Commission 25: STELLAR PHOTOMETRY AND POLARIMETRY
Photométrie et Polarimétrie stellaires

PRESIDENT: Andrew T. Young
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ORGANIZING COMMITTEE: S. J. Adelman, M. Breger, R. M. Genet, J. K. Knude, A. U. Landolt, J. D. Landstreet, J. Lub, J. W. Menzies, I. S. McLean, T. Moffett, C. L. Sterken, V. Straizys, F. J. Vrba

1. INTRODUCTION

At this General Assembly, Commission 25 co-sponsored Symposium 167 (New Developments in Array Technology and Applications), and Joint Discussions 12 (Accuracy of the HR Diagram and Related Parameters) and 15 (Statistical Evaluation of Astronomical Time Series).

Because of the large number of Working Groups under Commission 25, we held two business sessions at The Hague. Brief reports of these Working Groups, contributed by their chairmen, and edited by A. T. Young, are included below. The accounts of the business sessions are based on notes kindly taken by John Menzies.

The lack of a separate scientific session for our Commission was keenly felt, and was communicated to the Executive Committee by the President. If the policy of no single-Commission scientific sessions at General Assemblies continues, it will increase the need for IAU Colloquia on specialized topics.

2. SESSION 1

(chaired by A. T. Young)

2.1 Membership

The membership of Commission 25 remains constant at 200. Since the last General Assembly, we have lost 3 members (Al Hiltner, Wieslaw Wisniewski, and Zdenek Kviz) who died, and one (J. D. Bhang) who retired. However, Russell M. Robb has joined us, as have 3 new IAU members.

2.2 New Officers

The 30 members present elected John Landstreet President of Commission 25, and Chris Sterken Vice-President. The Committee lost Russ Genet, who wishes to be less active after his retirement, and gained Eugene Milone, whose interest in infrared photometry strengthens our hand in this active area. M. Jerzykiewicz suggested adding Don Kurtz, the new vice-president of Commission 27, whose expertise in high-precision photometry is very welcome. This suggestion was approved unanimously.

2.3 Reorganization

The reorganization of the IAU had already been discussed at the meeting of Commission Presidents with the Executive Committee before this business session. The proposed Division structure would be largely a cosmetic change, but would meet the Executive Committee's desire to deal with a small group of representatives rather than all 40-odd Commission Presidents. The suggestion to make Division heads members of the Executive Committee could not be adopted at this General Assembly, as it would require changes to the Bye-Laws. The proposed plan to place Commission 25 in a Division with Commissions 8, 9, 24, and 30 was explained.

I. Appenzeller (ed.), Transactions of the International Astronomical Union Volume XXIIB, 177-181.

Sterken suggested that a Division on photometric techniques would make more sense; it could include Spectral Classification (Comm. 45) and photoelectric radial-velocity techniques (Comm. 30). Tinbergen pointed out the general problem that the mixture of technology and science in the current Commissions does not allow a neat grouping of them along either dimension. Landolt complained that the proposed Division structure would add to the existing IAU bureaucracy, "and we don't want to see more bureaucracy." "Or more Commissions!" added Tinbergen. There was general discussion of the idea that the IAU should conduct more of its business by e-mail, with the recognition that people in remote places cannot be reached by e-mail and would still need to use regular postal service for some time.

2.4 Future Colloquia

Dave Philip proposed that the third meeting on Faint Blue Stars, dedicated to G. Haro and sponsored by Commission 45, be co-sponsored by Commission 25. Asked for justification, he said that most of the data on faint blue stars come from photometry. This proposal had already been circulated to the Organizing Committee, where reactions were favorable. In the discussion, A. Young supported C. Sterken's observation that it is important for the Organizing Committee to know why support is sought from Commission 25 for a particular meeting; this information has often been missing from past proposals.

2.5 Photometric Standards

Arlo Landolt's discussion of standard stars follows, as abridged by A. T. Young:

Highly accurate, well-defined standard stars are essential. We need to improve the most used photometric systems, so that astronomers can be confident of the zero points, transformations, and systematics of their results. We need fainter standards in every system for large telescopes, because very short shutter speeds, out-of-focus images, and neutral density filters degrade the photometry. Two recent excellent books on photometric systems are IAU Colloquium No. 136, and V. Straizys's new *Multicolor Stellar Photometry*.

While UBVRI is not the best photometric system for certain detailed investigations, more stars have been measured in UBV than in any other system, and its broad passbands allow deep exploratory investigations. The UBV system was explained by Johnson in *Basic Astronomical Data*: a specified equipment setup at about 7,000 feet elevation, a reflecting telescope, and a consistent reduction procedure define a systematically correct system.

I started a photometric standardization program some 30 years ago because there were not good standard stars for the Kitt Peak photometric telescopes. The results in my 1973 paper (AJ **78**, 959) were tied to Johnson and Harris (ApJ **120**, 196, 1954) and/or Johnson (in *Basic Astronomical Data*, 1963); Johnson considered those standards to define the UBV system. The best nights were then re-reduced, using the Johnson and Harris standard stars as unknowns, and my 1973 new standard stars as the standards; at that time, the results seemed reasonable.

The UBV values in my 1983 paper (AJ **88**, 439) were tied to the Johnson-Morgan system through my 1973 standards. The RI indices were tied to Cousins's E-region standards. The filters, those available to guest observers at Cerro Tololo, had been assembled by John Graham (PASP **94**, 244, 1982) for his faint sequences in the E-regions. The photomultiplier was a GaAs RCA 31034. The transformations from the instrumental to my 1973 version of the UBV system were non-linear. The UBVRI values in my 1992 paper (AJ **104**, 340) mostly used the same RCA photomultiplier as the 1983 paper. Non-linear transformations again were needed.

Both photoelectric and CCD work continues at both CTIO and Las Campanas to improve and extend to fainter magnitudes UBVRI photometric sequences around the celestial equator. I also am perhaps half finished with a program to provide 200 or so new UBVRI standards at +45 degrees declination in the magnitude range 9–16, using both a RCA 31034 photomultiplier and the new ccdphot instrument at Kitt Peak. There is no easy way to choose which stars should be made into standards. fainter than, say, 10th – 12th magnitude, essentially nothing is known about most stars. And the candidates are even more restricted when one wants to find a broad range in color, rather similar brightnesses, and all must fit on a ccd.

One needs at least four hours of photometric weather per night to measure extinction. I derive and use primary coefficients each night. I derive secondary extinction coefficients every night, but the results are more stable if I use "mean for the observing run" secondary extinction coefficients. I obtain from 15 to 30

standard stars every photometric night. All this means that I spend 25 to 35% of the time observing standard and extinction stars.

In pp. 165–172 of *Precision Photometry: Astrophysics of the Galaxy*, (L. Davis Press, 1991), Pel compared the Walraven, UBV, Geneva, and uvby systems. The Walraven-Geneva comparison showed a sinusoidal trend with right ascension. N. Cramer (p. 173 in that volume) discussed the Geneva system. He and his colleagues determine atmospheric extinction and its evolution during the night when the sky is good. Otherwise, program stars are measured at constant air mass with standard stars, and mean extinction is used.

Menzies et al. (MNRAS **248**, 642, 1991) re-observed the standard stars in Landolt (1983). Both data sets have high internal precision, but a sinusoidal difference in the V magnitude. Cousins and his colleagues also use the equal-altitude technique. And "normally they use a standard set of first-order extinction coefficients."

Both Pel's work and the Menzies et al. investigation suggest that differences as a function of right ascension occur between constant-altitude/constant-airmass reductions and those using all-sky photometry and nightly extinction coefficients. I don't pretend to know which technique is best, or even if one is better than the other. Obviously, when care is taken, precise results can be obtained with either technique. Equally obvious, I am much much more comfortable with all-sky photometry.

The question of long-term stability of standard stars, particularly the red standard stars, is also important. Weis (1994, AJ **107**, 1135) has found variability in many dwarf M stars, including eight UBV standards. Then there is HD 173637, which appeared to be a well-behaved standard B star (Landolt 1983) until the summer of 1993, when I found it 0.4 magnitude brighter (IAU Circular No. 5822). Over the past year it is essentially constant at its new brighter intensity.

W. W. Morgan in *Annual Reviews of Astronomy and Astrophysics* **26**, 1988, reminded us that the UBV system was specifically related to the MK spectral classification system. If new photometric systems are to be invented, the inventors should work closely with the spectral classifiers so that "the zero point of the color indices can be determined in terms of a certain kind of star which can be accurately defined spectroscopically" (Johnson and Morgan, ApJ **117**, 313, 1953). Johnson and Morgan connected the UBV system to the old North Polar Sequence; recall Harold Weaver's papers on the history of photometry in *Popular Astronomy*. The astronomical community needs to retain the ability to relate to past photometric observations. The huge UBV database, whatever the problems of the UBV system, means that astronomers must maintain a close photometric tie to the UBV data.

2.6 Working Group on Peculiar Stars

This group, headed by Michelle Gerbaldi, is shared between Commissions 25, 29, 36, and 45. It deals with peculiar A stars and related objects. Dr. Gerbaldi proposed that G. Mathys and J. Zverko become members of the WG from Commission 25, and called attention to Joint Discussion 12, in which the WG would conduct its business. The ensuing discussion centered on the lack of peculiar stars on standard-star lists, and the need for bringing such stars that might be suitable as standards to the attention of photometrists.

2.7 Other business

It was pointed out that the re-issue of Straizys's book is already out of print. A slide supplied by J.-C. Mermilliod was shown, describing the new catalog of mean UBV data for over 100,000 stars, to be published this fall by Springer. Straizys drew attention to the Sternberg publication of 15,000 stars in the WBVR system. J. Tinbergen announced his forthcoming book on polarimetry, to be published by Cambridge University Press next spring.

3. SESSION 2

(chaired by J. Landstreet)

3.1 Reorganization

The tentative proposal to create Divisions had been approved at the meeting between Commission Presidents and Vice-Presidents and the Executive Committee, by a vote of 36 to 3. Commission 30 (Radial

Velocities) shared our dissent in this vote. Commissions will conduct their own business as before, but will interact with related commissions through the Division structure; the Divisions will interact with the Executive Committee though their representatives. The proposed Division on Optical Techniques had shrunk because of the defection of the astrometrists (Commissions 8 and 24) to Division 1, "Fundamental Astronomy", leaving only Commissions 9, 25, and 30 in Division 9. [At a later meeting of the Presidents of these three Commissions, Colin Scarfe (Comm. 30; scarfe@uvphys.phys.uvic.ca) was chosen as the tentative Division representative to the Executive Committee, pending approval of participation in this Division by the members of Commission 30.] The Division structure is regarded as an experiment; we shall see how it works out, and make changes as required at the next General Assembly.

3.2 Working Group on Standard Stars

R. F. Garrison reported on the meeting of the WG on Standard Stars, which is co-sponsored by several Commissions. Garrison reported that he is publishing a hierarchy of standards in an attempt to reduce the confusion which has resulted from the publication of lists of standards by several groups and by individuals at different times. An outline of the plan, along with a table of MK System "Anchor Points" appears in A.S.P. Conference vol. 60, *The MK Process at 50 Years: A Powerful Tool for Astrophysical Insight*, edited by Corbally, Gray and Garrison, pp. 3-14.

In MK classification as well as photometric systems, standard stars play a crucial role. It is essential that the recommended standards be as well-defined as possible. Clarifying the situation is the function of this working group. Garrison (garrison@astro.utoronto.ca) is Chair, Corbally (corbally@as.arizona.edu) is editor of the newsletter. Anyone thinking of developing a new photometric system should become involved in this effort, to make sure that any new photometric standards have spectral classifications and other relevant data. The organization is very informal; membership is achieved by asking to be placed on the mailing list!

C. Sterken announced that he is organizing a NATO summer school on standards for May, 1995.

3.3 Working Group on Standardization of Filter Systems

This work has been done mainly by A. T. Young, with help from Chris Sterken and Mike Bessell. Johnson made a serious mistake in assuming that the UBV system could be defined by standard stars rather than by passbands. Although it appeared 3 years ago that transformations could be handled adequately by using higher-order terms in the classical series expansions, a counter-example (2 symmetrical passbands with the same centroid and width as B, and similar 4th-order moments, but producing magnitudes that differ by 0.1 mag or more) shows that convergence is too slow to be useful.

Therefore, a more fundamental approach has been taken (Young, *A. & Ap.* **288**, 683). Passbands are regarded as basis functions that span a subset of Hilbert space. Two systems can be transformed exactly if the passbands of one system are linear combinations of those in the other system. This is possible only if the passbands have sufficient overlap, similar to that required by the sampling theorem. The lack of overlap in existing systems, combined with the loose manufacturing tolerances of filters, produces the notorious conformity errors in current systems.

Schott glasses allow the construction of suitable passbands at wavelengths shorter than about 650 nm. However, to design a filter set, one must first know the detector's spectral response; this service is commercially available. Then, because of the glass tolerances, measure a particular piece of each glass on a good spectrophotometer, and have it ground and polished to the required thickness. The UBV bands can be synthesized more accurately from linear combinations of such passbands than manufacturing tolerances allow the direct construction of the UBV passbands in the usual way. Such a system, consisting of 7 or 8 bands, would provide more astrophysical information than UBV does.

More work must be done to demonstrate the validity of synthesizing passbands from a well-sampled basis set. Young has submitted a proposal to obtain funding for this work, which includes buying a spectrophotometer to measure filter glasses, and building an accurate photometer to establish standard stars.

In the discussion, Straizys proposed that a few international centers be established for the measurement of filters. Landstreet asked if Young would be willing to set up such a center; Young replied that he would be happy to do so, if his proposal is funded.

Bessell pointed out that a new glass developed by the Schott factory in Duryea, Pennsylvania, allows much better matches to ultraviolet passbands. The glass, called S-8612, is similar to BG 39, but has about 15 nm more UV transmission; it makes a good substitute for copper sulfate as a blocker for ultraviolet filters. This glass is not available from the Mainz factory, only from Duryea. Bessell also pointed out that a low-pass interference coating can be used to improve the long-wavelength side of the *I* band for CCDs.

3.4 Report of the Working Group on Infrared Extinction and Standardization

Ground-based infrared photometry is in principle the most precise means of acquiring photometric data from astronomical sources. Unfortunately the presence of variable amounts of atmospheric water vapour badly degrades that potential and with other effects, such as night sky emissions, causes a precision limit of about 3% in standardization work. Existing JHKLM passbands are poorly defined, and extinction curves show a large Forbes effect.

The IR Working Group has been working on the solution of these problems. With a modern grid of stellar atmosphere fluxes, a moderately high resolution atmospheric simulation, and a figure of merit to indicate the distortion by the atmosphere of the stellar fluxes, the passbands of existing infrared passbands have been examined and compared, and found to be difficult to transform to the highest possible precision. On the basis of extensive numerical experiments, a number of new passbands are recommended. These new passbands are freer of water vapour effects and should permit good quality infrared photometry to be done from sites at lower altitudes than is currently desirable, and improved precision from all sites. Most of the results are reported in Young et al. (A&AS, **105**, 259, 1994), but a fuller treatment of the predicted extinction curves and the responses to comments by members of the community will be published in a subsequent paper, still in preparation. The WG encourages purchase of the filters for new surveys and for extensive standardization, and will acquire as many of the filters as possible for testing purposes. Those wishing to join in the purchasing and testing of these filters are urged to contact E. F. Milone (milone@acs.ucalgary.ca) to coordinate efforts.

While good stewardship of resources dictates restraint in the purchasing of untested filters, astronomers who desire a high-precision instrument may wish to look at the purchases as a prudent investment and begin their own testing. Anyone deciding to do so should check the specifications of the filters (central WL; shape and width; leakage) carefully, so it is clear what passband is being checked, and report results to the WG as soon as possible, for wide circulation.

3.5 Working Group on Ap and Related Stars

Dr. Gerbaldi reported that her WG has changed its name as indicated above. The new President of its SOC is W. Wehlau (whwehlau@uwo.ca); P. North (north@obs.unige.ch) is the editor of its Newsletter.

3.6 Status of the Working Groups

We were asked by the Executive Committee to assess the status of each Working Group. After brief discussion, Don Kurtz proposed that all the Working Groups should be continued. The members of Commission 25 present adopted this proposal by acclamation.

3.7 Other Business

Prof. E. F. Milone announced that the proposed meeting on "Binaries in Clusters" had not been granted IAU support, but would still be held in Calgary, Alberta, Jan. 18–25, 1995. Despite the lack of IAU official support, he requested the Commission's endorsement, which was granted.

Our new President, acting on the recommendation at the first session that more use be made of e-mail, circulated IAU address forms to the members present, and promised to make as much use as possible of the e-mail addresses provided. You can reach him at jlandstr@phobos.astro.uwo.ca.

3.8 Acknowledgements

A. T. Young, who is responsible for this report, thanks R. F. Garrison, Arlo Landolt, E. F. Milone, and J. W. Menzies for their assistance in preparing it.