Astrometric and Photometric Calibration

Reference Catalogues: Present Status and Future Prospects

This review paper discusses the properties of the present IAU optical coordinate system, FK5 and its extension to fainter magnitudes and higher star densities. An outlook to developments in the near future is presented, special emphasis to Hipparcos and Tycho is given. Relations to the radio-VLBI system are discussed.

Siegfried Roeser
Astronomisches Rechen-Institut
Heidelberg, Germany

Astrometric Standard Fields for CCD Observations

The use of the astrometric information of CCD frames, especially for double stars, depends on suitable reference fields for the astrometric calibration. In addition to the list of standard double stars we present positions and proper motions of stars in eight small (3′ x 4′) fields distributed uniformly over right ascension and within ±20 degree declination of the sky. The data were taken partly from the literature, from new reductions of already existing data, and from new data mainly taken with the double refractor of Sternwarte Bonn (now at Observatorium Hoher List). First results of the calibration of CCD frames are given.

D. Sinachopoulos and J. Cuypers
Royal Belgian Observatory, Brussels

E. Oblak
Observatoire de Besançon, France

M. Geffert
Sternwarte der Universität Bonn

J. Colin and J.-F. LeCampion
Observatoire de Bordeaux, France

Calibration and the Large-scale Clustering of Galaxies

The machine measurements of UK Schmidt plates have produced two very large galaxy surveys, the APM survey and the Edinburgh-Durham Southern Galaxy Catalogue (from COSMOS). These surveys can constrain the power on large scales of $\gtrsim 10h^{-1}$ Mpc better than current redshift surveys, simply because such large numbers provide very high signal/noise in the estimated two-point correlation function for galaxies. In particular, the APM survey has been central to the many claims in the literature that the very attractive canonical cold dark matter model of the universe is not supported by observational evidence. However, the Lick survey, a visually measured catalogue, and the APM and COSMOS surveys give different scales for the 'break' in the correlation function, finding 10, 20 and 30 h^{-1} Mpc, respectively. We show here that even with the best determined survey so far, the APM survey, there could still be possible systematic errors present, making the estimation of the angular correlation function on large scales somewhat uncertain. With the estimate we find for such errors using the limited CCD data of Maddox et al. (1990), it would reduce the scale of the APM 'break' to $\sim 10h^{-1}$ Mpc, making it consistent with the Lick catalogue's result. Thus, because the APM $\omega(\theta)$ results are of such cosmological significance, even in the event of the acquisition of large galaxy redshift surveys, it is important to validate the APM and COSMOS surveys with external CCD calibrations. We consider here the calibration requirements for the surveys to constrain with confidence the amount of power needed on scales of $\gtrsim 10h^{-1}$ Mpc for the large-scale structure seen in the universe, as well as the form of the spatial correlation function on smaller scales.

R. Fong and N. Metcalfe
Department of Physics, University of Durham
Durham DH1 3LE, England, UK

The System and Quality of the AGK3U

During the course of the last few years my colleagues and I have:
1) developed new methods to objectively examine the internal consistency of star catalogs — both from the perspective of the worth of the position and proper motion mean errors and their residual systematics — and applied these new techniques to the FK3, the FK4, the FK5, the GC and the N30;
2) developed new algorithms to produce astrometric quality positions from wide field-of-view Schmidt plates and shown how to combine them with positions deduced from the more traditional astrographic plates to make an updated version of the AGK3 (i.e. the AGK3U), and
3) extended our work on the fundamental catalogs, wherein comparison showed the widespread presence of significant residual systematics in the FK3 and the FK4 but not to the same extent in the GC or the N30, to the large-scale catalogs the AGK3, the AGK3U, the ACRS (Part 1) and the PPM (North). (These results were reported on at the Cambridge meeting last June).

In the latter case the reference catalog was the GC at B1900.0 to ensure a large enough overlap set (~ 10,000 stars) to obtain statistically significant results while minimizing the effect of the GC proper motions. The AGK3RN/GC comparison was used to 'normalize' the results. Finally, the existence of the FK5 Extension, which has a 626 star overlap with the AGK3U, allows us to expand our fundamental catalog treatment to the AGK3U once the FK5 Extension has been placed on the system of the FK4 at B1950.0. We have both reduced the FK5 Extension to the system of the FK4 and used it to test the AGK3U. This confirms the system, the level of precision and the absence of systematics in the AGK3U.

L.G. Taff
Space Telescope Science Institute
3700 San Martin Drive
Baltimore, MD 21218, USA

Optimized Model-Functions for CCD-Camera based Astrometric Plate Measurements

While digitizing the first 1500 photographic plates (astrograph plates and primefocus plates of various telescopes) using our CCD-based measuring machine, we gained a detailed understanding of the properties of the digitized stellar images. These images are different from those obtained by digitizing photographic plates with microdensitometers and similar scanners. Therefore it was necessary to reject the modelling methods given in the literature and compose new models, which describe the stellar images more accurately. We will demonstrate that the improved modelling of the stellar image decreases the centring error, which is our main concern doing astrometry.

First results of simulating the whole imaging process, starting with the atmosphere, aberrations of the telescope etc. and ending by including the imaging properties of our measuring machine, show good agreement with the measured images as well as the modelling functions.

Lars Winter
Hamburger Sternwarte, Gojenbergsweg 112
D-2050 Hamburg 80, Germany

Determination and Application of Stellar Proper Motions of the Photographic Survey of the North Sky

In 1977 a project of photographic fourfold coverage of the northern sky (FON — shortened from Russian) was proposed at Kiev Observatory. FON is carried out by means of six wide-angle astrographs. Observations were started in 1982 and about 95% of required plates have been obtained over the past ten years. Measurements of the Kiev part of FON plates are carried out by means of the automatic measuring machine PARSEC. Nearly 300 plates have been measured by now.

The measurements of FON plates are used

for the construction of an astrometric catalogue of positions and proper motions of all stars of the Astrographic Catalogue (AC). Using the Fresneau catalogue and PPM as reference system at present proper motions of all stars with magnitudes up to 12^m in declination zone (+24° – +28°) and in selected areas of the north sky have been obtained. Comparison of the results with PPM and CMC data have been accomplished. Some thoughts on future prospects of FON project are discussed.

G.A. Ivanov, V.S. Kislyuk, L.K. Pakulyak, T.P. Sergeeva and A.I. Yatsenko
Main Astronomical Observatory
Goloseevo, 252127 Kiev, Ukraine

Photometric Calibrators for All-Sky Surveys: The GSPC-II Program

Digitized all-sky surveys, calibrated to sufficient photometric accuracy (0.05 to 0.10 mag), provide an enormous database for exploring astrophysical problems. The Guide Star Photometric Catalog-II (GSPC-II) program will provide CCD sequences in the B, V and R passbands with an accuracy of 0.05 magnitudes. The GSPC-II extends the existing GSPC to a magnitude limit of V=18, with an ultimate goal of V=20. The program is led by teams at STScI and OATo with observations taken at CTIO, ESO, Wise, KPNO, Mt. Megantic, MacDonald, Mt. Laguna and Lowell observatories. We present sky coverage statistics, reduction status, data accuracy, and publication plans.

A. Ferrari, E. Siciliano, A. Pizzuti, B. Bucciarelli, G. Massone, M. Postman, D. Rehner, C. Sturch, M. Lattanzi and B. Lasker
Osservatorio Astronomico di Torino
Strada Osservatorio 20, 10025 Pino Torinese
Torino, Italy

Space Telescope Science Institute
Homewood Campus, 3700 San Martin Drive,
Baltimore, MD 21218, USA

HI Survey of the Galaxy and the Magellanic Stream. Problems of Presentations and Comparisons of Large Sky Areas

While constructing contour maps of our 'Pulkovo Sky Survey in the interstellar neutral hydrogen radio line' as well as of RATAN-600 observations of very extended galactic regions in Orion and Scorpius-Ophiuchus, problems arose during comparisons with very wide field Hα photographs and with observations of other components of the interstellar medium emission. The same reference stars were taken for our and other data on the whole area surveyed. Their coincidence could show the degree of accuracy by comparisons.

For the Magellanic Stream zone a special 'magellanic' coordinate system was chosen to avoid the distortions in traditional systems and to judge features belonging to the Stream.

N.V. Bystrova
St. Petersburg Branch of the Special Astrophysical Observatory, Russia

Astrometry with the f/8 Harmer-Wynne Corrector on the Jacobus Kapteyn Telescope

The JKT has a photographic camera at its f/8 Harmer-Wynne focus, which provides a highly corrected 1.5 degree diameter field, designed with astrometry in mind.

The IAU at Patras adopted a list of quasars, unresolved at both radio and optical frequencies, which can be used to tie the two frames together. They have been photographed with the Wide Field Camera on the JKT and in each of these 1.5 degree fields the CAMC has measured the positions of some twenty reference stars.

Not only does the JKT extend the transit circle work to fainter magnitudes, it also smooths the accidental errors in the transit circle positions. This fact has been exploited by Argyle et al., 1991, *Mon. Not. R. astron. Soc.*, **250**, 576.

The most important proper motion programme with the JKT is a search for

common proper motion companions to stars of large parallax. The luminosity function of faint stars is poorly known and an improved knowledge would help to answer two outstanding questions. First, do brown dwarfs (i.e. non core Hydrogen burning stars) exist and if so in what numbers? Second, are there sufficient low luminosity stars to account for the 'missing mass' in the solar neighbourhood?

Derek Jones
ING Telescope Group, La Palma

Self-Consistent System of Stellar Magnitudes through an Internal Method of Characteristic Curve Derivation

For the purpose of performing UBV stellar photometry 4'.3 x 4'.3 area in the well resolved central region in GC M5 on six short exposure plates, as well as areas containing standard stars were digitized with the Joyce-Loebl microdensitometer of the National Astronomical Observatory. In the absence of an external photometric calibration scale on the plates, an internal calibration method using density profiles of the standard stars was used to obtain the characteristic curves. Peculiarities of the method are discussed in detail.

It was found that the method is very sensible to the uncertainties of the stellar magnitudes and can be used directly for stellar photometry. This feature is used to build up a secondary standard on the plates with a variable background and when necessary to correct some standard magnitudes in order to gain a self-consistent system of stellar magnitudes — the calibration curves using this stars show smaller r.m.s.

Haralambi Markov
National Astronomical Observatory, Bulgaria

Stellar Photometry with a Wide-field CCD: NGC 6822

It is well known that the advent of CCDs has triggered a major improvement in the photometry of bi-dimensional sources and, in particular of rich star fields with important crowding, making it possible to get data of much better accuracy and in an easier way. The only disadvantage of CCDs compared with photographic plates has been their small field size, which made them almost useless for the study of objects of large angular size. Since a few years ago, a new generation of large CCDs has become available in most observatories. These detectors provide wide field sizes which, in some cases, are beginning to compare with those of the traditional photographic plates.

We have used wide-field (11.5′ x 10.5′) CCD images to derive photometry of the resolved stars of the Local Group Dwarf Irregular galaxy NGC 6822. The large field is very useful for this kind of object, of relatively large angular size (about 12′ x 8′) for this galaxy). But care has to be taken in order to obtain reliable photometric data from these images, where undersampling is severe (0.55"/pixel, for seeing under 1"). DAOPHOT and DAOPHOT II have been used to derive the photometry of the stars. The most important difference between the two runs is the analytical form of the PSF (see manual of DAOPHOT II by P. Stetson): gaussian for DAOPHOT and Moffat function for DAOPHOT II. The results in *B*, *V* and *R*, obtained with both versions, for a total of some 25000 stars in the galaxy, show that the choice of the analytical PSF model has critical effects on the quality of the final photometry.

A. Aparicio, C. Gallart and J.M. Vílchez
Instituto de Astrofísica de Canarias

Intensity Calibration in the Presence of a Disturbing Effect Dependent on Wavelength

Conversion of signal measured by any light detector to intensity values is one of the most important factors that influence the precision of spectro conversion function (or calibration curve). It is determined and therefore valid for a fixed wavelength and certain measuring conditions. When a broader wavelength region is studied, some complications arise in connection with wavelength dependent sensitivity of detectors (i.e. light present in the spectrum, especially in some types of spectrographs). Generally, these effects can be considered as a disturbing factor, the level of which is slightly variable with wavelength. In such cases, a number of individual conversion functions has to be determined to calibrate spectral measurements properly.

We propose a more general method for evaluation of a calibration curve. Its shape is taken to be slightly dependent on wavelength and thus the curve takes into account the present disturbing factor. A brief description of the method, including some examples are presented.

P. Kotrč
Astronomical Institute, 251 65 Ondřejov
Czech Republic

Brightness Calibration on Objective Prism Plates

We present the method for brightness calibration applied to the Hamburg Schmidt Survey, which uses digitized objective prism plates for several purposes. The calibration simulates the Johnson B filter and uses in general standard stars from the Guide Star Photometric Catalogue. We achieve an accuracy of 0.3 mag for 13<B<16.5 mag and of 0.5 mag for B<18.5. Constrains on the selection of brightness limited complete samples are discussed.

D. Engels, L. Cordis and T. Koehler
Sternwarte der Universität Hamburg, Germany

A Photometrical Investigation on the RC System of the 2 m Ritchey-Chretien-Coude Telescope of the Rozhen Observatory

Surface photometry techniques of data processing are applied for the qualitative analysis on reflectivity of the two-mirror system in the prime focus of the 2 m Ritchey-Chretien-Coude telescope of the Rozhen Observatory. There are considerable variations in the reflectivity reaching to ±30%. An estimation on the upper limit of the average reflectivity (about 68% ±1%) of the two-mirror RC system is made. A loss of about 0.5 magnitudes in the limiting magnitude, due to the low reflectivity and to the decrease in the reflecting surface is found.

Rumen G. Getov
Rozhen National Astronomical Observatory
P.O. Box 136, 4700 Smoljan, Bulgaria

Digital Processing on Comets

Several digital techniques have been used to remove large-scale background variations on old photographic plates ORWO ZU2, caused by manufacturing and technology of photographic processing. Suppression of these large-scale background variations made it possible to study large-scale phenomena in cometary plasma tails better and to determine the solar wind characteristics.

The same digital experiments were done with KODAK IIIaJ and KODAK IIIaFH plates and with CCD images. The results obtained from images of several different comets were compared. It has been shown that the simple digital techniques used were applicable also to photographic plates which did not have high quality images. They may be utilized in treatment of old photographic plate stacks.

Dalibor Kubacek, Eduard M. Pittich and Judita Zvolankova
Astronomical Institute
Slovak Academy of Sciences
842 28 Bratislava, Slovak Republic

Unbiased Multi-Parametric Estimations of Distances and Peculiar Velocities of the Galaxies

Accurate Hubble distances $\lg R$ may be derived using together two or more distance indicators p_k (corrected apparent sizes, luminosities, other distance-dependent quantities) and some calibrators q_k (velocity dispersions of the ellipticals or HI-line widths of the spirals, mean surface brightness, colours, other distance-independent quantities).

The deceleration laws in the nearby universe are $\lg V = -\lg p_k + const_k$, where using the Hubble law $\lg V$ changes $\lg R$. The deviations $\Delta\lg V_{ik} = \lg V_i - \lg p_{ik} - const_k$ are **unbiased** raw estimations of the peculiar velocities. The regressions $\Delta\lg V_k = f_k(q_1, q_2, ...)$ are the multi-parametric generalizations of the Faber-Jackson or Tully-Fisher relations. The initial velocity estimations are $<\lg V_{ik}> = -\lg p_{ik} + const_k - f(q_{i1}, q_{i2}, ...)$ and the final ones $<\lg V_i>$ are obtained by the linear regression $\lg V = g\,(<\lg V_1>, <\lg V_2>, ...)$. The mean-square value of the final peculiar velocity estimations $\delta\lg V_i = \lg V_i - <\lg V_i>$ occurs about 1.2 times lower than that obtained by the pure methods of Faber-Jackson or Tully-Fisher.

Tsvetan Georgiev
Rozhen NAO, BG-4700 Smolyan, Bulgaria

Multi-Parametric Iris-Photometry

Good magnitude estimations may be reached by iris-measurements using two or more different comparative light beams, giving for the i-th star image iris-data d_{i1}, d_{i2},....., including the background measurements d_{ib} and the distances from the centre of the plate r_i. The initial estimations $<m_{ik}>$ are determined from the regressions $d_k = f(m, d_b, r^2)$ including up to third order term of m and linear terms of d_b and r^2. The final estimations $<m_i>$ are derived from the regression $m = g\,(<m_1>, <m_2>, ...)$. The typical accuracy of the multi-parametric method is about 2 times better than the classic one and the colour coefficient of the instrumental system occurs about 2 times lower. The proposed method needs well-exposed background and a rich standard sequence, well-distributed in magnitude, colour, background and position.

Tsvetan Georgiev
Rozhen NAO, BG-4700 Smolyan, Bulgaria