The Asiago Database on Photometric Systems

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Abstract. The Asiago Database on Photometric Systems (ADPS) is a compilation of basic information and reference data on 215 photometric systems (1386 bands in all), both from the ground and space, and covering the UV, optical and IR wavelength ranges. Paper I is available in book format (Moro & Munari 2000). It censed only the information available from the literature. Paper II (Fiorucci & Munari 2002) presents an homogeneous derivation and calibration of band and reddening parameters for all systems with known band transmission profiles (178 systems for a total of 1251 bands). Following papers in the ADPS project will include calibration of relations sensitive to physical quantities (like $T_{\text{eff}}$, $\log g$, $[\text{Fe}/\text{H}]$, $E_{B-V}$, etc.) and homogeneous transformation equations for all systems with known band transmission profiles. The ADPS project web page is http://ulisse.pd.astro.it/ADPS/

Key words. Photometric systems – GAIA

1. Introduction

The Asiago Database on Photometric Systems (ADPS) is a long term project to cense, document and analyze existing photometric systems in the UV, optical and IR spectral domains, both for the ground-based and space varieties. It has originated from the necessity to address the legacy of existing systems during the design phase of the photometric system for the GAIA Cornerstone mission by ESA (Munari 1999; Perryman et al. 2001), but since than it has developed into an independently sailing project. The ADPS Paper I offered a compilation of basic information and reference data on 201 photometric systems (14 systems were added later), available in book format (Moro & Munari 2000) as well as electronically (http://ulisse.pd.astro.it/ADPS). Only data from the literature were used, with all information traceable back to the original source. The extensive literature survey carried out in Paper I proved how poorly documented was the majority of the systems. For example, simple statistics about information provided by literature on band and reddening parameters for the 201 censed systems shows that:
Classification of early-type stars.

**GENERAL INFORMATION**

**AUTHORS**  
T. Walraven and J. H. Walraven

**TELESCOPE**  
0.91m (reflector), Leiden Southern Station, Union Obs., South-Africa

**DETECTOR**  
1P21 (for $V$, $B$, $L$ and $U$ bands) and Lallemand cell (for the $W$ band), refrigerated

**MAIN ARTICLE**  
Walraven, Th., Walraven J. H. 1960, BAN 15, 67

**SYSTEM DESCRIPTION**

<table>
<thead>
<tr>
<th>BANDS</th>
<th>$\lambda_{peak}$ (Å) [178], pg. 78</th>
<th>$\lambda_{eff}$ (Å) [178], pg. 78</th>
<th>FWHM (Å) [191]</th>
<th>$F_\lambda$ (erg cm$^{-2}$ s$^{-1}$ Å$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$W$</td>
<td>3270</td>
<td>3255</td>
<td>150</td>
<td>$2.12 \times 10^{11}$</td>
</tr>
<tr>
<td>$U$</td>
<td>3670</td>
<td>3633</td>
<td>260</td>
<td>$1.61 \times 10^{11}$</td>
</tr>
<tr>
<td>$L$</td>
<td>3900</td>
<td>3838</td>
<td>140</td>
<td>$1.52 \times 10^{11}$</td>
</tr>
<tr>
<td>$B$</td>
<td>4295</td>
<td>4325</td>
<td>420</td>
<td>$1.23 \times 10^{11}$</td>
</tr>
<tr>
<td>$V$</td>
<td>5450</td>
<td>5467</td>
<td>850</td>
<td>$6.73 \times 10^{12}$</td>
</tr>
</tbody>
</table>

The $W$, $U$, $B$ and $V$ bands are obtained in a spectro-photometer by redirecting to separate photomultipliers portions of the spectrum geometrically selected by a filter of quartz and Iceland spar (which transmits a spectrum of bright bands at regular intervals separated by dark regions. Quartz prisms are used as a cross-disperser to separate the bright bands and redirect them via a quartz collector lens to four individual photomultipliers).

The L band is more conventionally obtained via standard filter photometry with UG2 (2mm) + WG2 (2mm) placed in front of a fifth photomultiplier (1P21) [313].

The 0.91m telescope and the Walraven photometer were moved in 1979 from the Leiden Station in South Africa (Hartebeespoortdam) to ESO - La Silla. As a result the passbands of the system slightly changed [306]

**ZERO POINT:** Magnitudes and colors of HD 144470 = $\omega$ 1 Sco (B1V) are:

$V = 1.1760$, $(V - B) = -0.0025$, $(B - U) = +0.0052$, $(U - W) = -0.0020$, $(B - L) = +0.0039$. [191]

**SYSTEM ANALYSIS**

**COLOR INDICES AND PARAMETERS** [50]

$(V - B)$ : sensitive to reddening.

$(B - U)$ : measures the Balmer jump. Temperature indicator for O and B stars.

$(B - L)$ : depends mainly on gravity.

$(U - W)$ : measures the slope of the Balmer continuum. Both gravity and temperature dependent.

**REDDENING-FREE PARAMETERS** [50]

$$
[B - U] = (B - U) - 0.61 (V - B) \\
[B - L] = (B - L) - 0.39 (V - B)
$$

**REDDENING RATIOS** [191], [306], [50]

$$
E(B - U)/E(V - B) = 0.62 \\
E(U - W)/E(V - B) = 0.45 \\
E(B - L)/E(V - B) = 0.41 \\
E(L - U)/E(V - B) = 0.22 \\
E(B - V)/E(V - B) = 2.255 \\
A(V)/E(V - B) = 3.16 - 0.12 E(V - B)
$$

Fig. 1. Example of a documentation card (first of two pages) for a single system from ADPS Paper I [Moro & Munari 2000].
RELATIONS WITH OTHER SYSTEMS [50], [306]

**UBV** - Johnson and Morgan - 1953

\[
(V - B) = 0.0062 + 0.3873(B - V) \quad \text{for} \quad (V - B) < 0.15 \\
(V - B) = 0.0195 + 0.4744(B - V) \quad \text{for} \quad (V - B) > 0.10
\]

**RGU** - Trefzer - 1983

\[
V = 0.963G - 0.448(G - R) + 0.455 \\
(B - V) = 0.451(G - R) + 0.196(U - G) - 0.092
\]

**TRANSMISSION CURVES** [191]

![Transmission Curves](image)

<table>
<thead>
<tr>
<th>W ((\lambda(\lambda)))</th>
<th>U ((\lambda(\lambda)))</th>
<th>L ((\lambda(\lambda)))</th>
<th>B ((\lambda(\lambda)))</th>
<th>V ((\lambda(\lambda)))</th>
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<td>3390 0.000</td>
<td>3900 0.000</td>
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</table>

Fig. 2. Second and final page of the documentation card described in Fig. □
Fig. 3. Example of a card from ADPS Paper II (Fiorucci & Munari 2002), that computes band and reddening parameters for all censsed systems with known band transmission profiles. Various wavelengths and widths for the pure profile are given, together with moments of 2nd order, followed by effective wavelengths and widths for a selection of input normal spectra (B3, Vega, Sun, K2, M2, Carbon) and peculiar ones (Wolf-Rayet of C and N type, planetary nebulae of high and low electron density, novae in nebular stage, white dwarfs of hydrogen type). Then A(λ)/A(V) is provided for different extinction laws, as well as A(λ)/E(B-V) for R_V=3.1 and three different input spectra (B3, Sun, M2). Cardelli et al. (1989) a and b reddening coefficients are computed for E(B-V)=0.0 and E(B-V)=1.0 and for B3 and Sun input spectra. The behavior of effective λ and width with E_B-V are given for the R_V=3.1 case. Finally, polynomial fits are provided for the behavior of effective wavelength and width upon black-body temperature.
Fig. 4. **Left panel:** distribution in time of the appearance in literature of new photometric systems, separately for the UV (λ < 3000 Å), optical (3000 ≤ λ ≤ 10000 Å) and IR (λ ≥ 1µm) wavelength regions. All the 215 systems censed in the ADPS are included. The UV systems prior to the OAO2 orbiting satellite (1970) are relative to observations performed by Aerobee sounding rockets (UV-55, UV-57 and UV-64). **Right panel:** distribution of the 215 photometric systems censed in the ADPS as function of the number of bands. Note the large proportion of UV systems with many photometric bands and the lower corresponding number for IR systems.
Fig. 5. **Left panel**: distribution in wavelength of the photometric bands. The placing of the UV bands does not follow recognizable patterns, being mainly governed by transmission/sensitivity of available materials. The optical bands tend to cluster toward the more diagnostic blue wavelengths, with peaks in the distribution corresponding to the main hydrogen lines and the Balmer jump. The IR bands are heavily concentrated around the wavelengths of the classical JHKLM bands. **Right panel**: width distribution of the photometric bands. The UV and optical distributions are more complex and reflects the presence of both narrow interference filters as well as broad ones. The IR distribution is simpler and strongly peaked toward the typical width of Earth’s transmission windows in the 1-5 µm range.
Fig. 6. **Left panel:** distribution of the the 3rd order moment $I_{\text{asym}}$ (or skewness index) of the photometric bands for the UV, Optical and IR systems. An $I_{\text{asym}} < 0.0$ pertains to a band with an extended blue wing and an $I_{\text{asym}} > 0.0$ to a band with an extended red wing. Symmetric profiles are characterized by $I_{\text{asym}} = 0.0$. **Right panel:** distribution of the 4th order momentum $I_{\text{kurt}}$ (or kurtosis index) for the photometric bands of the systems censed in the APDS. The kurtosis index gives an indication of the balance between the core and the wings of a profile. It is $I_{\text{kurt}} = 0.0$ for a Gaussian profile. An $I_{\text{kurt}} > 0.0$ indicates a band transmission profile more peaked than a Gaussian, i.e. with more wings than core, and $I_{\text{kurt}} < 0.0$ pertains instead to a band with more core than wings. The kurtosis index for a square band is $I_{\text{kurt}} = -6/5$, for an equilateral triangular band it is $I_{\text{kurt}} = -3/5$, and for an $e^{-|x|}$ profile it is $I_{\text{kurt}} = 3$. 
24% had no wavelength or bandwidth information or they were in clear conflict with published band transmission curves, (b) 28% had poor information, typically just the mean or peak wavelength, (c) 44% had decent information (however pertaining typically to systems with square bands or Gaussian interference filters), and only for (d) 4% the available informations included effective wavelengths for more than one spectral type (just 2% in the case of effective widths). The situation with reddening parameters is even more depressing. Again, out of the 201 censed systems in Paper I, reddening information were (i) completely missing for 78% of them, (ii) poorly known for 15% of the systems (typically $A(\lambda)/E_{B-V}$ for just one or two bands), (iii) satisfactory for 4%, and (iv) complete for only 3% of the censed systems. It goes without saying that further information like transformation equations between systems or calibration into physical parameters ($T_{\text{eff}}$, $\log g$, $[\text{Fe/H}]$, $E_{B-V}$ while keeping to a minimum the effect of all the others). Later, a Paper IV will follow providing transformation equations between the censed photometric systems and, finally, a Paper V will intercompare the performances of the censed systems. A few figures of statistical content about the 215 systems and 1386 bands so far censed in the ADPS. Figure 4 shows the distribution with time of the appearance of new photometric systems in the literature and their distribution as function of the number of bands. Figure 5 presents the the wavelength and width distribution of the photometric bands. Finally, Figure 6 gives the distribution of the 3rd and 4th order moments (asymmetry or skewness index and kurtosis index) of the photometric bands.

Acknowledgements. The present work has been partially financed by CISAS under ASI contract to P.L.Bernacca.

References