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COMMISSION 25 **STELLAR PHOTOMETRY AND POLARIMETRY**

STELLAIRE PHOTOMÉTRIE ET POLARIMÉTRIE

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TRIENNIAL REPORT 2009-2011

1. Introduction

The Commission on Photometry and Polarimetry has a long and distinguished history in the IAU and its contributions to astronomy have been extensive and profound. Its efforts are centered on the issues of atmospheric extinction, photometric passbands, transformations among photometric systems, and calibration. Photometric and polarimetric techniques and standardization are essential tools in our exploration and investigation of astronomical objects and astrophysical quantities.

The volume *Astronomical Photometry: Past, Present, and Future* edited by Milone & Sterken (2011), and published in Springer's Astrophysics and Space Science Library series, summarizes the march to increased precision and accuracy, and in so doing also illustrates the role that Commission 25 has played in that development. Sterken *et al.* (2011) describe efforts to improve photometry over time while Milone & Pel (2011) focus on differential photometry as the historically most successful way to achieve this from the ground. This article is basically a tribute to Theodore Walraven, who passed away during the previous triennium, and his legacy. Howell (2011) carries the discussion on differential photometry into the most recent period, discussing CCD instruments and methods. Ambruster *et al.* (2011) describe the highly successful Pierce-Blitzstein pulse-counting differential photometer in use at the Flower and Cook Observatory for more than half a century. Landolt (2011) discusses the rise of "Johnson Photometry and its descendants." Wing (2011) discusses the use of photometry in and for spectral classification. Cohen (2011) and Adelman (2011) discuss absolute calibration in the optical & infrared photometry and in optical spectrophotometry, respectively. Bastien (2011) reviews the development of polarization studies, and Milone & Young (2011a) do the same for the infrared.

Thus the work by members of this commission is essential for photometric, spectrophotometric, and polarimetric surveys, and for both ground-based and space mission operations.

According to the IAU membership database, Commission 25 currently has 252 members. This represents about an 8% increase over the previous triennium. Because photometry and polarimetry are active and vital areas of astronomy, we can expect further growth.

In 2007, the Commission's website was moved from its previous host site at the Vrije Universiteit Brussel to the South African Astronomical Observatory. The URL of the current Commission 25 website is `http://iau_c25.saao.ac.za/`. We thank Dr Christiaan Sterken for having established the Commission's website and for having maintained it for a number of years. Its present administrator is Dr. Peter Martinez, past president of Comm. 25. In 2010 the Commission updated its website to bring it in line with the "look and feel" of the official IAU website. The Commission 25 website now contains a link to a very useful paper by G. Torres (2010), entitled "On the Use of Empirical Bolometric Corrections for Stars," that is essential reading for all photometrists. Finally, regarding IR sources, links are also provided to the key papers discussing the Infrared Working Group (IRWG) system. The website has a list of faint standard stars in the near-IR passbands Mauna Kea photometry system. Because the IRWG standard star magnitudes listed in Milone & Young (2005) have had zero points added to them to provide"familiar" values, this list can probably be used to standardize observations made with the IRWG iJ, iH, and iK filters at Mauna Kea. However, a better strategy would be to extend the list of IRWG standard stars found in Milone & Young (2005), to cover the entire sky, by determining secondary standards.

Now we discuss specific developments during the 2009–2011 triennium.

2. Photometry

2.1. *Photometric Standards and Calibration (B. J. Anthony-Twarog)*

Work on photometric standards and calibration, which underpins all photometric applications, proceeded during the triennium under review. Discussions in the earliest IAU General Assemblies dealt with such issues, namely the establishment of a widely accessible set of standards (e.g., the North Polar Sequence), as well as improved techniques, magnitude scales and zero points, and improved precision in measurement.

Some issues, past and present, of photometric and spectrophotometric calibration were discussed by Martin Cohen and Saul Adelman in two Historical Astronomy Division sessions of the Long Beach AAS meeting held in January, 2009, and reviewed in more detail in Sections 4 and 5, below.

From traditional mainstays to innovative space-based calibration solutions, interest in photometric calibration strategies is high. Tying ground based calibration efforts to space missions is the Absolute Color Calibration Experiment for Standard Stars (Kaiser *et al.* 2009). The goal of ACCESS is to transfer absolute laboratory standards to the stars by observing a select set of spectrophotometric standards from space. If successful, the precise calibration of flux from 0.35 to 1.7 microns will be achieved.

The already rich contributions by Arlo Landolt have been extended further by new $UBVRI$ (Johnson-Kron-Cousins) photoelectric observations for 202 stars centered on the celestial equator and at magnitude ranges suitable for faint CCD calibration (to $V \sim 16.3$). A catalog of VR (Johnson-Cousins) photometry developed for the Deep Ecliptic Survey has been published by Buie *et al.* (2011). Over 200,000 stars within

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6 degrees of the ecliptic plane are included, extending to $R \sim 16$ and $V \sim 17$. The calibration builds on the equatorial standard system of Landolt.

In this context, we note that Peter Stetson provides standard stars on the Landolt system for many fields, mostly centered on the Landolt fields and on globular clusters. This is an on-going project, 89360 stars in total as of 2010 December. Magnitudes and positions can be conveniently downloaded†.

As space-based astronomy explores wavelength regimes previously inaccessible from the ground, new and extended lists of calibrated standards are called for. Siegel *et al.* (2010) present a small but crucially uniform catalog of eleven new faint ultraviolet standards. This may sound like a small catalog — the authors point out that **four** white dwarfs, all brighter than $V = 13.4$, have comprised the ultraviolet calibration standard set until now. Using data from SDSS, GALEX and Swift, the new standards have consistently calibrated observations in 11 passbands, SDSS spectra and well-constrained model spectra for future applications.

The calibration of the photometric system for the wide-field camera of the UKIRT telescope ($ZYJHK$) has been described by Hodgkin *et al.* (2009). Among other uses, the WFCAM hosts the UKIRT Infrared Deep Sky Survey (UKIDSS). The $ZYJHK$ passbands extend from 0.84 to 2.37 mum. The 2MASS point source catalog provided the primary foundation for the calibration.

Photometry of resolved populations depends on precisely calibrated standard relations for determination of reddenings and chemical abundances. An update of the critical intrinsic Strömgren color calibration was published by Karataş & Schuster (2010). The calibration relation for $(b - y)_0$ includes 11 terms and is based on nearly 400 stars determined to be within 70 pc of Earth and therefore essentially unreddened. Differences between this and previously calibrated mean relations are gratifyingly minor.

What if every CCD exposure included a standard or two, tied to several standard photometric systems? Towards this ambitious goal, Pickles & Depagne (2011) present on-line catalogs of synthetically calibrated magnitudes in several bandpass systems (e.g., $UBVRI$–ZY and $ugriz'$) for several large-scale surveys, including the Tycho2, NOMAD and 2MASS surveys. Photometry for millions of stars has been synthesized by interpolating within a set of 20 CALSPEC spectrophotometric standards.

An entirely new photometric system has been characterized by Aparicio Villegas *et al.* (2010). The ALHAMBRA system uses 20 contiguous, equal-width bandpasses from 350 to 970 nm. The system is defined by a set of standard stars including several classic spectrophotometric standards as well as nearly 300 additional stars.

The detailed process of establishing the input catalog for stars studied by the Kepler mission is described by Brown *et al.* (2011). An important discriminant for each of the 160,000 potential Kepler targets was distinction between cool giants and cool dwarfs; four of the five SDSS bandpasses, plus a bandpass patterned after a DDO filter at 510 nm, were calibrated by ground-based observations and tied to model atmosphere fluxes. In addition to data for 284 primary standards, information for the Kepler Input Catalog is publically available through MAST.

While most astronomers strive for in-focus imaging and spectroscopy, Southworth *et al.* (2009) demonstrate that extreme de-focusing can be used to generate light curves with 0.0005 mag precision. Their paper discusses transit events for the extrasolar planetary system WASP-5, observed with the ESO Danish 1.5-m telescope. Extra-focal images were sometimes employed to achieve higher precision in the photographic era (cf. p. 6 of Sterken *et al.* (2011), for examples).

† http://www3.cadc-ccda.hia-iha.nrc-cnrc.gc.ca/community/STETSON/

Finally, the calibration of the photon detectors of the UVIT instruments to be flown on the Indian Space Research Organization's Astrosat mission has been reported by Postma, Hutchings, & Leahy (2011). This mission is a collection of three x-ray and two UV-optical telescopes on the same platform aligned to allow simultaneous detection of each pointed target.

2.2. *Large-Scale Photometric surveys (J. Knude)*

Among large-scale surveys' major data releases announced during the present triennium, was the final Sloan Digital Sky Survey II data release (DR7). Data releases for SDSS III have started in 2011 with DR8.

This may be the appropriate place to discuss photometry progress of the Gaia ESA keystone space mission project. The Gaia broad band photometric system (white light G, blue G_BP, red G_RP and G_RVS bands) was characterized and color-color transformations to other commonly used photometric systems (Johnson-Cousins, Sloan Digital Sky Survey, Hipparcos and Tycho) were established. The data and tools provided in Jordi *et al.* (2010) allow planning scientific exploitation of Gaia data, performing simulations of the Gaia-like sky, planning ground-based complementary observations and for building catalogues with auxiliary data for the Gaia data processing and validation.

Huge efforts are being devoted to the calibration of Gaia data acquired throughout the planned five years mission with more than 100 CCDs in the focal plane. The calibration is performed in two stages:

1. A first calibration step based on a large number of flux-constant sources defining an internal mean instrumental system; and

2. A second step tying the internal system to the real world and to physical units through a set of well defined Spectrophotometric Standard Stars (SPSS).

The results up to now for the first step, using simulated data, are detailed in Jordi *et al.* (2010). Spectrophotometric and photometric observational campaigns with the TNG telescope at La Palma, the NTT and REM at la Silla (ESO), the 2.2-m telescope at CAHA, the Cassini telescope at Loiano and the 1.5-m telescope at San Pedro Mártir, have been conducted semiannually or annually.

Other space projects are described more fully below.

2.3. *Space Photometry of Stars (D. W. Kurtz)*

Over the past decade the precision of photometric measurements of stellar brightness has improved to the parts per million level as a result of space-based photometric telescopes, such as the star-tracker on the WIRE mission (e.g., Bruntt *et al.* 2009), the Canadian MOST mission (e.g., Gruberbauer *et al.* 2011), the French-led CoRoT mission (Auvergne *et al.* 2009), and the NASA *Kepler* mission (Gilliland *et al.* 2011). This precision exceeds the best obtained from the ground (e.g., Kurtz *et al.* 2005) by a factor of 10, and it is in general an improvement of $100 - 1000$ times better than traditional ground-based photometric studies. This is coupled with duty cycles that can exceed 90% as a consequence of being above the weather and free of the Earth's day-night cycle. This combination has led to a revolutionary view of stellar variability, with deeper understanding of stellar astrophysics and the discovery of many new phenomena. The dominant missions in this triennium of the IAU are the CoRoT and *Kepler* Missions; *Kepler* will be used here to illustrate the new regime.

A consequence of this new era in photometric precision is that the activities of C25 and the methods of stellar photometry are fundamentally changed. When the IAU was founded in 1919 the measurement of stellar brightness was done by eye and by densitometry measurements of images on photographic plates with a quantum efficiency less than

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10%. The growth of the electronic photometer through the 1930s led to its dominance until the advent of CCD detectors. Now we have >90% quantum efficiency with only optical losses of the starlight in the photometric space missions. In past decades, studies were conducted on individual stars, often by single astronomers, or small groups. Now the *Kepler* mission is observing 160 000 stars nearly continuously for a minimum of 3.5 y with precision of $1 - 10\,\mu$mag, depending on the brightnesses of the targets. This means that many hundreds of astronomers are working in large teams to discover transiting extra-solar planets and study stellar activity, rotation, flares, eclipsing binary stars, asteroseismology of many types of pulsating stars, stellar structure and evolution. There are also many people working on further improvements to photometric precision, both in the hardware and in data processing.

This trend will continue with the upcoming ground-based surveys of PanStarrs† (e.g., Stubbs *et al.* 2007), DECam‡, scheduled for installation at CTIO as we write this, and the Large Synoptic Survey Telescope (LSST)¶ (e.g., Ivezić *et al.* 2008), as well as the ESA Gaia mission‖ (e.g., Eyer 2006). PanStarrs is primarily searching for near-Earth asteroids, the LSST will survey for all time variable objects from Supernovae to asteroids, and Gaia will measure the parallaxes of a billion stars to micro-arcsecond precision, as well as obtain light curves for over a million variable stars, half a million quasars, and half a million solar system objects. The cameras for these projects will exceed the 95 megapixel, 42-CCD camera of *Kepler* by more than a factor of 10: 1.4 gigapixels for PanStarrs and 3.2 gigapixels for LSST. Gaia has many instruments; it will have 180 CCDs, 110 of which are devoted to astrometry. Although the photometric precision and observing strategies differ for these projects, what they all share is data acquisition on an unprecedented scale in astronomy.

This flood of data will take us from the current working method of large teams to a situation where humans must be taken out of the data acquisition and initial analysis. LSST and Gaia will produce millions of light curves for many kinds of variable astronomical objects. Machines will have to make the first classifications of these and select subsets of the astrophysically most interesting targets to be studied by humans, hence machine learning studies will play a large part in future astrophysics. This part of the work of C25 will then be similar to that of the large particle physics experiments now, bringing changes in the way teams are managed, how students are trained, and how results are published.

At the time of this writing the problem of photometric *accuracy* (as opposed to *precision*) with the space data has not been studied. All four of the missions — WIRE, MOST, CoRoT and *Kepler* — use a single, broad white light bandpass with no calibration to standard star fluxes. WIRE, MOST and CoRoT are all in low Earth orbits, thus have to contend to varying degree — depending on their pointing — with scattered Earth-light and the radiation environment, particularly the South Atlantic Anomaly. They also have regular data gaps for targets that are not in the continuous viewing zone. The *Kepler* mission in its Earth-trailing solar orbit does not suffer from those problems, hence illustrates our new understanding of the limitations of CCD photometric precision. At μmag levels we not only see the stars in unprecedented detail, we also see the limitations of our instruments in new ways.

† http://pan-starrs.ifa.hawaii.edu/public/
‡ http://www.darkenergysurvey.org/
¶ http://www.lsst.org/lsst/
‖ http://www.esa.int/science/gaia

With ground-based CCD photometry flat-fielding and bias subtraction are standard image processing steps, as they are for spaced-based data, although in this case the flat field can be determined only in the laboratory, long before launch, and there is no way to monitor changes with aging in the instrument. The *Kepler* stellar images spread over many pixels (for the brightest stars this may be of the order of 1000 pixels) and the telescope pointing accuracy is to a small fraction of a pixel. Pointings last for one month between data downloads. Sources of noise are *intra*-pixel sensitivity variation (which usually is not considered in ground-based studies), differential velocity aberration, vibrations caused by reaction wheels, temperature variations caused by pointing changes for data downloading and solar panel and radiator positioning, cosmic rays, and, very importantly, changes in contamination by background stars with tiny pointing drift changes. At μmag precision nearly all stars are variable, so that variability in background stars is noise for target stars.

It might be thought at first that with 160 000 target stars differential photometry could remove instrumental effects. But many of those listed above are pixel specific, and all stars are variable. By using ensembles of thousands of stars it is possible to produce co-trending vectors that do allow some significant improvement in results from differential photometry. These are discussed in the *Kepler* data release notes †, which are essential reading for those making use of the data. It is interesting to note that the ultimate limit to our photometric knowledge of stellar brightness is now limited by the stars themselves for periods of hours and longer. Stellar activity is the major source of noise at μmag precision on this time scale.

Remarkably and unexpectedly, one lesson learned from the *Kepler* mission is that saturation is not a barrier to high precision CCD photometry. RR Lyrae itself is in the *Kepler* field-of-view and is extravagantly saturated. But once a potential well of a pixel is filled with electrons, new photons are still detected and the electrons flow to neighbouring pixels. This is well-known. The surprise is that by designing a mask that uses all the overflow pixels, all the photons can be counted precisely. That has been exploited for RR Lyrae with novel insight into the Blazhko effect and the discovery of period-doubling (Kolenberg *et al.* 2011). Thus it must also be true that ground-based CCD studies can be performed on bright targets, so long as all of the overflow electrons are captured by pixels on the chip.

We are in the midst of a revolution of new discovery of exoplanets and stellar astrophysics as a consequence of the vast improvement in precision of stellar photometry wrought by the photometric space missions. There will be no new grand improvement in precision as a result of improvements to CCD technology, or even a new photon detection technology: we now are close to being 100% efficient in capturing the photons gathered by our telescopes; the limitations are in the optics, not the detectors, and ultimately in the variability of the stars themselves. The great new instrumental developments are in the scale of the projects, such as PanStarrs, LSST and Gaia. The challenges for C25 in this field are in data management and exploitation with machine learning. Teams of astronomers will then study the most interesting objects, but there will still be space for the lone brilliant individual to discover what no else has seen or understood in the deluge of data. That has not changed since the inception of the IAU in 1919.

2.4. *Other Photometric Developments*

Neugent & Massey (2010) discuss the night sky spectrum at Kitt Peak over the past twenty years and report that the Kitt Peak sky brightness has changed little over that

† http://archive.stsci.edu/kepler/data_release.html

interval, with an increase of 0.1 mag. brighter at zenith and 0.3 mag brighter in the direction of Tucson. In addition, however, they found that the zenith brightness remained the same and the brightness in the Tucson direction decreased, compared with values ten years earlier. This is important for photometry, because it suggests that Tucson's light abatement strategies have been successful, despite increasing populations around Kitt Peak.

Finally, Stan Walker reports that members of Variable Stars South, RASNZ, are using standard DSLR cameras to observe Cepheids and eclipsing binaries to $V = 8.5$ with transformations to the standard $BVRc$ system accurate to 1% - 2% †.

3. Polarimetry (Pierre Bastien)

3.1. *Polarimetric Studies – Some Highlights*

With more than 14 000 hits on ADS during the period 2008 - 2011 (October), the subject of polarimetry is very active. Some particularly active areas are mentioned here. Stellar magnetism studies of more than 1 000 stars have been obtained with FORS1 at the VLT, HARPS at ESO and ESPaDOnS at the CFHT: chemically peculiar stars, hot stars [the MiMeS project; Wade *et al.* (2011)], Herbig Ae/Be stars and stars in clusters attract a significant attention. For example, it was found from the study of Ap/Bp stars in open clusters with known ages that the magnetic field strength decreases significantly during their Main Sequence lifetime [Landstreet *et al.* (2007), Landstreet *et al.* (2008)].

Circumstellar disks of young stars and exoplanets are under intense scrutiny. Hashimoto *et al.* (2011) reported high-resolution imaging polarimetry and detection of fine structures in the protoplanetary disk around the Herbig Ae star AB Aur with the high-contrast instrument HiCIAO on the Subaru thelescope. Their polarized intensity image in the H-band has a spatial resolution of only 9 AU. Quanz *et al.* (2011) resolved the disk around the Herbig Be star HD 100546 with polarimetric differential imaging using the AO assisted high-resolution camera NACO at the VLT in the H and K_s filters.

The Sun, pulsars, supernovae, active galaxies and Gamma-ray bursters continue to be favored targets for polarimetry.

3.2. *New Polarimetric Instruments*

A fast-switching spectropolarimeter has been used on the 1.8-m Plaskett telescope at the Dominion Astrophysical Observatory since 2007 mostly in support of the MiMeS project (see highlights above). A polarimetric unit, HARPSpol, has been installed for use with the HARPS spectrograph at the Cassegrain focus of the ESO 3.6-m telescope. See Piskunov *et al.* (2011).

High-contrast imaging polarimetry has been tested with ExPo at the William-Herschel Telescope for improving data reduction techniques in order to reach contrast ratios of 10^5. GPI for Gemini [McBride *et al.* (2011)] and SPHERE for the VLT [see Beuzit *et al.* (2010) and Schmid *et al.* (2010) for ZIMPOL, the polarimeter for SPHERE], both with polarimetric modes, are scheduled to be delivered to their respective telescopes some time in 2012.

The submillimeter polarimeter, POL-2, to be used with the SCUBA-2 detector on the James-Clerk-Maxwell Telescope has been installed on the SCUBA-2 cryostat in July 2010. Further work, i.e., early observations, completion of the data reduction software and commissioning of the instrument is pending the optimization of SCUBA-2 and its release to the astronomy community.

† http://www.variablestarssouth.org/index.php/research-projects/dslr-projects

4. Conferences

Conferences specifically on photometry and/or polarimetry were held during the triennium. Because of limited space, we do not attempt to report on the many other conferences on various astronomical topics in which photometric and polarimetric work was described and discussed!

The proceedings for the conference *Astronomical Polarimetry 2008 – Science from Small to Large Telescopes* which took place at the Fairmont Le Manoir Richelieu in La Malbaie, Québec, Canada are almost ready for publication [Bastien *et al.* (2011)].

Two sessions on the topic "Photometry: Past and Present" were organized by E. F. Milone and held at the Long Beach, California, meeting of the American Astronomical Society in January, 2009. Papers were presented on the development of: precise optical and infrared photometry (Milone, Sterken, and Young); CCD photometry (Steve Howell); the $UBVRI$ system (Arlo Landolt); calibration in visual and infrared passbands (Martin Cohen); spectrophotometry (Saul Adelman); and polarimetry (Pierre Bastien). A number of relevant poster papers (e.g., on photometric systems by Robert Wing) and another oral paper on the Pierce-Blitzstein photometer of the Flower & Cook Observatory by Carol Ambruster *et al.*), were also noted. All of these authors contributed to a volume of papers on these topics, which has now been published (Milone & Sterken, 2011).

The conference, *Stellar Polarimetry: From Birth to Death* was held 27 – 30 June 2011 in Madison, WI, with 81 registered participants. The focus was on current problems and future opportunities in the area of stellar polarimetry, with applications for forming stars (T Tauri stars, Herbig Ae/Be stars, UCHII, etc.), main sequence stars (Ap and Bp stars, Zeeman Doppler Imaging, etc.), post-main sequence stars (red and blue supergiants, WR stars, LBVs, etc.), stellar deaths (SNe, GRBs) and circumstellar media (disks, stellar winds, interacting binaries, colliding winds). Theorists and observers met with the goal of improving our understanding the physical processes operating in and around stars. More information is available on the web site: http://arwen.etsu.edu/starpol/.

We note that several conferences are planned for 2012, as reported by Russ Genet and by J. Allyn Smith, thus guaranteeing further discussion of devlopments in photometry, photometric telescopes, and calibrations, in the next triennial report.

5. Infrared Astronomy Working Group (E. F. Milone)

A separate report for the IRWG may be found elsewhere in this volume, so the report of the working group here will be brief. The IRWG maintains a separate website†, but other, updated information, and references, may be found at another site, as well ‡. The IRWG continues to champion the use of the optimized IRWG passband set described initially in Young *et al.* (1994), for which a set of preliminary standards were provided in Milone & Young (2005). The optimization of passband width and central wavelength (assuming triangular spectral profiles) created a set of passbands in which the water vapour absorptions are minimized. In the current triennium, emphasis was placed on the usefulness of the near-IR set, and the iN passband, for sites at *all* elevations where photometry can be carried out. This includes observatories that have traditionally carried out only optical photometry, and it includes amateur astronomers who have acquired experience in infrared photometry, perhaps at a local university astronomical observatory. The AAVSO has begun to encourage amateur astronomers to observe with a relatively

† http://people.ucalgary.ca/~milone/IRWG/
‡ http://people.ucalgary.ca/~milone/oip.html#IRPP

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inexpensive if uncooled system making use of the widely available Mauna Kea K_s filter, one of the better unoptimized filters.

Presentations emphasizing these points were made in several venues over the past few years. In the interval 2009-2011, a note was placed in the IAU daily newspaper during the IAU General Assembly in Rio de Janeiro in August, 2009, describing the suitability of these passbands for lower elevation sites, as well as for superior transformation properties and SN at the traditional high-elevation sites. Oral presentations on this theme were made also at the Telescopes from AFAR meeting in Waikalua, Hawaii, in February, 2011, and to the meeting of the Calgary Centre of the Royal Astronomical Society of Canada in September, 2011. The Waikalua presentation and the paper based on it (Milone & Young, 2011b) can be found on-line†.

We noted in these presentations that the organization of a "mass buy" of the Mauna Kea Near Infrared passbands in the mid 2000's, although inferior for photometric transformations of data obtained at traditional, high-elevation observatories, essentially precluded a mass purchase of the IRWG near-IR set. Of course, observatories will have to obtain new filters to replace old interference filters within a few years, because multilayer coatings can scarcely be expected to remain intact for as long as a decade, even if kept under vacuum conditions. Therefore it is our hope and expectation that the IRWG filters (thus far produced only by Custom Scientific, Inc., of Phoenix, AZ) ‡ will become the filters of choice for future infrared filter purchases, and so become available for precise IR photometry. See the IRWG report for more details and IR work carried out during the 2009-2011 triennium.

6. Ongoing and Future Work of Commission 25

The various large-scale surveys are generating a flood of new standard stars and standard star observations. The Commission believes that some form of coordination among the various initiatives would be helpful to the astronomical community at large. The Commission is thus planning to develop an IAU standard star data portal. This will be a one-stop location for all standard star data access. It would be an internet gateway to various recommended data servers. The information on the portal would be quality-controlled by a group of experts, so that observers could easily choose suitable and reliable standard stars that they need to use for their observations.

Apart from providing reliable standard star data, the envisaged data base could provide information on how to use those standards properly. It has been suggested that the Commission could compile educational material in the form of a "cookbook" on methods of doing and using photometry. In this regard the proceedings of the conference on *The Future of Photometric, Spectrophotometric and Polarimetric Standardization*, held in Blankenberge, Belgium in May 2006, would be particularly useful. A working group could take up these ideas at the next General Assembly. In keeping with this, it has been suggested that the Commission could consider organizing a symposium on standardization topics across the electromagnetic spectrum.

With regard to polarimetry, the need for faint polarized standard stars for large telescopes was raised at the Astronomical Polarimetry 2008 meeting, described in the report of the previous triennium (Martinez *et al.*, 2009). It was suggested that Commission 25 would be an appropriate forum to collate all the results in one place. A list of papers

† http://tfa.cfht.hawaii.edu/papers/milone_tfa_paper.pdf
‡ http://www.customscientific.com/

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containing polarized standards, bright and faint, should be in place on the Commission 25 web site in 2012.

Finally, a perennial problem is the proliferation of names of passbands. For example, the "Z" and "Y" designations of passbands in the near infrared by Warren and Hewett (2002), or the iz, iJ, iH, and iK designations for near Infrared passbands by Young *et al.* (1994). The "Y" is similar although not identical to the "iz" passband, and both are similar to a passband designated "Y" by Hillenbrand *et al.* (2002). Unfortunately, the "Y" designation was already given to a Vilnius passband, more than 40 years ago. Further discussion of passband designations for this spectral region can be found in Milone & Young (2008), and a discussion of other designation conflicts regarding the Johnson infrared passband designations can be found in Milone & Young (2011a). In addition, a new "y", not related the Strömgren "y" has recently been appropriated for an infrared passband with a central wavelength of 990 nm by High *et al.* (2010). The new filter is to be used with a red-enhamced CCD. The authors, themselves, decry such "degeneracy in terminology" but note that it "seems likely to persist." If something is to be done about providing guidelines to avoid such confusion, Commission 25 should do it. Consequently the Organizing Committee is reviewing the problem and may be making recommendations to the IAU at the Beijing General Assembly.

6.1. *Acknowledgements*

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