Astronomical Data Analysis Software and Systems XIII
ASP Conference Series, Vol. 314, 2004
F. Ochsenbein, M. Allen, and D. Egret, eds.

On the Analysis of Old Objective-Prism Plate Spectra with Modern Systems

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Abstract. Objective prism (OP) spectroscopic plates collected with Schmidt Telescopes are a heritage of the pre–electronic Astronomy which may still contain useful data for statistical researches, and precious information on unrecorded peculiar events as well. Modern imaging processing techniques may allow to extract rapidly the massive amount of information included in a single plate. We present the results of our preliminary analysis of a set of old OP plates collected to follow the spectral evolution of a Symbiotic Nova, with special regards to the problem of the spectrophotometric calibration and of the quality of commercial scanners.

1. Schmidt Telescopes' Objective Prism Plates

Objective prism (OP) spectral images collected with Schmidt telescopes are a heritage of 'pre–electronic' Astronomy which contain useful data for statistical researches, and may include precious information on peculiar events as well. A large number of OP plates are archived in the plate stores of astronomical observatories all around the world. Thanks to international initiatives (see Griffin 2001) many efforts are underway to construct electronic logbooks of the archived material. But the problem remains of how to extract in a rapid and correct way the massive quantity of data included in every single OP plate.

In the seventies Cassatella et al. (1973, 1975) developed in Roma a processing technique for the analysis of OP spectra based on the use of PDS–type microphotometers. The technique was applied to investigate the OP spectra of the symbiotic nova V1016 Cyg (Baratta et al. 1974) and of other peculiar objects. Modern techniques of image processing may give a fundamental contribution to the matter, although to exploit fully the relatively high resolving

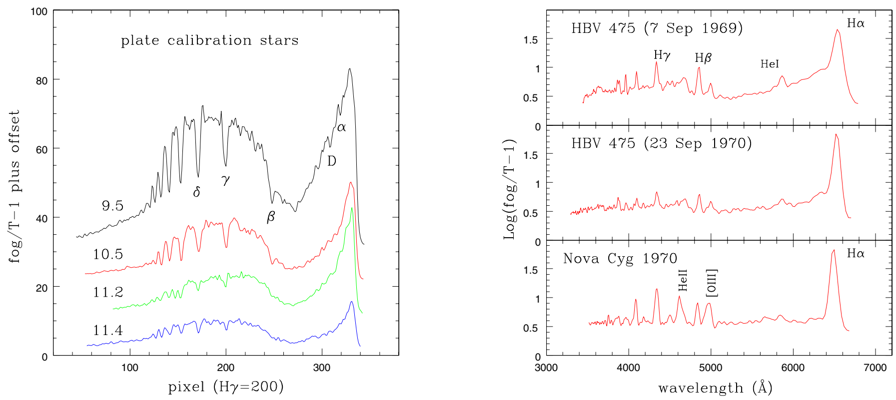

Figure 1. *Left*: Tracings of calibration stellar spectra extracted from an OP plate. The 103aE plate emulsion allows to cover a wide spectral range from the Balmer continuum to Hα. The spectrograms have been centred in order to have Hγ at pix = 200. The stellar B magnitudes are indicated. *Right*: the wavelength calibrated spectrum of the symbiotic star HBV 475 in 1969 and 1970, and of Nova Cygni 1970 in September 1970. Some prominent emission lines are marked.

power of the photographic emulsions (down to 10 μm), and, simultaneously, their large collecting surface (up to a few thousand cm^2) one needs a very expensive hardware.

Within a National Project aiming the scientific use of old astronomical plates, we have analysed a set of OP plates obtained during 1969–1975 to follow the spectral evolution of the symbiotic nova HBV 475 (also named V1329 Cyg). Our aim is to make a photometric calibration of the plates by using a number of stars in the field with known broad–band magnitudes. Here we present the preliminary results of our work and discuss some technical aspects.

The nova–like outburst of HBV 475 was discovered by Lubos Kohoutek in an OP plate taken in August 1969 at the 80/120/240 cm Schmidt telescope of the Hamburg–Bergedorf Observatory equipped with a 4° OP (Kohoutek 1969). With the aim of investigating the spectral evolution of HBV 475 following its nova–like explosion, Kohoutek collected during 1969–1975 a set of OP plates centred on the position of the symbiotic star using 23×23 cm^2 103aO, 103aD, and 103aE plates. Casually, in late 1970 a nova (Nova Cyg 1970) exploded in the same sky region, so that also the spectrum of the nova is recorded on several plates of the set.

The mid and low resolution 1969 spectrum of HBV 475 has been analysed by Crampton et al. (1970) and Baratta & Viotti (1989).

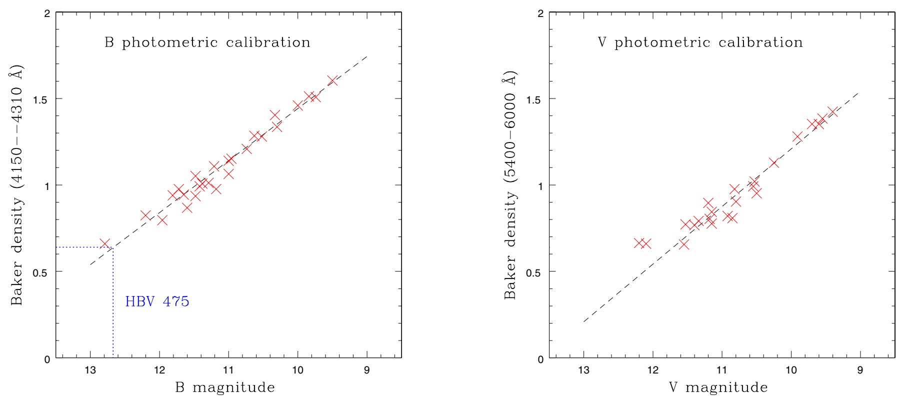

Figure 2. Blue and visual photometric calibration of plate no. 4382 (7 September 1969). The derived blue continuum magnitude of HBV 475 is indicated.

2. Plate Digitisation and Analysis

For each plate a central region of about one square degree has been scanned using a commercial 1600 dpi scanner (A3 size, 15.875 μm pixels). As discussed in Nesci et al. (2003), during the scanning a special care should be taken in the luminosity scale settings, and in the minimisation of the light scatter inside the scanner. In the present study, the first steps of the data reduction has been performed with the IRAF packages. For each image the plate transmission has been normalised to the plate fog level, and transformed into Baker density: Δ = log (fog/T-1). A number of stars showing strong hydrogen Balmer absorption lines indicating an A–spectral type, were selected in the image, and identified using the Digital Sky Survey. Their photometry (and possibly spectral type) were exported from CDS. Individual subimages were used to extract the spectrograms using the *twodspec* IRAF menu. Details of the digitisation procedure and data reduction are given in Nesci et al. (2003).

Then, the wavelength calibration was derived using a code purposely written for OP spectrograms running outside the IRAF environment. The resulting OP dispersion curve is: (λ - 1647 Å)(s + 567 μm) = 1.26 10^7 μm Å. In the absence of a zero point in the individual spectrograms, we set s(Hα) = 2000 μm. The reciprocal dispersion dλ/ds at Hγ is 575 Å/mm. Fig. 1 (left) shows some examples of wavelength–calibrated spectrograms of A–type stars. The OP plate was obtained on 1969 September 7 on a 103aE emulsion. Fig. 1 (right) shows the spectrum of HBV 475 in two epochs and of Nova Cygni 1970 just exploded.

For the photometric calibration of the plates, we have computed the average Baker density in a wavelength interval centred near the maximum response of the Johnson B–filter, and compared with the Johnson's B–magnitudes from the Tycho–2 Catalogue (Høg et al. 2000). The results for the 1969 plate are shown in Fig. 2 (left). For 26 calibration stars we have compared their B–magnitudes with the average plate density in the wavelength interval 4150–4310 Å. The derived regression line is shown in the figure (correlation coefficient r=0.96). The response appears linear within at least three magnitudes. The blue plate contrast (dΔ/dm) is -0.30 with a r.m.s. of 0.05. This procedure can be used to estimate the blue magnitude of all the early–type stars in the field. A blue–continuum magnitude of $\sim$12.7 was derived for the symbiotic star HBV 475 (see Fig. 2). We have also used a larger wavelength interval that includes the Hγ and Hδ lines, and found the same result with a slightly larger dispersion. The corresponding blue magnitude of HBV 475 turns out to be $\sim$12.2, due to the large contribution of the emission lines.

The situation is more complicate for the Johnson V–band, since its response curve includes the green–yellow region where the plate sensitivity changes rapidly with wavelength. In Fig. 2 (right) we plot against V the average plate density in the wavelength interval 5400-6000 Å. It is clear in the figure that the dynamical range is smaller, with a large dispersion for the faintest stars. The visual plate contrast is about -0.33. We are going to extend the analysis to other unblended stars in the field, and derive their B and V magnitude and spectral type, as described in Nesci et al. (2003).

The next steps of our work will be the spectrophotometric calibration of the OP plates using field stars with known photometry and spectral type, to which we attribute the energy distribution of standard stars scaled to their B, V magnitudes. This will allow us to study the spectral evolution of HBV 475 in a wide energy range.

This work has made use of the SIMBAD database at the CDS (Strasbourg).

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