Foreword

I have been asked to summarize the goals and accomplishments of the Colloquium, and provide a guide to the reader — a tall order, and one that cannot be filled impartially, for different participants had different goals, and will regard different accomplishments as most important. Because photometry is a vigorous and active field, anyone's choices will be disputed by someone else.

Some of the goals were certainly to bring together as many leading photometrists as possible; to review the current state of our art; and to discuss where we should go from here, and how we can get there. We wanted to have an interesting meeting that would stimulate lots of discussion, in greater depth than is possible at IAU General Assemblies. Moreover, the IAU encouraged wide geographic participation, and wanted to ensure that astronomers far removed from the leading edge of photometry would be brought closer to it. Finally, we wanted to honor the pioneers of photometry, and to develop some perspective from the history of the subject.

To meet these goals, the Scientific Organizing Committee selected seven major topics, and devoted one session to each: Photometric Systems; High-Precision Photometry; New Techniques; Automatic Photoelectric Telescopes; Global Networks; Photometry with CCDs; and Photometry from Space. The papers in this volume are arranged in this order. We invited a number of people to cover each area, trying to obtain speakers who could give good talks as well as provide technical expertise. In addition, we were fortunate in having an excellent historical review, presented by John Hearnshaw.

As the abstracts poured in, our plans changed a little. Some invited speakers were unable to come, and were replaced by contributed talks selected by the SOC. Many more excellent CCD papers were submitted than could fit into a single session, so some appeared in other sessions. A group of papers on extinction elbowed their way into the APT session. Members of the SOC wanted more papers presented orally than would fit in the program, so many interesting papers had to become poster talks.

I believe the quality of the papers is illustrated by complaints I received from two participants. "I had expected to skip a couple of sessions to explore the town," one said. "But the talks have been so interesting, I haven't had a chance to see Dublin." Another astronomer brought his family, expecting to do some sightseeing with them. But he spent so much time in the sessions that they vowed never to go to a scientific meeting with him again. I hope the reader finds the printed papers as interesting as the participants found the talks.

Rather than picking my personal favorites, I would like to call attention to some recurrent themes and ideas, which seem to characterize photometry today. We could have picked these, instead of the topics we chose, as the basis for organizing the Colloquium.

https://doi.org/10.1017/S0252921100007296 Published online by Cambridge University Press

First, as Lockwood et al., Breger, Grossmann, and others pointed out, a short-term precision of better than a millimagnitude has been reached repeatedly in the best work. This seems relatively straightforward to achieve by conventional means if the well-known problems such as temperature effects, centering errors, and filter nonuniformities are properly attended to. Millimagnitude precision has been reached with photomultipliers, CCDs, and silicon photodiodes. As the best ground-based observations are limited primarily by scintillation noise, and the best space-based observations by photon noise, the current limits in precision seem to be set more by telescope size than by detectors. Thus, despite the tantalizing prospects of new detectors and instruments offered in the session on new techniques, it appears that one can do very well indeed with the old techniques, simply by being careful and consistent. Wes Lockwood reminded us how important it is to have reliable funding in such work, as well as reliable equipment.

Second, CCDs and IR arrays continue to improve, but still have severe calibration problems at the 1% level. Walker, Stetson, Tobin, Kreidl, and Zeilik, among others, emphasized that each diode in these arrays is a different detector, with its own characteristics that must be calibrated. The best precision with CCDs still requires keeping the stars fixed on the same diodes, frame after frame, because of uncontrolled calibration errors. Both Walker and Tobin pointed out that at least some of the problem with flat-fielding is due to violating the basic rule of photometry: the calibration and program exposures *must* illuminate the detector identically. In many cases, stray light, often (according to Walker and Tobin) due to improper telescope baffling, causes large-scale flat-fielding errors. This is clearly an area where more effort needs to be invested, if CCDs are to compete more effectively with photomultipliers.

The areas where each of these two major detectors excels are now clearly defined. CCDs have completely displaced other methods for work in crowded fields, and for the faintest stars, where sky-brightness fluctuations demand simultaneous measurements of star and sky. For bright, isolated stars — especially those limited by scintillation rather than photon noise — the real-time readout and superior dynamic range of photomultipliers, as well as their simpler data-handling, make CCD methods "completely uninteresting" (according to Kreidl, in the discussion). We now have the major problem of joining together the systems of bright-star standards established with PMTs, and extending them to the faintest stars reachable with CCDs.

This brings me to the question of accuracy. Here, as opposed to precision, we have made little progress in recent times. This problem arose again and again: intercalibration of the channels of multichannel instruments, unifying the output of photometric networks, establishing the faint standards needed for CCD work, comparing ground- and space-based observations, and many other areas require accuracy as well as precision. In retrospect, we could well have had a session or two devoted to this topic.

Many speakers, including Bessell, Menzies, Straizys, Leggett et al., Budding, Sterken, Tinbergen, Milone, Zeilik, and myself, emphasized the importance of matching instrumental response functions to those of the standard system. Both Bessell

https://doi.org/10.1017/S0252921100007296 Published online by Cambridge University Press

and Zeilik insisted that one must first measure the spectral response of the detector before even designing the filters needed; and Menzies and I both pointed out that glass filters deviate significantly from nominal catalog curves. In particular, CCDs still show large variations in spectral response from one sample to the next; manufacturers' curves are *not* good enough to use as a basis for filter design. Even with the best efforts at matching response functions, transformations are necessarily nonlinear (Menzies; Young). Cubic transformation equations are now becoming standard (Dodd et al.; Stetson). It is more important to obtain small residuals from the transformation than to obtain small transformation coefficients (Bessell).

The substantial differences between Cousins's and Landolt's careful and independent realizations of the UBV system, documented by Menzies, show that Johnson's insistence on defining the system only by standard-star values, rather than by instrumental response functions, was a serious mistake. Both standard stars and standard response functions are needed. It is clear that experimental measurement and control of instrumental spectral response on the one hand, and theoretical investigation of the transformation problem on the other, are the areas in which progress must be made if we are to solve the accuracy problem. Without this progress, we will be unable to use CCDs and other new techniques, such as multichannel instruments, multitelescope networks, and observations from above the atmosphere, to their full potential.

Other points, such as the importance of improved spectrophotometry for synthetic photometry (Shobbrook; Glushneva); the measurement of extinction and its variations (Poretti & Zerbi; Reimann & Ossenkopf; Milone & Young); the need for well-documented reduction programs (Sterken; Hauck; Stetson); the lack of late-type standard stars (Bessell; Sterken), or even standard stars that are really constant (Lockwood et al.); the importance of high-quality automated telescopes for future photometric investigations (Genet; Pyper et al.; Hall; Tinbergen; Florentin-Nielsen; Crawford; O'Donoghue & Provencal); and economic considerations (Crawford; Lockwood; Budding; Taylor & Bless) all deserve careful attention; but I have no room to discuss them. The attentive reader should find something of interest in every paper.

In sum, we have here a long-needed review of the state of photometry, which suggests where future effort should be directed. We have made good progress in precision, but much work is needed elsewhere. I believe the two most pressing problems are the need for better CCD flat fielding, which seems to require attention to the entire telescope optical train; and the development of techniques that can provide accurate transformations between different instruments. The increasing use of CCDs makes these photometric problems urgent for users of the largest telescopes, as well as the smaller ones to which photometry is often confined. I hope these hurdles will be overcome by the time of the next IAU Colloquium on photometry.

Andrew T. Young
Chairman of the Scientific Organizing Committee

https://doi.org/10.1017/S0252921100007296 Published online by Cambridge University Press