);2 Hauck and Mermilliod (1990); 3 Danford and Lea (1981); 4 Przybylski and Kennedy (1965); 5 Adelman and Philip (1990); 6 Neckel and Chini (1980); 7 Adelman and Philip (1992); 8 Guetter (1980); 9 Adelman and Hill (1987); 10 Landolt (1983); 11 Baschek and Sargent (1976); 12 Johnson *et al.*(1966); 13 Lester *et al.*(1986); 14 Kontizas and Theodossiou (1980); 15 Malagnini and Morossi (1990).

archive (Wamsteker *et al.*1989). The basic data of our program stars are summarized in Table I.

ESTIMATING E(B-V) FROM PHOTOMETRY

For the A–type stars we derived an E(B-V) value from the Johnson photometry, by subtracting from the value of (B-V), found in the SIMBAD data base, the $(B-V)_0$ given in Fitzgerald (1970) for the spectral type of the stars. For the B-type stars in our sample we used Johnson's Q method as described by Heintze (1973) and implemented in the QMETHOD code of Dworetsky (1985).

We derived E(B-V) from Strömgren photometry by dereddening the indices (b-y), m1 and c1 given in the Hauck and Mermilliod (1990) catalogue by means of the UVBYBETA code of Moon (1985), which provides a value of E(b-y) and an estimate of T_{eff} . The E(b-y) values were then converted to E(B-V) values by means of the relation of Crawford and Mandwewala (1976):E(B-V)=E(b-y)/0.74 . Table II lists, in column 2 the values of E(B-V) derived from the Johnson photometry, in column 3 the values derived from the Strömgren photometry, while columns 4 and 5 contain published values of E(B-V) and E(b-y) and column 6 contains the values derived in the present study (see next section).

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ESTIMATING E(B-V) FROM VISIBLE SPECTRUM SCANS

For each program star we searched in the literature for determinations of log g, T_{eff} and [M/H] (columns 10,11 and 12 in Table I). We extracted from Kurucz's (1991) new grid the fluxes from models having the parameters log g and [M/H] closest to the values found in the literature (we used those determinations which were used in fine abundance analysis, when available), but having different T_{eff} ranging over an interval of 1000 K in T_{eff} around the literature value. For each star we compared the visible observed fluxes with this small grid of theoretical fluxes. The observations were those of Philip and Hayes (1983), when available, or from the Breger catalogue (Breger, 1976). We assumed different values of E(B-V) for dereddening the observed fluxes. Reddening corrections were computed using the average law of Mathis (1990) with $R_V = 3.1$. From visual inspection of plots we fixed that value of E(B-V) which gives the best match with both the Balmer and the Paschen observed continua (Table II, column 6). Then we plotted the theoretical fluxes along with the absolutely calibrated low resolution IUE spectra (corrected for the change in sensitivity of the IUE cameras as described in Bohlin and Grillmair ; 1988) dereddened with the E(B-V) value derived from the visual region.

REMARKS ON INDIVIDUAL STARS

CD-26 10505

For this star the reddening derived from the visual region allows a good fit for the UV region too. Neglecting the reddening should produce an underestimate of ≈ 500 K for the temperature.

BD-17 3883

For this star Cacciari *et al.*(1987) derived from the analysis of the 220 nm feature, a rather high value of E(B-V), which differs from our estimate by 0.1 mag . We find that E(B-V)=0.15 gives a very poor fit for the visible data. The well exposed IUE spectrum SWP23442L is consistent with our adopted reddening. Unfortunately no well exposed spectrum in the IUE long wavelength range exists in ULDA. We also explored the effects of the metallicity, but this turned out to be a second order effect with respect to that of reddening.

BD-06 86 and BD+25 3344

It is not surprising that the colour excess deduced from the photometry is inconsistent with that indicated by the spectrophotometric data, since the calibrations to compute reddening corrections are valid for MS stars but not for HB stars, like these two.

BD+30 2431

This star has often been assumed to be unreddened, mainly because of its galactic location; yet we find that a slight reddening is necessary to fit its visible flux. Owing to its high effective temperature the effect of neglecting the

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reddening is rather large when estimating T_{eff} and leads to an error of ≈ 1000 K. We computed fluxes from models which take into account the well-known He deficiency of this peculiar star.

BD+39 2031

The spectrophotometric data for this star fit the theoretical models poorly . A non-zero reddening worsens the fit rather than improving it. We remark that Adelman and Hill (1987) obtain a rather good fit to the Philip and Hayes data by using a Kurucz (1979) model with T_{eff} =8700 K, log g =3.70 [M/H]=-0.5. The discrepancy with our results needs further investigation.

Pop I stars

These three bright standard stars appear to be unreddened, as widely reported in the literature. We do not find any support for the value of E(B-V)=0.09 for BD+15 2383 (β Leo) given by Malagnini and Morossi (1990).

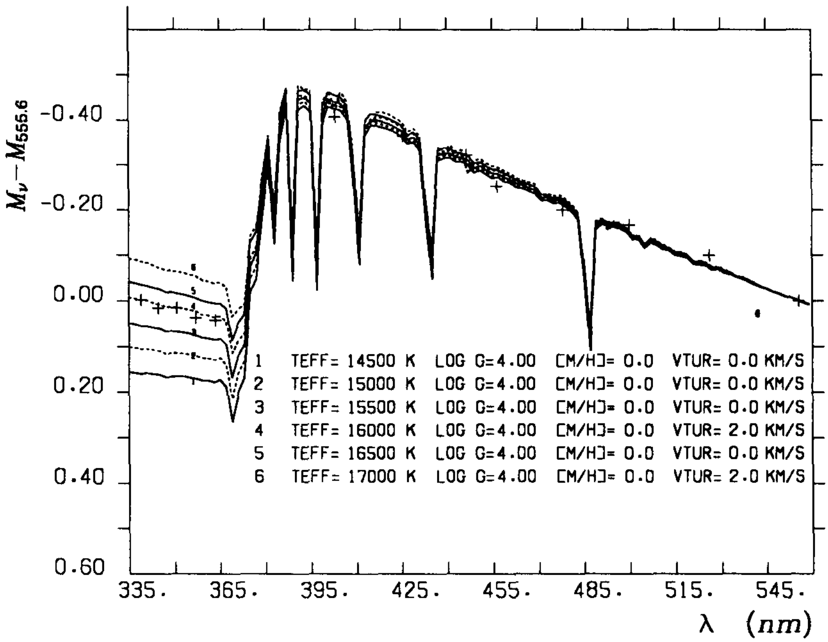

Fig. 1. The visual flux of BD+30 2431 from the Breger catalogue (magnitudes are normalized at 555.6 nm) compared with computed fluxes. The observed flux has been corrected for the effect of reddening assuming E(B-V)=0.06 mag.

CONCLUSIONS

We find that the visible continuum flux is a good indicator of reddening, provided that the model parameters are correctly selected. The criterion to be followed is to choose that reddening for which the same computed flux fits both the Paschen and the Balmer continuum. This method is applicable also to B-type stars, where the slope of the Paschen continuum loses its temperature sensitivity.

For a slightly reddened star (E(B-V)<0.1) the effective temperature derived from the energy flux distribution is underestimated from 250 K to 1000 K if the reddening is not considered. The worst errors occur for the highest effective temperatures.

TABLE II Reddening of the program stars

Star	E(B-V) UBV†	E(B-V) uvby‡	E(B-V) publ.	E(b-y) publ.	E(B-V) this paper	Ref*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
CD-34 12784	0.02	0.03	0.00	–	0.00	6
CD-26 10505	0.09	0.08	0.10	0.06 ; 0.04	0.05	1,2,3
BD-17 3883	0.09	0.08	0.02 ; 0.15	0.01	0.05	1,4,3
BD-06 86	0.14	0.18	0.02	0.02 ; 0.014	0.05	1,2,3
BD+13 3899	0.02	0.03	0.01	–	0.00	7
BD+15 2383	0.00	0.00	0.09	–	0.00	7
BD+25 3344	0.10	0.18	0.02	0.01	0.00	1,3
BD+30 2431	0.06	0.02	0.00 ; 0.03	–	0.06	1,5
BD+39 2031	0.02	0.03	–	0.01	0.00	2

†values derived from UBV data;‡values derived from uvby data; * References of the values E(B-V) and E(b-y), given in columns 4 and 5.

1 Huenemoerder *et al.*(1984); 2 Kodaira and Philip (1984); 3 Hayes and Philip (1988); 4 Cacciari *et al.*(1987); 5 Baschek and Sargent (1976); 6 Code *et al.*(1976); 7 Malagnini and Morossi (1990);

Traditional methods based on photometry to estimate the colour excess may yield inconsistent results when applied to Pop II HB stars.

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