Baltic Astronomy, vol.3, 67–73, 1994.

ULTRAVIOLET INTRINSIC COLOUR INDICES OF O- AND B-TYPE STARS

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Received September 14, 1993.

Abstract. Revised UV intrinsic colour indices derived from the ANS data are presented for O- and B-type stars. The mean colour excess ratios evaluated from the ANS data are given as well.

Key words: techniques: photometric – stars: early type: UV intrinsic colour indices – extinction – ultraviolet: interstellar

1. Introduction

Photometric observations obtained with the Astronomical Netherlands Satellite (ANS) (Van Duinen et al. 1975) are widely used for the study of interstellar extinction in the Galaxy. This is usually motivated by two reasons. First, these observations represent the most comprehensive and accurate photometric data set of O- and B-type stars in the ultraviolet. Second, the observed stars are rather evenly distributed in the Milky Way. Our interest in the ANS data is related with a purpose to use these data for investigation of interstellar extinction in combination with observations in the Vilnius photometric system (Straižys 1992).

The photometric system of the ANS consists of five rectangular passbands with the following mean wavelengths: 155, 180, 220, 250 and 330 nm. The widths of the passbands are in the range of 10–20 nm. In this paper, the magnitudes of the ANS system, m_λ, will be denoted as m_{15}, m_{18}, m_{22}, m_{25} and m_{33}, where subscripts stand for the abbreviated mean wavelengths.

The knowledge of precise intrinsic colour indices is very valuable for investigation of interstellar extinction and physical properties of stars. Intrinsic colour indices in the ANS system have been derived by a number of authors (Wu et al. 1980, Wesselius et al. 1980, Gałęcki et al. 1983, Krełowski and Strobel 1987, Papaj and Krełowski 1992, Papaj et al. 1993).

A comparison of the results presented in these papers shows that there are noticeable differences between intrinsic colour indices obtained by different authors for a given spectral type. It has also been almost impossible to achieve a smooth transition from the ultraviolet portion of the interstellar extinction curve derived on the basis of observations in the Vilnius photometric system to that obtained from the ANS data using the published intrinsic colour indices. These differences may be due to diverse samples of stars and/or methods used in the above mentioned papers for derivation of intrinsic colour indices.

Therefore, we attempted to derive the intrinsic colour indices for early type stars from the ANS data. We restricted ourselves to the stars of spectral types O5–A0, since these are mainly used for investigation of interstellar extinction.

2. Data

The catalogue of Wesselius et al. (1981) was the source of photometric observations in the ANS system. This catalogue also contains MK spectral types and photometric data in the *UBV* system. *UBV* photometry taken from this catalogue was used in our further investigation, while MK spectral types were selected from the catalogue of Jaschek (1978). We selected stars of spectral types O5–A0 according to the following criteria:

1) a star has reliably measured colour indices in the *UBV* and ANS systems,

2) a star has an unambiguously determined MK spectral type,

3) the spectrum of a star shows neither emission lines nor other peculiarities,

4) a star is located outside the regions with anomalous interstellar extinction law (e.g., Orion, Cygnus Rift or others),

5) a star is not found among known binaries.

We selected 1430 stars that satisfy the above mentioned criteria.

3. Method

Determination of intrinsic colour indices of O and B stars is complicated by the fact that all the stars of these spectral types are reddened. However, this problem becomes simpler if we assume a certain colour index to be known. Since the intrinsic colour indices $(B-V)_0$ of the *UBV* system are evaluated sufficiently accurately, one can easily derive E_{B-V} of a star according to its MK spectral type and the observed $B-V$. Then calculation of an intrinsic ultraviolet colour index, $(m_\lambda - V)_0$, is based on the corresponding colour excess ratio

$$(m_\lambda - V)_0 = (m_\lambda - V) - \frac{E_{m_\lambda - V}}{E_{B-V}}[(B-V)-(B-V)_0] \,. \qquad (1)$$

The latest version of intrinsic colour indices $(B-V)_0$ may be found in Straižys (1992). Ratios of colour excesses may be evaluated by using two-colour index diagrams. For that purpose we sorted out all observed stars according to their MK spectral types. For each spectral type and each colour index $(m_\lambda - V)$ we plotted two index diagrams, $(m_\lambda - V)$ versus $(B-V)$. For those diagrams where the stars were fairly evenly distributed along the reddening line and where the range of colour excesses E_{B-V} was large enough (> 0.7), we calculated colour excess ratios. Suitable diagrams were found for the following MK spectral types: O8 IV–V, O9 IV–V, B0 IV–V, B0 III, B I, B0.5 IV–V, B0.5 III, B0.5 I, B1 IV–V, B1 II, B1 I, B1.5 IV–V, B2 III, B3 II. Preliminary colour excess ratios were calculated as the weighted mean of the ratios obtained for each spectral type mentioned above. Using these ratios we calculated preliminary intrinsic colour indices by formula (1).

Then the obtained indices were used for estimation of colour excess ratios for each star:

$$\frac{E_{m_\lambda - V}}{E_{B-V}} = \frac{(m_\lambda - V) - (m_\lambda - V)_0}{(B-V)-(B-V)_0} \,. \qquad (2)$$

The mean colour excess ratios were evaluated as weighted means of the individual values.

The obtained colour excess ratios were further used for calculation of intrinsic colour indices for each star in a second approximation.

Then we derived the weighted means of intrinsic colour indices for a given MK spectral type. Slightly smoothed values of those means have been adopted as the final intrinsic colour indices.

4. Mean colour excess ratios

Final values of colour excess ratios for the ultraviolet, derived in the present paper, are given in Table 1. These ratios represent the mean interstellar extinction law for the Galaxy.

Table 1. Mean colour excess ratios for the UV and their errors

$\frac{E_{m_{33}-V}}{E_{B-V}}$	$\frac{E_{m_{25}-V}}{E_{B-V}}$	$\frac{E_{m_{22}-V}}{E_{B-V}}$	$\frac{E_{m_{18}-V}}{E_{B-V}}$	$\frac{E_{m_{15}-V}}{E_{B-V}}$
2.065	4.209	6.615	4.903	5.170
.001	.002	.002	.002	.003

5. Intrinsic colour indices

The derived intrinsic colour indices in the ANS system are given in Table 2. In the last column of the table, the number of stars used for calculation is indicated. Errors of the intrinsic colour indices are given in Table 3.

Table 2. UV intrinsic colour indices, $(m_\lambda - V)_0$, for O–B stars

Sp	$B-V$	m_{33}	m_{25}	m_{22}	m_{18}	m_{15}	n
O9 I	-0.27	-1.82	-2.86	-3.25	-3.60	-3.75	10
O9.5 I	-0.25	-1.81	-2.80	-3.20	-3.54	-3.68	12
B0 I	-0.23	-1.73	-2.71	-3.11	-3.40	-3.48	16
B0.5 I	-0.21	-1.66	-2.60	-2.92	-3.25	-3.27	28
B1 I	-0.19	-1.58	-2.45	-2.69	-2.91	-3.00	35
B1.5 I	-0.18	-1.51	-2.32	-2.50	-2.64	-2.76	5
B2 I	-0.16	-1.44	-2.13	-2.25	-2.47	-2.56	17
B2.5 I	-0.15	-1.34	-1.88	-2.08	-2.29	-2.34	2
B3 I	-0.13	-1.22	-1.72	-1.93	-2.12	-2.17	16
B5 I	-0.10	-1.10	-1.42	-1.59	-1.86	-1.95	15
B6 I	-0.08	-0.97	-1.20	-1.29	-1.64	-1.69	6
B8 I	-0.04	-0.70	-0.75	-0.77	-1.06	-1.06	14
B9 I	-0.02	-0.51	-0.40	-0.52	-0.80	-0.75	10
A0 I	-0.01	-0.25	0.11	-0.11	-0.24	-0.14	9

Table 2 (continued)

Sp	$B-V$	m_{33}	m_{25}	m_{22}	m_{18}	m_{15}	n
O9 III	-0.30	-1.83	-2.95	-3.45	-3.76	-3.93	14
O9.5 III	-0.30	-1.82	-2.90	-3.40	-3.74	-3.82	13
B0 III	-0.29	-1.79	-2.85	-3.34	-3.70	-3.78	39
B0.5 III	-0.28	-1.73	-2.76	-3.19	-3.54	-3.70	42
B1 III	-0.27	-1.66	-2.63	-3.01	-3.32	-3.47	45
B1.5 III	-0.26	-1.57	-2.48	-2.84	-3.22	-3.43	6
B2 III	-0.24	-1.45	-2.32	-2.65	-3.02	-3.19	43
B3 III	-0.20	-1.24	-1.95	-2.27	-2.64	-2.80	41
B5 III	-0.16	-0.97	-1.57	-1.97	-2.20	-2.38	24
O5 V	-0.33	-1.97	-3.14	-3.70	-4.22	-4.45	9
O6 V	-0.32	-1.95	-3.09	-3.64	-4.13	-4.37	14
O7 V	-0.32	-1.93	-3.04	-3.54	-4.06	-4.27	36
O8 V	-0.31	-1.91	-2.99	-3.47	-3.98	-4.23	40
O8.5 V	-0.31	-1.88	-2.95	-3.42	-3.95	-4.22	6
O9 V	-0.31	-1.85	-2.92	-3.37	-3.92	-4.20	30
O9.5 V	-0.30	-1.82	-2.89	-3.34	-3.86	-4.09	13
B0 V	-0.30	-1.77	-2.83	-3.26	-3.77	-3.96	33
B0.5 V	-0.29	-1.72	-2.71	-3.13	-3.58	-3.80	49
B1 V	-0.27	-1.63	-2.57	-2.99	-3.45	-3.66	85
B1.5 V	-0.26	-1.55	-2.40	-2.86	-3.28	-3.52	32
B2 V	-0.25	-1.40	-2.26	-2.71	-3.11	-3.32	149
B2.5 V	-0.23	-1.25	-2.08	-2.57	-2.93	-3.17	53
B3 V	-0.21	-1.18	-1.98	-2.43	-2.77	-3.02	119
B5 V	-0.17	-0.99	-1.64	-2.03	-2.36	-2.59	86
B6 V	-0.15	-0.87	-1.44	-1.82	-2.14	-2.35	47
B7 V	-0.13	-0.74	-1.22	-1.52	-1.96	-2.10	25
B8 V	-0.10	-0.53	-0.92	-1.29	-1.65	-1.76	40
B9 V	-0.07	-0.30	-0.64	-1.03	-1.31	-1.36	42
B9.5 V	-0.05	-0.15	-0.46	-0.81	-1.04	-1.07	17
A0 V	-0.02	0.00	-0.19	-0.54	-0.71	-0.65	43

The derived colour indices were compared with those of Wu et al. (1980) and Wesselius et al. (1980) . Our intrinsic indices are bluer by about 0.1 mag than those of the above mentioned authors. This is well demonstrated in Fig. 1 where the results for $(m_{33} - V)_0$ are shown.

Table 3. Errors of the intrinsic colour indices

Sp	$\sigma_{m_{33}-V}$	$\sigma_{m_{25}-V}$	$\sigma_{m_{22}-V}$	$\sigma_{m_{18}-V}$	$\sigma_{m_{15}-V}$
O5–B5	0.03	0.06	0.07	0.08	0.09
B6–B9	0.05	0.06	0.08	0.09	0.10
A0	0.08	0.09	0.11	0.14	0.18

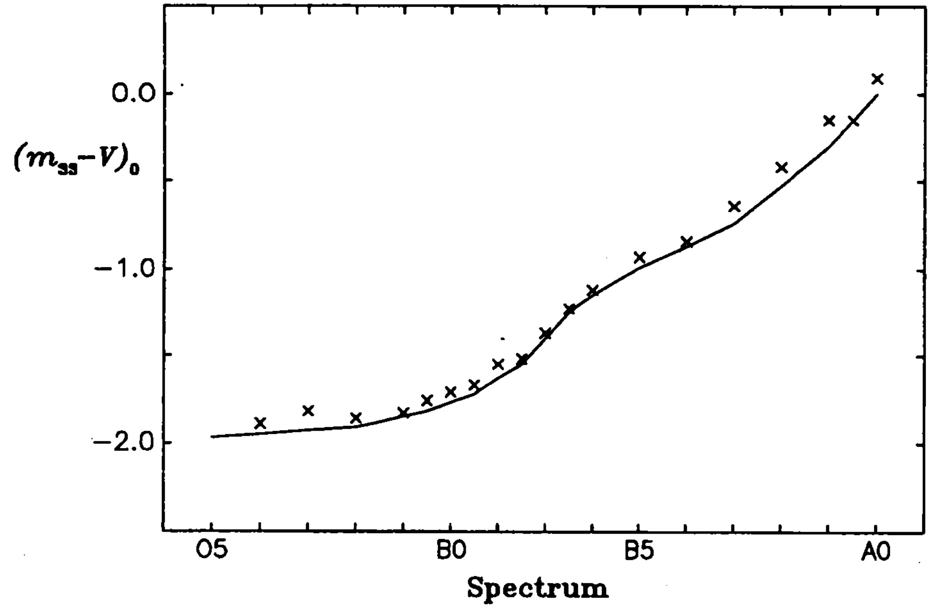

Fig. 1. Intrinsic colour indices $(m_{33}-V)_0$ for the main sequence stars plotted vs. spectral type. The curve represents our results. The data of Wu et al. (1980) are indicated by crosses.

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