# 25. STELLAR PHOTOMETRY (PHOTOMÉTRIE STELLAIRE)

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## INTRODUCTION

During the past three years there has been increased activity in many fields where photometric methods are employed; more telescopes have been commissioned or adapted for photometric measurements and new magnitude systems have been proposed and tried, but much of the observing is now of a routine nature. Most of this continues to be done in the wide-band UBV system, but more measurements are now being made in the red and infra-red.

More interest is being shown in narrower band-widths that emphasize particular features of a stellar spectrum, because these offer better prospects of separating the effects of temperature, luminosity, interstellar reddening, composition and duplicity. Attention has been given to finding the most useful bands and practical ways of measuring them, both photoelectrically and photographically.

The use of narrow bands, pioneered by B. Strömgren, and applied to other spectral features by the Cambridge group, continues to be exploited, especially for measuring the strength of Balmer lines.

Spectrum scanners are now in use at a number of observatories and, while spectroscopy is not the responsibility of Commission 25, quantitative data of this sort are of vital importance for the proper interpretation of the results of stellar photometry. There is a need for more accurate spectrophotometry in the UV and IR. Conventional photometry, in its turn, is now frequently used to find the stars that promise to be of interest spectroscopically.

New techniques have been developed for measuring the rapid fluctuations of flare stars and the even faster changes of pulsars. Automatic devices are being used to an increasing extent for observing, measuring of plates, and for reducing the measures. Photometry from rockets and satellites is extending our knowledge of the far UV.

## CATALOGUES AND FINDING LISTS

An important event has been the publication of the Washington *Photoelectric Catalogue* (**1**) containing the collected results of virtually all photoelectric photometry of non-variable stars in the UBV system published prior to 1967. This constitutes a "general catalogue" as contemplated at the Moscow meeting of Commission 25 (**2**). As it gives the individual data from each source it not only serves as a finding list but enables the user to form some idea of the reliability of the available information. Data are given for 20705 stars taken from 424 different sources, most of them independent.

C. Jaschek reports that the La Plata photometric catalogue is almost ready for printing. It gives complete references to all photoelectric measurements – in any system – of stars in our Galaxy. If a star has been measured in the UBV system, average values of $V$, $B-V$ and $U-B$ are given. There is also a code telling in what other systems a star has been measured. 22000 stars have been listed from 1760 references up to 1967·0. The catalogue will give the effective wavelengths and the number of stars included in each reference. It is expected that it will be published in 1970.

Jaschek (**3**) has discussed information problems in astrophysics, including photoelectric photometry. He advocates data centres with card catalogues that are kept up-to-date and available for reference, and the production of printed catalogues at relatively frequent intervals. Members may wish to discuss this matter further at Brighton.



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When using a "general" catalogue it is important to remember that published material, even photoelectric, is not uniform in quality and that some of it is no more reliable than if it had been obtained photographically. Some care is needed when selecting zero point stars.

The *Cape Catalogue of Bright Stars* (**4**) is being extended to include all HR stars lying between $+10°$ and $-10°$ declination. These stars were observed at the Cape following the Berkeley meetings of the IAU, when attention was drawn to the desirability of obtaining photometric and other data for the equatorial stars (**5**). The Cape measures have been revised, applying the same corrections as for the brighter stars, and combined with other published material as weighted means.

Rybka reports that the reduction of 9110 RHP (H. A. 50) magnitudes to a uniform system has been completed and they are now being transformed to the $V$ system.

With the completion of the *Cape Photographic Catalogue for 1950* there is now two-colour photometry for a large fraction of the stars brighter than $V = 10{\cdot}0$ south of $-30°$ declination. The standard errors are approximately $\pm 0^m_{\cdot}05$ for $V$ and $\pm 0^m_{\cdot}06$ for $B-V$ derived from these catalogues. Work is in progress on the remaining (Cape Astrographic) zone, $-40°$ to $-52°$.

## PHOTOGRAPHIC PHOTOMETRY

(A. N. Argue)

The level of activity in photographic photometry has been maintained. This is evident, for instance, from Bok's summary of the Basel Symposium, 1969 (**6**). The Swedish Astronomers in particular have continued steadily with their projects. Schmidt telescopes of moderate size are playing a useful part, but the construction of very large instruments with Ritchey-Chrétien optics, combined with fast automatic plate measuring machines currently under development, indicate trends in the direction of fainter limiting magnitudes combined with data acquisition on a considerably increased scale. There seems little likelihood of photography being rendered obsolete as a photometric method just yet, although viable alternatives appear to be not far off.

Harvey (Cape) reports progress with the 40-inch "Elizabeth Telescope" reflector-corrector system. Stopping down the corrector to 31 inches and removing the Cassegrain baffles give a reliable working field of at least 1°40′. Stephenson reports favourably on a new mercury flotation system for radial support of the primary mirror of the Warner and Swasey Schmidt. Difficulties previously encountered due to differential thermal expansion between mirror and cell have now been overcome. The maintenance of a uniform figure over the mirror is essential for the Schmidt system because different parts of the mirror are used in different parts of the field. Chi and Pop (Cluj) report on methods of field correction. Kristenson (**7**) has described a photographic method of squaring on the plateholder in the Brørfelde Schmidt, and van Breda (**8**) the use of the Hartmann test in the adjustment of Schmidts.

Taylor reports on a combined autoguider and focus servo under construction by Boller and Chivens for the Steward Observatory 90-inch. It consists of a reflecting rotating knife edge for guiding, and Foucault test for focus. An autoguider for the Kitt Peak 36-inch using an image dissector has been described by Ball and Hoag (**9**), and the Anglo-Australian Project Group are developing an autoguider for the 150-inch based on beam-splitting prisms and a "Channeltron" electron multiplier used as image dissector.

Progress continues in the development of plate measuring machinery. The Lick automatic machine is in production, the Edinburgh "Galaxy" nearly so. Kibblewhite is working on a fast laser scanning system at Cambridge (U.K.). Numerous hand-operated machines have been rendered semi-automatic by application of servos to discrete operations such as centring the image or adjusting the iris diaphragm. These modifications generally lead to greater speed and consistency, making less demand on the skill of the operator. Output on to punched tape or cards and automatic computer reduction are commonplace. Wayman (Dunsink) reports on the development of reduction programs. Individual observers usually have their own ideas as to how reductions should be carried out and prefer to devise their own programs, but a stock of readymade programs can also be drawn on from the literature.

No difficulties have been reported over the purchase of emulsions, although rationalizations by certain manufacturers have sometimes resulted in supplies having to be obtained by roundabout routes and at increased cost. Cousins reports a batch of photovisual plates for the *Cape Photographic Catalogue* as giving very uneven results even though to outward appearance everything "looks normal". Stephenson complains of a batch failing to reach the expected limiting magnitude by 1 magnitude on the Michigan Schmidt at Cerro Tololo early in 1967, and would like to hear if other observers had similar experiences at the same time. Bok (**10**) reports favourably on tests with a new red-sensitive emulsion, Kodak Special Plate Type 098-01.

Kron (Flagstaff) reports on an investigation into hypersensitization by pre-exposure being carried out by Ables, Hewitt and Janes, who find significant gains in signal-to-noise are obtained by pre-exposure to a background density corresponding in the case of Eastman IIa-0 to the beginning of the density-intensity curve (D = 0·2 to 0·3). Van Altena and Bessell (Yerkes) have been investigating the effects of pre-exposure. They find no significant dependence on the duration of the pre-flash over the range 0·001 to 1 s, and advocate flsahing to the minimum density for which near maximum gain can be achieved. Typical gains are times four at density 0·05 and two at 0·2, but they advocate that each emulsion-developer combination should be investigated separately. There is a considerable literature on these and other technical matters which cannot be discussed here. Useful sources of reference are *Photographic Abstracts of the Royal Photographic Society* (London) and *Abstracts of Photographic Science and Engineering Literature* of the Society of Photographic Scientists and Engineers (Washington). There is also a new journal for astronomers, *Photo-Bulletin* published by the American Astronomical Society.

Although most photographic photometry is being done in UBV, other systems are being developed. Straižys (Vilnius) reports on the practical development of a seven-colour (UPXYZVS) system employing glass filter combinations (See p. 244). Schreur (Steward) reports on photometry with a system similar to Strömgren's uvby in Selected Areas 27, 56 and 108. The limiting magnitude is $m_y = 19$. Steinlin (**11**) has published a thorough revision of the RGU system including new transformation equations from UBV, and Todoran (Babes-Bolyai) reports on an investigation into transformations of photographic systems. These developments are to be encouraged. The impending data explosion referred to earlier will place astronomers under obligation to optimise their photometry.

Further work has been put into intensity calibration. To obtain mean magnitudes and colours with accuracy approaching photoelectric measurements, each plate needs, in round figures, at least 30 calibration stars for setting up an intensity scale and calibrating field corrections. At high galactic latitudes the number of stars per ten square degrees averages about 40 brighter than $11^m$. To this limiting brightness, then, photography is unproductive since virtually every star would need to be calibrated photoelectrically. The alternative of transferring a standard sequence photographically is economical but less accurate.

To fainter limiting magnitudes, and especially in crowded star fields, photographic photometry is certainly profitable, but local sequences are needed and at the faint end photoelectric measurements are costly in telescope time. This has led to a revival of interest in objective gratings and similar step-intensity methods of calibration. Provided the characteristics of the system are carefully determined photoelectrically under the identical observing conditions, and the zero point is securely tied in, most of the objections to the earlier use of this method are overcome. Eelsalu reports on work carried out, to be published in Tartu Publications. Reddish (**12**) has proposed an objective mosaic prism, and Brück *et al.* (**13**) have tried a doubly-refracting crystal filter calibrator. Butler and Wayman (**14**) have used a coarse grating with the ADH Baker-Schmidt at Bloemfontein to extend Magellanic Cloud sequences from $15^m$ to $18^m$. They find the "grating constant" to depend on brightness but to be predictable within $\pm 0\overset{m}{.}15$. Hardie (Dyer) reports on tests with a grating to extend magnitude sequences by $4^m$. He finds an unaccountable dispersion in "grating constant" ranging up to about $0\overset{m}{.}08$. P. J. Andrews has obtained promising results with the Radcliffe reflector.

The following new photoelectric calibration sequences have been reported. Wayman and Butler: 140 stars in UBV, $10^m$–$18^m$ in the Magellanic Clouds. Bok and Bok (**15**): southern Milky Way

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regions and LMC, limit $14^m$ to $16^m$, UBV. Elvius (Lund) refers to southern Selected Area UBV sequences calibrated by him and his associates and reported to Commission 33, and reports also on three UBV sequences each comprising about 50 stars $7^m$–$13^m$ centred on $1^h46, +62{:}0$; $1^h52, +64°5$ and $22^h04, +52{:}5$ to be published by Bern and Virdefors, and a fourth at $6^h35, +9{:}5$ by Karlsson (**16**). Fr. McCarthy reports on a sequence in IC4665 in $B$ and $V$ to limit $14^m$ (**17**), and sequences in Selected Areas 28, 54, 106 and 107. He stresses "the importance of using systematically determined sequence of standards as opposed to a collection of randomly determined measures of individual stars".

Published sequences for clusters can be located from the *Catalogue of Star Clusters and Associations* of G. Alter, J. Ruprecht and V. Vanýsek, but sequences in the general field are sometimes difficult to find. The following list, while not complete, may serve as a starting point.

**Table 1. Published photoelectric sequences for photographic calibration in the general field**

| Regions | Scales | Limit | References |
|---|---|---|---|
| SA 3, 4, 5 | UBV | $13^m_{\cdot}5$ | (**18**) |
| SA 51, 54, 57, 71, 82, 94, 107, Aql | UBV | $17^m$, $18^m$ | (**19**) |
| SA 141, 193, 158, LMC, S. galactic pole | UBV | $15^m$, $16^m$ | (**20, 21**) |
| SA 169, 205, LMC, Car-Cen, Norma | UBV | $16^m$ | (**15**) |
| $-45°$ E regions | $U_cBV$* | $15^m$ | (**22**) |
| $-45°$ E regions | $U-B$ | $10^m$ | (**23**) |
| Sco | UBV | $13^m_{\cdot}3$ | (**24**) |
| S. Milky Way ($l^{II}$ 237° − 7°) | UBV | $13^m_{\cdot}5$ | (**25**) |
| S. Milky Way ($l^{II}$ 310° −340°) | UBV | $16^m_{\cdot}5$ | (**26, 27**) |
| Pup | UBV | $13^m_{\cdot}8$ | (**28**) |

* $V$ needs a correction $+0^m_{\cdot}005$ to conform to the revised standard zero point.

## WIDE BAND PHOTOMETRY

Many of the observations made in the UBV system have been of variable stars or for population studies of clusters and other groups of stars of more interest to other Commissions. Some of the sequences are of more general interest as noted under "Photographic Photometry", and some work of this nature is included in this section of the Report. Other observations deal with individual stars selected for a variety of different reasons. Most determinations of $R$ and $I$ magnitudes fall into this category. In some cases stars have been observed specifically as standard or zero point stars.

The following reports of wide band photoelectric photometry have been received:

B. J. Bok (Steward Observatory, Arizona) has published, jointly with P. F. Bok, standard UBV photoelectric sequences for a number of fields (**15**). J. J. Schreur has established UBV sequences in SA 47 (to $V=16$) and in a nearby field centred on BD $+31°588$ (to $V=15$).

Feinstein (La Plata) has published UBV observations of 135 stars in the region of Carina-Centaurus (**29**), and reports that UBVRI observations are in progress of 70 Be stars, 110 metallic line stars and 30 bright red M stars.

E. H. Geyer (Observatorium Höher List) used the ESO 1-m photometric telescope in 1968 to obtain UBV observations of 54 stars ranging from 7·8 to 15·7 $m_{pg}$ in SA 157 and the Scutum Cloud. W. Seggewiss observed 162 stars in 7 sequences in the UBV system at the ESO Observatory in 1969, all in the galactic plane, near $l^{II} = 212°$, 223°, 243°, 265°, 279°, 290° and 300°, respectively. The limiting magnitude is $V=15$.

Landolt (Louisiana State University) reports that he is establishing secondary UBV standard star sequences in Selected Areas on the celestial equator in the approximate range $10^m_{\cdot}5 < V < 12^m_{\cdot}5$ over as wide a colour range as possible. Observations have been begun in SA 92, 93, 94, 95, 96, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 113, 114 and 115. Eventually 300 to 400 stars will have an average of 10 observations each. Not only will the resulting photoelectric sequences be useful for photometric studies of the Selected Areas, but well-established secondary UBV standards will be available for large telescopes in either hemisphere. The observations are being obtained at the Kitt Peak National Observatory.

Mendoza (Observatorio Nacional, Mexico) has completed several series of UBVRI observations, giving special attention to $R$ and $I$ and the resulting two-colour relationships for different types of objects (**30, 31, 32, 33**). He has also made measures at $5\mu$ (**34**).

Rybka has re-reduced some of the observations made by himself and associates to the UBV system (**35**), and is supervising the photoelectric observations of additional standard stars of magnitudes 7·5, 9·0 and 10·5 and spectral types A, F-G and K in SA 1—43 which have been started at Abastumani Observatory by O. P. Abuladze.

Velghe (Observatoire Royale de Belgique) reports that the UBV photometry of 350 OB-stars obtained at Boyden Observatory (1966) and at La Silla (1968-9) is being discussed by J. Denoyelle. 230 OB-stars in Circinus are to be measured photoelectrically by E. Elst in UBV.

A. A. E. Wallenquist reports on Swedish observatories as follows:

At Lund Observatory A. Ardeberg, K. Särg and S. Wramdemark have investigated the properties of the 61-cm photoelectric telescope in Jävan when used for UBV photometry. A. Ardeberg and K. Särg have measured UBV magnitudes for about 40 luminous B-type stars in Cepheus and 17 stars in the Ursa Major Cluster as well as in a field centred at $\alpha = 17^h21^m$, $\delta = +58°40'$. A. Ardeberg and S. Wramdemark have measured UBV magnitudes for about 40 early type stars in Ophiuchus. G. Lyngå has determined photometric and spectroscopic data for a number of distant O and B stars and studied blue stars in three regions in Carina, at the Uppsala Observatory Southern Station. C. Roslund has determined magnitudes in the UBV system of 24 stars in a region south of NGC 5128 (Centaurus A). U. Lindoff has determined UBV magnitudes for stars in open clusters, 12 southern and 3 northern.

At Stockholm Observatory, Saltsjöbaden: L. O. Lodén has measured UBV magnitudes for a large number of stars in standard sequences in Cru, Vel, Pup, Car and Nor (the latter with B. Nordström). He has also measured UBV magnitudes for about 800 stars situated in "loose clusterings". J. Arkling has measured UBV magnitudes for stars in standard sequences in Milky Way regions and G. Gahm has started a photoelectric investigation of strongly-reddened OB-stars.

At Uppsala Observatory, T. Oja and L. Häggkvist have made photoelectric measurements of $V$ and $B-V$ for 368 stars in three regions, in Cas and Per, around the north galactic pole and in SA 17. In addition, $V$ and $B-V$ have been determined photoelectrically for more than 600 stars, late-type stars brighter than $V=5{\cdot}05$ located north of declination $-10°$, and stars brighter than $V=6{\cdot}05$ in the polar cap, $b>60°$. They have also published accurate photoelectric $V$ and $B-V$ for 34 standard stars distributed over the northern sky. H. Lindén has investigated the atmospheric extinction on the basis of photoelectric measurements made at Uppsala during 1959–1968. B. Westerlund has determined photoelectric UBV magnitudes of OB-stars near the supernova remnants RCW 86 and RCW 103. He also reports UBVRI photoelectric and photographic photometry of open clusters and OB-stars in Cru and Nor.

T. Elvius, at Lund Observatory, reports photoelectric measurements of stars in a number of SA in the southern sky to serve as standard sequences. G. Lyngå and C. Roslund have continued to make photoelectric observations for this programme at Siding Spring Observatory; A. Ardeberg is working at ESO in Chile. Y. Ekedahl has observed sequence stars photoelectrically in northern SA at Uppsala.

At the Cape Royal Observatory the photometry of the HR (= BS) stars south of the equator in the $U_cBV$ (or UBV) system is virtually complete (**36, 37**). Cousins has published $U-B$ for 526 stars in the E regions (**23**) and has UBV data (to $V\sim 10$) for more than 200 comparison stars in variable star sequences (**38**). Evans and Wild have used UBV photometry to look for sub-dwarf stars (**39, 40**).

Atmospheric extinction in wide-band systems has been investigated empirically and by numerical

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integration. Observations have been reported from Cerro Tololo, Torun and Uppsala. Mendoza *et al.* (**41**) have found significant and systematic variations in the ultraviolet extinction during the night. Stock (**42**) has discussed the subject of atmospheric extinction in photoelectric photometry in some detail. The usual procedures are satisfactory for reducing observations to a uniform instrumental system but can lead to significant errors when used to compute extra-atmospheric values. There is no simple way of computing a strictly extra-atmospheric $U-B$ and it may be better not to do so. It would be simpler to make extra-atmospheric observations conform to the present standard system by employing suitable filters.

M. Jerzykiewicz (Wroclaw Observatory) has continued his investigations of extra-atmospheric extinction (**43, 44**). The effect he has found is small but appears to be significant. If the interpretation is correct one would expect to find periodic changes of zero point in stellar magnitude systems, and this would be a serious matter. The difficulty of avoiding all observational errors correlated with the day, the month and the seasons is, however, very great and more convincing evidence is needed before one can be sure that there is a significant amount of extra-atmospheric or interplanetary absorbing material present.

At various times there have been proposals to replace the usual $U$ by a narrower band and Straižys has suggested several filters, or combinations of filters, for doing this. Such a change would seem to be desirable for photoelectric photometry but might cause too much loss of light for faint-star photography.

The choice of standard stars for the UBV system and a possible change in the $U$ band should be discussed at the next meeting of the Commission.

Several groups have used numerical integration methods to study the effects of atmospheric extinction, interstellar absorption, mirror tarnish and other changes on wide-band magnitude systems. The effect on $U-B$ is rarely a simple function of $B-V$ or $U-B$. Wesselink (**73**) has discussed the relationship between surface brightness and $M_v$ and other stellar parameters.

## NARROW-BAND AND INTERMEDIATE-BAND PHOTOMETRY

(David L. Crawford)

At Stockholm Observatory, Saltsjöbaden, U. Sinnerstad and J. Arkling have measured intensities of the absorption lines Hβ, Hγ, He I 4471 and 4922 in bright B0-B5 stars, and U. Sinnerstad and I. Furenlid, J. Arkling, S. H. Alm and P. Brattlund have measured line-photometry photoelectrically for early B-type stars.

At Uppsala Observatory L. Häggkvist has determined Hγ absorption for 365 northern stars, including nearly all stars brighter than $V=5{\cdot}1$ and classified A2 or earlier, using interference filters centered at 4059 Å, 4346 Å, and 4508 Å, with half widths of about 40 Å. P. Malmström has measured monochromatic magnitudes photoelectrically for 276 stars using interference filters with maxima at 3937 Å, 4346 Å and 4508 Å (half-widths 23–56 Å).

A. G. Davis Philip (Dudley Observatory) reports that forty field horizontal-branch stars have now been found in fields at high galactic latitudes by means of Strömgren four-colour photometry (*Ap. J.*, **152**, 1107; *Astr. J.*, **74**, 209; *Astr. J.*, **74**, 812). Hβ photometry has been started. Preliminary results show that, between $(b-y)_0=0{\cdot}00$ and $0{\cdot}15$, the β index is $0^m_{\cdot}06$ smaller than the β index of Population I stars of the same colour. Four-colour and Hβ photometry has been started on blue horizontal-branch stars in the globular clusters M 4, NGC 362, NGC 6809. All A5 and earlier type stars in a 30 sq. degree region surrounding the NGP were photometered (*Astr. J.*, **73**, 1000) in the UBV and four-colour systems. The reddening at the pole was found to be $E_{B-V}=0{\cdot}05$. At $V=11{\cdot}5$, the A stars change from mostly Population I to mostly Population II. A similar study is underway at the south galactic pole.

John D. Bahng (Northwestern University, Illinois) reports that intermediate-band photometry of late-type stars in the infrared was carried out. The three bands are centered at 1·21, 1·59 and 2·15 μ with half-widths of approximately 5% of the central wavelengths. For normal G, K and M stars a continuum emission peak near 1·6 μ was observed. For carbon stars, this peak was not observed,

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indicating that neither $H^-$ nor $H_2O$ is an important source of continuous opacity. The infrared colours of carbon stars are not correlated with Morgan-Keenan C-classification nor with the vibrational temperatures derived from CN bands.

John Graham reports that he is continuing at Cerro Tololo his program of uvby photometry of faint high-latitude stars and of white dwarfs. He has recently completed observations of H$\beta$ indices for 450 OB-type stars in Carina.

M. Golay (l'Observatoire de Genève, Switzerland) reports that the multicolour photoelectric system described in *Vistas in Astronomy* (Vol. 14, Part II) has been used at Geneva Observatory since 1963. The new photometric catalogue, by F. Rufener (*Publ. Obs. Geneve*, in press), will be published in 1970. This will contain 1400 stars in 7 colours. The accuracy is better than 0·01 magnitude. There are $[U]$ $[B]$ $[V]$ $B_1$ $B_2$ $V_1$ $G$ colours of (a) metallic line stars, (b) peculiar stars, (c) nearby stars (listed by Gliese), (d) stars of associations Cas VII, Per I, II, III, Aur I, Gem I, Mon I, II, Cyg I, II, III, VIII, IX, Cep I, (e) stars of galactic clusters (Pleiades, Coma Ber, Hyades, Praesepe, h and $\chi$ Per, NGC 188, 752, 1545, 1647, 2168, 2244, 2264, 2682, 6633, 6871, 7092, 7160, 7822, IC 348, 1805, 4665 and (f) Giant G, K, M.

Recent work on K and M stars seems very promising and the observing program is being considerably extended.

The Geneva group has studied the properties of colour indices and parameters obtained by linear combination of colour indices. Two-dimensional representation gives a large separation of luminosity effects for stars B 3 to F 8, chemical composition effects for stars A 1 to G 8, rotational effects for stars B0–B7 and between A 6 and F 2 (Golay, *Pub. Obs. Genève*, no 75. A Maeder, *Publ. Obs. Genève,* nos. 74, 75, B. Hauck, *Publ. Obs. Genève*, nos. 74, 75). Three-dimensional representation permits the separation of some kinds of peculiar stars, A VI, Si 3955 Cr, 4012, $\lambda$ Boo, Sr-Cr-Eu. The effect of the several laws of interstellar extinction on the linear combinations has been studied to be able to calculate parameters free of the interstellar extinction effects (Goy, thesis, Genèva, 1969). This last work, applied to young galactic clusters, shows that we can have different interstellar extinction laws in the same cluster. To calibrate the photometric measurements in the Geneva system in terms of certain physical characteristics of the atmospheres considered, Peytremann (thesis, in press, Geneva) prepared a program for computing a grid of model atmospheres, (for different $\log g$, for effective temperature between 10000 K and 5000 K, for different metal-to-hydrogen ratios and opacity due to the metallic lines). To study the photometric effects of rotation, Maeder and Peytremann (thesis, in press, Geneva) compute the flux emitted by rotating stars employing the method proposed by Collins. The blanketing effect of the hydrogen lines is taken into account. The aim is to try to separate the $v$ from $\sin i$ by photometric means and to estimate the influence of the rotation of a star on the position of the turn-off point.

At Kitt Peak and Cerro Tololo, we are continuing photometry with the uvby and H$\beta$ systems. Observations have been completed on the following programs, some published, the rest being prepared for publication:

1. Standard stars for uvby photometry;
2. Colour and $M_v$ calibrations for B stars, and for A and F stars;
3. O-G0 stars, $V \leqslant 5{\cdot}0$, south of $\delta = -10°$;
4. O-B5 stars, $V < 6{\cdot}5$, north and south;
5. B8-A0 stars, $V < 6{\cdot}5$, $\delta > -10°$;
6. Stars in the areal vicinity of globular clusters, to derive reddening;
7. Open clusters and associations: Hyades, Coma, UMa, Praesepe, Pleiades, $\alpha$ Per, NGC752, NGC6231, h and $\chi$ Per, 1C4665, I Sco, III Cep.

Activity in the sub-field of narrow- and intermediate-band photometry, during the past two years, has been primarily in the following subjects (some of the investigators are listed, selected from the main journals):

1. Classification of late-type stars:

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Eggen, O. J. 1969, *Ap. J.*, **158**, 225.
Jones, D. H. P. 1968, *Mon. Not. R. astr. Soc.*, **139**, 189.
McClure, R. D., van den Bergh, S. 1968, *Astr. J.*, **73**, 313.
Wallerstein, G., Helfer, H. L. 1966, *Astr. J.* **71**, 350.

2. OB Stars:
Graham, J. A. 1968, *Bull. astr. Inst. Neth., Suppl.* **2**, 397.
Graham, J. A. 1968, *Astr. J.*, **73**, 17.
Gutierrez-Moreno, A., Moreno, H. 1968, *Ap. J. Suppl.*, **15**, 459.
Smith, L. F. 1968, *Mon. Not. R. astr. Soc.*, **140**, 409.

3. High-Latitude Blue Stars:
Graham, J. A. 1967, *Bull. astr. Inst. Neth.*, **19**, 161.
Graham, J. A., Doremus, C. 1968, *Astr. J.*, **73**, 226.
Newell, E. B., Rodgers, A. W., Searle, L. 1969, *Ap. J.*, **156**, 597.
Philip, A. G. D. 1968, *Astr. J.*, **73**, 1000.

4. H$\alpha$:
Andrews, P. J. 1968, *Mem. R. astr. Soc.*, **72**, 35.
Tebbe, P. L. 1969, *Astr. J.*, **74**, 920.

5. Open Clusters:
Crawford, D. L., Barnes, J. V. 1969, *Astr. J.*, **74**, 407.
Crawford, D. L., Barnes, J. V. 1969, *Astr. J.* **74**, 818.
Crawford, D. L., Barnes, J. V. 1969, *Astr. J.*, **74**, 1008.
Epstein, I. 1968, *Astr. J.*, **73**, 556.
Geneva workers, see Golay report above.
Graham, J. A. 1968, *Astr. J.*, **73**, 152.
Perry, C. L., Hill, G. 1969, *Astr. J.*, **74**, 899.
Sears, R. L., Whitford, A. E. 1969, *Ap. J.*, **155**, 899.

6. Variable and Peculiar Stars:
Breger, M. 1969, *Astr. J.*, **74**, 166.
Breger, M. 1969, *Ap. J. Suppl.*, **19**, 79.
Hayes, J. E., Heiser, A. M. 1968, *P.A.S.P.*, **80**, 57.
Johnson, H. M., Golson, J. C. 1968, *Ap. J. Letters*, **154**, 77.
Johnson, H. M., Golson, J. C. 1969, *Ap. J. Letters*, **155**, 91.
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## POLARIZATION

(V. B. Nikonov and N. M. Šahovskoj)

*Instrumentation and methods of observation*

Nearly all new polarimeters belong to one of the two following types.

(1) Differential dual-beam polarimeters are used for precise measurements of polarization of the light of bright stars. An instrument of this type has been described by Elvius and Engeberg (**45**). Polarimeters of the same type have been developed at Konkoly Observatory (Hungary) and at some other observatories. At Yerkes and Mt Stromlo Observatories such polarimeters are being used with rotating telescopes. The principal problems to be tackled, using this type of polarimeter, are studies of interstellar polarization in the vicinity of the Sun (**46**), the establishment of precise standards for polarimetric measurements (**47**) and polarization measures of the light of bright variable stars.

(2) Integrating polarimeters are used for the observation of faint objects. The main principle employed in the design of these instruments is the integration of results obtained from many cycles of a fast-rotating polarizing device. Digital or analogue outputs are used for registration. This permits long exposure times and consequently observations of very faint objects. The method under consideration is very insensitive to changes of observing conditions. Polarimeters of this type, designed for stellar measurements, have been described by Appenzeller (**48**), Leinert *et al.* (**49**) and by Efimov and Šahovskoj (**50**). Polarimeters for planetary research have been designed by Ksanfomaliti (**51**) and Bugaenko *et al.* (**52**).

Some theoretical aspects of the polarimetric method have been discussed by Hall (**55**), Wiedling (**53**) and Efimov (**54**).

Among the other types of polarimeters, recently developed, that of Hall (**55**) for faint extended objects (galaxies, nebulae) must be mentioned. Pratt (**56**) has devised a special polaroid filter enabling simultaneous monitoring of observing conditions in the outer parts of the field.

A new method for photographic polarimetric measurements of stellar radiation has been developed by Treanor (**57**).

*General problems of stellar polarization measurements*

Efimov studied theoretically the dependence of the accuracy of stellar polarimetric measurements on the observing conditions. The case of a single-beam integrating polarimeter, using photon-counting, for observing variable stars with very fast changes of brightness (flare stars) has been considered. A theoretical analysis of the accuracy of polarimetric measurements has also been given by Bugaenko *et al.* (**52**) and by Wiedling (**53**).

The general theory of instrumental polarization has been considered in detail by Jäger and Oetken (**58**). Some particular aspects of this problem have been considered by Efimov *et al.* (**59**) and by Efimov and Šahovskoj (**60**).

Sahovskoj developed a method of analysis of multicolour polarimetric observations when interstellar and stellar components of polarization are both present (**61**).

Observations of stars having little polarization, which can be used as standards for polarimetric investigations, have been published by Walborn (**47**) and Appenzellar (**62**). Early-type stars observed for polarization by Goyne and Gehrels in seven colours (3200–10000 Å) (**63**) may be used as standard stars with a high degree of polarization.

## EXTRA-TERRESTRIAL STELLAR PHOTOMETRY

(M. Golay)

The experiments which were performed in the first half of the present decade provide the bulk of the photometric data which are available to date. These experiments showed that an appreciable

**Table 2**

| Experimenter | $\lambda_{eff}$(Å) | $\Delta\lambda$(Å) | Field of view | Absolute calibration accuracy | Observations reported | Spectral type | Mag. of faintest object listed | Estimated accuracy of data |
|---|---|---|---|---|---|---|---|---|
| [1] Bless *et al.* | 2100 | 300 | 3° × 3° | | 45 | | | |
| | 2500 | 300 | 3° × 3° | ±15% | 43 | B 0·5-F 8 | 5·9(B 9)-4·8(A) | ±25% |
| | 2800 | 300 | 3° × 3° | | 44 | | | |
| [2] Smith | 1376 | 200 | 2° | 50% | 96 | WC-A 2 | 6·55(B 5) | 10% (relative) |
| [3] Yamashita | 1120 | 120 | 5° | 50% | 6 | O 9·5-B 7 | 3·0(B 2) | |
| | 1290 | 120 | 5° | | 6 | | | |
| | 1415 | 130 | 5° | | 6 | | | |
| [4] Carruthers | 1115 | 130 | 7° | ±20% | 8 | WC 7-A 1 | | |
| | 1270 | 120 | 7° | | 8 | | 3·7(O 8) | ±5% (relative) |
| [5] idem | | | | | 20 | O 8-B 5 | 6 | ±5% (relative) |
| [6] Campbell I | 2150 | 250 | | | | | | |
| II | 2550 | 270 | | | 100 | O 9·5-A 0 | 7 | ±3% (absolute) |
| III | | 2750–5000 | | | 50 | | | |
| [7] idem but III | | 3500–5000 | | | I-II:20 III:50 | O 9·5-A 0 | 7 | ±30% |

*Remarks and References:*

[1] 6256B EMI photomultipliers with Al-$MgF_2$ interference filters. Unguided Aerobee launched September 1964. (1968, *Ap. J.*, **153**, 557.)
[2] Bendix resistance-strip magnetic electron multiplier with $SrF_2$ filter. Magnetically stabilized satellite launched December 1964. (1967, *Ap. J.*, **147**, 158.)
[3] Ionization chamber with short cut-off window. Unstabilized K-10-3 rocket launched March 1967. (1968, *Astr. Space Sci.*, **2**, 4.)
[4] Ionization chambers with short cut-off windows. Stabilized Aerobee launched March 1967. (1968, *Ap. J.*, **151**, 269.)
[5], [6] and [7] 1969, *IAU Symposium* no. 36.

improvement had been achieved in the observational techniques involved and gave a fairly large amount of data suitable for photometric analysis. Whenever a star was observed several times during the same flight, the internal consistency was found to be better than 20%. In the wavelength range longward of 2000 Å, the measures of Bless *et al.* (**64**) and Bogess (**65**) agreed within $\pm 0^m.25$ for the 12 stars they observed in common. But, as is pointed out by Wilson (**66**), it is probably optimistic to expect such consistency for the whole range of observations. It seems very likely that the major uncertainties do not arise as much from instrumental differences and errors as they do from errors involved in the calibration procedure. Bless (**46**) has suggested the use of a synchrotron radiation source as secondary standard for the ultraviolet range, instead of a sodium salicylate-coated photomultiplier assumed to have a constant quantum efficiency over this range.

The photometric data were primarily used to check the validity of atmospheric models. The extended analysis which was made by Bless *et al.* (**67**) and included results obtained by Byram *et al.* (**68**), Chubb and Byram (**69**), Smith (**70**) and Bless *et al.* (**64**) showed that most of the 35 Main-Sequence B and A stars fell within $\pm 0^m.5$ of the theoretical predictions derived from the line-blanketed models of Morton and Adams (**71**). An average deficiency of about $0^m.25$ was however noted and it was assumed, at that time, that such a discrepancy could fall within the calibration uncertainties. A more recent comparison between models and ultra-violet observations (**72**) suggests that B- and A-type stars may emit less energy in the UV than predicted for models which do not include Si, Mg and C as appreciable sources of opacity. These photometric observations were also used to determine the interstellar extinction curve in the UV (**66**) (**67**).

The photometric observations are listed in Table 2.

A large amount of very valuable photometric data will be available in the near future thanks to the successful operation of the Orbiting Astronomical Observatory, OAO-A2, which was launched in December, 1968. Several hundred stars have already been observed by the photometers and spectrophotometers of the Space Astronomy Laboratory of the University of Wisconsin. The approximate effective wavelengths and widths (in parentheses) of the bands measured with the four 8-inch ($f/4$) stellar photometers are 1300 (540), 1400 (660), 1550 (600), 1900, 2350 (960), 2900 (1000), 3300 (1000) and 4200 (1400) Å. The 16-inch ($f/2$) nebular photometer measures four bands at 2100 ($\Delta\lambda = 300$), 2500 (410), 2900 (410) and 3300 (500) Å. Ascop 541 F photomultipliers are used for $\lambda_{eff} < 2500$ Å; E.M.I. 6256B for $\lambda_{eff} > 1700$ Å, with bands in common. The field stops are 10′ and 20′ for the stellar photometers and 30′ and 10′ for the nebular photometer.

The preliminary results (presented at the 1969 IAU Symposium) suggested an upward revision of the stellar temperature scale for stars earlier than B 3 *V*. Interesting results were also given on the interstellar reddening which seems to have a real "bump" at $1/\lambda = 4{\cdot}5$, and a minimum in the vicinity of $5{\cdot}5$ to $6{\cdot}0\,\mu^{-1}$.

During the last three years a series of stellar observing instruments, both photometric and spectrophotometric, developed by the Space Research Group at the Royal Observatory, Edinburgh, have been flown in ESRO roll-rate controlled Skylark rockets. Successful flights produced the observations as given in Table 3.

**Table 3**

| | | | | | | |
|---|---|---|---|---|---|---|
| Date of firing | 26.5.67 | 22.5.67 | 3.12.67 | | 7.10.67 | |
| ESRO rocket number | S05/2 | S11/2 | S27/1 | | S47/1 | |
| Experiment number | R62 | R65/1 | R100 | | E121A | R120 |
| Instrument description | [1] | [1] | [1] | [2] | [1] | [3] |
| Number of stars observed | 20 | 20 | 50 | 100 | 50 | 11 |

[1] 2-channel photoelectric photometer, collecting area 120 cm² using interference filters with 250 Å passbands centred on 2100 and 2500 Å.

[2] Large aperture (340 cm²) single-channel photoelectric photometer recording the range 1300–2000 Å.

[3] Single-channel photoelectric photometer, aperture 32 cm², for recording sky brightness in the regions 1650–3200, 2400–3200 and 2650–3200 Å.

A payload with objective prism and Schmidt camera having a magazine holding 9 photographic plates will be flown early in 1970. In parallel with this instrument is a wide-band photometer to assist in the absolute calibration of the photographic data.

The Edinburgh group's main effort is at present engaged on a collaborative experiment with Institut d'Astrophysique, Liege, in the TD1 ESRO-Satellite. It is expected to measure the brightness of early-type stars down to $m = 8$.

The Laboratoire d'Astronomie Spatiale et Observatoire de Marseille group (Courtès, Cruveillier, Roussin, Valerio, Viton, Sivan) has flown sounding rockets. The preliminary results obtained with a photoelectric photometer having 4 passbands show an UV excess of the central part of And nebula relative to the sky background. The preliminary results from a second flight, to photograph the sky in UV, give the magnitudes of 201 stars at 2600 Å.

The space research group of the Observatory of Geneva has developed a balloon technique. These experiments are to extend into the UV region the ground-based observations of the Geneva multi-colour stellar photometry. Modern balloons are large enough to carry a 200 kg payload to an altitude of 43 km. During the last four years eleven flights have been carried out with French and American balloons. The observations were recorded photographically with a small Maksutov camera and with a 16-cm Schmidt telescope. These results have revealed the feasibility of UV photometric measures using balloon techniques.

## PHOTOMETRIC INSTRUMENTATION

(G. E. Kron)

A conventional UBV photometer designed by Kenneth Janes has been built and is in operation on the 20-inch reflector at the Bethany Observing Station of Yale University Observatory (P. Demarque).

At the Okayama Station of Tokyo Astronomical Observatory, the photometric equipment has been modernized by employing transistor amplification, electronic logarithmic conversion, and digital voltage display. Sky brightness in the vicinity of a star is sampled by displacement of the telescope focal plane by means of a tilted quartz plate (K. Osawa).

A two-channel Elliptical Polarization Photometer has been designed and built by Blitzstein and Wolf for the Flower and Cook Observatory. Measurements with this instrument lead to the determination of the normalized Stokes parameters of partially elliptically polarized radiation. The instrument employs intermediate band interference filters, achromatic quarter-wave plates, an analyzing prism, and a depolarizer. The output of each channel is integrated, and the integrals are read out sequentially by an integrating digital voltmeter controlled by a digital clock (W. Blitzstein).

Two new classical photometers have been put into service by the Geneva Observatory for stellar photometry at stations at Haute Provence, Jungfraujoch, and Gornergrat. Research work is being undertaken to develop photon counting techniques. An automatic guider, to permit stellar photometry with smaller focal plane apertures, is being built for the 100-cm telescope in Haute Provence (M. Golay).

At the Royal Greenwich Observatory stellar photometry has been done with an RCA-Carnegie Institution image intensifier on the 91-cm telescope. With IaO plates, exposure times were about 30 min for $m_v = 18$, with standard errors of $0\overset{m}{.}1$. A magnitude scale was derived from densitometric calibration and integration of the star images, a procedure possible with the fairly diffuse images resulting from the large scale of 15 arc sec per mm. (Communicated by the Astronomer Royal.)

At the Dominion Astrophysical Observatory, Victoria, a single channel photometer that features an offset guider, thermoelectrically refrigerated photomultiplier, and a pulse counting electronics system has been designed and built by Walker, Brealey, Brosterhus and Morbey. Walker, with help from Pfannenschmidt and Smyth, installed his four-channel photometer with a Vidar data acquisition system on the Mount Kobau 16-inch telescope. The Evans 16-inch telescope has been rebuilt with an electronic drive by Andrews. This telescope and a Boller and Chivens 16-inch telescope have been installed on Mt Kobau for photometry (K. O. Wright).

Steward Observatory, Tucson, has acquired a dual beam photometer from Astro-Mechanics for use with the new 90-inch reflector for general purpose photometry. The photometer has a dichroic beam splitter enabling simultaneous measures in red and blue light. A Johnson-type JKL photometer has been purchased from the Lunar and Planetary Laboratory for operation this fall. A polarimeter built in cooperation with Gehrels should be in operation by summer, 1970. The 36-inch and 90-inch photometers now transfer photometric data to magnetic tapes, which are processed in Tucson by the CDC 6400 computer (W. Fitch).

Photoelectric stellar and surface photometry is being done at the Flagstaff Station of the U.S. Naval Observatory with the Navy Electronic Camera on either the 61-inch Astrometric Reflector, or the 40-inch RC reflector. The plates, which give a linear response to exposure, are assessed by a scanning and integrating procedure employing a modified Joyce-Loebl-Tech-Ops Isodensitracer. Data are fed into an IBM card punch, and are reduced by computer. The limiting magnitude for measurable images yielding a standard deviation of $0\overset{m}{.}2$ is $B = 23$ to 24 magnitude, depending on the seeing, for a one hour exposure with the 61-inch. The full accuracy associated with photoelectric photometry is obtained up to about $B = 21{\cdot}5$ to 22 magnitude, depending on the seeing (G. Kron).

A UBVRI photometer employing two photomultipliers is being constructed at the University of St. Andrews. Photomultiplier selection is by interposition of a diagonal mirror into the light beam; multiplier and filter can be selected by remote control. Measurement can be by pulse counting or charge integration at the will of the observer. In the integration mode, digitization is effected by sampling the output voltage of the integrator and then discharging the sampling amplifier at a constant rate. The time of discharge is proportional to the output voltage of the integrator (D. W. N. Stibbs).

The 1955 *F*/5 scanner at the University of Michigan, Ann Arbor, is now fitted with a two-channel pulse-counting photometer constructed by Lasker and Williams. The second channel provides compensation for changes in sky transparency. Diaphragms, filters, and wavelength have been encoded and are recorded automatically for each observation. Output is on punched paper tape (J. A. Williams).

At the Royal Observatory, Cape, conventional photometers are used with d.c. recording or with electronic integration. Output is printed out from a digital voltmeter, and then processed with a keyboard electronic computer. Plans have been made for replacing some of the older photometric equipment which has been much used for many years.

At Northwestern University, Dearborn, a photoelectric spectrum scanner by Bahng has been built for use with the 100-cm reflector. Spectra are scanned very rapidly by rotating the grating. Output from the photomultiplier is sent to an on-line PDP 8/S computer where signal counts from each 10 Å interval are stored in a separate location of the core memory, thus producing an accumulative spectrum. The computer also controls the scanning operation, so programming can be very flexible. An H$\alpha$ scanning photometer by Bahng and Caplan has also been furnished for the 100-cm reflector. This instrument, which has photoelectric output, scans over a wavelength range of several Angstrom units in the vicinity of the H$\alpha$ line; resolution is about 0·4 Å. Dispersion is by echelle grating for predispersion and a fixed-space Fabry-Pérot etalon. The dispersing units are in separate chambers and are simultaneously pressure-scanned with nitrogen (J. D. Bahng).

The Catania Astrophysical Observatory at Serra la Nave, Sicily, is now in regular operation with telescopes of 91-cm, 41-cm and 31-cm apertures fitted with photoelectric photometers. Amplifiers employing field effect transistors are employed and a photometer for simultaneous stellar photometry in three colours (**74**, **75**) has been constructed to facilitate the observation of flare stars (G. Godoli).

Three groups in Romania, at Bucharest, Timsoara University and Cluj University, are using photoelectric photometers (G. Chis).

A. T. Young has continued his studies of sources of error in photoelectric photometry with a discussion of stripchart reading errors (**76**) and the causes and effects of scintillation (**77**).

## STELLAR PHOTOMETRY IN THE U.S.S.R.

(V. B. Nikonov)

### 1. *Instrumentation*

Two 125 cm Ritchey-Chrétien photometric telescopes (Draft Report 1967, p. 472) are under construction.

A three-channel stellar photometer has been constructed and is now under test at the Radioastrophysical Observatory of the Latvian Academy of Sciences (G. Spulgis, G. Zarevsky).

A two-channel photoelectric photometer designed for the photometry of nuclei of galaxies is being put in operation on the 2·6-m telescope of the Crimean Astrophysical Observatory (A. B. Severny, N. A. Dimov, A. Sčerbakov).

At the Engelghardt Astronomical Observatory an iris photometer automatically accounting for the plate background has been constructed (L. A. Urasin, S. S. Tohtas'ev, S. K. Fomin).

### 2. *Methods of observation and reduction procedures*

The complex of two (twin) 48-cm Cassegrain telescopes of the W. Struve Astrophysical Observatory, Tartu (Estonian S.S.R.) (Draft Report 1967, p. 471) is being used to study the possibilities of compensating for the effects of atmospheric variations (U. K. Weissmann).

At the Crimean Astrophysical Observatory the work on stellar TV photographic photometry is being continued. It is used mostly for the narrow-band multicolour photometry of faint variable stars showing rapid changes in brightness. Further improvements of the method are being made. The photometric field error is studied and taken into account when reducing observations. It was found that by cooling the target of a sensitive image orthicon down to $-30°C$ its sensitivity is increased by $3^m$ and the accumulation of charges on the target may be for as long as 10 min (N. A. Abramenko and V. V. Prokof'eva).

Investigations in connection with fundamental photoelectric photometry are being carried out at the Crimean Astrophysical Observatory (Precise account of atmospheric extinction, control of the stability of photometric systems, reductions to standard systems) (V. B. Nikonov, V. Burnašov).

### 3. *Photometric systems and standards*

Tests of the glass version of the Vilnius (Straižys's) multicolour photometric system UPXYZVS, carried out at Vilnius and Crimean observatories, show that it is somewhat better for classification purposes than the interferometric one (UPXYZTS), reported to Commission 25 at the Prague meeting. The maximum separation of luminosity classes is reached for B and K-M spectral types. The accuracy of classification of A-G stars using the Vilnius system is the same as with the Strömgren one. The Vilnius system is being tested photoelectrically as well as photographically. For the calibration of the Q, Q diagrams, used for classification, nearly 300 stars of different spectral types, luminosity classes and chemical content have been observed with the help of the Crimean Astrophysical Observatory. Subdwarfs, and different kinds of peculiar stars have been observed too. The possibility of detecting unresolved binary stars photometrically has been demonstrated.

To study the photographic version of the Vilnius system the necessary observations have been obtained of the clusters NGC4996 and 7654 at the Main Astronomical Observatory of the Ukrainian Academy of Sciences and at the Radioastrophysical Observatory of the Latvian Academy of Sciences; the Cassegrain focus of a 70-cm telescope and a Schmidt telescope have been used. The photoelectric standards were obtained with the 70-cm telescope of the Crimean Observatory.

Two standard sequences in the UPXYZVS system have been established in Cygnus and Aquila each containing 32 stars from $5^m$ to $7^m$ of different spectral types and luminosity classes.

### 4. *Photoelectric sequences*

V. M. Kovalenko (State Sternberg Astronomical Institute) is making UBV photoelectric observations of the $5^m\!.5 - 6^m\!.0$ BS catalogue stars having no accurate photometric data.

### 5. *Photographic sequences*

N. B. Grigor'eva and E. M. Roščina determined *B*, *V* magnitudes for 830 stars down to $12^m$ in a region of 30 square degrees centered at $\alpha = 19^h32^m$ $\delta = +22^\circ\!.5$. T. A. Uranova made similar observations of 85 stars in the region centered at $\alpha = 19^h08^m$, $\delta = +14^\circ$ and 199 stars in three regions with centers at $\alpha = 19^h27^m$, $19^h32^m$ and $19^h38^m$ and $\delta = +8^\circ\!.5$. She is carrying out *B*, *V* photographic photometry of O-F 5 stars in three other regions 1° in diameter in field N 1 of Parenago's plan and centered at $\alpha = 18^h24^m$, $\delta = +22^\circ\!.5$; $\alpha = 18^h52^m$, $\delta = +13^\circ$ and $\alpha = 19^h15^m$, $\delta = +9^\circ45'$. A. S. Sharov determined *B*, *V* magnitudes for 266 stars brighter than $15^m\!.5$ in the neighbourhood of NGC7142. N. M. Artjuhina and E. P. Kalinina, when studying proper motions, determined approximate values of *B* magnitudes for 4228 stars down to $13^m\!.5$ in an area 4·5° in diameter around the Pleiades and for 2964 stars within a 2·5° circle around the cluster M 39 (Sternberg Institute).

*UBV* magnitudes have been determined for nearly 10000 stars to $B = 15^m$ in the directions of SA 26 and 27 (S. S. Tohtas'ev) and SA 28 (I. A. Dudjago). Similar observations have been made of 4021 stars in the region of NGC1664 (L. A. Urasin) (Engelghardt Observatory).

### 6. *Extra-atmospheric stellar photometry*

Photoelectric photometry of the sky background outside of the atmosphere has been carried out in two wavelength regions (at 2700 Å and in the visual, near to *V* system). The field of view of the photometers was 18°. They worked on Cosmos 51 and 213. The minimum value of the brightness, observed near the Galactic Pole, was ~ 30 stars of $10^m$ per square degree (N. A. Dimov, A. B. Severny, A. Zvereva) (Crimean Astrophysical Observatory).

Two photoelectric photometers for the wavelength bands at 2270 Å (halfwidth 50 Å) and 2750 Å (halfwidth 80 Å) having object glasses of 50 mm diameter and field of view of 1° were used on Cosmos 215. Pulse-counting was employed and stars down to $5^m$ have been observed (N. A. Dimov, V. K. Prokof'ev) (Crimean Astrophysical Observatory).

### 7. *Miscellaneous*

A. S. Šarov and N. N. Jakimova (Sternberg Institute) completed a list of photoelectric catalogues and regional photometric standards.

Two papers (Riives, *Tartu Publ.* no. 38; Eelsalu, ibid. no. 39) where the law of darkening of faint photographic images is derived from the concept of a two-stage reaction of the grains to exposure are awaiting publication.

#### ACKNOWLEDGMENT

In conclusion, the President wishes to express his thanks to all who have contributed to this Report, either individually or by preparing sections. All contributions have had to be edited to conserve space. It cannot be regarded as a comprehensive report. It is worth considering what form future Reports should take and whether some of the contents should not be published elsewhere.

A. W. J. COUSINS
*President of the Commission*

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