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UBV CCD Photometry of "Close" Visual Double Stars [1]

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ABSTRACT: **We use the CCD cameras of the 61-cm UTSO and the 90-cm Dutch telescopes of the Las Campanas and European Southern Observatories respectively in order to perform UBV photometry of visual double stars.**

Our sample contains southern visual binaries with A–type (470 pairs) and G–type primaries (170 pairs), which have angular separations mainly between 1″.5 and 5″. The double stars of our sample have been selected from the WDS according to their astrophysical interest and the technological limits of contemporary CCDs.

1. INTRODUCTION

We know remarkably little about the astrophysical parameters and the evolutionary status of the components of visual binaries. The reason is a technical one: the use of photographic field– or photoelectric aperture photometry in the derivation of accurate brightnesses and colors of close visual double stars is practically impossible.

Rakos *et al.* (1982) have tried to solve the problem using the "area scanner" technique. Doing so, they derived brightness differences of the components of about 200 double stars of all spectral types and small angular separations. This technique has not yet been more widely spead, due to the technological problems of its earlier versions.

Using CCDs it is now possible to observe even close visual double stars (the definition of "close" is given in the next section) and to derive very accurate brightnesses of both components, as discussed by Sinachopoulos & Seggewiss (1989) and Sinachopoulos & Prado (1992).

2. THE OBSERVATIONS AND THE CCD DATA

We use the 61-cm UTSO telescope of the Las Campanas, Chile and the 90-cm Dutch of ESO, La Silla, Chile, which are the only small reflectors with CCD cameras at southern observatories available to us. Both components of the visual double stars are brighter than magnitude 13 and therefore CCD–frames have to be obtained with telescopes with apertures less than 1.0 meter if possible. Otherwise neutral filters have to be used which are not UV transparent.

We perform CCD photometry of visual double stars with separations mainly

[1] **Based on observations made at UTSO Las Campanas and ESO La Silla, Chile**

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less than 5″ in order to observe physical pairs. The minimum angular separation of the selected double stars was determined by the scale of the telescopes. As this is 0.45″/pixel for the 61-cm (Sinachopoulos & Prado 1992), and 0.38″/pixel for the 90-cm Dutch (Sinachopoulos 1991), we put our lower limit to 1″.5 in order to get data satisfying the sampling theorem. Thus, we can get instrumental magnitude differences of high accuracy.

As it is known, the dynamic range of CCDs is limited to a few 10,000 analog digital units (ADUs) per pixel. That obliges us to define the exposure time as short as needed for not overexposuring the primary. Consequently, we must repeat the exposure as many times as needed for getting enough photons from the secondary in order to obtain accurately its magnitude. Repeating the exposure consumes a lot of time and for this reason, we decided that the magnitude difference between the components of the pairs in our sample had to be at most 3.0 magnitudes.

The UBV photometric system is a good tool for the study of A– and G–type stars. Not only is the index $(B-V)$ a temperature indicator, but the two colour diagram often permits a luminosity class determination of such objects.

We have built a sample containing about 650 southern visual double stars fulfilling the above conditions, using the *Washington Double Star Catalogue* (WDS) (Worley & Douglass 1984), which contains information for more than 70,000 double stars.

We decided to perform as many exposures as necessary in order to get an instrumental precision of the magnitude difference between the components of $0^m.01$ or better. When both components have about the same brightness, two exposures per filter are made in order to be able to estimate the instrumental accuracy of our measurements. As the magnitude difference between the components increases, also the number of the exposures increases according to the formula: $N_{exp} = 10^{\Delta m/2.5}$, where N_{exp} is the number of the exposures necessary for getting from the secondary as many ADUs as from the primary in one exposure, and Δm is the components magnitude difference.

We chose a maximum exposure time of 30 seconds in order to avoid image distortion due to telescope tracking error. Usually, exposures times of a few seconds are enough for the B and V filters, but things are dramatically different in U due to low quantum efficiency of the CCD chips at those wavelengths, the lower transparency of the U filter, and the lower energy output of the primaries of our sample in UV. For this reason, more than 70% of the total exposure time is used for the U exposures.

The efficiency of the observations strongly depends on the telescope used. We can observe up to 3 binaries per hour at the 90-cm Dutch telescope, but it is almost impossible to observe 2 double stars per hour using the 61-cm UTSO.

Figure 1 shows a visual double star observed at Las Campanas. Its primary has the Durchmusterung code +12° 3383. The angular separation of the components is $\rho = 6''.9$ and the position angle $\theta = 257°$. The magnitudes of the components as listed in the WDS are $7^m.0$ and $7^m.4$. The primary's spectral type is A0. The figure shows an exposure of 0.5 seconds made through the V filter.

For the photometric reduction a Franz profile (Franz 1967) is fitted to the projected data (see also Sinachopoulos & Prado 1992).

More than 70% of the sample with the A-type primaries has been observed

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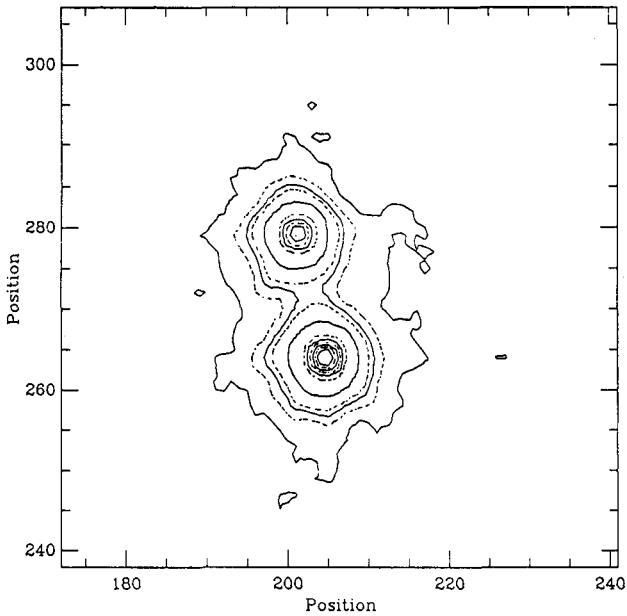

FIGURE 1. A typical CCD frame of a visual binary.

at least once at the 61-cm UTSO during the last two years. 46 nights have been already allocated to the project. The first data set, containing the very early observations has been already published (Sinachopoulos & Prado 1992).

On the other hand, we have already observed once about 40% of the sample with the A-type primaries at the 90-cm Dutch last December in five photometric nights. Seven more nights have been allocated to our project at the same instrument next June.

3. ACKNOWLEDGMENTS

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