ON PHOTOMETRIC STANDARDS AND COLOR TRANSFORMATION

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ABSTRACT. We have carried out a preliminary investigation of a method of observation and reduction which leads to a large improvement in the accuracy of the color transformation of photometric measurements. This method involves the use of extra filters for some of the observations. It is argued that the better precision obtained is well worth the additional telescope work.

1. INTRODUCTION

Exact matching of photometric instrumental systems is very difficult to achieve. Hence color transformation procedures are needed in order to get results which can be compared with those obtained in the standard system. Color transformations are valid for a family of spectral distributions. For example it is easy to find the transformation, over a limited range of wavelengths, adapted to a family of spectra such as:

$$f(\alpha,T,\lambda) = \lambda^{\alpha}\, B(T,\lambda) \qquad (1)$$

where B is the Planck function and α a parameter. Actual spectra however are irregular and satisfactory color transformations do not exist over more than a small range of spectral types. This is amply demonstrated by theory (see e.g. Young 1974) as well as experience: reduction of many observing runs in the *uvby* system with various equipment shows that errors as high as .05 magnitude, and more, are not uncommon. Similar results have been obtained by other authors (e.g. Graham and Slettebak, 1973).

In order to solve those difficulties, we have developed an idea proposed by Young. The subsequent analysis is devoted to the Strömgren photometry, but would apply equally well to any other system.

2. METHOD

In order to transform an instrumental system into another one, the local behavior of the spectra around the filter wavelengths is needed.

D. S. Hayes et al. (eds.), Calibration of Fundamental Stellar Quantities, 495–498.

To obtain this information we add a second set of filters with slightly different wavelengths. An interpolation algorithm restores the standard values from the two sets of data. Both data sets are first reduced to the standard system by use of a conventional method (see Manfroid and Heck, 1983, for one which performs well: it allows one to incorporate the eight filters and to account for additional constraints between the filters of each pair with only slight modifications). The interpolation is then straightforward.

3. RESULTS

We have tested the method in extensive numerical simulations, the complete results of which will be published elsewhere (Manfroid 1984). The instrumental systems were made as close as possible to real equipment. In order to check the atmospheric effects we simulated the extinction of the spectra through various airmasses. The data created in that way had the form of observational data obtained with systems differing by the filter shapes and/or the cathode response. Since no source of random errors was included, the variance of the final data, after reductions, reflected the atmospheric color effects and reached .01 mag. in the *u* filter for blue objects.

The first investigations were made with spectra represented by (1). Objects with spectral anomalies (lines, depressions) were added. The results were very satisfying even with the most critical objects. This was confirmed by simulations using the data from the spectrophotometric catalog by Gunn and Stryker (1983). See Fig. 1. When other sets of filters with different slopes are used or when other photomultipliers are taken, similar results are obtained. Adding any amount of interstellar reddening does not modify the results. Evidently, some filter combinations are to be avoided. A look at the tracings of the filter transmissions allows us to make good choices.

4. CONCLUSION

A considerable improvement in the absolute photometry of any star can be obtained by using a second filter set. The observing time is certainly not doubled. In most cases it could be sufficient to spend a small fraction of the observing runs on the double measurements. Only if different stars are observed every night (which is also the worst case for conventional reductions, Manfroid and Heck, 1983) or if the transmission curve of the filters varies, is it necessary to double every observation. That few double measurements are necessary comes from the differential nature of the corrections. Many effects cancel in the process (uncertainties on the atmospheric extinction, on the zero points).

To work properly the method requires a knowledge of the standard values in each filter. It will be necessary to check this problem in the *uvby* system where no standard exists for *y*. An arbitrary decision about such a standard could lead to an impossible standard system, i.e. one which could not be reproduced by any instrumental system.

A byproduct of the method concerns the stellar classification. A great accuracy is already advantageous, but the four additional measurements give very useful information on the spectral distribution. This will be discussed in a forthcoming paper.

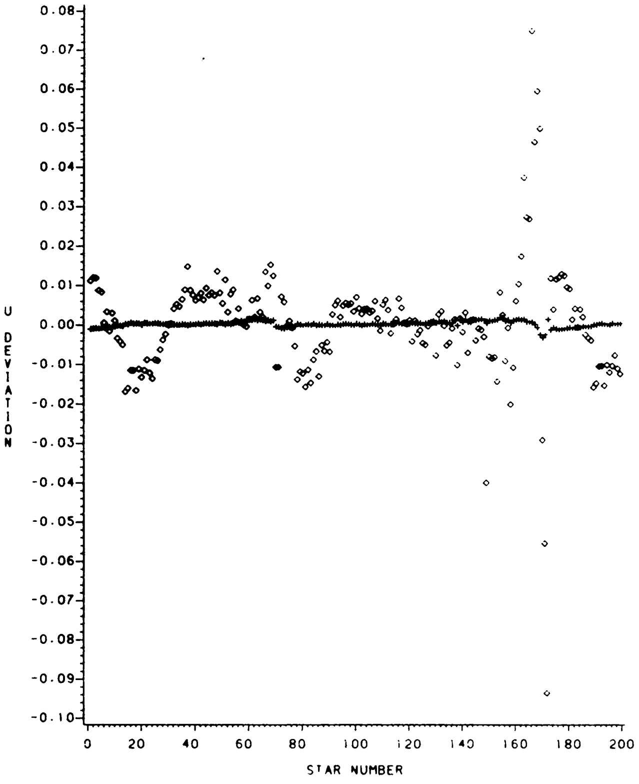

Fig. 1. Comparison of the deviations to the standard values for stars of all types and classes. ◆: conventional reductions when the filter u is shifted by 20 Å; +: reductions with our method.

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5. RFERENCES

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DISCUSSION

WALKER: This is a general comment. It is now possible to achieve, routinely 1% precision photometry with CCD's. Their high sensitivity is leading photometrists to use narrower bands. To what extent do the single star, photomultiplier-based calibrations we have been hearing about provide a good basis for more extensive CCD photometry given that there are problems with blocking filters, bandpass definition, etc.?

CAYREL: I agree: the era is now coming when we must think about how to calibrate future photometry done with CCD techniques.

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