THE RESPONSE FUNCTION S(λ) OF THE UBV COLOR SYSTEM - A PROBLEM AGAIN AND AGAIN?

Erich E. Lamla

Observatory, University of Bonn

ABSTRACT. By comparing the numerical data for the response functions of the UBV color system originally given by Matthews and Sandage (1963) with the improved functions published by Ažusienis and Straižys (1969), taking into account of the extinction values given by Melbourne (1960), the response function of U and B is found corrected for a printing error and other mistakes.

As is well known, the UBV color system was defined originally by Johnson and Morgan (1951). However, they did not publish the complete numerical data, S(λ), of their photometer, used at their telescope under different observing conditions. Therefore, one may find in the literature several data lists of S(λ) without knowing all the details of the reconstruction of the color system used, which are more or less similar to the original one.

The numerical data, given by Matthews and Sandage (1963) have been used very often, although Hayes (1975) found some 'numerical noise' in the figures. In preparing the new Landolt-Börnstein compilation Lamla (1982) detected as a reason for that 'noise' an apparent printing error and errors in reading off the numerical values of the response functions of U and B by a bad interpolation in the overlapping wavelength range around λ = 3900 Å.

Ažusienis and Straižys (1966) improved the original S(λ) of the UBV system published by Johnson and Morgan (1951) by using the extinction of the earth's atmosphere given by Melbourne (1960). One can follow that reconstruction step-by-step in their English version of it, published in 1969.

By comparing the differences, Δ, between the S(λ) given by Matthews and Sandage (1963) and those reconstructed by Ažusienis and Straižys (1966) I found the differences violate the Gaussian distribution at some wavelengths (see Table I and II, column 5). By making the biggest differences smaller, I could correct the values of

D. S. Hayes et al. (eds.), Calibration of Fundamental Stellar Quantities, 525–528.

the response functions U and B which are then in accord with the even curves of S(λ). The corrected values are given in column 6 of the Tables I and II.

TABLE I

The response function S(λ) of the U magnitude. Comparison of the figures given by Matthews and Sandage (1963) and by Ažusienis and Straižys (1966), and the corrected values.

S(λ)					
λ Å	U_1	U_{cal}	U_{tab}	Δ (10^{-3})	$U_{1,corr}$
3100	0.250	0.078	0.060	- 18	
3200	0.680	0.237	0.170	- 47	
3300	1.137	0.442	0.375	- 67	
3400	1.650	0.720	0.675	- 45	
3500	2.006	0.975	1.000	+ 25	
3600	2.250	1.220	1.250	+ 30	
3700	2.337	1.390	1.390	0	
3800	1.925	1.234	1.125	- 109	1.800
3900	0.650	0.440	0.600	+ 160	0.750
4000	0.197	0.139	0.140	+ 1	
4100	0.070	0.051	0.030	- 21	

U_1 = U for sec Z = 1; Matthews and Sandage (1963).

$U_{cal} = U_1 \cdot P_1 = U_2$ = U for sec z = 2;

P_1 = extinction coefficient; Ažusienis and Straižys (1966).

$U_{tab} = U_2$; Ažusienis and Straižys (1966).

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TABLE II

The response function S(λ) of the B magnitude. Comparison between the values given by Matthews and Sandage (1963) and by Ažusienis and Straižys (1966), and the corrected values.

	S(λ)				
λ Å	B_o	B_{cal}	B_{tab}	Δ (10^{-3})	$B_{tab,cor}$
3571	0	0	0	0	
3600	0.015	0.008	0.006	− 2	
3700	0.100	0.058	0.080	+ 22	
3800	0.500	0.312	0.337	+ 25	
3900	1.800	1.185	1.425	+ 240	1.270
4000	3.620	2.484	2.253	− 231	2.523
4100	3.910	2.789	2.806	+ 17	
4200	4.000	2.950	2.950	0	
4300	3.980	3.012	3.000	− 12	
4400	3.780	2.919	2.937	+ 18	
4500	3.500	2.745	2.780	+ 35	
4600	3.150	2.507	2.520	+ 13	
4700	2.700	2.175	2.230	+ 55	
4800	2.320	1.892	1.881	− 11	
4900	1.890	1.558	1.550	− 8	
5000	1.530	1.273	1.275	+ 2	
5100	1.140	0.956	0.975	+ 19	
5200	0.750	0.633	0.695	+ 62	
5300	0.500	0.425	0.430	+ 5	
5400	0.250	0.214	0.210	− 4	
5500	0.070	0.060	0.055	− 5	
5560	0	0	0	0	

B_o = B(sec z = 0) ; Ažusienis and Straižys (1966)

$B_{cal} = B_1$ = B(sec Z = 1) = $B_o \cdot P_1$

$B_{tab} = B_1$; Matthews and Sandage (1963).

DISCUSSION

JASCHEK: Does the analysis of Matthews and Sandage, and Ažusiensis and Straižys refer to the same sample of observations of the same stars?

LAMLA: There is no need for that! One has to measure the sensitivity

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function of the filter, the multiplier, the optics (reflectivity of the mirrors as a function of wavelength) and one has to put in the transmission of the Earth's atmosphere. This was done earlier by Matthews and Sandage, and Ažusiensis and Straižys in the same way. A comparison of both values for the sensitivity function then shows differences (in one case it can be a printing error!). And I made these differences smaller; the new values for V and B are in agreement with those given by Arp (1961 Astrophys. J. 133, 874). What can then be done is to calculate, with an energy distribution of a star, color differences with the new sensitivity function and see how good the values are compared to the observed color indices.

CODE: The Matthews-Sandage UBV sensitivity function came from actual laboratory measurements of 1P21 response and filter transmission carried out by Harold Johnson and published by him (1951 Astrophys. J. 114, 511). To these measurements I added the reflectivity of two aluminum surfaces, which was adopted by Matthews and Sandage. Thus the UBV sensitivity functions are the measured response of the original UBV photometer of H. Johnson and W. W. Morgan and not a deduced function.

LAMLA: I agree.

HAUCK: Did you compare your response functions with those of Buser?

LAMLA: Yes, I did. There are no big differences.

BOHLIN: Art Code says that the original UBV transmissions (Matthews and Sandage) were measured on a monochromator for the filters and 1P21 and then multiplied by typical aluminum reflectances for two mirrors. Were the new curves measured using monochromatic light or were they inferred from the need to make the photometry consistent internally?

LAMLA: I used the old UBV sensitivity functions corrected as Code said. These new curves were again corrected only by calculation: to make the differences between the values given by Ažusiensis and Straižys and those given by Matthews and Sandage smaller. I did not try to calculate synthetic color indices to see if one found the same or other values. The sensitivity functions, with the corrected values, are exactly the same as those given by Arp. There are differences between Arp and Matthews and Sandage.

BESSELL: I have also measured the ultraviolet response of several 1P21 and several ultraviolet filters, 1 mm UG2 and standard thickness 9863. The red cut off measured was identical to that of Buser, but the blue cut off was about 100 Å bluer, although not so blue as that of Matthews and Sandage. However, to fit synthesized (U-B) colors from spectrophotometry one must use the Buser blue cut off. Clearly, the original Johnson system U appears to require more UV absorption such as would be supplied by several mm of soda glass.