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# A COMPUTER PROGRAM FOR TWO-DIMENSIONAL QUANTIFICATION OF NORMAL STARS IN THE VILNIUS PHOTOMETRIC SYSTEM

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**Abstract.** A description of an interactive program, CLASS, for the two-dimensional quantification of single and binary stars in the Vilnius photometric system on an IBM AT and compatible computers is given.

**Key words:** techniques: photometric – stars: classification – stars: fundamental parameters

## 1. Introduction

A program for automatic two-dimensional quantification of stars observed in the Vilnius photometric system (i.e., determination of the spectral type and absolute magnitude $M_V$) has been proposed by Jasevičius (1986). However, this program takes a lot of time to determine the parameters for each star and is, therefore, not a particularly convenient tool when a huge amount of data (say, from CCD photometry) is involved. We have made an attempt to develop a more comfortable and prompt program for this purpose.

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## 2. The method of quantification

The quantification is based on a comparison of the observed colour indices of a star with those from the bank of standard stars (BSS). For this purpose we use the value $\Delta$ which is calculated by the formula:

$$\Delta = \sqrt{\frac{\sum_{i=1}^{n} W_i (CI_i - CI_{0i} + E_i)^2}{\sum_{i=1}^{n} W_i}}.$$

Here $CI_i$ is the observed colour index $U$–$P$, $P$–$X$, $X$–$Y$, $Y$–$Z$, $Z$–$V$ and $V$–$S$,
$CI_{0i}$ is the corresponding colour index from the BSS,
$E_i$ is the colour excess,
$n$ is the number of colour indices used,
$W_i$ is the weight of the observed colour index, i.e., $W_i = \frac{1}{\sigma_i^2}$, where $\sigma_i$ is the r.m.s. error of the observation.

$\Delta$'s are calculated for all points of the HR diagram with a step of one MK subclass for the spectral type and 1 mag for the absolute magnitude $M_V$, and the isomap of the obtained values is presented to the user. $E_i$ is calculated by minimizing $\Delta$ at each point of the HR diagram. Then the user has a possibility to choose interactively (with a mouse) a region in which it is necessary to calculate $\Delta$ with a ten times smaller step in both coordinates. After that the user can choose any point from the fine structure diagram and send all the adopted parameters to the output file.

The quantification of the unresolved binary stars is similar to that of single stars, i.e., all possible pairs of the points in the HR diagram are analyzed and a $\Delta$ map is presented to the user. We assume that in this case the stars are physical binaries: they have the same distance and the same interstellar extinction.

## 3. The bank of standard stars

BSS consists of intrinsic colour indices and colour excess ratios. Separate tables are prepared for the intrinsic indices $U$–$P$, $P$–$X$, $X$–$Y$, $Y$–$Z$, $Z$–$V$ and $V$–$S$ and the colour excess ratios $E_{U-P}/E_{Y-V}$, $E_{P-X}/E_{Y-V}$, $E_{X-Y}/E_{Y-V}$, $E_{Y-Z}/E_{Y-V}$, $E_{Z-V}/E_{Y-V}$ and $E_{V-S}/E_{Y-V}$ in the spectral type range from O5 to M5 and the

absolute magnitude $M_V$ range from –9 to +12 mag. The whole area of the HR diagram which has astrophysical meaning is filled.

Intrinsic colours are based on the General Catalogue of stars observed in the Vilnius photometric system (Straižys and Kazlauskas 1993). For their determination, we have used only normal chemical composition stars brighter than $V = 9$ mag, which have reliable MK spectral types, luminosity classes and $BV$ photometry. The colour indices of these stars were dereddened according to the intrinsic $(B - V)_0$ values for the MK spectral types (Straižys 1992). Absolute magnitudes were derived according to the MK calibration of Straižys (1992). BSS has been filled smoothly by a two-dimensional spline approximation of colour indices of the dereddened stars. For this we have used more than 1200 stars.

Synthetic colour excesses were computed by numerical convolution of the following functions: the spectral energy distribution (Sviderskienė 1990), the interstellar extinction law (Sūdžius 1974) and the response functions of the Vilnius system (Straižys 1992).

In this way we have prepared the tables for all MK spectral subclasses and for a full range of $M_V$ with a 1 mag step.

## 4. Possibilities of the program

The CLASS program is written in the C language. It requires an IBM AT or a compatible computer, MS DOS v. 3.3 or higher operating system, a colour EGA/VGA adapter and a mouse.

The quantifying possibilities of the program are as follows :

- all single and binary stars of normal chemical composition in the spectral range O5–M5,
- step of quantification is 0.1 of MK subclass and 0.1 mag in $M_V$,
- the parameters obtained are: spectral type, $M_V$, dereddened colour indices in $E_{Y-V}$, $A_V$, distance $r$ and deviation of each colour index from the adopted model,
- possibility to apply a user-defined interstellar extinction law,
- interval or precise setting of the colour excess $E_{Y-V}$ range,
- the use of all of the observed indices or only of the selected ones,
- the use of the calculated or scaled weights of colour indices,
- a quick comprehensive analysis of each star in the full space of the parameters,
- writing of the desirable results into the output file.

## 5. Precision of the quantification

Stars from the Vilnius catalogue (Straižys and Kazlauskas 1993) brighter than $V = 8$ mag were processed for testing of the program. The spectral types obtained for 1750 stars were compared with the MK spectral types (Fig. 1). The linearity of the scale is very good. The r.m.s. error of the determined spectral types is $\pm 0.7$ of MK subclass.

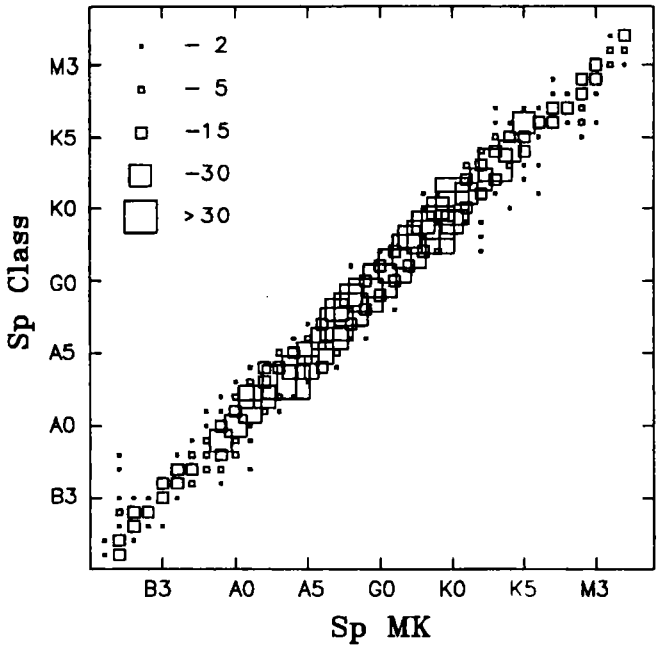


**Fig. 1.** Comparison of the CLASS spectral types with the MK types.

Absolute magnitude data from the catalogue compiled by Sviderskienė (1980) have been used for testing of the $M_V$ reliability. The r.m.s. error of $M_V$ for 314 stars (Fig. 2) is 0.8 mag.

Therefore, the new program may be used for quantification of single and binary stars of normal chemical composition with a comparable or even better precision than that achieved in the earlier program written by Jasevičius (1986). Also, the program CLASS is much more convenient to use and is more universal.

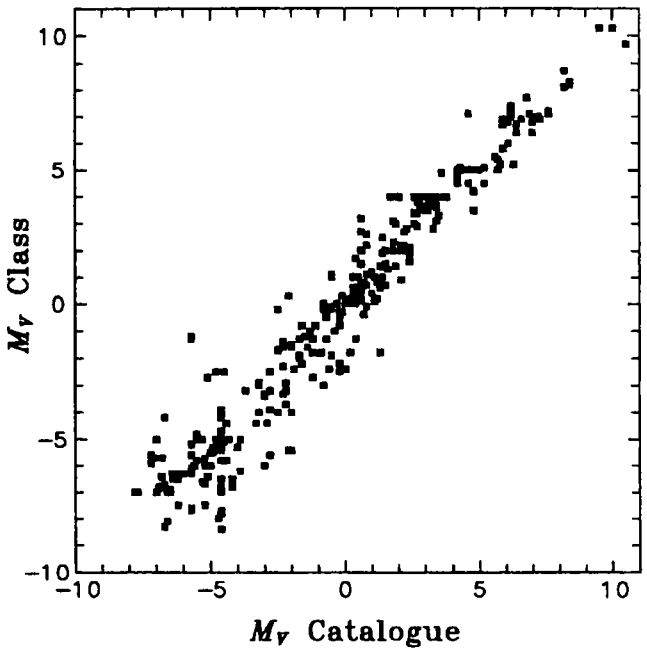


**Fig. 2.** Comparison of the CLASS absolute magnitudes with the compilations prepared by Sviderskienė (1980).

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