THE NEW PHOTOELECTRIC PHOTOMETER [1]

of

THE SECTION OF ASTROPHYSICS, ASTRONOMY AND MECHANICS
THE DEPARTMENT OF PHYSICS, UNIVERSITY OF ATHENS

Construction, description, software, instructions

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December 01, 1997

1997

[1] This photometer has been built in the framework of the joint program of the University of Athens (Dr. P. Niarchos) and the Astronomical Institute (Dr. L. Hric) of the Slovak Academy of Sciences.

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V.K. in bracket denotes Vladimír Kollár as the author of the chapter; R.K. for Richard Komžík

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Abstract

The aim of this manual is to give detailed description of the photoelectric photometer construction. The article contains long-term experience with the photoelectric photometer at Skalnaté Pleso and Stará Lesná observatories. The authors wish this manual to serve for better knowledge and correct work with the photometer as well as to outline some future features.

The electronic version of this document (in PostScript form with gzip compression is available at the URL: "`http://www.ta3.sk/~rkomzik/ftp/photometer_manual.ps.gz`".

Generally it is possible to say this photometer is an optimal solution having in mind the needs of an astronomer and the economic considerations. The photometer is relatively complicated device exposed to weather conditions. The observational conditions, expensive observational time ask for high reliability, time and thermal stability of the device.

The authors are aware of some possible improvements of this device. This was the reason to have the device construction very flexible with possible exchange of some items in the future.

1 INTRODUCTION

The authors offer an universal open system for stellar photometry. The conception allows to adapt the photometer for specific needs of various observatories. Mechanically and electronically it is prepared for future development. By simple exchange of e.g. the detector and/or electronics it is possible to obtain a device of a different quality. Basically, this system is prepared for user-friendly standard stellar photometry. The classical mechanical-optical part was developed by prof. Pavel Mayer from the Charles University of Prague. This reliable device was used for many years at Slovak observatories and later it was improved by adding the modern electronics by ing. Vladimír Kollár; software was developped by RNDr. Richard Komžík.

2 DESCRIPTION

The light enters the photometer and is directed by means of a flip mirror to the focusing eyepiece or the photo-multiplier tube (PMT). Light passes through the aperture stop (diaphragm) which separates the object from the field of the the telescope, next passes through the filter. A Fabry lens then projects an image of the aperture onto the photocathode of the PMT. Under the diaphragm there is a second flip mirror for precise check of the star position in the diaphragm.

The PMT can be cooled by the Peltier cells. The PMT has a mu-metal shield of high permeability to reduce the effect of external magnetic fields. Under PMT there is a place for re-chargeable silica gel

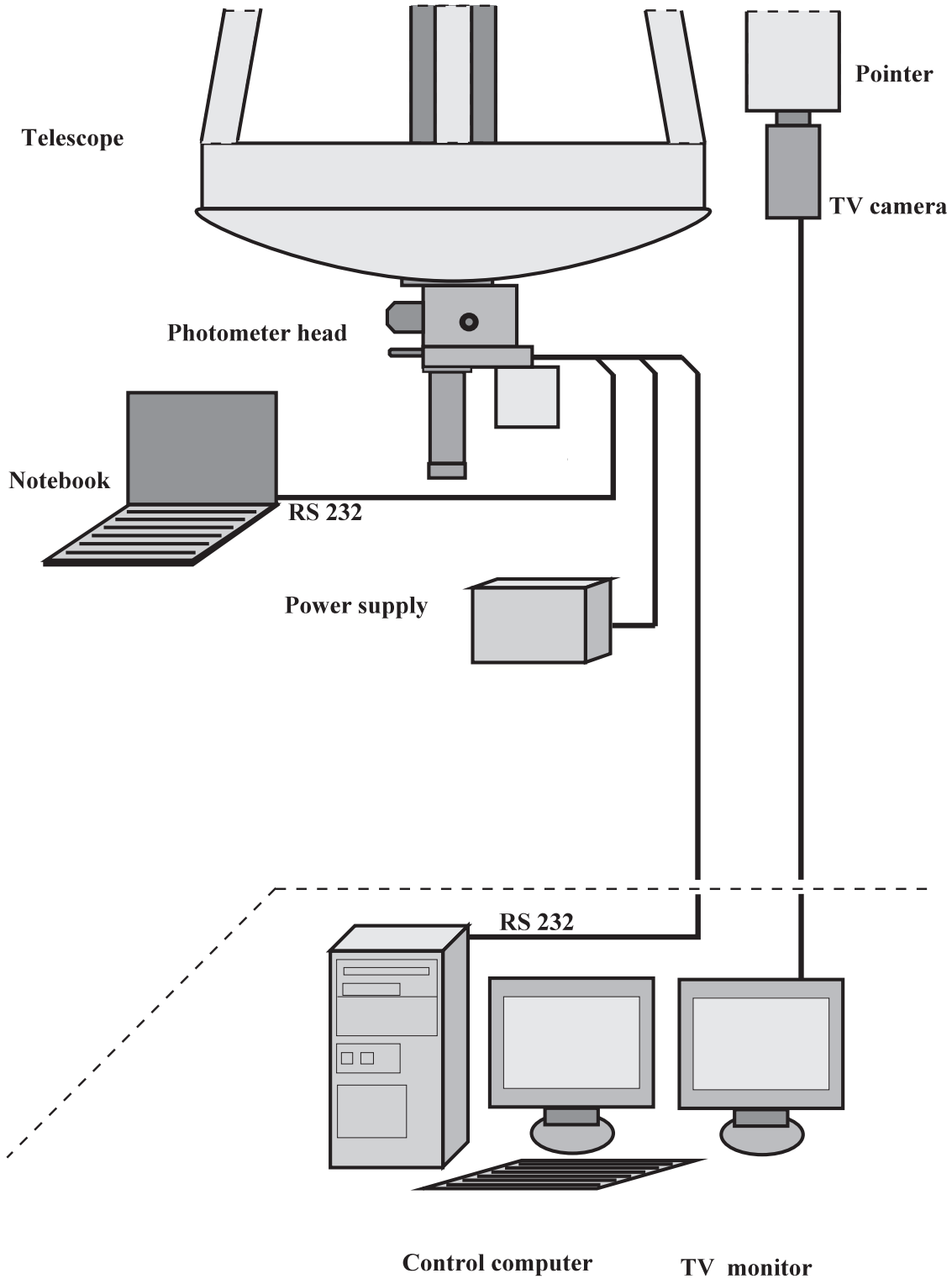


Figure 1: The photometer scheme

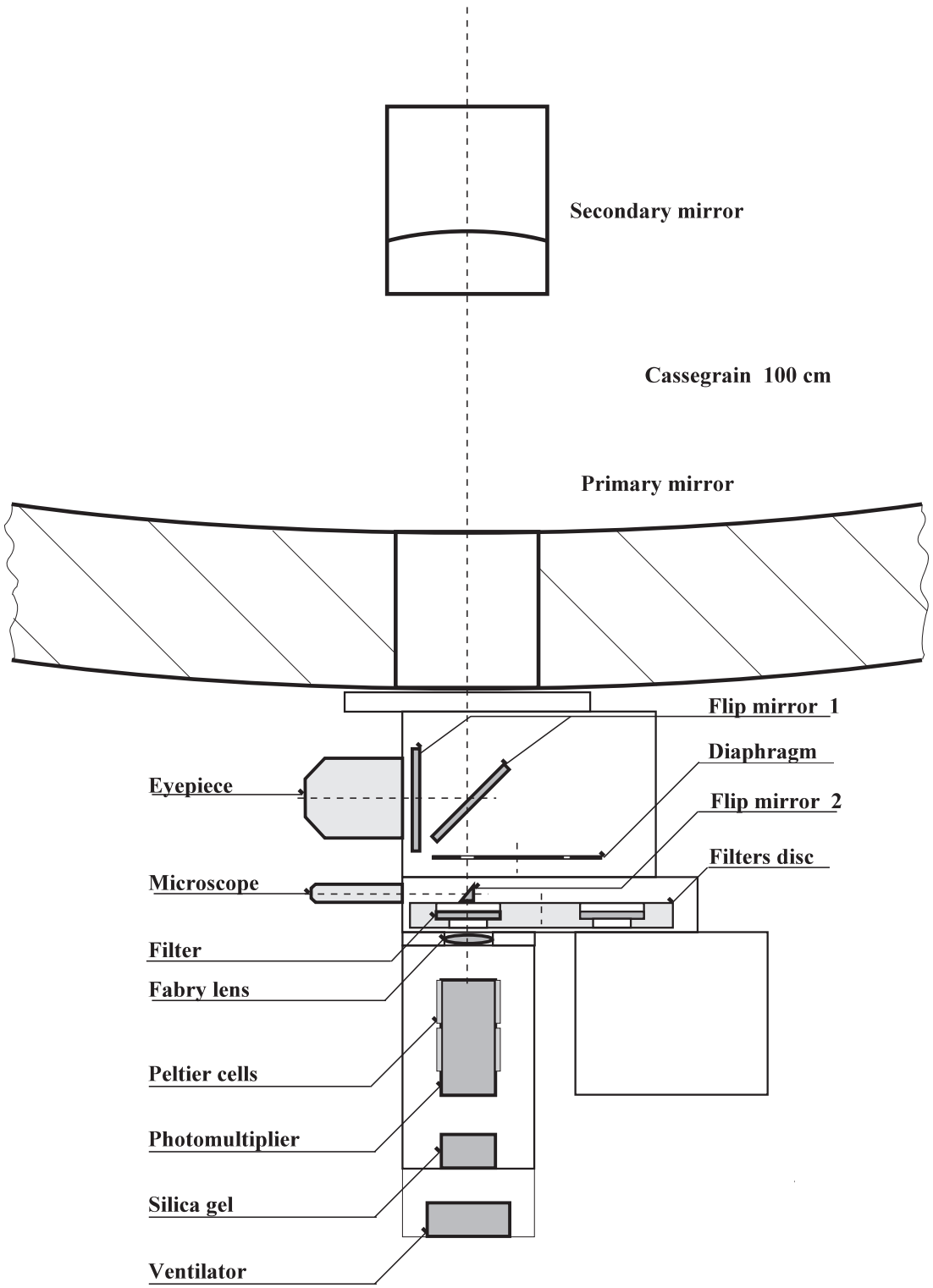


Figure 2: The schematic placement of the optical and mechanical parts in the head of the photometer

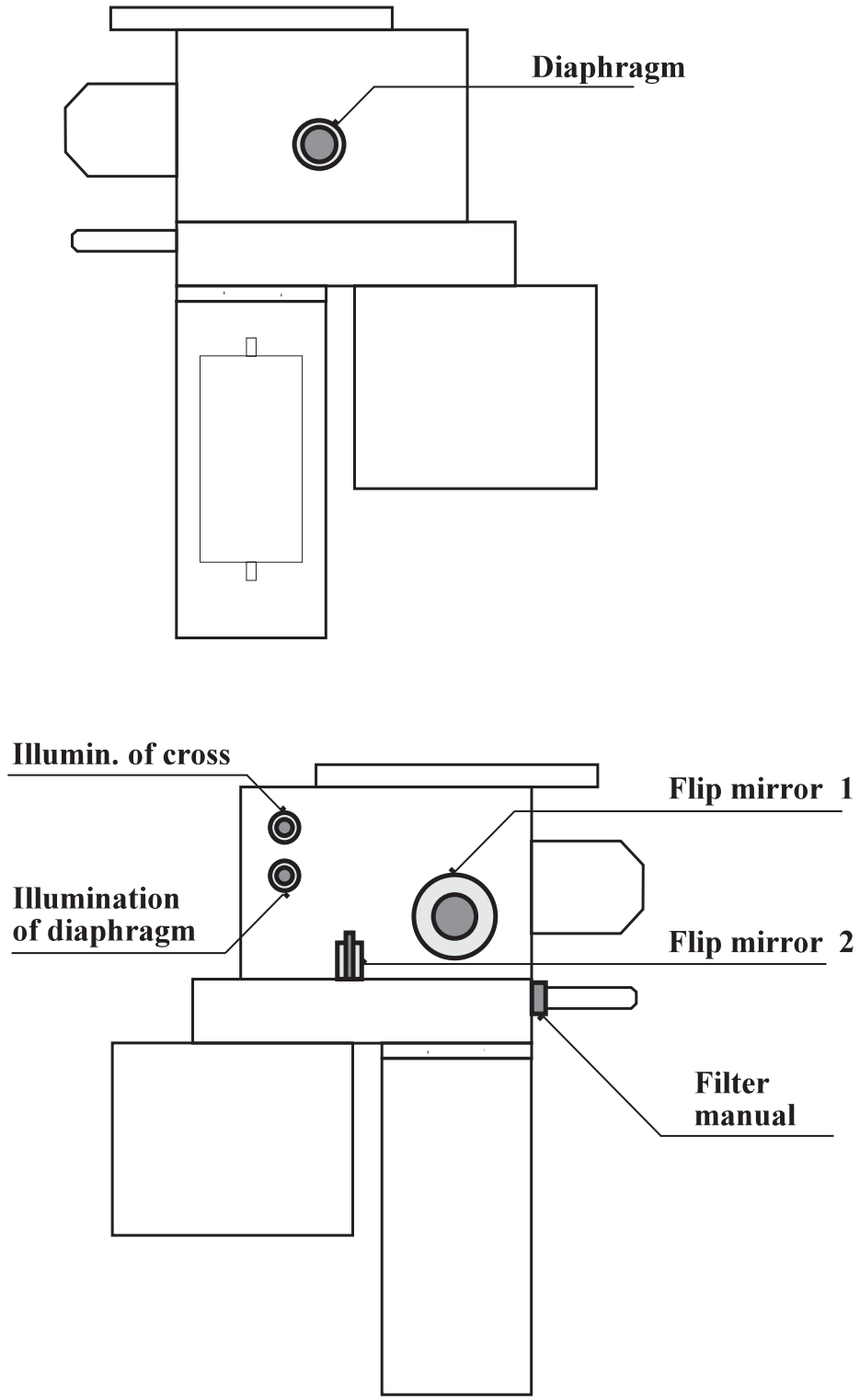


Figure 3: The schematic placement of the operating elements on the head of the photometer

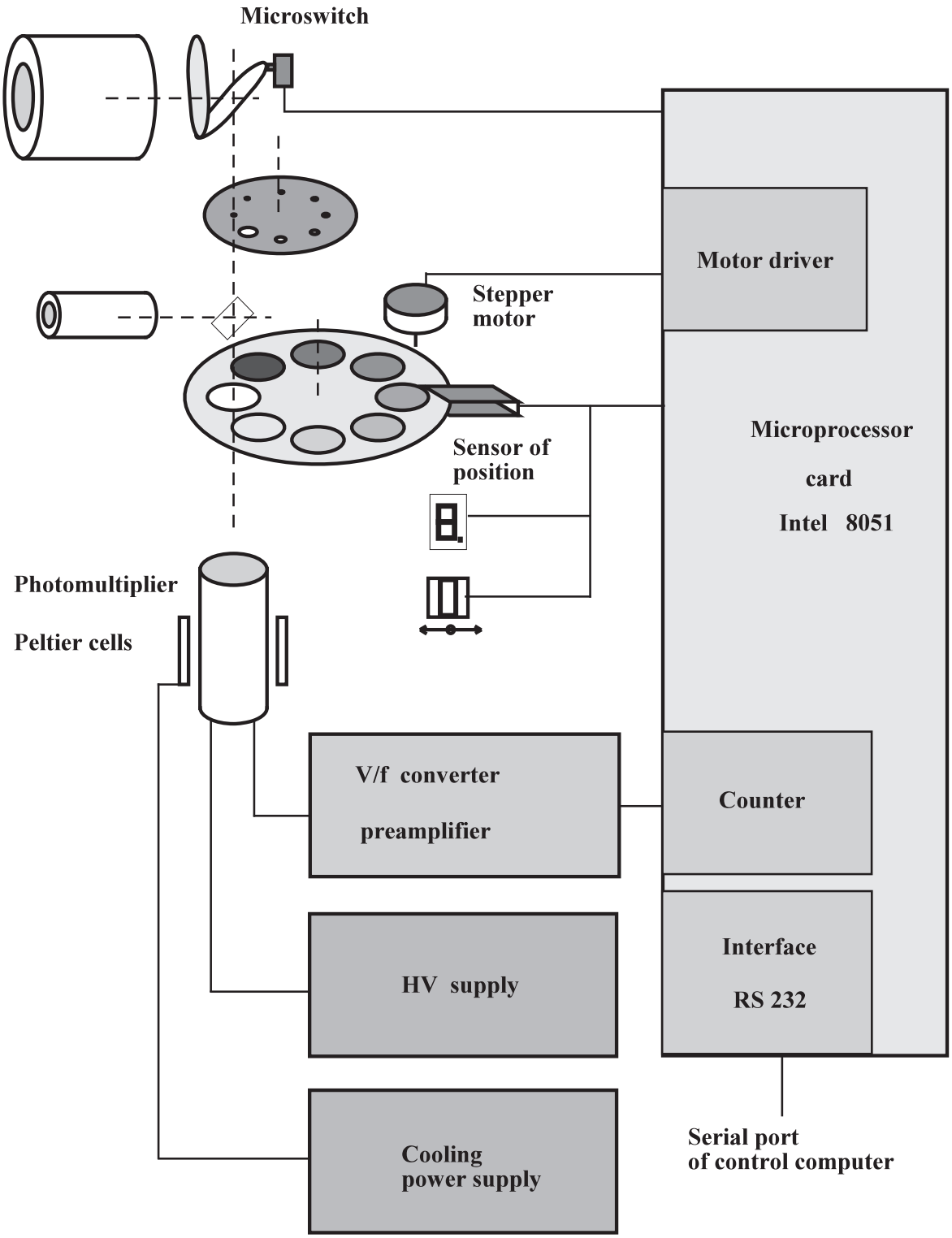


Figure 4: The principal block scheme of the photometer electronics

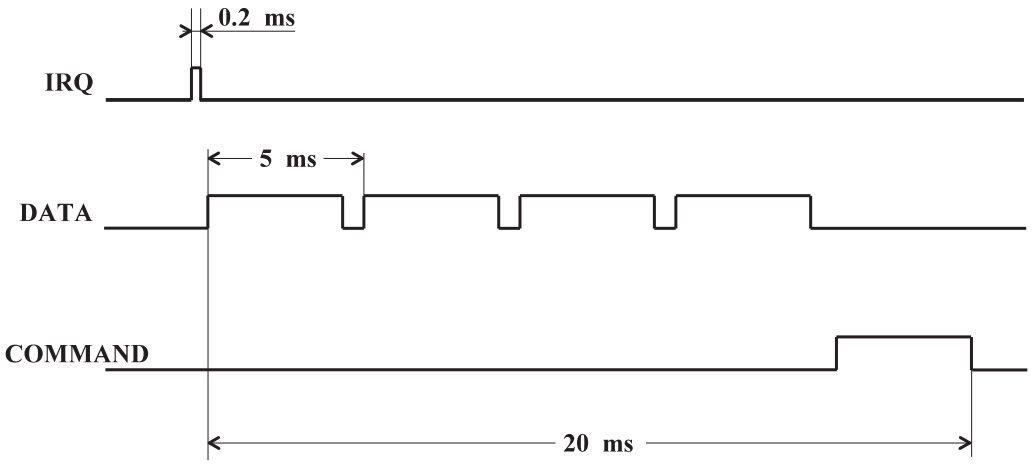


Figure 5: The time diagram of the signals in communication line

canister. The silica gel pellets are dark blue when activated and turn pale pink when its drying ability is diminished. The PMT box is humidity isolated.

Computer control and data acquisition enable more observational methods with one or two observers. The photometer uses a high linear voltage to frequency converter. The counter of impulses is placed as well in the photometer head. The disc of filters is turned by the aid of a stepper motor. The microcontroler evaluates the position of this disk by reading a position sensor. It performs all necessary functions in two work methods: an autonomous or a slave one. The communication with a master computer is done via the standard serial port RS 232 without any special interface computer card.

3 ACTIVITY

The communication with PC is controlled by the synchronization impulses from synchronization unit. The synchronization unit is a precise clock which producees short impulses on the RS 232 level (+12 V level of impulse). Basically, the generator of synchronization impulses is a master computer. By means of these impulses the information from counters is written into latches and the sending routine of microcontroler is initialized. In sending routine the microcontroler reads the information from position sensors and information from latches of counters and then the routine sends the information into the serial port. The master computer receives the information via the serial port COM1 or COM2, after processing this information by the resident program it is displayed on the screen. The screen is used as a communication medium between the resident program and an application program. The application program reads information from the screen as a character string from a specific place and saves it into an output file. The control instructions (e.g., for setting filters and beginning of a measurement) are sent via a specific place on the screen as well. The resident program reads it and sends it through the serial line into the microcontroler.

4 SPECIFICATIONS

Diaphragms	number of diaphragms	8
	dimensions	
Filters	number of filters	8
	dimension	1 x 1 inch
Photomultiplier	type	EMI 9789B
	photocathode	13VBCsSb
		10 mm
V/f converter	full scale frequency	1 MHz
	linearity	$< 0.01\%$
	offset	100 Hz
Counter	synchronous binary	
	24 bits	
Microcontroler	Intel 8051	
Computer requirements	PC 286 or higher	
OS requirements	MS DOS 3.0 or higher	

5 SOFTWARE FOR PHOTOMETER

The software consists of three basic components. The programs can run at the same time. After the proper configuration these programs can communicate and work together.

1. software in the photometer head: KR.A51; (section 5.1)
2. PC resident: FOT??.EXE; (section 5.2)
3. user software: UNIV; (section 7)

5.1 KR.A51

The program is implanted into the EPROM memory. It is written in the assembler language for microcontroler INTEL 8051. The program controls all functions and via the serial port RS 232 communicates with the master computer. After turning on the photometer power supply initialization routine starts. It sets the speed of communication and the workmode for timer TIM-0; the priority of interrupts (the INT-0 has the highest priority and TIM-0 has the following priority). This initialization routine also sets available interrupts and program ends in a never-ending loop. The program is activated by the hardware interrupts.

The INT-0 interrupt is produced by the synchronization impulses coming from a master computer or from an external synchronization unit. **The highest priority level (INT-0)** activates a service routine which reads the actual filter position, status switches and sends obtained information via the serial port in one byte. Following the information from level of counters is sequentially read and sent to the serial port as well. The receiving register contains the command sent by a master computer, this is also read by the routine. This one byte long command contains the number of the requested filter. **The lower priority level (TIM-0)** activates a routine which controls the stepper motor movements. The frequency of these interrupts determines the speed of the stepper motor (for turning the disc with filters).

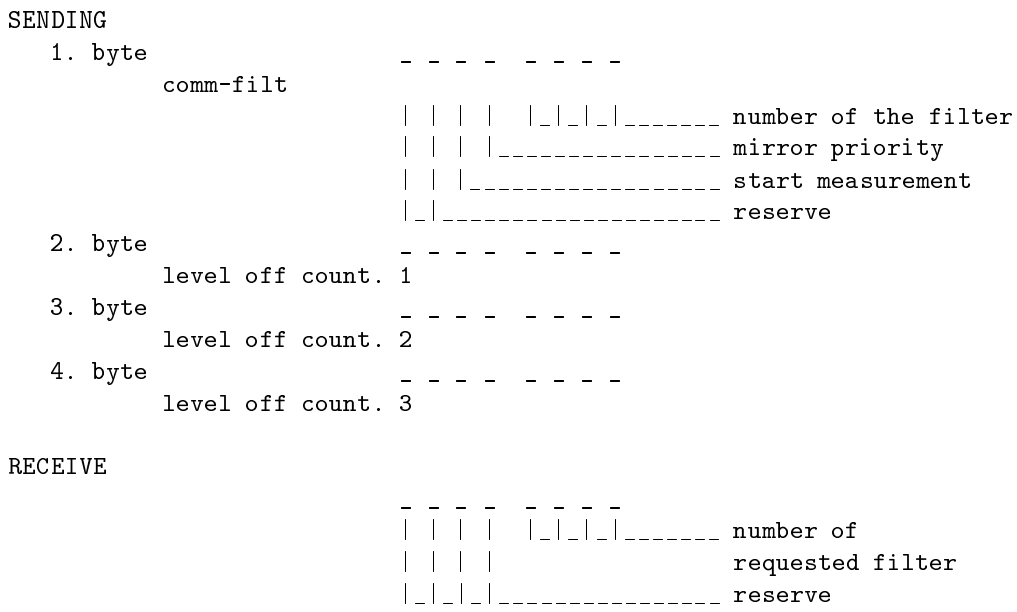


Figure 6: The meaning of the bytes in communication

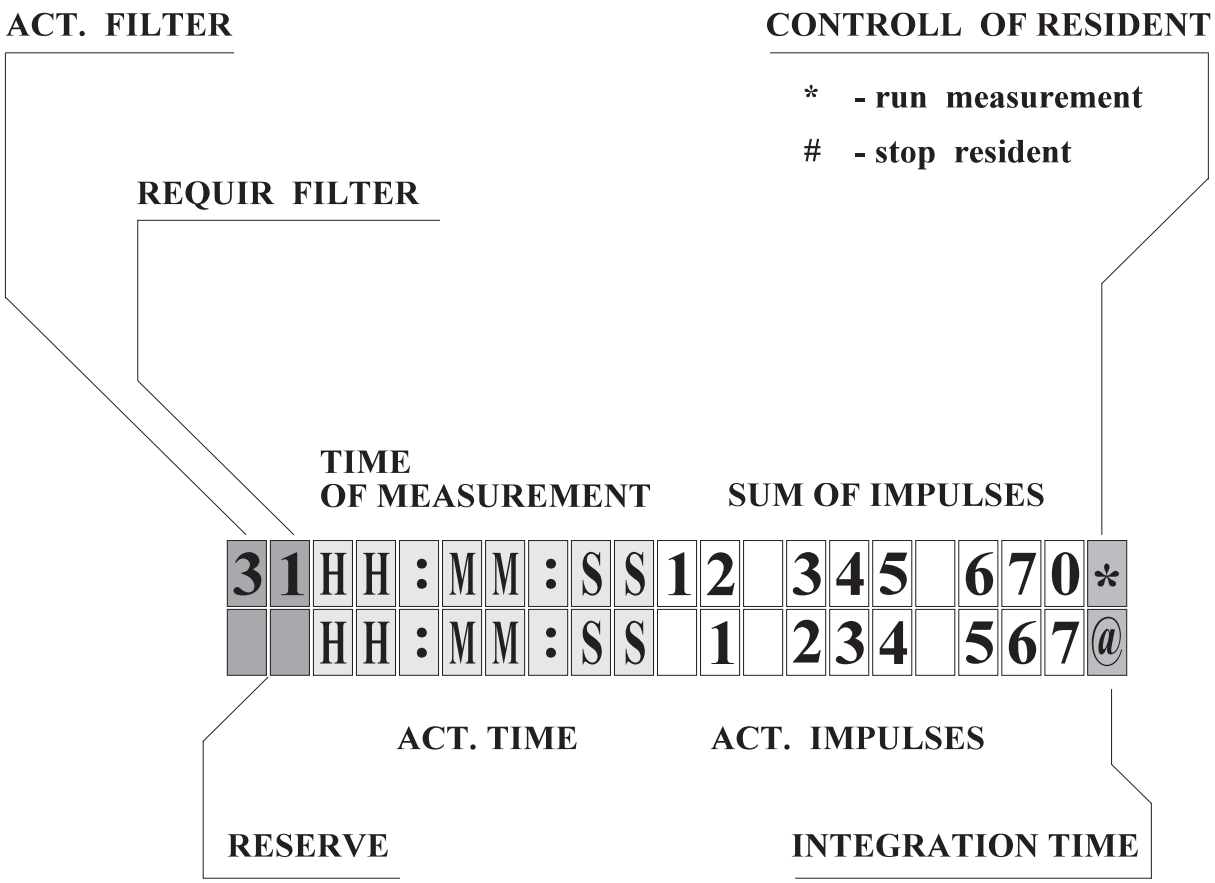
5.2 PC resident

This resident program is activated by a defined hardware interrupt. The timer of system clock can periodically start this resident. It uses IRQ8 interrupt; the period is 1 second. At first the resident sends a short 0.2 milisecond synchronization impulse, and then waits for four bytes from serial port. After decoding the obtained information it displays it at a defined place of the screen communication box. Following action of the program is reading the commands for photometer head from other defined place in video memory. These commands are sent to the serial port.

The information about installing this resident program (FOT??.EXE) in your PC computer can be found in section 7.2.

6 PHOTOMETER ERRORS

1. **NO DATA RECEIVED** on the computer screen
   (a) check the power supply (change the fuse)
   (b) check the connection between the computer and the photometer (the signal cable)
   (c) check if the computer serial port you are using for the connection with the photometer is COM1 (it cannot be COM2, etc.). Check if other codes do not use this port (e.g. a mouse driver).
   (d) check if this serial port COM1 is functional, e.g. by attaching a mouse into this port and loading a corresponding mouse driver (the mouse should work).
   (e) try to change the filters manually (the button on the photometer head; the flip mirror must be in position in which the light goes into the upper eyepiece). If it is not possible to change the filters manually you must exchange the microcontroler card. The bad microcontroler card should be sent to Vladimír Kollár.
   (f) other errors must be corrected by an electronics engineer.



	offset videoadr.	row/column hex	dec	
actual filter	:0ED7H	17/3B	23/59	ASCII number
requested filter	:0ED9H	17/3C	23/60	ASCII number
actual time	:0F7BH	18/3D	24/61	ASCII string
time of measurement	:0EDBH	17/3D	23/61	ASCII string
actual pulses	:0F85H	18/45	24/69	ASCII string
sum of the pulses	:0EE5H	17/45	23/69	ASCII string
integration time	:0F9EH	18/4F	24/79	hexadecimal number
resident controls	:0EFEH	17/4F	23/79	graphical sign

decimal number	hexadecimal number	graphical sign
49	31H	1
50	32H	2
35	23H	#
42	2AH	*
43	2BH	+
45	2DH	-

Figure 7: The items on the screen communication box: their positions and meaning

2. **impossible to change the filters**, however the **data connection is OK**
   (a) check the signal cable
   (b) check the black connector on the block of filters.
   (c) exchange the microcontroler card. The bad microcontroler card should be sent to Vladimír Kollár.
   (d) other errors must be corrected by an electronics engineer.
3. **the filter indication** on the photometer head does not work
   (a) try to change the filters manually (the button on the photometer head; the flip mirror must be in position in which the light goes into the upper eyepiece).
   (b) exchange the LED indicator of the filter number.
4. **the received pulses are equal 0 (zero)**
   (a) check the connector from the power supply and the connector to the V/F converter
5. **the pulses per second do not change**
   (a) if the pulses per second is more then $\sim 1\,235\,000$ and this number changes just at the last digits you must decrease the high voltage. This is the highest value for pulses per second.

7 USER SOFTWARE

7.1 The basic ideas, philosophy

The observational code UNIV is shipped along with the photoelectric photometer. This code serves during the observation. Though the code is quite "flexible", its basic purpose is to be used for differential photometry of variable stars. The direct output of this code is an output file (section 7.5), where (raw) observational data are stored. To get "astronomical quantities" (magnitudes) suitable for further analysis, these data must be reduced. The reduction can be done with the help of the reduction codes package.

The code UNIV will not allow you to change the diaphragm or integration time during the observation of a given object. This is the way how it tries avoiding vital errors during the observation. In spite of this behavior an observer or an applicant for the observation is asked to follow another guidelines (given in section 7.4) to obtain as good results as possible.

As the UNIV code was developed step by step following experience with the photoelectric photometry at the Stellar Department of the Astronomical Institute of the Slovak Academy of Sciences at Tatranská Lomnica, there was the need for "backward compatibility". Consequently, there are two principal disadvantages: the structure of the output file is obsolete; a very complicated way of referring the objects (stars) at the auxiliary file KATALOG.

An explanation of many terms (seasonal extinction coefficients, Johnson's international UBV system, transformation coefficients...) used in this part can be found in a book by Henden & Kaitchuck (1982) [7].

7.2 Installation

The steps needed for a proper installation of the observational code UNIV at your computer are described in this section. Computer requirements: an IBM-compatible PC x86, operating system DOS, about 150 KB of free disk space at your computer hard disk.

The code UNIV itself consists of several parts:

- the observational code **UNIV.EXE** itself. This code controls the observation process, raw data are gained;

- the resident part of the code **FOT??.EXE** At the position of the first "?" you can find: 1 = for a photometer controlled by synchronization impulses from the COM (serial) port, 2 = the synchronization impulses are generated by the computer. The second "?" stands for one of the following possibilities: H = Hlohovec, G = Kryonerion (Greece), R = Roztoky, P = Skalnaté Pleso(an American photometer Optec with ing. Vladimír Kollár's adjustments), O = Skalnaté Pleso(a "raw" American photometer Optec without any adjustments), L = Stará Lesná. This resident part serves for communication between the computer and the photometer.
- **configuration files**. Various information about a given photometer and objects (stars) are given in these files. The content and their format are described in detail in section 7.3.

The code UNIV is distributed on a 3.5" (or 5.25") DOS diskette. Installation should be done as follows:

1. Create the directory **C:\OBSERV** and copy to this directory from the installation diskette the files **UNIV.EXE** and **FOT??.EXE**.
2. Create the directory **C:\KATALOG** and copy here from the installation diskette the configuration files **KATALOG** and **OBSERVAT.??** (explanation of these two "??" can be found in section 7.3.2). You can copy OBSERVAT.LST, TIME.COR and TR_KOEF.DAT here as well. These last three files are not used during the observation by the UNIV code itself they are, however, needed during the reduction process and are used by codes from the reduction package (section 7.8).
3. Create the directory **C:\DATA**. The output files with raw observational data will go here by default.
4. In the file **C:\CONFIG.SYS** there must be the driver ANSI.SYS started, because the UNIV code uses ANSI Escape sequences. Put the line:

   ```
   DEVICE=C:\DOS\ANSI.SYS
   ```

   into C:\CONFIG.SYS (depending in what directory the file ANSI.SYS can be found).
5. We suggest that you have a colour **monitor**. If your monitor is monochromatic, it is needed to put into your **C:\AUTOEXEC.BAT** file the line (depending in what directory the file MODE.COM can be found):

   ```
   C:\DOS\MODE co80
   ```

   To make the things simpler, you can also join to PATH variable the directory C:\OBSERV in your C:\AUTOEXEC.BAT file.
6. Reboot your computer and you can start the observational code by entering the command:

   ```
   C:\OBSERV\UNIV.EXE
   ```

7. To run the observational code even in a simpler and more elegant way, it is possible (although not necessary) to copy the file POZNAMKA from the installation diskette into the directory C:\OBSERV. Very basic observational principles and various remarks can be given here. Copy the batch file OBSERVAT.BAT from the installation diskette into a directory within your PATH (given in C:\AUTOEXEC.BAT) e.g. C:\DOS or C:\BAT. This batch file types the file POZNAMKA on the screen, sets the working directory, reminds you of the amount of free disk space, and starts the observational code UNIV itself. The best way how to run the batch file OBSERV.BAT is to place it as an item named OBSERVATION in the Norton Commander's menu.

The names of given directories where files should be placed can differ (e.g. your hard disk is not divided into multiple partitions: a disk E does not exist; or you do not have a hard disk at all: are there really such computers at these days?). In this case a new version of UNIV.EXE following your requirements will be shipped to you.

7.3 Configuration files

The code UNIV reads some information from auxiliary configuration files. In the file KATALOG information about stars is stored, the file OBSERVAT.?? (the explanation of these two ?? can be found in section 7.3.2) contains the information about filter positions (order) in the photometer at a given time. Both configuration files are described in detail in sections: 7.3.1 and 7.3.2.

7.3.1 Stars catalogue

The information about stars (observation objects): star identification; the HD, SAO and HR numbers; coordinates right ascension α and declination δ with their equinox; proper motions (without precession!) in coordinates α, δ; optionally (if the object is a variable with a known period) time of minimum JD_{0hel} and the period given in days is stored in the file KATALOG.

For every object (star) there are 2 lines in the file: an odd and the next even line. For example, 8 lines from the file given below. They represent the records corresponding to 4 various objects (stars):

```
tx uma   cmp 1                  HD92764       SA043442        HR
       .000000     .000000000 10.4029338   45.1245810      .0007   -.009   1950
tx uma   cmp 2                  HD92787       SA043444        HR4191
       .000000     .000000000 10.4037108   46.2801900     -.0261   -.072   1950
tx uma   cmp 3                  HD93213       SA043467        HR
       .000000     .000000000 10.4336024   44.2200600     -.0135   -.036   1950
tx uma                          HD93033       SA043460        HR
2448594.479570    3.063329000 10.4224445   45.4945740      .0014    .001   1950
```

A great disadvantage, of a historical origin, is the way of object identification. The stars used during the observation of variable stars (see section 7.4) can basically be divided into 2 groups: variable stars and standard stars. The next historic convention is that a variable star is denoted as object with number 4, a comparison star has number 1, a check is the object number 3. For other possible standard stars we have numbers 2 and $5-99$. The standard star number 2 is, following this convention, the object with number 2 and so on. (This notation is originally adopted from the Stellar Department of the Astronomical Institute at Ondřejov, The Czech Republic and number 1 was to denote the "blue standard", 2 for the "red standard"). From this notation we have identification in the file KATALOG. Let us take as an example the observation of the variable star TX UMa. The object identification is a string 14 characters long. First 9 characters serve to denote a variable star under consideration. The best way is to use a variable star name in lowercase, in this example `tx uma`[1]. To these 9 characters we append at 10–12 positions a string `cmp` and the number of the object in format I2 (FORTRAN convention). The last sentence does not apply for a variable. See:

Object	**Denotation in file KATALOG**
comparison star for variable TX UMa	`tx uma  cmp 1`
check for variable TX UMa	`tx uma  cmp 3`
variable star TX UMa	`tx uma`
standard star No. 15 for variable TX UMa	`tx uma  cmp15`

A disadvantage is clear from given facts: if a star used as a comparison is used as a check as well (theoretically) for a different variable star, let us say TY UMa, it would have to be in file KATALOG twice: for the first time with identification `tx uma  cmp 1` and the second time as `ty uma  cmp 3`. Having in mind a small number (to tell the true it has not happened at Stellar department of the Astronomical Institute of the Slovak Academy of Sciences yet) of these cases, we can tolerate this "nuisance" of the file KATALOG.

[1] It is needed to specify clearly the notation for "problematic" variables; do not use once `n cyg`, then `nova cyg` and the third time `novacyg`, or `hd 8912` and then `hd8912`. To avoid this situation you can have an agreement and in the observational form (see Appendix) there is also a cell "Star name"; an applicant for the observation is expected to write the information about observation objects into file KATALOG.

To ensure unambiguous identification of an object in the file KATALOG, there are (if they exist) the **catalogue numbers** from star various catalogues: HD – Henry Draper Catalogue (Cannon & Pickering, 1918–1924, [4]), SAO – Smithsonian Astrophysical Observatory Star Catalog (1966 ,[10]) and HR – Yale Catalogue of Bright Star (Schlesinger & Jenkins, 1940, [9]; Hoffleit, 1964, [8]). It is needed to find as many as possible catalogues numbers of a given object. The data are archived and this can help in the distant future to identify the observation. Keep in mind that the experiment (observation) cannot be repeated in astronomy, and every *good* observation has its great value. The Internet URL: "http://adswww.harvard.edu/list_abs.html" or "http://adsabs.harvard.edu/abs_doc/list_abs.html" can help you find the catalogue numbers.

If the period of a variable is known, give the time of minimum in Julian days (JD) and the period in days. If the object is not periodic (all standard stars must be of this type) put on this place 0 (zero) for both these values (i.e., time of minimum and period).

Right ascension and declination are given for a certain equinox which can be arbitrary. The right ascension is to be given in hours, minutes and seconds. The number 10.4224445 from the example above for the variable star TX UMa means $\alpha_{1950} = 10^h42^m24^s.445$. Declination is to be given in degrees, arc minutes and arc seconds. The number 45.4945740 from the example above stands for $\delta_{1950} = 45°49'45''.740$.

In the file KATALOG there are given also "raw" (i.e., this means without precession!) proper motions in right ascension and declination. The proper motion in right ascension is given in seconds per annum; the proper motion in declination is given in arc seconds per annum.

The precise position (format) of all data in the file KATALOG is described by the following lines from a FORTRAN source code:

```
      double precision jd0, per
      real mirs, midas
      integer rh, rm rs1000, dd, dam, das1000, epoch
      character*11 hd, sao, hr
      character*14 ident

      open(12, file='KATALOG')
      write(12, 100) ident, 'HD', hd, 'SAO', sao, 'HR', hr
100   format(A14, 18X, A2, A11, 1X, A3, A11, 2X, A2, A11)
      write(12, 200) jd0, per, rh, '.', rm, rs1000,
     +               dd, '.', dam, das1000, mirs, midas, epoch
200   format(D14.6, 1X, A2, D14.9, 1X, I2, A1, I2, I5, 2X,
     +       2X, I3, A1, I2, I5, 3X, F8.4, 1X, F7.3, 3X, I4)
      close(12)
```

The meaning of the symbols (variables): `ident`: object's identification, `hd`: HD number, `sao`: SAO number, `hr`: HR number, `jd0`: time of minimum in JD, `per`: period in days, `rh`: right ascension-hours, `rm`: right ascension-minutes, `rs1000`: 1 000 × right ascension-seconds, `dd`: declination-degrees, `dam`: declination-arc minutes, `das1000`: 1 000 × declination-arc seconds, `mirs`: raw proper motion in right ascension - seconds, `midas`: raw proper motion in declination - arc seconds, `epoch`: equinox of the coordinates - integral year.

The file KATALOG can be created/appended following the given rules by using an arbitrary editor or you can take advantage of the auxiliary code KATIN.EXE; see section 7.8.

If the file KATALOG does not exist the code UNIV will warn you; see section 7.7.

7.3.2 Photometer configuration

The configuration of your photometer may change (e.g. by adding new filters). For this reason, the code UNIV uses the configuration file **C:\KATALOG\OBSERVAT.??** (at the positions of ?? there must be one of the following codes – depending on observatory: HL = Hlohovec, GR = Kryonerion (Greece), RO = Roztoky, SP = Skalnaté Pleso, SL = Stará Lesná), where the "time-dependent" information about your

photometer is stored. In addition to the information about the filters order, there is also the information not used by UNIV, however, needed during the reduction of the observational raw data: extinction coefficients for all the filters and transformation coefficients for the transformation of the instrumental magnitudes in Johnson's filters into the international system.

After every change in your photometer configuration it is needed to up-date this file! You must add a new group of five lines, following the notation and format given below.

The format of the file C:\KATALOG\OBSERVAT.?? is as follows. There are remarks explaining briefly the contents and format of the file on the first 15 lines. After these mandatory 15 lines there is an arbitrary number of 5-line groups. Each of these groups describes the photometer configuration from a given Julian date (JD). These groups must be chronologically ordered following increasing JD! An example of two such groups are given here:

```
------------SKALNATE PLESO Observatory   Pleiades 27/28 JAN '92 (UBV STANDARDS)
 2448649.4
U  B  V
0.675 0.386 0.277 0 0 0 0 0 0 0
  -0.14626   1.02690   1.03747
------------SKALNATE PLESO Observatory   IC4665   10/11 MAY '93  (MIRROR WASHING)
  2449094.5
U  B  V  R  u  v  b  y
0.675 0.386 0.277 0 0 0 0 0 0 0
  -0.00748   0.99970   1.03690
```

- **(15+(n × 5)+1)-st line:** a remark is given here. It is advisable to make a note here what was changed (e.g. new filters added, a computation of new transformation coefficients...)
- **(15+(n × 5)+2)-nd line:** in format F11.1 (FORTRAN convention) the JD is given here. It is the JD from which the values are valid.
- **(15+(n × 5)+3)-rd line:** in format 10(A3) the signs of filters are given. It is not possible to have more than 10. The 0 position is to be used as a "free" position. The filters can be put just into positions 1—n ! If you do not have as many filters as the positions in the photometer, place them in positions starting from the position number 1 and in this line of the configuration file set just signs of really existing filters in your photometer. If you decide to have a free position between filters, it is needed to set a sign for it here as well; let us say `NUL`. 3 spaces cannot serve as a sign, the code would not recognize subsequent filters.
- **(15+(n × 5)+4)-th line:** the first-order seasonal extinction coefficients are given here in free format (there must be 10 of them). They must be given in the order of filters (following previous line). If you have not measured an extinction coefficient for a given filter yet, or there is no filter in the photometer at this position place 0 (zero) at the respective position.
- **(15+(n × 5)+5)-th line:** the transformation coefficients (ϵ, μ, ψ) without zero points in format 3(F10.5) for the transformation into international UBV magnitudes are given here. The transformation equations are:

$$\begin{aligned} V - v &= \epsilon \times (B - V) + \zeta_v \\ B - V &= \mu \times (b - v) + \zeta_{bv} \\ U - B &= \psi \times (u - b) + \zeta_{ub} \end{aligned} \tag{1}$$

  Capital letters U, B, V denote Johnson's international magnitudes, lowercase letters u, b, v denote instrumental magnitudes.

If we write down the system of transformation equations for a comparison star S_1 and the same for variable V, we can subtract them to get:

$$\begin{aligned} \Delta V - \Delta v &= \epsilon \times (\Delta B - \Delta V) \\ \Delta B - \Delta V &= \mu \times (\Delta b - \Delta v) \\ \Delta U - \Delta B &= \psi \times (\Delta u - \Delta b) \end{aligned} \tag{2}$$

without zero points $(\zeta_v, \zeta_{bv}, \zeta_{ub})$. The symbols Δ's stand for differential magnitudes, the differences of the magnitudes of a variable V and a comparison star S_1 for a given filter, e.g.: $\Delta U = U_V - U_{S_1}$. This is the reason why on the (15+(n × 5)+5) line of the configuration file just the transformation coefficients (ϵ, μ, ψ) without zero points are given. However, we suggest that the differential photometry is done. If we want to have Johnson's international UBV magnitudes of a variable V after reduction, we must know (find in the catalogue) Johnson's international UBV magnitudes of a comparison star S_1.

The configuration file can be modified/appended by using an arbitrary editor.
The file must exist, otherwise the code UNIV will stop with an error message; see section 7.7.

7.4 Observation principles

The code UNIV was written to make on one side a variable stars observation easier and on the other side, to exclude possible errors of an observer during the observation. Such features are: impossibility to change the integration time and diaphragm during the observation of a given object and so on. We tried to use all our experience with photoelectric photometry at the Stellar Department of the Astronomical Institute at Tatranská Lomnica. Anyway, an observer and an applicant for an observation must follow certain principles even during the preparation of an observation. Let us mention some of these principles:

- As a **standard comparison star** S_1 it is needed to choose an invariable object of approximately the same brightness as the variable star (dynamic range of the photometer), approximately the same spectral type (the second order extinction coefficients are not taken into account during the reduction) in a relatively small angle distance (maximally a few degrees) from the variable star (if this condition is satisfied you minimize the time needed for transitions between objects; moreover, the extinction corrections will be negligible, so even the first order extinction coefficients given with a big error will not lead to a result with a great error; finally there are given borders for "telescope fine movements"). Whereas it is not possible to be sure about invariability of an object chosen as the standard comparison star (you can be the first human being to discover its variability) it is recommended to choose another standard star, the so-called **check**, and measure it during the observation approximately every 30 minutes. If you find that S_1 was not chosen well, you can use a check instead of it during the reduction.

- It is needed to prepare good bedding for every observation in advance. Remember, it should be complete, clear and everybody should understand it, not to be confused during the observation, loosing the time trying to figure out how it was meant. A good, high quality **map** is needed for any observation. It must contain notations for all objects. Such a map can be for example produced by means of the code *STARCHART* freely available in the INTERNET; this was the way together with using the *The Guide Star Catalog, ver. 1.1* CD ROM how the maps for observation of the UBV standards given in Appendix were created. Xerox copies from Bečvář's atlases (Bečvář, 1979, [2]; 1978, [1]; 1974, [3]) are very useful as well. Resolution of the map should be good enough for the observer to find in the map all the objects which he can see through the pointer (or on the TV monitor). It is also useful to attach a very good photography of a given field with very faint objects in order for the observer to be able to choose the place where the sky can be measured. For this purpose a xerox copy from the Palomar photographic atlas (Dixon, Gearhart & Schmidtke, 1985, [5]) is suitable. You must also prepare a brief, but complete and clear **observation direction**.

You must enter all needed data on photometer setting (e.g. voltage, diaphragm) and also the data on observation (integration time, used filters, objects sequence). You can use an observation form given in the Appendix for this purpose.

- The observation can start only when the sky is dark enough and its brightness does not change dramatically. The **nautical twilight** (the Sun is 12 degrees below the horizon) is adequate in most cases for a photometric observation. Stars under standard weather conditions can be observed with good results in **heights $> 30^\circ$ over the horizon**. In lower heights, smog and dust in the Earth's atmosphere will spoil or even prevent a really good observation in most cases.

- As the brightness of the sky is not zero due to light dispersion, you must perform a **sky measurement** before every object measurement. The sky should be measured close to the object (several arc seconds or minutes) at a place where no faint stars bringing their own light into the measurement are present. To choose such a place the above mentioned photography of the field is useful. Although the code enables you to omit the sky measurement, this is necessary. The sky is measured always before the measurement of the object.

- You must begin and end the observation with the measurement of a comparison star S_1. If this condition is satisfied during reduction, just an interpolation will be used and there will be no need for any extrapolation. For example, a suitable **cycle** is: S_1 - CH - n×[S_1 - V - S_1 - V - S_1 - V - S_1 - CH] - S_1. The object's sky measurement must be done before the measurement of object itself, of course.

- At the end of the observation it is a good idea to describe the **night quality** and write down all **remarks** concerning the observation. This can be very useful for you when trying to understand older observations in the future.

- It is also useful to have an **observation diary/journal**. At least the following entries should be present there: date, observed variable star, observer, used filters, voltage, diaphragm, the exact time of observation (the time of the first and last integration, optionally observer's remarks. Systematic **archiving** deserves your attention as well.

- The simplest and non-confusing thing (especially in our longitudes where the difference is just few hours) is to use **GMT** (Greenwich Mean Time) - the time of Greenwich meridian for your observations. The code UNIV requires to set this time in your computer. If you use GMT strictly in all data you will have no problems in the future with trying to find out what time was used.

7.5 Output file of the code UNIV

The output from the UNIV code is an output file which contains all data measured during the observation and needed for further reduction.

The **name of the output file** is following a convention which allows a fast orientation concerning the observation. The DOS operating system has some file-naming restrictions: the name of a file can be just 8 characters long plus 3 characters in extension. For this reason we choose for the first `n` ($0 < n \leq 5$) characters of the file-name the observation identification (best is to use the variable star's name), e.g. `txuma`. The rest is appended automatically by the code UNIV following the rules: in the `n+1`-st position there is the code of the observatory (H = Hlohovec, K = Kryonerion, R = Roztoky, S = Skalnaté Pleso, G = Stará Lesná); in the `n+2`-nd and `n+3`-rd positions is the day of the month (as the actual date always the **"evening"** date is taken, even if the observation started after midnight); in the `1`-st position in extension there is the code for the month: (`1`–`9` for January–September, `O` - October, `N` - November, `D` - December); in the `2`-nd and `3`-rd positions in extension denote the year. For example the output file name `txumas04.096` means that it was the observation of TX UMa at Skalnaté Pleso Observatory in the night 4/5 October 1996. Following these rules the name of the output file is generated by the the UNIV code.

At first we will show an example of an output file:

```
"STAR NAME:","tx uma","DISKETTE:","sp"
"INT.TIME [S]:","10","OBSERVERS:","ko"
"DATE:","4","-","10"
"-","1996","JULIAN DATE:",2450360.500000
"TEMPERATURE, HUMIDITY, SEEING: ","4","70","7"
"OBJECT:","TIME:","FILTER:","COUNTS:"
" 0"," 17:42:12"," 4"," 8516"
" 0"," 17:42:24"," 6"," 4850"
" 1"," 17:42:58"," 4"," 554489"
" 1"," 17:43:10"," 6"," 147196"
" 0"," 17:48:39"," 4"," 8785"
" 0"," 17:48:51"," 6"," 4803"
" 4"," 17:49:23"," 4"," 629356"
" 4"," 17:49:35"," 6"," 165624"
   .
   .
   .
" 0"," 18:49:20"," 4"," 9233"
" 0"," 18:49:31"," 6"," 5002"
" 1"," 18:50:03"," 4"," 528666"
" 1"," 18:50:15"," 6"," 132046"
# NIGHT QUALITY FLAG: 2 (1=excellent, 2=good 3=variable, 4=poor 5=unusable)
# NIGHT QUALITY REMARK: night was good, but the seeing is quite great
# NIGHT QUALITY REMARK: great scintillation
```

The file consists of 3 parts: the header (first 6 lines), the body with observational data themselves and remarks at the end of the file.

The **header** contains the name of the observed variable star (following identification in the configuration file KATALOG, see section 7.3.1); the observatory code: (HL = Hlohovec, GR = Kryonerion (Greece), RO = Roztoky, SP = Skalnaté Pleso, SL = Stará Lesná); the integration time in seconds; the observer's code; the date of observation (day, month, year; let us stress again that this is the "evening" date, even if the observation starts after midnight); Julian date of the previous midnight; temperature in degrees Centigrade; air humidity in %; seeing (apparent "size" of stars in the eyepiece of the telescope) in arc seconds. The form of this header is "historic" as well, and just the following data are used during the reduction: name of the observed variable star, observatory code; "evening" date of the observation (day, month, year).

The **body** of an output file consists of 4 columns which store measured data. In the **first column** there is the object code following convention described in section 7.3.1, let us recall: 4 - variable star, 1 - comparison star, 3 - check, 2 and 5 – 99 - optional other standard stars. The code 0 denotes the sky; it must be emphasized that it is the sky for the following measured object (from the example given above the first and second line of the body contain the measurements of the sky of a comparison star S_1, while the fifth and sixth lines contain the measurement of the sky of variable star V. The **second column** contains the time of the middle of integration in GMT: hours, minutes, seconds. In the **third column** there is the position of a used filter in the photometer (see section 7.3.2). The **fourth column** contains pulses measured by the photometer during the integration time (this value is proportional to the energy from a light source falling onto a photocathode of a photo-multiplier if the dead time is zero).

The **remarks** at the end of the output file (the last 3 lines in the example given above) may have an arbitrary number of lines. Each of these lines begins with the sign # (hash). In their first line there is the code (range 1–5) for the night quality. Following lines may contain all important facts which occurred during the observation. An observer enters them at the end of the observation of a given variable star.

7.6 Running the UNIV code

Controlling the UNIV code should be intuitively clear. It can communicate in English or Slovak (following your request the desired mutation will be shipped). The possible answers to its questions are in brackets, e.g.: `Is this setting correct? [Y/n] =>` . Here you have the possibility of answering "yes" by entering `Y` (or `y`) or "no" by entering `N` (or `n`). The capital letter in the bracket means an implicit value (in this case it is `Y`). If you simply hit `ENTER`, the implicit answer will be used (in this case "yes").

After starting the UNIV code the initial screen is displayed for a few seconds with the information about authors and the **UNIV version**. An initial dialog follows. You must enter the **name of the variable star** which is to be observed. You must enter the name which appears as the object identification in the file KATALOG (see section 7.3.1), e.g. `tx uma`. The next question is the **"evening" date**. If the date setting in your computer is correct (it must be!), the code will provide you with proper setting, even if the observation starts after midnight. The third question asks you to set the observers' codes. These codes are signs which you use for observers. The code accepts maximally 10 characters as an answer. The **integration time** is accepted within the range 2 - 254 seconds and it must be an even number. This is the time how long a single integration (one measurement of a given object in one filter) will take. This time is the same for all measurements and cannot be changed: the sky, standard stars and variable star measurements must be done with the same integration time. At the Stellar Department of the Astronomical Institute at Tatranská Lomnica in most cases 10 second integration time is used. If you find during the observation that a wrong integration time was chosen (e.g. there is a bad signal-to-noise ratio), you must finish the actual measurement and start a new one with a new "good" integration time setting in the initial dialog. Remember that if you enlarge the integration time to improve the signal-to-noise ratio, you worsen the time resolution. Following questions on **temperature**, **humidity** and **seeing** have just an informational meaning. You must enter a **directory** where the **output file** will be placed and first maximally 5 characters from the name of the output file (see section 7.5 regarding the output file naming convention). The code again offers you default answers. Existence of the directory and non-existence of the file with the same name as the output file (not to overwrite it) is checked. In such a case the code asks you again to enter new values for the directory and name of the output file. At the end of this first screen the code asks if all questions were answered correctly. If not, the initial dialog starts again and you can enter correct values.

Next is the **GMT setting** (see section 7.4). It is needed to be entered as precisely as possible: this is an astronomical observation! Remember, this time will be set as well as the system time of your computer.

Following screen allows you to enter the required **cycle of filters**. To be provided with all possibilities (all filters you have currently in your photometer) the configuration file OBSERVAT.?? (see section 7.3.2) must be properly written. Enter within this screen all filters you want to use during the actual observation, e.g. U–B–V.

Next is to enter the required **cycle of stars** (objects) you want to measure during the observation. This cycle will be re-started (repeated) when finished. Following the rules in section 7.4, let us suppose you enter the following cycle: S_1–S_2–CH–S_1–V–S_1–V (at the end of observation it is needed to measure S_1). Next you must answer questions about the **number of measurements of the sky of standard stars** (all stars except for the variable): let us answer 1; **number of measurements of standard stars**: let us answer 1; **number of measurements of the sky of the variable star**: let us answer 1; **number of measurements of the variable star**: let us answer 2. To understand the questions and answers from the last two screens, here is the scheme of the observation following the request from the given example. The order of simple integrations will be: OS_1^U - OS_1^B - OS_1^V - S_1^U - S_1^B - S_1^V - OS_2^U - OS_2^B - OS_2^V - S_2^U - S_2^B - S_2^V - OCH^U - OCH^B - OCH^V - CH^U - CH^B - CH^V - OS_1^U - OS_1^B - OS_1^V - S_1^U - S_1^B - S_1^V - OV^U - OV^B - OV^V - V^U - V^B - V^V - V^U - V^B - V^V - OS_1^U - OS_1^B - OS_1^V - S_1^U - S_1^B - S_1^V - OV^U - OV^B - OV^V - V^U - V^B - V^V - V^U - V^B - V^V The superscript stands for the filter used within the integration and "O" before the star sign means the sky measurement for that star.

If your photometer allows you to control the diaphragm setting, the question on the next screen enables you enter the number of the required diaphragm. The observation as a whole will be done in this

diaphragm.

After answering all these questions the code sets the filters into their basic position, optionally sets the required diaphragm, tries to find the data about stars which are to be observed within a given star cycle in the configuration file KATALOG (section 7.3.1). If this file does not exist or there is no record in it about the given star, the code UNIV displays a warning; see section 7.7.

After this, the screen with some information about the given setting appears. It also offers you following possibilities within the **main menu**:

- by hitting the + key the code starts the measurement of the next object within a given sequence (star cycle). It asks you to position the telescope onto the required object, its sky (if the number of measurement of skies is not set to zero) and, after the sky onto the star itself. If there were previous measurements of this object within this observation, the code displays the information about the last measured values in all filters and the number of measurements done so far. If you hit "+", the actual integration begins. It will be performed in all filters given in a filter cycle and it will be repeated so many times as was the number of measurements for the actual object set. The measured values are displayed in a simple table on the screen. Hitting the "-" key you can refuse the measured values and following the subsequent answer to repeat the measurement (this is useful if the object placement in the diaphragm was not good), or you may go back to the main menu and perform a desired action. If the measured value differs from the previous value by the amount greater than 10%, the measured value is displayed blinking. After finishing the measurement in all filters you can decide whether to repeat such a measurement (default) or to accept it. The mentioned 10% is just a conventional value, following your request we can ship you the UNIV code with different value of this toleration.

- the **I** key brings you to the Info-screen. At first you must choose a star you want to be informed about. After this selection the screen with information appears. In addition to the number of measurement done so far, last values of measurements of the star itself and its sky in all filters, you can also find further helpful information: actual declination, hour angle (both in real time) so that you may use it for **positioning the telescope** on a given object. The phase (if the star is a periodic variable), air mass, heliocentric JD, local sidereal time and other values are displayed as well.

- the **B** key causes a skip from the actual object within given cycle of stars to its beginning: the next object to be measured will be that which was given as the first in the star cycle.

- the **F** key allows you to enter a new filter cycle.

- the **C** key allows you to enter a new star cycle (sequence of objects).

- If the timing of your computer is not good, or for any other reason you must set the correct time again, use the key **T**: you can enter again correct GMT.

- If you finished the observation of the given variable star and you want to start the observation of another variable star use the key **N**. The current observation comes to its end: the code asks about the night quality, allows you to enter your remarks (section 7.5), optionally to print the measured values on a printer. After these tasks, the code starts again the initial dialog: it looks like it started from the beginning, so you can enter the a variable star, filter cycle, star cycle (sequence of objects) ...

- If you want to finish the last observation within the night, use the key **E**: the observation finishes: the code asks about the night quality, allows you to enter your remarks (section 7.5), optionally you can print the measured values on a printer. The resident part of the code is being uninstalled, the code UNIV exits and you are set back to the DOS shell (operating system) from where the UNIV was initialized.

7.6.1 The future of UNIV code; features to be implemented

To simplify and fasten transitions between the objects, we intend to implement into the UNIV code automatic transition from the last measured object to the next object in a given object sequence. For this purpose fine movements of the telescope must be equipped with stepper motors and the code will control them. At the beginning of the observation the observer will have to set positions of objects "manually", following a finding chart. The code will store differences (the number of steps of stepper motor) between the objects and during the following transition will be able to switch from one object to another. However, the observer will still be left the possibility of refining this "rough" positioning: the code will store the new position. This behavior (position corrections) is required due to various errors in telescope construction, refraction, features of stepper motors...

7.7 Error and warning messages of the UNIV code

During the run of the UNIV code some errors or warnings may appear. Error messages appear if the code cannot find some configuration files which are necessary for its work: the code stops after these errors. Warnings will not lead to code abortion as the code can go on, but some functions will not be present (usable) any more:

- ERRORS:
  - **FOT??.EXE file not found**. As it was explained in section 7.2, the UNIV code needs its resident part to run. This resident part is stored in this file. Without it the code cannot communicate with the photometer so it stops with an error message. Following the instructions in section 7.2 you must correctly install this file from the installation diskette.
  - **the configuration file OBSERVAT.?? not found** (section 7.3.2). In this case the UNIV code cannot find the configuration of your photometer: the number and the order of filters. It stops with this error message. Following the instructions in section 7.3.2 you must create and install (section 7.2) this file.
  - **disk full**. The amount of free disk space for the UNIV code work is about 10 KB at least. This space is used to store output data (an output file). Moreover, during its run the code creates some temporary working files. For this reason it is reasonable to start the code from a directory on a disk with a sufficient amount of free space. If the disk becomes full during the observation, the code stops with this fatal error. The last temporary file remains in the working directory so it is possible to restore the last measurements which have not been written into the output file yet. Nevertheless it is recommended to have in the batch file OBSERV.BAT (see section 7.2), which starts the UNIV code, a part providing the observer with the information about the amount of free disk space available in the working directory. If this error occurs, you must create a suitable amount of free disk space on your disk and re-start the code UNIV.
- WARNINGS:
  - **the configuration file KATALOG not found** (section 7.3.1). In this case the code cannot find the information about any star from the given star cycle. This is the reason why when hitting the key "I" in the main menu (see section 7.6), you cannot get any information regarding the star. At the place of these data the warning reminding you of non-existence of the KATALOG file will be displayed. We strongly recommend that you create the file KATALOG (e.g. you may use the code KATIN.EXE: section 7.8) and to install it (section 7.2), respectively, to check whether the KATALOG file is placed in the correct directory.
  - **the star ... not found in the KATALOG file**: the situation similar to the previous one. Though the file KATALOG exists and is installed correctly (the UNIV code can find it), there is no record in KATALOG file concerning the required star. For this reason the information screen (key "I" in the main menu: section 7.6) for this particular star will be incomplete. It

is recommended to put the information about this star into the KATALOG file: you may use the code KATIN.EXE (section 7.8), or an arbitrary editor as described in section 7.3.1.

7.8 Auxiliary codes

The codes described in this part should facilitate your work with management of the configuration file KATALOG, controlling the photometer functionality, and in computing various astronomical data which make the observation planning easier. The reduction process of raw data is mentioned in brief.

- **KATIN.EXE** This code serves for simple entering the data about particular stars into the configuration file KATALOG (see section 7.3.1). Besides entering new records it will allow you to delete bad records or to fix errors in records. The code tries to be self-explanatory.
- **DEMOFOT.EXE** This code was written as a simple front-end code to demonstrate controlling the photometer operation by means of a personal computer. It uses the resident part **FOT??.EXE** (see section 7.2). It enables you to set the integration time and to perform a particular integration. It can remove the resident part from the computer memory as well. The code should be used for quick checking of the correct photometer functionality and its communication with the computer.
- **MINF.EXE** This code basically computes the **observerability of a star**. To get the information about a star (coordinates, etc.) it uses the configuration file KATALOG (section 7.3.1). It computes the timings of twilights; timings of the setting and rise for a particular star (to be more precise: when the star's height above the horizon is greater than a given value); the phases of a periodic variables; times of minimum; culmination time; etc. Many values can be modified when the code starts (e.g. the latitude, the longitude, the "height" (better to say "depth") of the Sun for twilight timings; the height above the horizon for times of a star "setting" and "rise" computations). The output of this code should enable you to plan your observations in an optimal and effective way, indeed.
- **SPHEL.EXE** The output of this code contains almost all astronomical data on a particular star in a given time: local sidereal time, actual right ascension, declination, height above horizon, zenith distance, hour angle, air mass, heliocentric Julian date, heliocentric and barycentric corrections of time and radial velocities, optionally the phase and epoch if the star is a periodic variable. This code uses the configuration file KATALOG (section 7.3.1), as well and the geographic location of the observatory can be modified when the code starts.
- **the reduction codes package for raw photometric data reduction** Explaining the whole process of raw photometric data (e.g. obtained via the UNIV code) reduction is behind the scope of this document. This reduction package can be obtained upon request from the Stellar Department of the Astronomical Institute at Tatranská Lomnica. The output of the reduction contains the data usable in astronomy: heliocentric observation time, magnitudes (they can be instrumental or Johnson's international UBV ones) and further helpful information. By means of this package it is possible to compute the first order extinction coefficients. If you average this values over particular time period (a season), you can get seasonal extinction coefficients mentioned in section 7.3.2. By reducing the observations of UBV standard stars (the finding charts as well as the directions for observing of 3 such UBV standard stars groups: Pleiades, Praesepe and IC 4665 can be found in the Appendix) you can compute the transformation coefficients into the Johnson's international UBV system (see section 7.3.2). Many configuration files (some of them mentioned in section 7.3) are used by the reduction codes package as well.

Acknowledgements

The authors thank to many members of the Stellar Department of the Astronomical Institute at Tatranská Lomnica for their kind help; for valuable discussions on experience with photoelectric photometry, mainly

RNDr. Jozef Žižňovský, CSc. and RNDr. Ján Budaj, who is also a co-author of the reduction programs package (the part for the transformation of instrumental magnitudes into international UBV system). Our gratitude also belongs to prof. RNDr. Pavel Mayer, DrSc. who is the author of the optical-mechanical part construction, Ing. Milan Minarovjech, CSc. for the help with the construction of the analog part of the photometer and RNDr. Metod Saniga, CSc. for emendation the English translation of this manual. This manual was written using the typesetting system LaTeX.

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APPENDIX

OBSERVATION FORM

STAR								α_{1950}	δ_{1950}	U	B	V	Spec.
Sign	Name	SAO	HD	HR	BD	AGK		h m s	^{o} $'$ $''$				type
S_1													
S_2													
CH													
V													

Star name (lowercase!!!)		**Applicant**	
Scale Voltage		**Integration time** (sec)	
Diaphragm		**Filters**	
Sequence			
Number of measurements of	sky standards variable		
Observerability			
Remarks			
Appendices	map, field photography, Palomar atlas xerox		
Date			

OBSERVATION OF UBV STANDARDS

PLEIADES

Star			HD	SAO	HR	α_{1950}			δ_{1950}			U	B	V	Spec.
						h	m	s	°	′	″				type
S10	pleiades cmp10	B	23338	76140	1145	3	42	13.6	24	18	42.9	3.74	4.20	4.31	B6V
S2	pleiades cmp 2	C	23753	76215	1172	3	45	22.9	23	16	08.8	5.06	5.38	5.45	B8V
S8	pleiades cmp 8	D	23712	76206		3	45	07.0	24	50	09.1	10.23	8.16	6.46	K5
S9	pleiades cmp 9	E	23568	76183		3	44	00.3	24	22	00.4	6.78	6.85	6.82	B9V
S1	pleiades cmp 1	F	23763	76216		3	45	31.1	24	11	36.4	7.16	7.07	6.95	A0
S16	pleiades cmp16	G	24013	76259		3	47	28.8	24	20	42.1	7.67	7.55	7.42	A2
CH	pleiades cmp 3	H	23654	76202		3	44	38.7	23	27	23.1	10.07	8.95	7.72	K0
V	pleiades	I	23512	76175		3	43	36.2	23	28	12.2	8.75	8.46	8.11	A0
S11	pleiades cmp11	K	23375	76149		3	42	35.6	24	18	30.4	9.06	8.95	8.60	A2
S12	pleiades cmp12	L	23665	76203		3	44	44.2	23	23	26.6	10.75	9.94	8.79	K0
S5	pleiades cmp 5	M	23949	76248		3	46	55.8	24	04	02.5	9.47	9.32	9.16	A0
S7	pleiades cmp 7	N	23584			3	44	11.1	24	07	26.0	9.95	9.93	9.46	F8
S6	pleiades cmp 6	O				3	42	41.0	24	28	22.0	10.30	10.25	9.70	F8
S13	pleiades cmp13	P				3	45	27.5	23	53	48.0	10.67	10.58	10.02	
S14	pleiades cmp14	Q				3	43	55.7	23	25	50.0	11.32	11.16	10.52	F9
S15	pleiades cmp15	R				3	46	25.5	23	41	19.0	12.51	12.13	11.35	G2

by **Henden, A.A. & Kaitchuck, R.H.**: *Astronomical Photometry*, 1982, New York

Star name: pleiades
to be entered in lowercase!

Voltage:

Diaphragm:

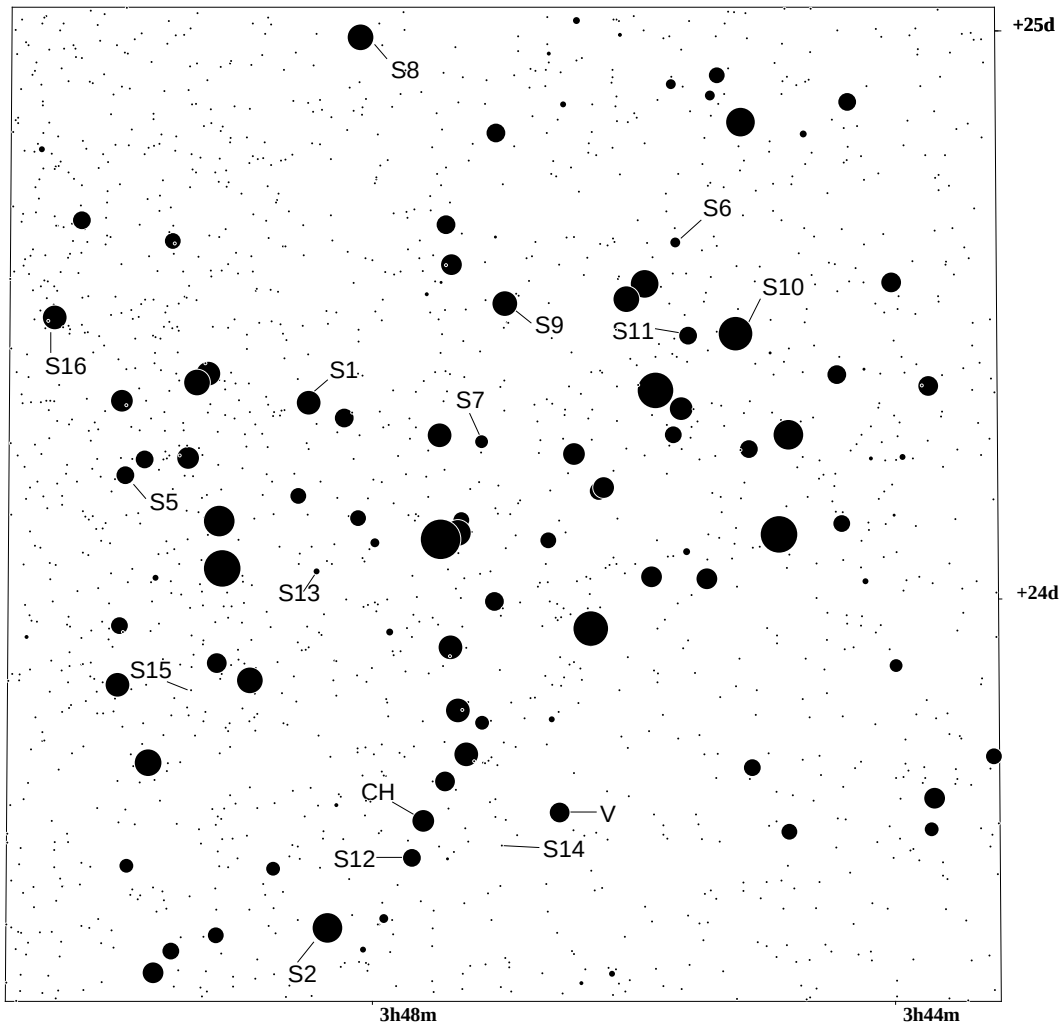
Filters: U - B - V

Sequence: twice per night (the air masses difference should be as large as possible) following super-cycle:
$2 \times [S1 - S2 - CH - V] - 2 \times [S1 - S8 - S9 - S10] - 2 \times [S1 - S16 - S5 - S7] - 2 \times [S1 - S15 - S12 - S14] - S1$
When observing conditions are not ideal do not measure the faintest stars.

Number of measurements: sky: 1, stars: 2

Applicant:

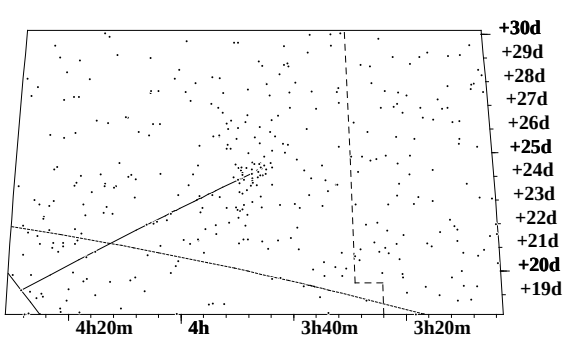
Observerability: from the beginning of September till the end of February;
beginning of September: rise $\sim 23^{00}$ UT, observerable till $\sim\ 2^{30}$ UT;
end of February: setting $\sim 20^{30}$ UT, observerable from $\sim\ 17^{30}$ UT.



Pleiades (2000.0)

(3h47m,+24d10m lim: 20.0)

5	6	7
8	9	10
11	12	13
14	15	16
	double	variable
Planet	Asteroid	Comet
Cluster	Globular	Open
Nebula	Planetary	Diffuse
Galaxy	Elliptical	Spiral
Unknown	Other	Quasar



OBSERVATION OF UBV STANDARDS

PRAESEPE

Star			HD	SAO	HR	α_{1950}			δ_{1950}			U	B	V	Spec.
						h	m	s	°	′	″				type
CH	praesepe cmp 3	A	73731	98024	3429	8	37	35.1	19	43	23.1	6.63	6.47	6.30	A2
S6	praesepe cmp 6	B	73665	80333	3427	8	37	14.0	20	11	08.0	8.20	7.37	6.39	K0II
S2	praesepe cmp 2	C	73710	98021	3428	8	37	30.1	19	50	52.9	8.36	7.46	6.44	K0II
S13	praesepe cmp13	D	72779	97928	3387	8	32	27.1	19	45	48.3	7.50	7.25	6.58	G0II
V	praesepe	E	73598	98010		8	36	58.7	19	43	06.6	8.27	7.55	6.59	K0II
S5	praesepe cmp 5	F	73666	80336		8	37	19.1	20	08	56.6	6.64	6.62	6.61	A0
S8	praesepe cmp 8	G	73819	98032		8	38	04.4	19	45	32.3	7.09	6.95	6.78	A6V
S1	praesepe cmp 1	H	73785	98030		8	37	51.1	19	53	51.6	7.20	7.05	6.85	A9II
S7	praesepe cmp 7	J	73974	80361		8	38	57.9	20	03	13.1	8.60	7.86	6.90	K0II
S9	praesepe cmp 9	K	73711	98018		8	37	26.2	19	42	36.1	7.83	7.70	7.54	F0II
S10	praesepe cmp10	L	73450	98002		8	36	17.1	19	46	10.0	8.82	8.75	8.50	A9V
S11	praesepe cmp11	M	73397	97994		8	35	54.9	19	40	38.8	9.35	9.32	9.00	A5
S14	praesepe cmp14	N	73640	80332		8	37	08.7	20	18	48.9	10.09	10.11	9.67	F6V
S12	praesepe cmp12	P				8	35	39.9	19	38	30.0	11.80	11.02	10.01	G5
S15	praesepe cmp15	Q				8	37	02.7	20	14	34.0	10.60	10.60	10.11	
S16	praesepe cmp16	R				8	38	33.7	20	07	22.0	11.42	11.32	10.72	

by **Henden, A.A. & Kaitchuck, R.H.**: *Astronomical Photometry*, 1982, New York

Star name: praesepe
to be entered in lowercase!

Voltage:

Diaphragm:

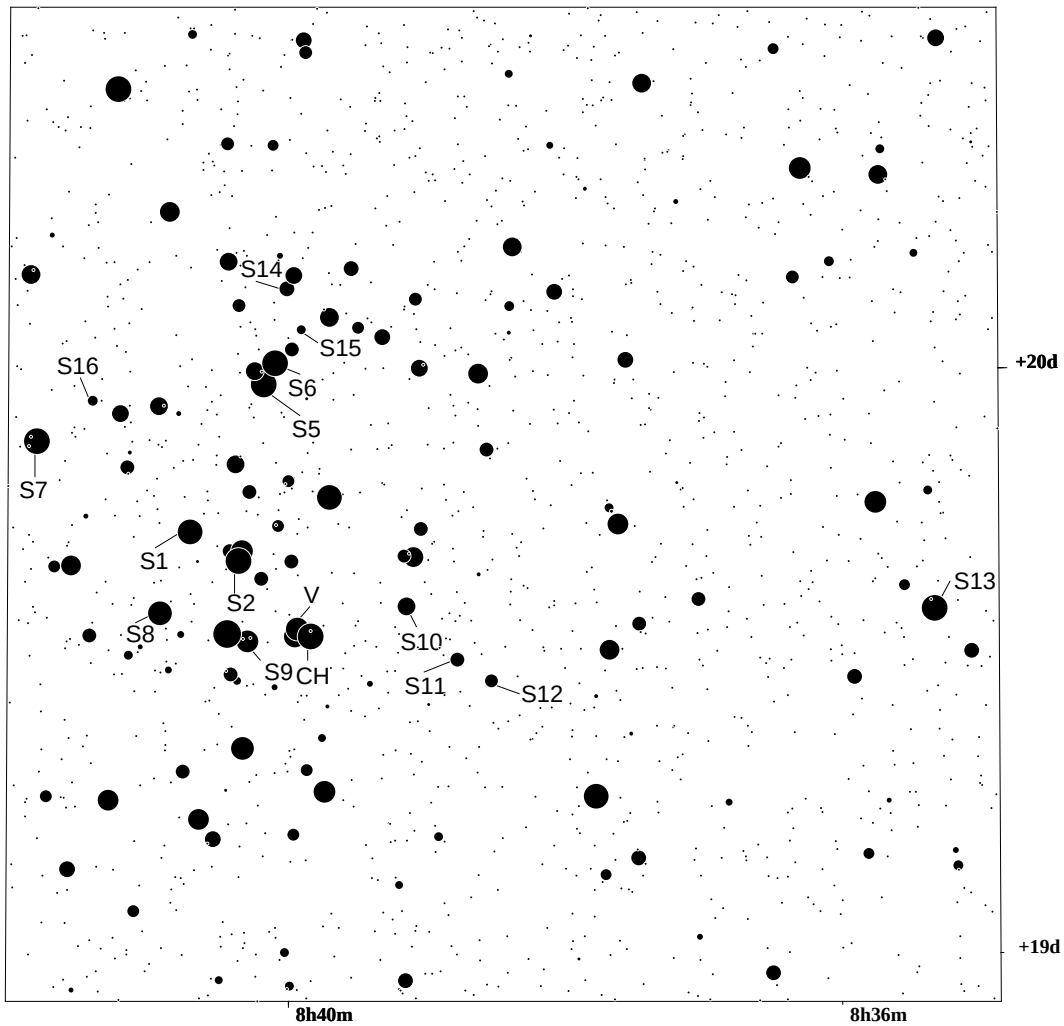
Filters: U - B - V

Sequence: twice per night (the air masses difference should be as large as possible)
following super-cycle:
$2 \times [S1 - S2 - CH - V] - 2 \times [S1 - S5 - S6 - S7] - 2 \times [S1 - S8 - S9 - S10] - 2 \times [S1 - S11 - S12 - S13] - 2 \times [S1 - S14 - S15 - S16] - S1$
When observing conditions are not ideal do not measure the faintest stars.

Number of measurements: sky: 1, stars: 2

Applicant:

Observerability: from the beginning of October till the end of April;
beginning of October: rise $\sim 2^{00}$ UT, observerable till $\sim 3^{30}$ UT;
end of April: setting $\sim 21^{00}$ UT, observerable from $\sim 19^{00}$ UT.

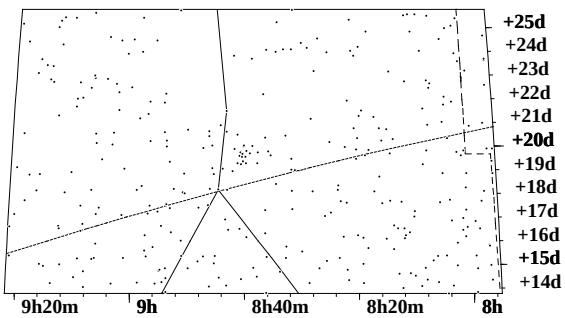


Praesepe (2000.0)

(8h38m,+19d46m lim: 20.0)

5 6 7
8 9 10
11 12 13
14 15 16

	double	variable
Planet	Asteroid	Comet
Cluster	Globular	Open
Nebula	Planetary	Diffuse
Galaxy	Elliptical	Spiral
Unknown	Other	Quasar



OBSERVATION OF UBV STANDARDS

IC 4465

Star			HD	SAO	HR	α_{1950}			δ_{1950}			U	B	V	Spec.
						h	m	s	°	′	″				type
S2	ic4665 cmp 2	A	161573	122723		17	43	40.1	5	32	54.5	6.32	6.86	6.85	B4V
CH	ic4665 cmp 3	B	161677	122735		17	44	14.0	5	47	31.0	6.66	7.14	7.12	B8
V	ic4665	C	161603	122725		17	43	43.7	5	40	35.2	6.90	7.36	7.34	B9
S6	ic4665 cmp 6	D	161223	122683		17	41	36.9	6	04	57.4	7.91	7.76	7.43	A2
S7	ic4665 cmp 7	F	161572	122716		17	43	29.9	5	42	46.4	7.10	7.59	7.59	B6V
S9	ic4665 cmp 9	G	161660	122734		17	44	09.8	6	08	18.1	7.18	7.73	7.74	B9
S12	ic4665 cmp12	H	161242	122686		17	41	45.4	5	16	16.6	10.21	9.11	7.83	K2
S10	ic4665 cmp10	I	161638	122732		17	44	02.1	6	15	14.2	9.69	8.92	7.89	K0
S1	ic4665 cmp 1	J	161622	122731		17	44	00.8	5	24	54.8	8.38	8.39	7.94	F0
S5	ic4665 cmp 5	K	161184	122676		17	41	24.8	5	51	57.2	7.95	8.12	8.05	A0
S8	ic4665 cmp 8	L	161698	122738		17	44	19.4	5	34	57.4	8.03	8.33	8.22	B9
S16	ic4665 cmp16	N	161820	122746		17	45	01.7	5	37	14.6	12.14	10.06	8.33	K5
S14	ic4665 cmp14	O	161867	122753		17	45	21.0	5	22	43.3	10.67	9.63	8.40	K2
S15	ic4665 cmp15	Q	161980	122770		17	45	55.3	5	19	32.0	11.28	10.21	8.96	
S11	ic4665 cmp11	R	161481	122710		17	43	07.4	5	26	44.1	9.46	9.36	9.10	
S13	ic4665 cmp13	T				17	42	19.0	5	13	14.0	11.99	10.95	9.68	

by **Henden, A.A. & Kaitchuck, R.H.**: *Astronomical Photometry*, 1982, New York

Star name: ic4665
to be entered in lowercase!

Voltage:

Diaphragm:

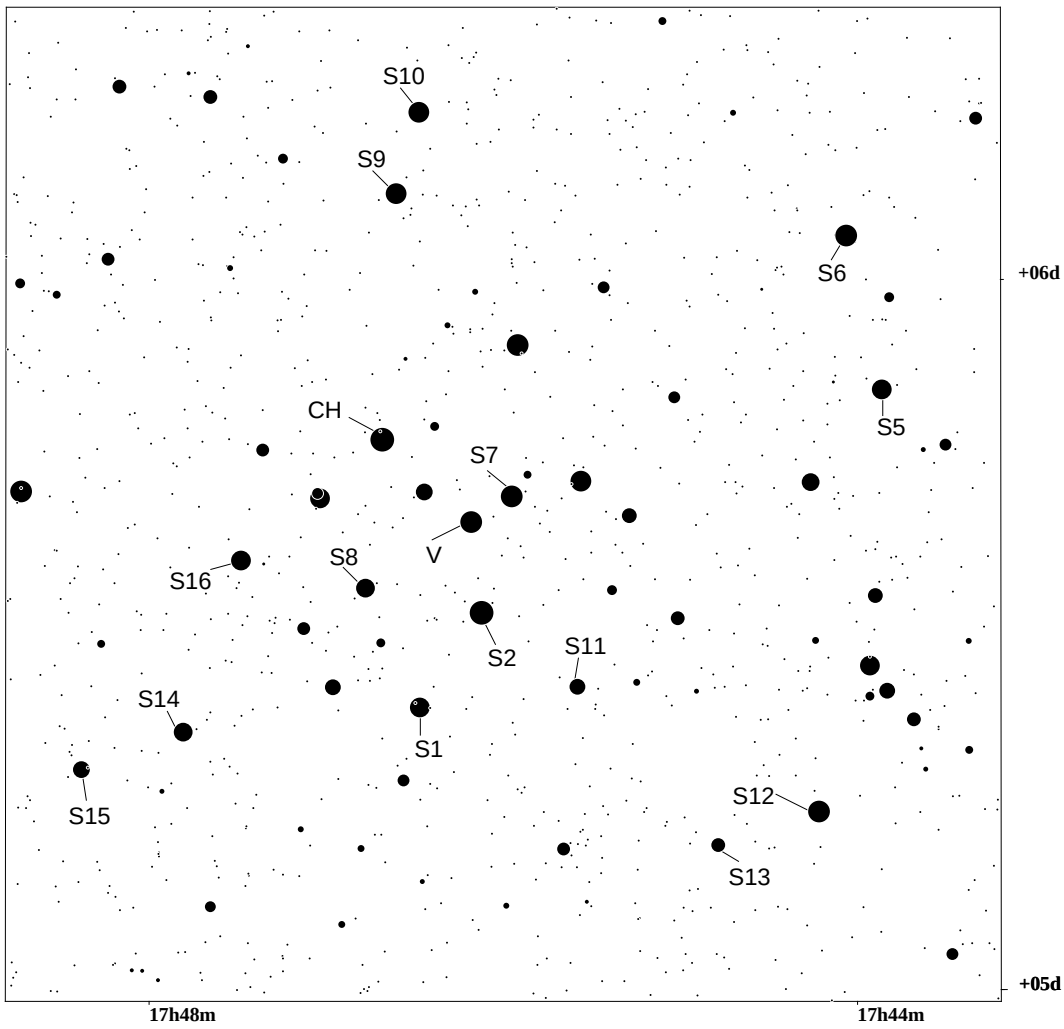
Filters: U - B - V

Sequence: twice per night (the air masses difference should be as large as possible) following super-cycle:
$2 \times [S1 - S2 - CH - V] - 2 \times [S1 - S5 - S6 - S7] - 2 \times [S1 - S8 - S9 - S10] - 2 \times [S1 - S11 - S12 - S13] - 2 \times [S1 - S14 - S15 - S16] - S1$
When observing conditions are not ideal do not measure the faintest stars.

Number of measurements: sky: 1, stars: 2

Applicant:

Observerability: from the beginning of March till the end of September;
beginning of March: rise $\sim 2^{30}$ UT, observerable till $\sim 4^{00}$ UT;
end of February: setting $\sim 19^{00}$ UT, observerable from $\sim 17^{30}$ UT.



IC4665 (2000.0)

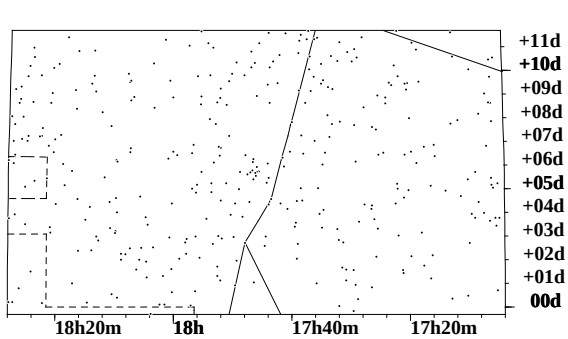
(17h46m,+05d41m lim: 20.0)

6 9 12 15
7 10 13
8 11 14

Planet
Cluster
Nebula
Galaxy
Unknown

double
Asteroid
Globular
Planetary
Elliptical
Other

variable
Comet
Open
Diffuse
Spiral
Quasar



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