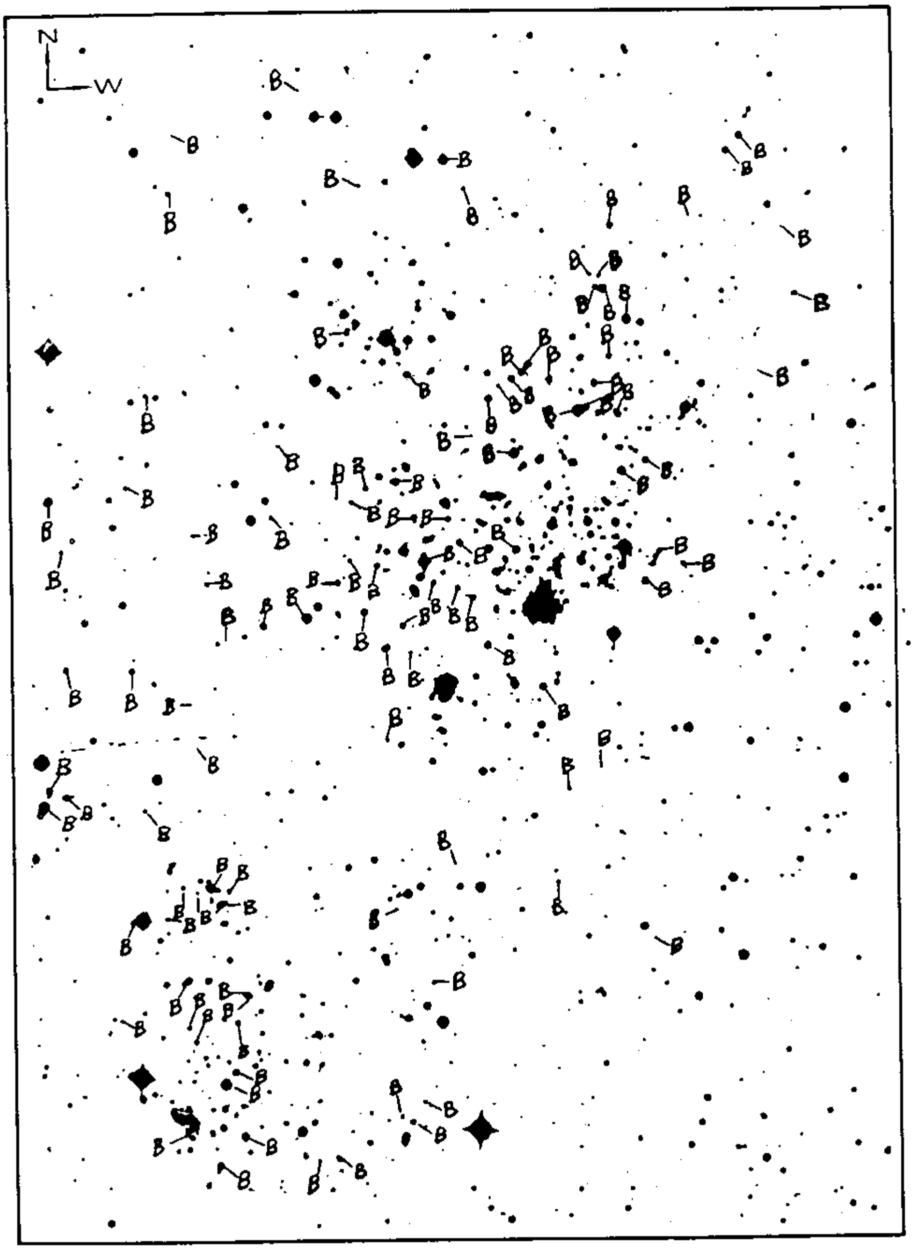
International Astronomical Union
Commission 9



Working group
on
"Wide-field imaging"

Newsletter 3

IAU WORKING GROUP
ON
WIDE-FIELD IMAGING

Newsletter No. 3

February 1993 **Editor: H.T. MacGillivray**

Front cover:

The distribution of OB stars in Shapley I (denoted by the letter "B"). See article on page 12.

Typeset by E.B. Thomson

Contents

Editor's Note 1
Harvey T. MacGillivray

The IAU Working Group on Wide-Field Imaging 2
Richard M. West

IAU Symposium 161: Astronomy from Wide-Field Imaging 4
Richard M. West

First Results from the Hitchhiker CCD Sky Survey 6
Simon Driver and Steve Phillipps

Galaxy Clustering at $B \sim 25^m$ 7
N. Roche, T. Shanks, N. Metcalfe and R. Fong

The Muenster Redshift Project — A Progress Report 10
P. Schuecker

Stellar Complexes in the Large Magellanic Cloud 12
S.E. Maravelias, M. Kontizas, E. Kontizas and A. Dapergolas

Stellar Population and Galactic Evolution: A Photometric and Astrometric Sample Survey 15
A.C. Robin, O. Bienaymé, M. Crézé and V. Mohan

An Abundance and Kinematic Analysis from High Dispersion Spectroscopy of Early-Type, High Galactic Latitude Stellar Candidates from the UKST UBVRI Survey 18
N.C. Hambly, E.S. Conlon, P.L. Dufton, F.P. Keenan and R.J.H. McCausland

Wide Field Cometary Polarimetry using a Novel Device 21
Edward H. Geyer and Klaus Jockers

Far Ultraviolet Imaging with the FAUST Telescope 27
Timothy P. Sasseen, Stuart Bowyer, Xioayi Wu and Mike Lampton

A CCD-based Sky Patrol 30
Peter Kroll and Thomas Lehmann

LITE: the Large Imaging Telescope 41
L. Vigroux, V. de Lapparent, J. Rich, Y. Mellier, H.J. Breuer, H. Lorenz and S. Marx

Linking the Sonneberg Field Patrol to Project LITE 43
Gerold A. Richter and Hans-Jürgen Bräuer

Scanning Activities at Sonneberg Observatory 46
Peter Kroll

Report from the Space Telescope Science Institute 48
Brian McLean and Barry Lasker

The Hamburg Schmidt Survey 50
D. Engels, L. Cordis, D. Groote, H.-J. Hagen and D. Reimers

A Technique for Stacking Digitized Photographic Plates 52
Jonathan Bland-Hawthorn and Patrick L. Shopbell

Inventory by the Wavelet Transform 57
A. Bijaoui

Tech-Pan UKST Films: Some Preliminary COSMOS Data Comparisons 60
Quentin A. Parker, David H. Morgan and S. Phillipps

An Astrometric Comparison Between Glass and Film Negatives on the UKST 64
Dafydd W. Evans

Using the FK5 Extension on the B1950.0/FK4 System to Test the AGK3U 68
M.G. Lattanzi and L.G. Taff

News about the Wide-field Plate Archive Database 72
Milcho K. Tsvetkov and Katya P. Tsvetkova

Wide-field Plate Archive Database: a Management System for Personal IBM XT/AT Computers 77
Michail-Ernesto Mihailov and Zvezdelin Borisov

Observations Catalog for the 2 m RCC Telescope at NAO-Rozhen 78
K.Y. Stavrev

Flare Stars Database 80
Milcho Tsvetkov, Maria Chukova and Katya Tsvetkova

Astronomical Glass Plates Made in Germany 81
A. Ohnesorge

Computer-Readable Version of the Rozhen Schmidt Telescope Plate Log Book 83
Asen S. Mutafov, Petya K. Ilcheva, Mariana M. Kusheva, Michail-Ernesto S. Mihailov, Zvezdelin H. Borisov and Nikolai S. Lazarov

Erratum: Clarification of the Minutes of the 1st Meeting of the WFI WG Organising Committee 86
Roberta M. Humphreys

Availability of KODAK Astronomical Plates 87
David Malin

Availability of KODAK Astronomical Plates — Questionnaire 88
Gordon P. Brown

Editor's Note

This 3rd Newsletter of the IAU Working Group on Wide Field Imaging has turned out to be even larger than the previous two!! It indicates that the members of the WG are truly very active, and that the WG is very much alive and well. My thanks again to the contributors of this issue who responded enthusiastically to the call for contributions.

Readers will see the broad range of issues covered in the present Newsletter, from deep galaxy counts done using CCDs on large telescopes to reports of the status of plate archives and sky surveys. The WG is achieving what it hoped when started, viz covering a broad spectrum of science and a wide range of technical aspects.

1993 will be an important year for the WG, with the first major conference (now an IAU Symposium) to be held in Potsdam in Germany from 23 – 27th August. This promises to be a large and comprehensive meeting with a large number of presentations already promised.

The serious situation regarding continued availability of photographic materials must be brought in this note to the attention of members. You will see a number of items in this Newsletter relating to such, and you should read the very important announcement by our Chairman (Richard West) in the box below. In the interests of ensuring the continuation of these important emulsions from KODAK, all readers are strongly urged to complete the questionnaire at the end of the Newsletter and to return the questionnaire to KODAK.

Harvey T. MacGillivray

To all users of Photographic Emulsions!

This Newsletter contains important information about recent developments in connection with the availability of photographic plates from KODAK. In particular it unfortunately appears that certain emulsions may not be available for some time to come. This may have profound temporary implications for astronomical programmes in many places.

A questionnaire is included in this issue (page 89) which should be filled out by all users of KODAK plates to gauge the present use of and need for astronomical emulsions from this supplier. Please note that it is very important that you take time to do so, especially since the future availability of KODAK plates may strongly depend on the perceived need!

More details will be found in the article by D. Malin on page 87. We also call your attention to the note by A. Ohnesorge about ORWO plates on page 81.

Richard M. West

The IAU Working Group on Wide-Field Imaging

Let me begin by wishing all WG members and other friends of Wide-field Astronomy a Happy and Prosperous New Year with plenty of interesting opportunities! 1993 will obviously be an important and busy year for our WG. The publication of the 3rd WG Newsletter signifies the half-time of the present term. We have made good progress since the creation of the WG in Buenos Aires, and we must soon start to think about the continuation at the following IAU General Assembly in Amsterdam next year.

1. The Potsdam Meeting

However, before then we shall meet in Potsdam in just about seven months time. You will find more details about this meeting inside the present issue. By the way, you did remember to send back the form with your preliminary registration, didn't you?!

As you will remember, the Scientific Organizing Committee (SOC) sent an application to the Executive Committee of the IAU for support of our proposed meeting as an *IAU Colloquium*. This was discussed at the EC meeting in Bangalore (India) in early September last year and the outcome was unexpected: not only did the EC members agree to this, they also upgraded it to become *IAU Symposium 161*! I was later told that this decision was influenced by the apparent, very broad interest in this subject which is supported by the fact that six IAU Commissions, nos. 5, 9, 24, 27, 28 and 33 have agreed to be official sponsors of the meeting. This expectation has been confirmed by the large number of responses, well above 150, which have already been received to the First Announcement which was sent out in late October 1992. In the meantime, a beautiful wide-format conference poster has also become available and is now displayed at most major astronomical institutes — it may well induce even more colleagues to come.

The recognition of our meeting as an official IAU Symposium is certainly a most welcome and prestigious development, and it approximately doubles the IAU financial support which we had hoped for. Together with the expected local money, it now looks as if we will be able to provide travel and subsistence support to a substantial number of participants. The SOC expects to allocate an important part of this support to participants who come from far-away and also to many young astronomers. It is moreover the intention to take advantage of the central European location of Potsdam and ensure that many astronomers from Central and Eastern European countries will be able to participate.

In this connection, it should be noted that the annual meeting of the European Astronomical Society (EAS), this year with the title 'Extragalactic Astronomy and Observational Cosmology' will take place in Toruń, Poland, from 18 – 21 August 1993, i.e. just before our meeting and at close geographical distance. This will facilitate participation in both. For further information about the EAS meeting, please contact **Richard Wielebinski (Chairman of SOC), MPI für Radioastronomie, Auf dem Hügel 69, D-5300, Germany, or Jan Palouš, EAS Secretary, Astronomical Institute, Budečská 6, CS-12023 Prague 2, Czech Republic (email: ASTDSS@CSEARN.bitnet).**

2. The Noble Art of Photon-Catching

The interest in Wide-field observations is clearly increasing, especially among CCD astronomers. Several new projects now aim at putting very large CCD mosaics at the foci of medium-size telescopes with fields of the order of 2° – 3°. In all cases, the driving ideas are of a rather specific scientific nature, ranging from the search for distant long-period comets well before perihelion to the recognition of the largest structures of the Universe by means of very large numbers of accurately determined galaxy redshifts. We shall certainly hear much about these and other exciting projects in Potsdam.

I believe that this particular interest in Wide-field Astronomy may be interpreted as the most recent and obvious expression of the eternal desire of astronomers to exploit the available technology to the limit. Astronomical and astrophysical advances have almost always been technology driven and during the past years we have witnessed a tremendous evolution that has taken place in several well-considered steps. With the risk of being accused of oversimplification, I think that the main problem of observers has always been to obtain the largest possible number of relevant photons in the shortest possible time and at the highest possible signal-to-noise ratio, i.e. while suppressing all extraneous, non-relevant photons. More photons basically equal more information, and in the best case this information leads to important new insights.

The first major step forward was the introduction of *more sensitive detectors*, from the human eye to photographic plates, and then via photomultipliers and image intensifiers to CCDs and other digital devices. When quantum efficiencies close to 100% had been reached in the early 1980s, the natural next step of the photon-hungry observers was to *increase the collecting surface* of their telescopes. This is now happening as 8-metre and larger telescope projects are underway at various organisations. These new giant telescopes will of course be placed at sites with the largest possible number of clear nights, again increasing the total photon flow.

Another line of attack has been to *improve the angular resolution*. This had been achieved by choosing observing sites with the best possible seeing, optimizing telescope domes and actively controlling the telescope optics. There are new and important developments within the difficult art of speckle interferometry and adaptive optics at single telescopes now guarantees that the light from individual objects is better focused throughout an observing session. This reduces the number of simultaneously recorded photons from the sky background and, all other things being equal, increases the S/N-ratio and therefore the information content of the observation. And the large optical interferometers at the Keck and ESO VLT facilities will soon follow.

In order to further increase the information flow from above, the only way forward is then to *increase the field* and enable the simultaneous observation of as many objects as possible! Multiple-slit techniques is one example which however only cover a (small) part of the available field; full-field coverage by truly panoramic detectors is even more efficient. For the time being, the available (non-interferometric) astronomical optical systems which are applicable to very large (i.e. non-Schmidt) telescopes do not allow to increase the field-of-view beyond 1° – 1.5°, if an angular resolution which is equivalent to the best seeing conditions shall be maintained, but serious theoretical efforts are now underway to push towards larger, high-definition (i.e. 0.2 – 0.3 arcsec) fields.

3. The Importance of Wide-Field Techniques

In other words, the presently increasing interest in Wide-field Astronomy may be seen as a logical development which occurs at the time when other photon-catching techniques are beginning to approach their natural limits. Simultaneous observations of large numbers of objects not only increase the overall efficiency in terms of time spent and efforts invested, it also facilitates comparative studies by removing many of the calibration problems that plague sequential observation techniques. Moreover, the data recorded during a few precious observing hours at a Wide-field instrument may provide so much material that even today's advanced computers will need months to digest the new information.

And then there is of course always the wonderful element of serendipity in wide-field work — who knows which new and strange phenomena will some day be discovered this way?

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IAU Symposium 161: Astronomy from Wide-Field Imaging

IAU Symposium 161 'Astronomy from Wide-field Imaging' which is organised by the IAU Working Group on Wide-field Imaging will take place in Potsdam near Berlin (Germany) from 23 – 27 August 1993.

In what follows, some additional information is provided which complements the announcement in Newsletter No. 2 (page 74).

1. General Remarks

As mentioned in the Introduction (page 2), the IAU Executive Committee, in its September 1992 meeting decided to support this meeting and to include it in the prestigious series of IAU Symposia as No. 161. This has the immediate effect of approximately doubling the IAU financial contribution (now about SwFr. 17,000.-) which is available to support the travel and subsistence of some participants. Other sources of support within Germany are being sought; the first responses have been positive. Moreover, the Government of Brandenburg (the German "Land" of which Potsdam is the capital) has expressed great interest in this meeting, and considers it to be one of the important cultural events within the celebration of Potsdam's millennium year. We are therefore convinced that further help will also be forthcoming in different shapes from that side.

The response to the First Announcement has been very satisfactory, more than 150 replies have been received so far, most with indicated titles of papers.

The Scientific Organising Committee (SOC) consists of the members of the WG Organising Committee, plus Dr. Michel Mayor (Geneva Observatory, Switzerland), who also acts as representative of Commission 33. The Local Organising Committee (LOC) with members from the Potsdam, Hamburg, Tautenburg and Sonneberg Observatories began the preparatory work last October and has held regular meetings since then.

A conference poster in wide-field format (what else!?) showing a strip of the Milky Way and the facade of the famous Sanssouci palace has been prepared and was sent to all major institutes. There is some indication that it has in the meantime become a collector's item; complaints about inexplicable disappearances from display boards and quite a few requests for additional copies were recently received by the LOC. A second printing run will therefore be arranged. It is also the intention to make it available (for a nominal price) to all participants in the meeting.

2. Scientific Programme

The SOC has been busy arranging the key (i.e. invited) talks of the various sessions. By mid-January, a few talks still had to be set up, but the acceptance rate has been good and the response quite positive. The overall programme structure, as shown in Newsletter No. 2 has remained unchanged.

To prepare the detailed programme, the SOC decided to arrange a meeting in Potsdam on February 25 – 26, 1993; this would also give the opportunity to inspect the localities foreseen for the meeting and to interact directly with the LOC. Moreover, it will be necessary during this meeting to decide about the first allocation of support to participants; the IAU rules demand that this is done not later than five months before the meeting, in order to allow those participants who will need visas and otherwise have difficulties in obtaining supplementary funds enough time for the planning of their trip to Potsdam.

Due to the geographical distance, not all SOC members will be able to come to this meeting. For that reason, the deliberations will partly be done at distance and before the meeting, giving all SOC members the opportunity to actively participate in the decisions.

It is the intention to publish the Abstracts of IAU Symposium 161 in the July 1993 issue of the WG Newsletter. The Proceedings will be published in the IAU Symposium series by the official IAU publisher, Kluwer Publishing Co. in the Netherlands. They will hopefully become available at the latest in the beginning of 1994, i.e. well before the next IAU General Assembly.

3. Social Events

The following information has been received from Dr. K. Fritze, on behalf of the LOC:

"Potsdam is a very beautiful town in the midst of the unique landscape along the Havel River, just southeast of Berlin.

"In 1993 Potsdam celebrates its millennium with a lot of cultural, political and social events. The many theatres, cabaret, galleries and museums in the city will present a most interesting entertainment.

"For IAU Symposium 161, the LOC has foreseen several social events. In the evening of the day of arrival on Sunday, August 22, an Informal Gathering will be held at the Sternwarte Babelsberg. It is the observatory which succeeded the famous Berliner Sternwarte when it was relocated to Babelsberg in 1913. The Berlin–Babelsberg Observatory has an astronomical tradition of three hundred years and a long-standing experience in wide-field imaging during the last decades.

"Another part of the AIP is the Astrophysical Observatory Potsdam at the Telegrafenberg with the famous 'Einstein Tower' — a solar tower telescope which is in full scientific operation inside a unique, expressionistic scientific building.

"During the meeting it will be possible to visit both observatories with their scientific facilities as well as the historical instruments and exhibitions.

"A boat tour will be arranged with a steamer of the White Fleet on Wednesday afternoon; this will be a real highlight and surely a very rewarding experience for all participants.

"On Thursday, August 26, the penultimate day of the meeting, the Closing Dinner will be held at the Residence-Hotel.

"During your spare time (if you will have any!), there are many interesting sights of Potsdam which are worth visiting. Prussia's glitter and glory are closely connected to the name of Potsdam: the Sanssouci Palaces and Gardens, the New Garden or the Park and Palace of Babelsberg, and last but not least the historical city of Potsdam."

4. Next Announcement

Full details about the scientific and social programmes will be included in the Second Announcement which will be sent by the LOC in early March 1993 to all prospective participants and others who have expressed interest in learning more about this meeting. At the same time the hotel reservation forms, etc., will be included.

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First Results from the Hitchhiker CCD Sky Survey

Hitchhiker is a parallel twin CCD camera mounted on the William Herschel Telescope at La Palma. It operates in parallel with scheduled spectroscopic observers by means of a special pick-off mirror and optics which enable it to image an off-axis region of the telescope's field of view. Observations are made simultaneously in two bands (usually B and R or V and I) by means of a dichroic beam splitter. (See Wide-field Imaging Newsletter No. 1 for more details).

Hitchhiker (HH) was commissioned in November 1990 and data for the 8 runs (1 – 2 weeks each in dark/grey time) in the first year have now been reduced and archived. Naturally, because of its parallel nature, the HH sky survey is entirely serendipitous in terms of the fields surveyed, and exposure times per field vary enormously.

The first scientific output, which we report on here, comes from the analysis of a single high Galactic latitude field for which particularly long exposures were obtained, viz. 2 hours in B and R and another half hour in V and I. There are about 10 more fields with exposures of order an hour or more in the first year's data. Both because of their current scientific interest and as a stringent test of HH's capabilities and performance we have concentrated so far on producing deep galaxy number counts in each band and the corresponding faint galaxy colour distributions.

The CCD data is reduced by a combination of standard and instrument specific routines. The most important are flat fielding, background subtraction and dust subtraction. Flat fielding was achieved by using a median night sky frame built from a stack of many (~ 80) suitably normalized (mostly empty) deep frames from the HH archive. HH frames suffer from vignetting patterns in their outer regions so background subtraction is vital. This was performed by fitting a bi-cubic spline surface to a grid of points representing the local median sky values on a given frame and subtracting this surface from the data. This is superior to simply subtracting a smoothed version of the data frame since median filtering does not spread out large images and leave artefacts in the subtracted data. Also, because one of the HH lenses is near a focal plane of the instrument any dust on this lens leaves ring shaped depressions in the final image. These artefacts were cured by obtaining a smoothed version of a frame containing only the negative fluctuations below sky. This combination of procedures flattened the sky to an rms scatter of only 0.3% in the best case (the R frame — the CCD is less efficient in the B so there is considerably more Poisson noise).

Finally we have used FOCAS for the image detection and parameterization. We set a low isophotal threshold but count only those objects with signal-to-noise (S/N) ratio (inside the limiting isophote) of at least 7.5. Notice that this is not the same thing as having a pure magnitude limit, compact objects of a given magnitude have higher S/N than corresponding lower surface brightness images. It does, though, reflect how images are really detected. In total we have 526 objects to B = 26.4, 283 objects to V = 24.9, 1151 objects to R = 26.3 and 195 objects to I = 22.5 in our final image catalogues for the four bands. From analysis of the sizes and surface brightness of the images we estimate that we are complete (i.e. the S/N limit does not cause the loss of a significant number of objects) to limits about half a magnitude brighter than these quoted values (which obviously refer to compact star-like images). The numbers and number magnitude count slopes are in excellent agreement with previous workers and it appears that this is the first time that a single field has been studied to this depth in all four bands.

We also have colour information on the objects which have matching images on more than one frame. The B–V and V–R colour histograms show the well known trends for fainter galaxies to be bluer on average, but the V–R colour shows no sign of a similar trend, possibly suggesting that we are not seeing many high redshift objects (where we would be seeing essentially rest frame U–B). Interestingly in R–I we see a population of very red objects which are consistent with non-evolving or passively evolving early type giant galaxies at moderately high z.

In summary, the serendipitous HH CCD survey has been able to reach magnitude limits competitive with all but the very largest programmes of deep CCD imaging of faint galaxies. We have another 10 fields available, just from year 1, and are thus in a position now to start looking at field to field variations in numbers and colours. HH is currently being refurbished and the third year of observations will begin early in 1993.

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Galaxy Clustering at B ~ 25^m

The angular two-point correlation function, $\omega(\theta)$, for galaxies can be used as a probe of their redshift distribution N(z) and, therefore, of galaxy luminosity evolution. Without redshift data, we can still observe the projection onto the two-dimensional sky of the three-dimensional clustering of galaxies. The autocorrelation of this projected distribution is described by $\omega(\theta)$. Observations have indicated that $\omega(\theta)$ follows a $\theta^{-0.8}$ power-law (Peebles 1980) and that the index of the power-law remains approximately constant to the faintest limits of photographic surveys (Jones, Shanks & Fong 1987) The $\omega(\theta)$ amplitude is related to the amplitude of the 3-dimensional two-point correlation function $\xi(r)$ by means of an integration over N(z) using Limber's formula (see, for example, Phillipps et al. 1978).

The scaling of the $\omega(\theta)$ amplitude for the galaxies with survey depth will therefore relate to the change with depth of N(z). The wider the range of redshifts over which galaxies are distributed the more the observable clustering will be diluted by projection.

Here we estimate the $\omega(\theta)$ amplitude and investigate its scaling for 4540 galaxies observed on 12 CCD frames (total area 284 arcmin^2) at the INT. These data were published as number counts by Metcalfe et al. (1991) and is limited at $B_{ccd} < 25.0$.

The $\omega(\theta)$ was calculated as described by Infante (1990) and Efstathiou et al. (1991) using a local normalization of the galaxy number density for each field. The resulting $\omega(\theta)$ for all $B_{ccd} \leq 25.0$ galaxies in this survey was fitted with a function '$A(\theta^{-0.8} - 16.1)$' which gave the $\theta^{-0.8}$ power-law amplitude at one degree, corrected for 'integral constraint'. The result was $(4.124 \pm 2.044) \times 10^{-4}$ (field-to-field errors), consistent with the $\omega(\theta)$ results given by Efstathiou et al. (1991) for the deep CCD fields of Tyson (1988). The $\omega(\theta)$ amplitude can similarly be estimated for brighter subsets of our data catalogue, enabling its scaling to be investigated over magnitude limits in the range $23.25 \leq B_{ccd} \leq 25.00$.

In addition we have a new result from the single deeper field described by Metcalfe, Shanks & Fong (1991) in which 1442 galaxies were detected to $B_{ccd} = 27.0$. This gave an even lower clustering amplitude of $(2.971 \pm 1.525) \times 10^{-4}$.

The graph shows our correlation amplitudes for different magnitude limits, compared with those obtained from other surveys. For details of these earlier results see Stevenson et al. (1985), Jones et al. (1987), Koo & Szalay (1984), Infante (1990) and Efstathiou et al. (1991). Our correlation amplitudes appear to be consistent with the photographic data to the final limits of such surveys ($B \approx 24$).

We also compare our results with the predictions of two models, differing only in the evolution with redshift of the characteristic galaxy luminosity L^*. A correlation radius of $r_0 = 4.3h^{-1}$Mpc (fitting the Zwicky catalogue clustering at brighter limits) and a value for q_0 of 0.05 were used. A model without luminosity evolution was computed using the k-corrections given by

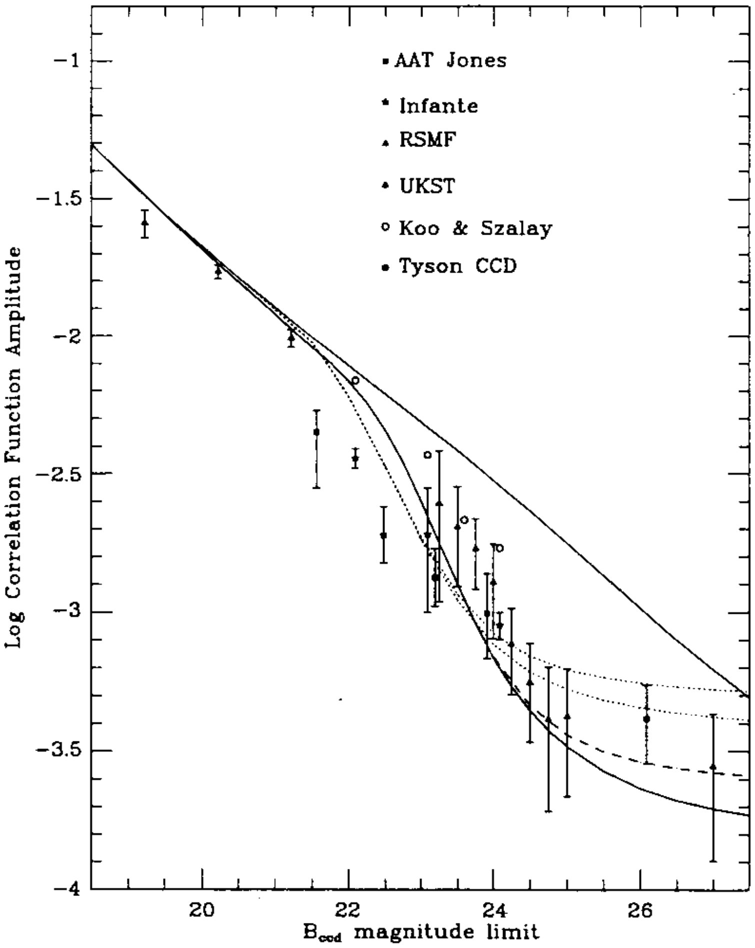

Figure 1. Estimates of the correlation function amplitude obtained from photographic surveys and from CCD frames, compared with the predictions of a non-evolving model (upper curve) and a model incorporating pure luminosity evolution (lower curve), over a range of blue magnitude limits. The solid curves are the two models computed with $q_0 = 0.05$ and a maximum redshift of 4. The dashed curve shown at B > 24 is the Bruzual model with N(z) cut off at $z = 3$ rather than at $z = 4$. The dotted curve shows the evolving model with the same (k+e)-corrections as previously, but computed with $q_0 = 0.5$ giving it a higher amplitude at faint limits. This divides into two at B > 23 to show the predictions for $z_{max} = 3$ (upper) and $z_{max} = 4$ (lower).

Metcalfe et al. (1991). Our evolving model, also described by Metcalfe et al. (1991), used the pure luminosity evolution models calculated by Bruzual (1981), with an exponentially decreasing ($\mu = 0.5$) star-formation rate for the early type galaxies.

The effect of luminosity evolution is to enable more galaxies to be seen at higher redshifts, so giving a *lower* $\omega(\theta)$ amplitude. The Bruzual model N(z) is bimodal at $B \approx 23 - 25$ with a very broad second peak of starbursting galaxies, centred at about $z = 1.85$. This model gives a reasonable fit to the number counts whereas a no-evolution model underpredicts them. However, as far as the $\omega(\theta)$ scaling is concerned no-evolution may approximately represent pure density evolution or an extremely merging-dominated model where N(z) has been hypothesised to have a similar form (Lilly, Cowie & Gardner 1991). Evolution of this type essentially raises the normalisation of N(z), rather than enabling galaxies to be seen to higher redshifts, so would have little effect on $\omega(\theta)$.

It is clear that our correlation amplitudes do not follow the no-evolution scaling, being significantly lower at $B_{ccd} > 23$ and much closer to the Bruzual model predictions. The no-evolution model is in fact rejected by 4σ at B = 24.5. Any conclusions about the redshift distribution on the basis of correlation amplitudes depend on the assumption, which is made in these models, that galaxy clustering is stable in proper coordinates. However, to fit the $\omega(\theta)$ amplitudes with a no-evolution N(z) would require clustering evolution much greater than would be predicted by any simple gravitational model. If galaxies at B $\simeq$ 24 and fainter are found to have such a redshift distribution, then more complicated models such as the inclusion of a numerous and very weakly clustered population of dwarf galaxies which is no longer visible at the present day (Babul & Rees 1992), may be required.

To summarise, we find the $\omega(\theta)$ amplitude for faint galaxies to be significantly lower than would be expected for a model in which clustering is stable in proper co-ordinates and the redshift distribution maintains a no-evolution form. The low $\omega(\theta)$ amplitudes are most easily explained if the very blue (flat-spectrum) galaxies appearing faintward of B $\simeq$ 23 are at $1 \leq z \leq 3$ (and are undergoing rapid star-formation), as their colours suggest (Tyson 1988; Koo 1990; Metcalfe et al. 1991). An alternative explanation is that they are at lower redshifts and very weakly clustered in comparison to other galaxies.

Additionally, taking our results in conjunction with those of Efstathiou et al. (1991) it appears that the $\omega(\theta)$ amplitude may reach a lower limit at B_{ccd} = 24.5 – 25.0, remaining approximately constant for even fainter limits. This could be due to the N(z) reaching an upper redshift cut-off at these deep limits, caused either by the epoch of galaxy formation or by the Lyman limit entering the B passband. The amplitude at which the $\omega(\theta)$ scaling levels out appears to be in the range we would expect for stable clustering and reasonable values of q_0 (i.e. 0 to 0.5) and the cut-off redshift ($3 \leq z_{max} \leq 4$).

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The Muenster Redshift Project — A Progress Report

The aim of the Muenster Redshift Project (MRSP, Seitter et al. 1989; Duerbeck et al 1989) is to use large samples of optical data to find constraints for fluctuations of galaxy number densities on various scales (Schuecker & Ott 1991; Seitter 1992a, b), constraints for number evolution of galaxy pairs in two and three dimensions (Boschan & von Kürten 1993), to detect distant clusters and to provide estimates of their redshift (Naumann 1991; Ungruhe 1991), to determine galaxy luminosity and diameter functions (Schuecker 1990), mean values of internal absorption in spiral galaxies (Cunow 1992a), and the cosmological parameters H_0 (Duemmler 1992), Ω_0 (Ott 1988), Λ (Feige 1992). The statistical approach to these topics relies on fully automated measurements and reductions, using pairs of direct ESO/SERC J and F Schmidt plates and UK objective prism Schmidt plates. The film copies are digitized with two microdensitometers PDS 2020 GM^{plus}. From the direct plates, object positions, star/galaxy separation, semi-major and minor galaxy axes, position angles (Horstmann 1992), magnitudes (Cunow 1992b, c), and morphological galaxy classification (Spiekermann 1992) are obtained. From the very low dispersion objective prism plates (reciprocal linear dispersion 246 nm mm^{-1} at Hγ) redshifts are measured, and for 75% of the galaxies with $z \leq 0.3$ the error distribution yields $\sigma(z) = 0.012$ (Schuecker 1993).

In order to keep the magnitude limits constant over the total survey area, CCD sequences are presently observed with the SAAO–1.0 m and ESO/DUTCH–0.9 m telescopes. Wavelength zero points for the redshift measurements are obtained by astrometric transformation of object positions from the direct plate to the objective prism plate (Tucholke & Schuecker 1992). Mapping algorithms, combining the results obtained from individual Schmidt plates (Naumann & Ungruhe 1992), and crowded-field algorithms for the analysis of regions with high object number densities (Groeneveld 1992) are being developed.

The derivation of global parameters of the universe relies to a large degree on the proper selection of galaxies for the redshift measurements. In our survey, the classifications of objects obtained from the J *and* F plates can be compared, thus increasing the reliability of the star/galaxy separation process and the morphological classification (Ritzmann 1992). The simultaneous measurements of magnitude, colour, morphological type and redshift permits the proper application of *K*-corrections and the detection of clustering, evolutionary and segregation effects. Data pertaining to the MRSP-catalogues are:

Current status of the MRSP-catalogues

Catalogue	**Plate Material**	**Area □°**	m_{Limit}	N_{Objects}
Galaxies	ESO IIIa-F	5100	20.0	$7.9 \cdot 10^6$
Stars	ESO IIIa-F	5100	20.0	$21.3 \cdot 10^6$
Galaxies	ESO/SERC IIIa-J	400	21.0	$6.5 \cdot 10^5$
Galaxy-Types	ESO/SERC IIIa-J	400	19.5	$1.0 \cdot 10^5$
Stars	ESO/SERC IIIa-J	400	21.0	$1.0 \cdot 10^6$
Redshifts	UKST IIIa-J	300	19.8	$1.2 \cdot 10^5$

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Stellar Complexes in the Large Magellanic Cloud

The concept of complexes and supercomplexes has been introduced relatively recently by Efremov (1988). Thus, Efremov defined as 'stellar complexes' giant groupings with sizes from $\approx$ 0.2 Kpc to 1.2 Kpc, comprising gas, clusters and OB associations, from 10^6 to 10^8 years old. Hence, complexes could be briefly defined as galactic hyperstructures, the principal components of which are extreme population I objects (Maravelias et al. 1992).

McKibben Nail & Shapley (1953) were in fact the first to distinguish the giant stellar and gaseous aggregates of the LMC, the well known Shapley 'constellations' I to V, whereas later on van den Bergh (1981) named the 'constellations' VI to IX. They seem to be the most active areas of the Cloud. Theoretical studies have appeared some years later (Feitzinger & Braunsfurth 1984) where it is proved that the distribution of emission regions and OB associations in the LMC is not random.

The main scope of this research project is the study of the large scale structures of star formation in the LMC, namely stellar complexes and supercomplexes, giving precise criteria, based on the assumptions by Efremov, for defining a complex and investigating its relation to star formation. On these grounds, star counts and spectral classification were carried out in some selected complexes of the LMC, namely Shapley I, IV, IX, as well as the newly defined Shapley X, in order to determine the boundaries and find the dominant stellar component of those areas. We present here some preliminary results for Shapley I, as a typical example of a stellar complex. An area of $\approx$ 360 pc x 360 pc, centred on $\alpha \approx 05^H23^M$ and $\delta \approx -68°02'$ was examined.

The star counts were carried out on three plates, taken with the 1.2 m UK Schmidt telescope, in U, I and V respectively. A square réseau was fixed on the screen of a magnifying device, where each pixel corresponded to $\approx$ 11 pc for the LMC. Thus, the number density was measured there per $\approx$ 120 pc^2. A faint star limit was set up a little higher than the actual detection limit, to avoid confusion with the photographic emulsion grains, and compensate for the masking of faint stars in crowded areas. The counts were repeated after a lapse of some weeks in crowded areas and the mean values have been taken into account. In order to study the background effects and define a lower limit of the number density of stars inside this complex, star counts were carried out on the same plates in two (one being adjoining) fields at less crowded areas of the LMC, with dimensions $\approx$ 190 pc x 190 pc. The counting errors have also been considered. The mean values of number density are $\langle d \rangle \approx 9$ stars/A, $\langle d \rangle \approx 13$ stars/A and $\langle d \rangle \approx 19$ stars/A for U, I and V plates respectively, where A $\approx$ 120 pc^2, with standard deviation $\sigma \approx 2$ stars/A. Hence, the lower limit of the number density was defined to be:

$$d_{min} \approx \langle d \rangle + 3\sigma \qquad (1)$$

The data were processed with a contour plotting software package to produce the iso-contour mapping of this complex. The minimum contour was chosen to satisfy Equ. 1, while the step was taken to be equal to 2σ. Plates of various exposure times in various colours were used to reveal the structure for different detection limits and the stellar population as well. The iso-contour mapping reveals the morphology and the structure of Shapley I. In Fig. 1 we can see the iso-density map derived from the U plate, whereas the shaded areas illustrate the minimum boundaries of the I plate contour map superimposed, where it is evident that the peaks of this mapping correspond to the 'nuclei' of OB associations. It is very interesting to note that there exist some additional dense 'starry cores' in this complex, other than the OB associations listed by Lucke & Hodge (1970).

For the spectral classification, the best available copies of the UKST low dispersion prism UJ plates were used. The effectiveness and the criteria of the low dispersion objective prism plates for spectral classification have been discussed in the past by several authors, and are reviewed by Dapergolas et al. (1986) and by Kontizas et al. (1988). The accuracy of the classification is about one spectral type. Adopting a distance modulus of 18.5 mag for the LMC, we can observe stars brighter than $M_V = 0$ mag. Hence at the present magnitude range, A type main sequence stars and/or red

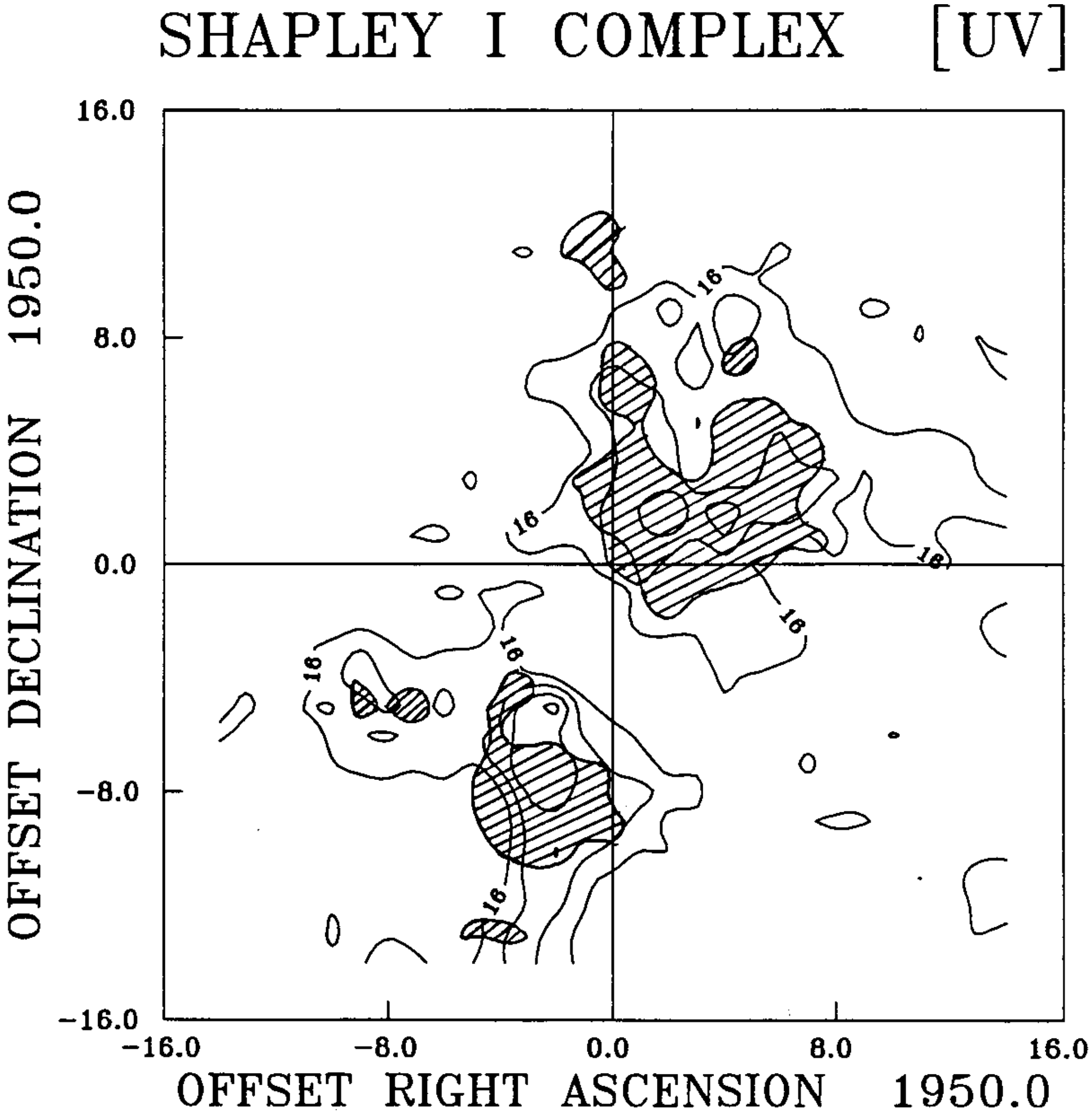

Figure 1.

giants of luminosity class III, are the faintest stars that can be detected. The distribution of OB stars (denoted altogether by the letter "B") in Shapley I, is illustrated in Fig. 2, where it is shown that the concentrations of the early type stars are mainly located inside the boundaries of this complex, as defined above by the iso-contour mapping.

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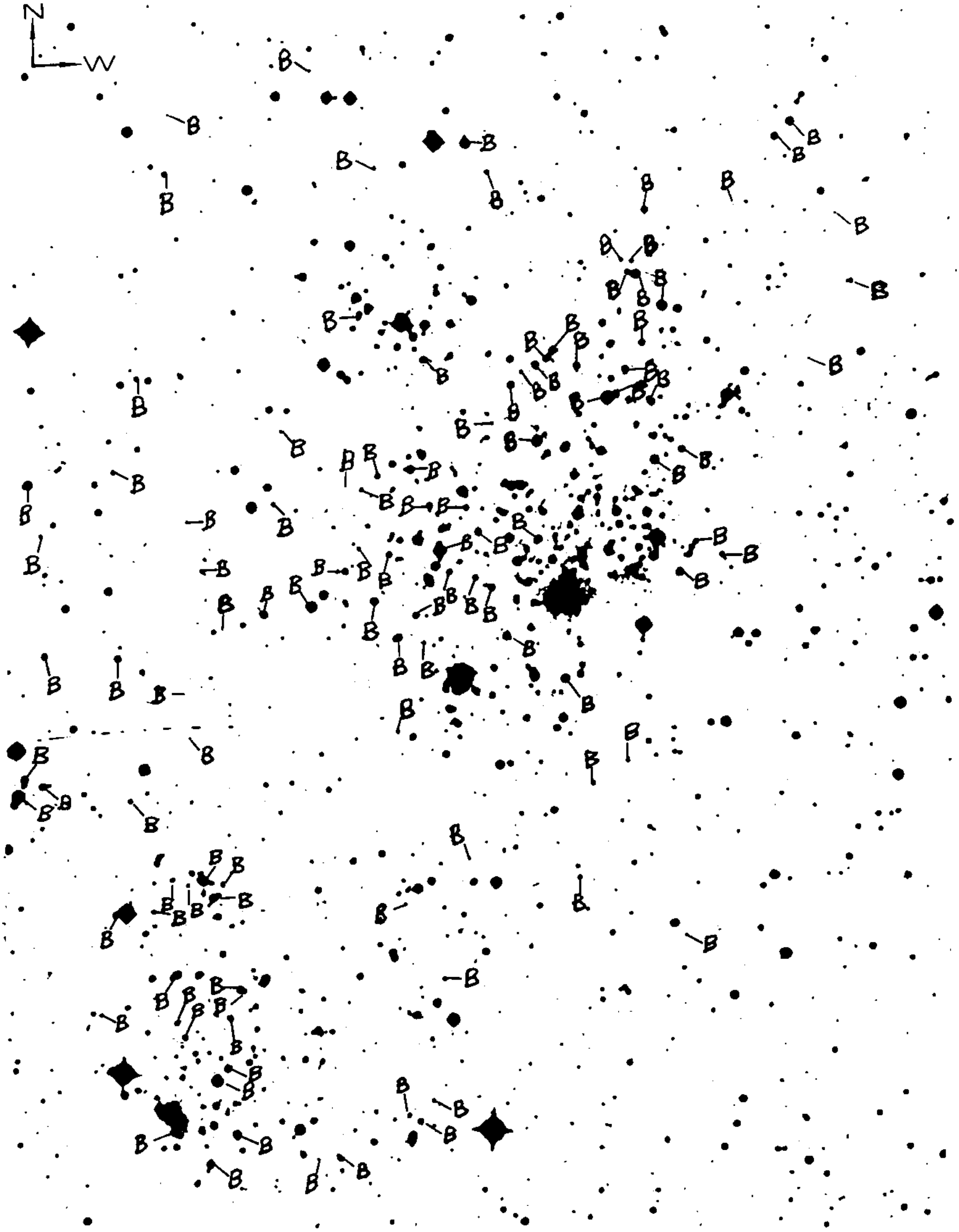

Figure 2.

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Stellar Population and Galactic Evolution: A Photometric and Astrometric Sample Survey

1. Introduction

Strasbourg Observatory, Besançon Observatory (France), C.A.I., Observatoire de Paris and U.P. State Observatory (India) are conducting a sample survey in UBV photometry and proper motions as part of an investigation of galactic structure and evolution supported by the Indo-French centre for the Promotion of Advanced Research — Centre Franco-Indien pour la Promotion de la Recherche Avancée. The project is based on Schmidt plates (from Tautenburg, Palomar, ESO and OCA [Observatoire de la Côte d'Azur] telescopes) digitized with the MAMA machine (C.A.I., Insu Paris). The high astrometric quality of the MAMA gives access to micronic accuracy leading to a few mas per year accuracy on proper motions, using plates spread along a 30 year baseline. Medium photometric accuracy and high proper motion accuracy for complete faint star probes in large fields will give access to the properties of star samples out of the solar neighbourhood. The Schmidt sample survey is complemented by deep CCD photometry in some fields in order to get a wider magnitude range and to give access to faint or remote populations. To interpret this multidimensional data set we have developed a synthetic approach of galaxy modelling. Model simulations compared to observed stellar distributions in the space (V, B-V, U-B, μ_l, μ_b) will lead to suitable tests for galactic structure, dynamics and evolution.

2. Description of the Survey Plan

2.1 Sample survey

The chosen directions constitute a set of fields at high and intermediate latitudes and in the galactic plane:

- near the North Galactic pole (M3, l = 50°, b = 80° [Soubiran, 1992]);

- the direction of M5 (l = 3°, b = 47° [Bienaymé et al. 1992]);
- direction (l = 270°, b = 45°);
- direction (l = 210°, b = 45°);
- special Area 23 (l = 179°, b = 2.5°), a region in the plane of particularly low extinction (Mohan et al. 1988; Robin et al. 1992).

2.2 Photometric reduction

Photometry is made using at least two plates per colour in the three photometric bands UBV. Photometric sequences are photoelectric sequences and CCD photometric ones obtained at the 1.2 metre telescope of Observatoire de Haute-Provence and 1.0 metre telescope of U.P.S.O., Nainital (India). These CCD frames are spread over the Schmidt field and used to check for geometrical variations of the sensitivity over the plates. About 40 to 80 stars are typically used to determine the calibration curve in each passband. Colour transformations between the Johnson system and the instrumental system of the O.C.A. Schmidt have been obtained by Mohan & Crézé (1987). The typical rms magnitude scatter ranges from 0.08 to 0.10 in the magnitude range 11 to 18.

2.3 Astrometric reduction

The present astrometric analysis is purely differential. Except for the low galactic latitude field we use galaxies to determine the absolute proper motions. In the future Hipparcos and Tycho catalogues could be used for this purpose.

The performance of a number of centring algorithms have been intensively tested (Bienaymé et al. 1988; Bienaymé et al. 1992). The autocorrelation centring method gives the best accuracy over the whole magnitude range. A mathematical transform (Legendre polynomial expansion) is used to model the transform between plate coordinates from the two epochs. For this purpose it is assumed that the mean proper motion over the considered field is null or constant. After reduction, galaxies can be used to convert relative proper motions to absolute ones. The mean error corresponds to about 0.5 µm on bright stars. The global errors are definitely less than 3 mas yr^{-1} for bright stars and about 6 mas yr^{-1} for the faintest (V = 17.5).

The final catalogues include photometry in UBV and proper motions to a specified completeness limit in each photometric bands (measured from the maximum of the histogram of star counts).

3. Methods of Analysis

From such a survey the raw observational data do not allow to directly derive intrinsic parameters such as distance, mass, age, space velocities, chemical evolution of individual stars. However some information relevant to the distribution of these quantities is reflected in the n-dimensional distribution of observables. Connecting observable distributions to the main process they come from is basically a multivariate problem for which we have developed at the Besançon Observatory a synthetic approach of Galaxy modelling referred to as the Besançon model (Robin & Crézé, 1986; Bienaymé et al. 1987). Model simulations allow the comparison of predictions from theories or scenarios for galactic structure, dynamics and evolution with observed stellar distributions in multidimensional spaces, leading to suitable tests for the theories.

In this particular project statistical methods have been developed in order to qualitatively and quantitatively constrain the galactic structure parameters. Different methods have been used such as maximum likelihood, χ^2 test, least square fitting, discriminant analysis, and density estimations.

4. Preliminary Results

This synthetic approach and the multivariate sample survey plan have given until now a number of substantial results concerning galactic structure and stellar evolution:

- *determination of the scale length of the old stellar disc and detection of the edge of the galactic disc.* Using the anticentre field, the scale length is measured using Schmidt plate photometry complemented with deep CCD frames. We find a scale length of 2.5 ± 0.3 kpc and a sharp cutoff of the counts at a distance of 5.5 to 6 kpc from the sun (Robin et al. 1992a, b);

- *existence of the thick disc population and constraints on its circular velocity.* From the direction near M5, an analysis of the 5-dimensional space gives constraint on the existence of the thick disc population (Robin et al. 1989) and on its circular velocity. It is found to be about 150 km/s at a distance of 2 kpc above the plane (Robin & Chen, 1992);

- *constraints on the velocity dispersion ratios* have been obtained from data towards M5, the north galactic pole and in the anticentre (Pandey & Bienaymé, 1993, in preparation);

- *constraints on the kinematics of old populations in the direction of the north galactic pole.* Velocity dispersions in U and V are obtained for the old disc, the thick disc and the halo. The intermediate population is found to rotate at 179 ± 16 km/s, compatible with the value obtained in the M5 direction (Soubiran, 1993, in preparation).

We hope to have reduced most of the fields by the end of this year and to start an overall comparison of the data in all directions to give consistent tests for galactic structure and evolution.

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An Abundance and Kinematic Analysis from High Dispersion Spectroscopy of Early-Type, High Galactic Latitude Stellar Candidates from the UKST UBVRI Survey

1. Introduction

In recent years a number of apparently normal, population I B-type stars have been discovered at large z-distances from the galactic plane. The origin and nature of these stars has been the subject of much discussion in the literature — if all the candidates so far discovered are subluminous for some reason (subdwarf or post-AGB stars for example) then their existence can be quite naturally accounted for by the currently accepted models of galactic structure and star formation. If, on the other hand, these stars have the apparently normal bolometric luminosities inferred from observational data and derived atmospheric parameters, their ensuing distances make them somewhat unusual members of the galactic halo. Establishing accurate atmospheric parameters, element abundances, total luminosities and subsequent distances is therefore vital to these studies, and by comparing high resolution spectra with model atmospheres in order to derive such data, compelling evidence for normal B stars at large z-distances has been presented — see Keenan et al. (1986a), Keenan et al. (1986b), Conlon et al. (1989) and references therein. The presence in the halo of many of these stars can be accounted for by ejection from the plane of the galaxy by various mechanisms (Conlon et al. 1990); however, there appears to be a subset of these stars for which formation in the halo is the only possible explanation of their existence (Conlon et al. 1992).

2. This Survey

We are currently undertaking a wide-field magnitude limited survey for these peculiar halo objects by exploiting the UKST UBVRI survey database — this is based on COSMOS measures of intermediate to high galactic latitude UKST plates — see Mitchell, Miller & Boyle (1990) for more details. This database is an ideal source of information for both galactic and extra-galactic surveys, being over a wide field and reasonably photometrically accurate in five colours. Low dispersion spectra of candidates initially selected from UBV colours was presented in Holmgren et al. (1992); high resolution spectra of five promising young B-type stars have been obtained on the William Herschel Telescope in order to derive atmospheric parameters, metal abundances and kinematic information so as to determine which, if any, may have formed in the halo.

3. Results

By comparing hydrogen and helium line profiles and metal line equivalent widths from Kurucz (1979) model atmospheres with those from the spectra, the parameters shown in Tables 1 and 2 are found (for more details on the precise methods, see Hambly et al. [1993]). Figure 1 shows a comparison between the observed and modelled spectra for two of the stars in the range 3990 to 4170 Angstroms, with lines identified and used in the analysis indicated. Table 1 gives atmospheric parameters and inferred masses and ages for the stars; Table 2 indicates the mean elemental abundances obtained for the two best candidates. Comparing these values with those of young population I disk stars, candidates 791-2, 866-1, 863-4 and 867-5 appear to be good candidates for normal B-type stars high in the galactic halo, while 867-2 is fairly conclusively a subdwarf. Table 3 presents kinematic results from radial velocities and inferred distances assuming the parameters in Table 1. Following the analysis in, for example, Conlon et al. (1988) and Conlon et al. (1989), the best candidate for formation in the halo is 791-2, with an evolutionary time much less than its time-of-flight required to attain its current position from the star forming regions within the galactic plane. For the other candidates, evolutionary times and flight times are comparable, although for 863-4 the ejection velocity from the plane is somewhat larger than can be accounted for by plausible ejection mechanisms (Conlon et al. 1990). However, it is necessary to exercise caution before concluding too much from the current results. The values in Table 3 assume that the radial velocity gives a good

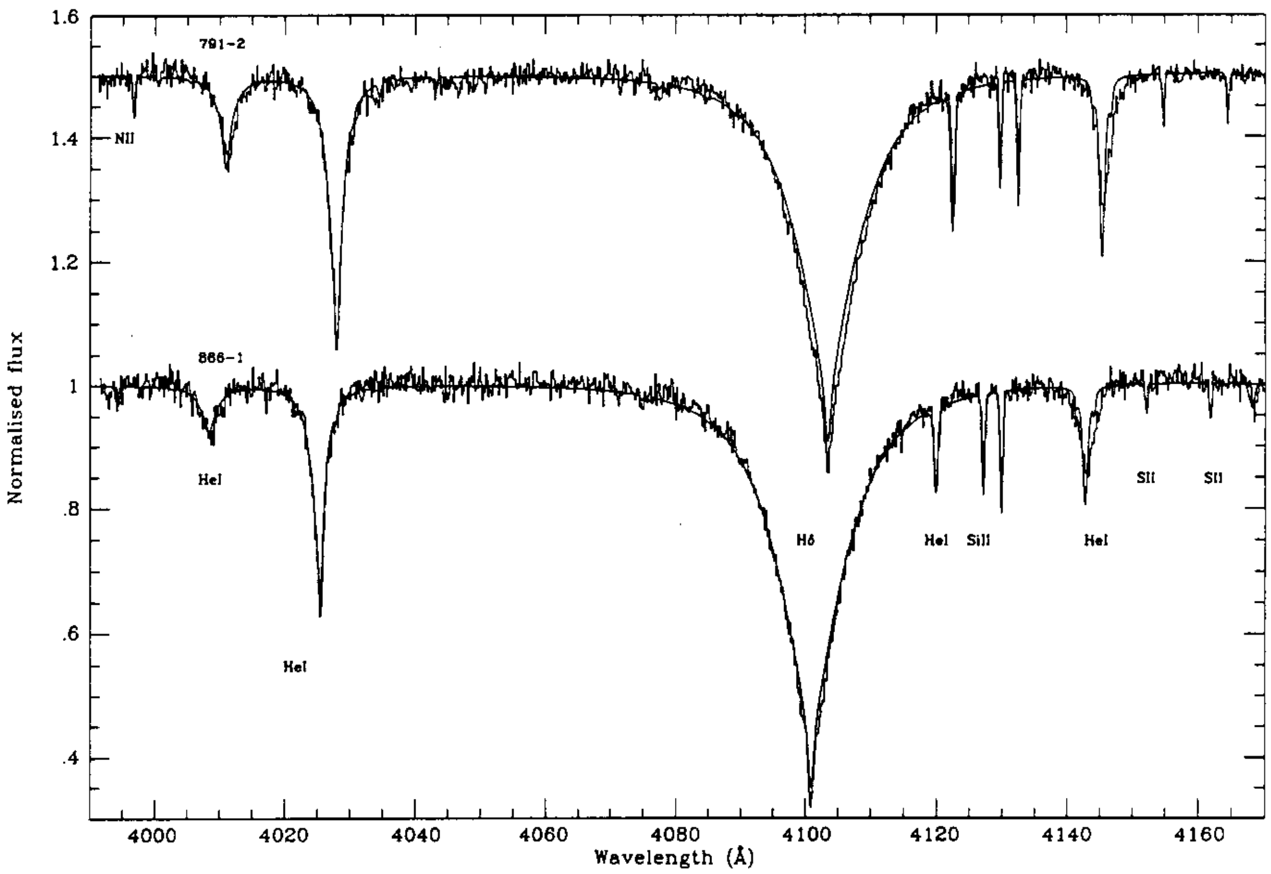

Figure 1. Comparison between observed (histograms) and modelled (solid curve) spectra for the two stars 791-2 and 866-1. Some of the measured lines are identified. These two stars are apparently normal, population I type objects at high galactic z-distances.

approximation to the velocity in the z-direction (reasonably true at these higher galactic latitudes); also the assumption that 863-4 and 867-2 have normal main-sequence like luminosities is based on relatively poor s/n spectra, with no independent method of checking the effective temperatures. All four stars are, nonetheless, worthy of further study. A more detailed analysis of these results and their implications will appear in Hambly et al. (1993).

4. Conclusions and Future Work

We have identified four excellent young, high galactic latitude candidates from the UKST UBVRI survey by model atmospheric analysis from high resolution spectra. Further analysis of this data, along with more spectra of brighter candidates from the survey will enable us to estimate possible stellar formation rates in the galactic halo. This work will also benefit from the superior photometric and astrometric data resulting from the completion of second generation whole-sky surveys (e.g. those currently underway at the Palomar and United Kingdom Schmidts) and the advent of better measuring machines (e.g. SuperCOSMOS).

Table 1. Atmospheric parameters for the program stars

Star name	Effective temperature (K)	log(g)	Mass (solar units)	Log (age)	BC	Luminosity (solar units)
791-2	19000 ± 1000	4.3 ± 0.2	6.0 ± 0.4	<6	-1.96	2.99
867-2	25000 ± 1000	5.4 ± 0.2				
866-1	16000 ± 1000	4.2 ± 0.2	4.5 ± 0.5	7.4	-1.55	2.66
863-4	12500 ± 1500	3.5 ± 0.5	3.2 ± 0.8	7.8	-0.86	2.79
867-5	12000 ± 2000	4.2 ± 0.5	3.0 ± 0.8	7.9	-0.78	1.99

Table 2. Mean abundances for the two stars 791-2 and 866-1. The normal B-star abundance for neon comes from Gies and Lambert (1992); the rest are from Keenan et al. (1986)

Element	791-2	866-1	Normal B star value
He	10.7 ± 0.1	10.7 ± 0.1	10.9
C	7.9 ± 0.2	8.1 ± 0.2	8.2
N	7.6 ± 0.3		8.0
Ne	8.5 ± 0.1	8.2 ± 0.1	8.5
Mg	7.4 ± 0.2	7.2 ± 0.2	7.4
Al	6.2 ± 0.2		6.2
Si	7.5 ± 0.1	7.2 ± 0.1	7.5
S	6.9 ± 0.1	6.9 ± 0.2	7.2
Fe	7.5 ± 0.2	7.0 ± 0.2	7.5

Table 3. Kinematic parameters for the stars

Star	RA			Dec			b	Radial	z	Age	Flight time	Ejection velocity
	h	m	s	d	am	as		km/s	Kpc	Myr	Myr	km/s
791-2	13	15	1.0	-7	42	0.3	54	+134 ± 5	3.02	1	19	178
866-1	14	9	50.7	-1	2	1.2	56	-57 ± 1	3.23	25	77	134
863-4	13	26	13.7	2	6	44.1	63	+130 ± 20	21.11	63	86	347
867-5	14	38	35.2	2	22	3.3	54	0 ± 50	7.09	79	74	184

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Wide Field Cometary Polarimetry using a Novel Device

Abstract

The polarization of cometary comae and tails had already been detected by Arago in the comets 1819-III and 1835-III-Halley, but it was Öhman in 1941 who found for the first time that two mechanisms produced the polarization of comets: the scattering of sunlight by the cometary dust particles and the fluorescence of the molecular cometary plasma.

Due to the strong and variable polarimetric contribution of the moon-lit or dusk/dawn night sky, the study of polarimetry of comets is one of the most difficult tasks in observational astronomy. It demands that the Stokes parameter for linear polarization are obtained simultaneously, otherwise too many systematic errors make a quantitative interpretation of the observations unsafe.

Recently I have developed a new type of polarimetric device for simultaneous astronomical point sources and extended object linear polarimetry, and which is presently being tested at our observatory.

The device consists of a double Wollaston calcite prism, the two halves of which are arranged in a special way. The device is inserted into the exit pupil of a telescope – focal reducer and splits a point source into four images, each having by 45° different polarization angles. For extended astronomical objects like comets, surface polarimetry is possible by a masking technique (multi-object observing mode) in the focal plane of the telescope.

1. Introduction

Together with laboratory experiments, the polarization measurements of comets and generally for all solar system bodies is an important observational approach for the understanding of their constituents of their outer layers.

As cometary comae and tails can be considered as strongly variable atmospheres of scattering molecular plasma and dust constituents, the scattered solar light is more or less polarized for the observer.

Although the discovery of the polarised light from the moon and the comets 1819-III and 1835-III-Halley by Arago roots back in the first half of the last century, it was only until 1941 when Öhman found, that the cometary polarization is produced by two different mechanisms:

a) the scattering of the sunlight by the cometary dust particles;
b) the fluorescence of the molecular cometary plasma.

The main contribution to the total polarization of comets is that of mechanism a). Therefore the circular polarised light contributes only marginally.

Recent reviews and compilations about the polarization observations in comets have been given by Dobrovolsky et al. (1986), Lamy (1985) and McDonnel et al. (1991), which show that the basic observational photopolarimetric material for different comets is sparse and in most cases concentrated into the inner coma and nucleus. Only the last comet Halley apparition yielded a satisfactory set of polarimetric measurements by several groups over a phase angle range of about 80°, but also mainly for its inner parts.

There are several reasons for this observational lack of intrinsic polarimetric measurements on comets, especially their outer coma and tails:

a) the bulk of existing astro-polarimeters is based on photomultiplier detectors, which have only a very limited field of view and low spatial resolution, given by the focal plane diaphragm. Therefore the polarimetry of many different parts of extended celestial objects cannot be done simultaneously, and demands long observing runs;

b) due to the fast proper motion of comets the recentering onto certain positions is unsafe and difficult with ground based telescopes;

c) as comets are mainly observable with phase angles < 90° (dusk or dawn observations) the sky fore- /background is polarimetrically strongly variable. To this also contributes the stellar background on account of the comets' proper motion. Both influences are difficult to account for.

The state of art of these types of astro-polarimeters has been given nearly 20 years ago by Serkowski (1974), though many improvements for astro-polarimeters have been made in the meantime.

1.1 Polarimetric definitions

Conventionally the (linear) polarisation in astronomy is given by the polarisation degree P and the azimuth angle ϕ of the direction of the vibration of the electric field vector. Normally the Stokes parameters I, Q, U, V are used:

$$I = \langle E^2_{x0} \rangle + \langle E^2_{y0} \rangle; \quad Q = \langle E^2_{x0} \rangle - \langle E^2_{y0} \rangle;$$

$$U = \langle 2E_{x0}\, E_{y0} \cos(\delta y - \delta x) \rangle; \quad V = \langle 2E_{x0}\, E_{y0} \sin(\delta y - \delta y) \rangle.$$

Here E_x and E_y are the field vectors amplitudes, δx, δy the phases. For linear polarisation $(\delta y - \delta x) = 0$. P and ϕ are given by:

$$P = (Q^2 + U^2 + V^2)^{1/2}/I; \quad \phi = \tfrac{1}{2} \tan^{-1}(U/Q).$$

In normalized form the Stokes parameters for linear polarized light are easily obtained by measuring the flux in 4 different orientations of the polarizer:

$$Q/I = \{I(0^\circ) - I(90^\circ)\} \,/\, \{I(0^\circ) + I(90^\circ)\};$$

$$U/I = \{I(45^\circ) - I(135^\circ)\} \,/\, \{I(45^\circ) + I(135^\circ)\}.$$

2. Optical Layout of the New Focal Reducer Surface Astro-Polarimeter

Nearly 10 years ago, when I and my collaborators had developed the focal reducer techniques for the 1 m Cassegrain telescope of the Hoher List Observatory, I had the idea for incorporating a device for obtaining *simultaneously* I(0°), I(45°), I(90°) and I(135°) and thus the Stokes parameters for linear polarisation of stars and extended cosmic objects over a large part of the telescope field.

Yet at that time CCD detector systems were not available to us, and it did not make sense to use photoplates on account of their limited photometric accuracy. It was only recently that I could realise this idea after having a good CCD detector system acquired by the support of the Deutsche Forschungsgemeinschaft.

The basic principles and purposes of a focal reducer system (FRS) are:

a) to reduce the large f-number of a long focus telescope to a small one, thus reducing the image scale;

b) to decrease the diameter of the telescope entrance pupil to a small exit pupil (EP);

c) to increase the field effectiveness of a telescope for small detectors like CCDs.

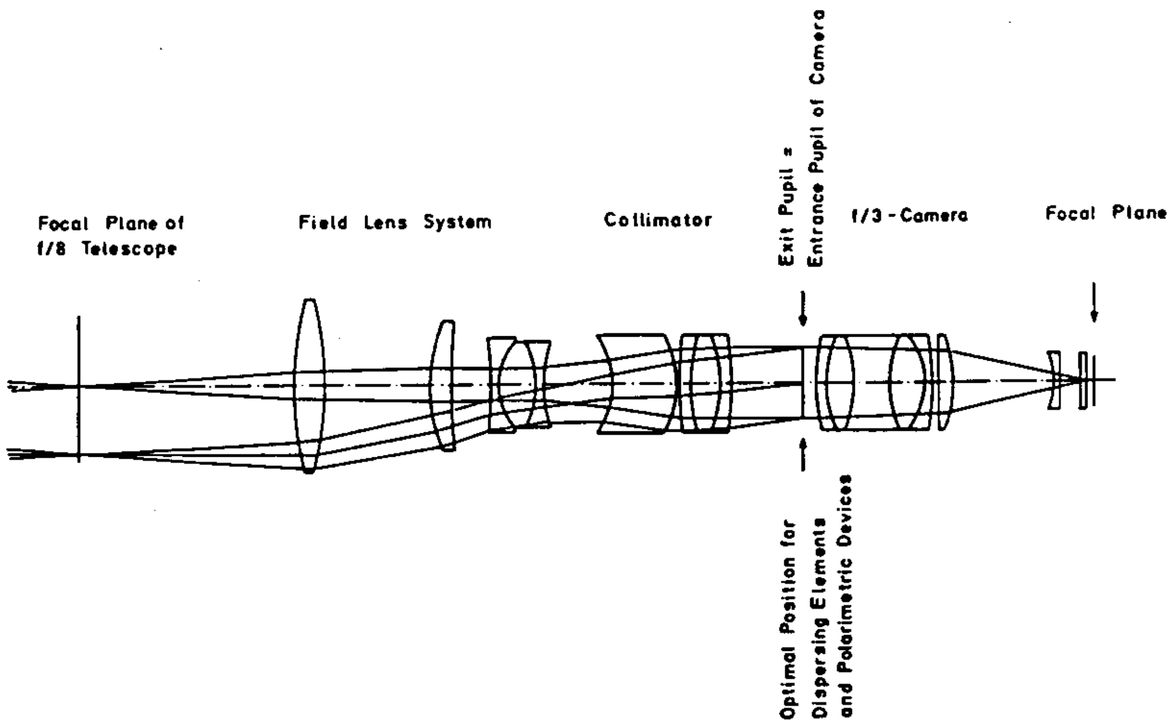

Figure 1. The C. Zeiss-Jenoptik focal reducer system for f/8 RC telescopes. The effective f-number of the system is 3.

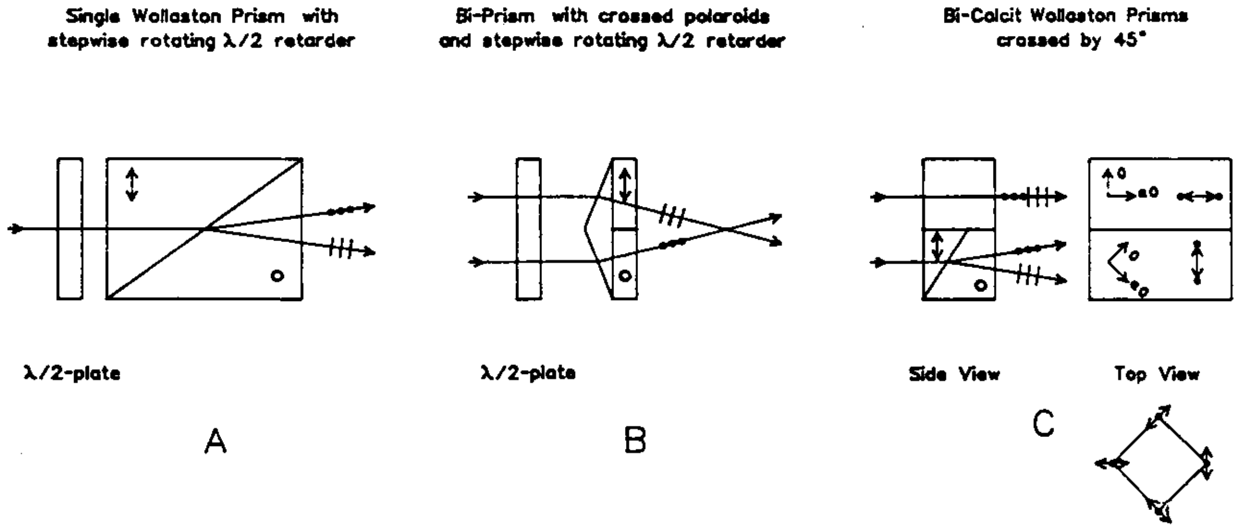

Figure 2. A, B, C. Schematic sketch of polarizer arrangements for focal reducer systems. Only the novel device (C) allows the simultaneous analysis of light in 4 directions of polarization, and which are shown in the lower part of C.

There are two kinds of focal reducers:

1) in the case of a so-called 'focal' FR, the telescope focal plane is refocussed by it directly onto the detector. The exit pupil is then in front of the detector, with the disadvantage that each bright star within the telescope field produces unsharp images of the telescope entrance pupil;

2) in the second case, the 'afocal' focal reducer, the optics works like a collimator with a field lens forming a *real exit pupil* with *parallel* light bundles (similar to a Kellner eyepieces of a binocular glass) into which optical filters, dispersing and polarising elements can be optimally placed. With a camera optics, the entrance pupil of which has to coincide with the exit pupil of the collimator, the telescope focal plane is finally focused onto the detector. As this type of FRS decouples completely the telescope optics from that of the camera, it has the best performance.

As both systems use a *field lens*, which should be behind the telescope focal surface, a large field of the telescope may be more or less usable, depending on the size of the detector. In addition the telescope focal surface is thus fully accessible with the advantage that positive or negative *masking technique* can be applied. As we shall see this is essential for surface polarimetry. Figure 1 shows schematically a recently designed, by C. Zeiss-Jenoptik, 'afocal' focal reducer for f/8 Ritchey-Chrétien telescopes of perfect quality over a wide spectral range. As the Hoher List Observatory 1 m telescope has an f/14.5 focal ratio such a complex optic is not necessary for the field lens collimator.

There are several possibilities for polarizers of different designs to be placed into the exit pupil of an FRS:

1) Figure 2 A shows the classical Wollaston prism which yields symmetrically arranged double images which are perpendicularly polarized. *Simultaneity* for polarization measurement is not achieved as a second exposure has to be taken by turning the FRS by 45° against the telescope focal plane or by a stepwise rotating a half-wavelength retarder plate. As both devices must have the size of the FR exit pupil (≥ 50 mm) they are extremely expensive;

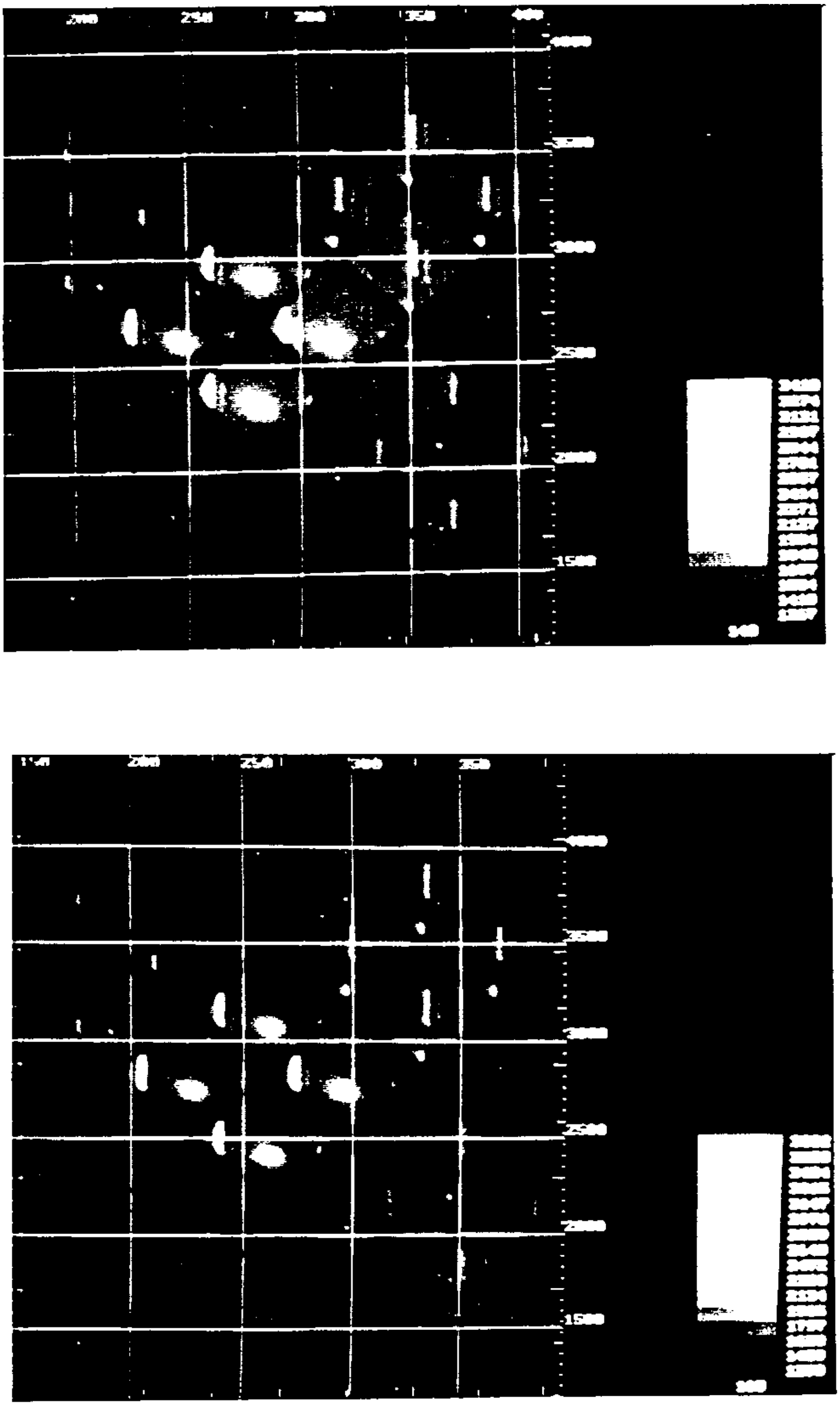

Figure 3 A, B. Double Wollaston / R-filter CCD-frame of Comet (1992d) Tanaka-Machholz on May 3, 1992. Exposure time was 900 secs. Overlaid on these CRT computer photographs are horizontal scans of height 8 pixels through the comet (upper picture) and the upper right comparison sky field.

2) a much cheaper version is shown in Fig. 2 B. Here the FR exit pupil is divided into halves by a double wedge. Each wedge half is covered on their back by crossed polaroids thus yielding double images similar to the Wollaston arrangement of Fig. 2 A. Simultaneity is also not possible and the FR has to be rotated or a half-wavelength retarder has to be used. In addition this type of polarizer is inefficient as the polaroid itself transmits only less than 50% of the oncoming flux.

The principle of the novel polarimetric device — the *Double Wollaston* — is shown in in Fig. 2 C. Here again the exit pupil of the FRS is divided into two halves each covered by a single Wollaston prism: the lower Wollaston is specially cut and turned towards the upper half, so that the 4 resulting light bundles have E-vector directions differing by 45° each. The flux of a non-polarized *point source* thus produces in the focal plane of the FR camera *simultaneously four images*, which are linearly polarized and arranged in a *rhomb*, containing ¼ of the flux energy (neglecting light losses). This is schematically shown in the lower part of Fig. 2 C.

For polarization observations of extended cosmic objects we apply the so-called *masking technique* as previously mentioned: in the focal plane of the telescope we place a multi-hole mask of circular or square form onto which the extended celestial objects are imaged by the telescope; thus certain parts of the telescope field are masked. Each hole with an angular diameter corresponding to the divergence angle of the Wollaston halves and relevant distances to avoid image overlapping is imaged by the FRS via the double Wollaston onto the detector in the above mentioned rhomb form. The hole arrangement of the mask and its orientation can be optimized in such a way that the CCD detector is optimally used.

Figure 3 shows the CCD double Wollaston observation of comet (1992d) Tanaka-Machholz on May 3, 1992, made by Dr. K. Jockers and Dr. N.N. Kiselev of MPI-Aeronomie with the above mentioned instrumentation of the Hoher List Observatory.

Acknowledgements

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Far Ultraviolet Imaging with the FAUST Telescope

Abstract

The Far Ultraviolet Space Telescope (FAUST) flew on the Space Shuttle in March 1992 and obtained 22 wide-field images covering about 3% of the sky in the wavelength range 1400-1800 Å. We discuss the advantages and difficulties we have encountered while doing wide-field imaging in the far ultraviolet (FUV). We have measured and cataloged approximately 4000 FUV sources. Our photometric measurements of these sources are found to contradict TD1 FUV measurements and are currently being used to refine current UV stellar population models. We have encountered difficulty in performing measurements of the diffuse astronomical background because of geocoronal airglow present in our wavelength band. Our studies of these data are continuing.

1. Introduction

The Far Ultraviolet Space Telescope (FAUST) was designed to do wide-field (7.6° diameter) imaging of diffuse and point astronomical sources at wavelengths between 1400 and 1800 Å (Deharveng et al. 1979; Lampton et al. 1990). FAUST is distinguished from other instruments that have operated in this wavelength range, such as the Hubble Space Telescope and the Ultraviolet Imaging Telescope on Astro-1, by virtue of its extremely wide field. Prior to its latest flight in March 1992 on board the Space Shuttle, the instrument was upgraded to include a photon-counting wedge and strip microchannel plate detector (Lampton et al. 1986; Siegmund et al. 1987) in place of an intensified film camera. During the recent flight, we obtained 22 images, covering a range of targets and galactic latitudes. The complete list of targets is given in Bowyer et al. (1993).

2. Point Sources

A variety of environmental and geophysical backgrounds are seen in the data and must be eliminated as part of the data reduction process (Lampton et al. 1993). These include shuttle attitude control thruster firings, twilight, nightglow, auroras, and South Atlantic Anomaly passages. Our photon-counting, time-resolved data system makes it possible to eliminate these time-dependent backgrounds.

We scanned the resulting images for point sources and found over 4,800 above 3σ. Most of these were below the threshold of the all-sky ultraviolet survey made by the TD1 satellite (Gondhalekar et al. 1980). Where there was overlap between FAUST and TD1 sources, we discovered a significant discrepancy between the fluxes measured by each instrument. Since no such discrepancy was present in a similar comparison between FAUST and IUE, we have concluded that the TD1 fluxes have a larger error than has been published. (For a complete discussion, see Bowyer et al. [1993]).

A detailed study of the far ultraviolet (FUV) stellar population in the area of the North Galactic Pole is underway (Brosch et al. 1993). This work compares the number of stars seen as a function of magnitude with the model of Brosch (1991). Preliminary results are that more FUV stars are present in the image than are predicted by this model, yielding intriguing options as to the identity of these sources.

3. Measurements of the Diffuse FUV Sky

An important component of the FAUST observational program was to measure diffuse astrophysical sources. Topics include measuring the diffuse ultraviolet glow at many different galactic locations as a tracer of interstellar dust and the UV radiation field, mapping dense regions in the interstellar medium (ISM), and measuring the extragalactic background ultraviolet light. Additionally, FAUST made downlooking observations of Earth's nightglow (described in Chakrabarti et al. 1993). In Fig. 1, we show the FAUST image of the Ophiucus region, one of the densest parts of the ISM. This image shows clearly variations in the diffuse emission, as well as a number of point sources (in fact, we have identified more than 300 stars in this field.

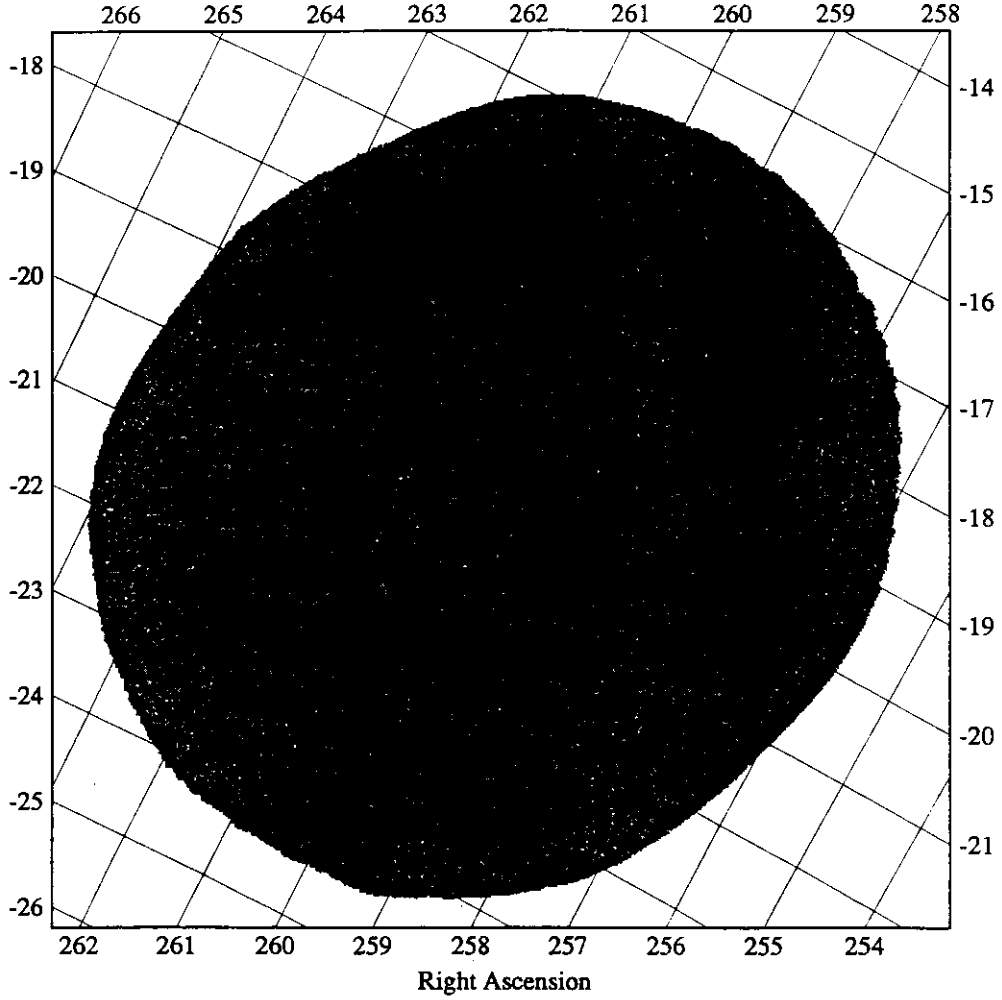

Figure 1. FAUST image of Ophiucus, with coordinate grid (in degrees) superimposed. Obscuration of starlight is clearly visible, caused by dust and gas in this region.

From our studies of the nightglow and a careful comparison with other measurements of the UV astronomical background (Hurwitz et al. 1991; Bowyer et al. 1991), we have concluded that FAUST measures a higher baseline level of UV diffuse flux than previous measurements. We show in Fig. 2 FAUST measurements of the diffuse background as a function of atomic hydrogen column. Also plotted are the measurements of Hurwitz et al. (1991). These data show factor of 2-3 difference between the two measurements. One of the clues to the origin of this excess emission comes from FAUST's operation during a period of high solar activity compared to some of the earlier measurements. We attribute the excess flux seen in the FAUST images to recombination emission from atomic oxygen, which has emission lines within our bandpass. The presence of this emission in our images makes absolute flux measurements uncertain but does not preclude differential measurements within an image.

4. Conclusions

In summary, the wide-field images made with the FAUST camera have provided sensitive measurements in the far ultraviolet of diffuse and point sources. Stellar observations sample a substantially different population of stars than are seen at optical wavelengths, and present a new window towards complete galactic population studies. Studies are underway of the diffuse emissions measured by FAUST. These sensitive diffuse observations are complicated by the presence of nightside airglow from the upper atmosphere.

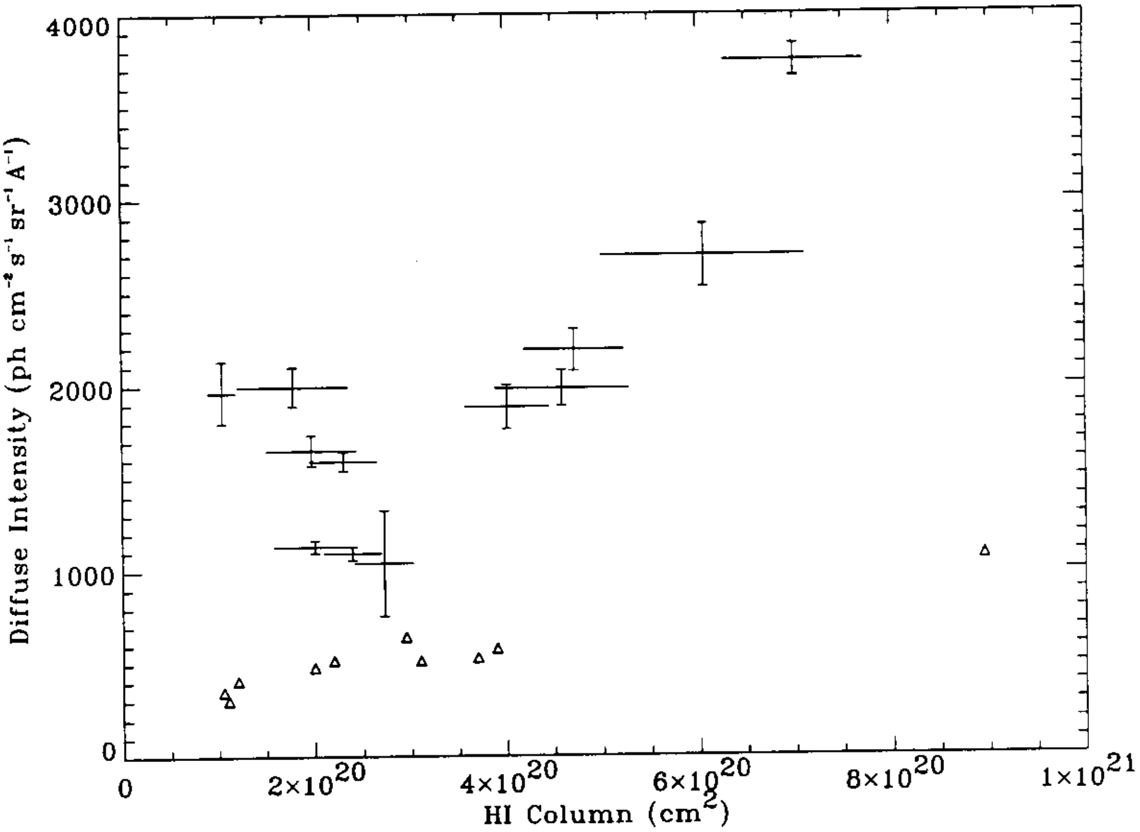

Figure 2. Diffuse intensity measured by FAUST vs. HI column. The bars show standard deviation of variation of column and diffuse intensity over field of view. Triangles are measurements of Hurwitz et al. (1991). FAUST measurements are higher because of residual airglow in images.

Acknowledgements

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A CCD-based Sky Patrol

On December 11 1992 an informal meeting about 'A European Large Wide-field Telescope' took place, chaired by R. West, at the Garching ESO Headquarters (see page 41 of this Newsletter). During the meeting we mentioned briefly the past and recent activities of the Sonneberg Sky Patrol and the need for a modern CCD-based patrol which monitored the whole sky. Through this Newsletter we would like to introduce the concept of an international joint project and to invite discussion.

1. Definition of Sky Patrol

In the last Newsletter (MacGillivray 1992), West gave a short overview about sky surveys and patrols. To make clear what we mean by 'sky patrol' let us first give our own definition:
A sky patrol aims to record, as often as possible, all the sky that is visible from an observing site down to a certain magnitude in one or more optical or near-optical wavelength regions.

This definition emphasises the contrast to a sky survey, which aims to cover the full sky once or twice and goes very deep, is carried out at high resolution, and may also be multi-coloured. Sky patrols cannot go so deep because of the time needed to cover the sky and on account of the huge amount of data produced. "As often as possible" means every clear night or even shorter up to about once a month. In a sense a sky patrol can be seen as a sequence of regularly performed sky surveys. Multi-coloured sky patrols are desirable but hardly feasible because it would entail an increase of the data bank and the number of cameras needed, or a decrease in the frequency of monitoring.

2. Sky Patrols Past and Present

A sky patrol — like any scientific observational programme — aims at a particular field of interest. This includes objects with more or less rapid changes, mainly variable stars in general (variable in magnitude) and solar-system objects like comets and asteroids (variable in position and magnitude).

From Tsvetkov's article (Tsvetkov 1992) concerning wide-field plate archives, it appears that most sky patrols began in the first decades of this century. The largest archives based on an extended sky patrol are the Harvard Collection, going back to 1889, and the Sonneberg Plate Archive, to 1926.

Both patrols aimed to monitor the behaviour of variable stars, which was a focal point of research in astronomy in the first half of the century. During the last decades the emphasis of interest obviously shifted to extragalactic topics and to the investigation of particular stars, and sky patrols were relegated to second place or lower. That trend was responsible for the cessation of the sky patrol at Harvard 30 years ago, and for stopping the sky patrol at Boyden Station (managed from Bamberg Observatory) 20 years ago, and now politicians are considering closing the Sonneberg Sky Patrol in 1995.

Although the initial motive for establishing each sky patrol was a specific scientific project, the databases are now used for other purposes too. Not only can several tens of thousands of variable stars be investigated through a long-lived archive, but so too can objects which became popular only during recent years. This archival material is the only testimony to the behaviour of those objects in the past. Moreover, the longer a sky patrol has worked, the more and better results can be expected through the archive, and the more its value increases. Nobody knows what kinds of new objects will be discovered in the present photographic archives if they were digitised and processed by modern techniques. It is quite clear that, because of the lack of manpower and computers in the past, little more than 1% of the information stored in these archives has probably been investigated in the sort of detail that it deserves. So far, only the somewhat conspicuous events have been recognized on the plates. A *systematic* search for variables, comets and asteroids can only be carried out when the plates have been digitized. Today we may not have more manpower, but we do have computers to do the work.

This (incomplete) sketch of past and recent sky patrols demonstrates that they may be useful for different scientific purposes but that only homogeneous and long-lasting recording over the years can guarantee results. One should also bear in mind that several famous objects (e.g.HZ Her = Her-X1, BL Lac), which currently are targets of multi-wavelength and high-resolution observations as well as test-cases of modern physical theories, were not discovered by accident but through systematic searches of variable objects on sky-patrol data.

The only sky patrol currently working on a large extension is obviously that at Sonneberg. Despite its threatened closure but fighting for a reprieve, the sky patrol will be continued in photographic mode until at least the end of 1994. The patrol equipment, consisting of 14 cameras on two mountings, has already been in service in its current state for more than 40 years, so the homogeneity of the archived plates is guaranteed (see Bräuer & Fuhrmann 1992). Photographic plates are indisputably very advantageous in the case of wide-field imaging (see West 1992). But we feel that CCD-based methods must now be brought in. The pros and cons of CCDs and photographic plates have often been discussed in this Newsletter, and we do not have enough experience with CCDs to want to add anything here to that dispute. Nevertheless, we are convinced that sooner or later the electronic sensor will dominate in this field.

However, the envisaged take-over by CCDs raises the problem of homogeneity. The photographic plate as a logarithmic detector allows the recording of bright stars as well as faint ones. In the case of the Sonneberg patrol that implies an interval of more than ten magnitudes. Such a dynamic range (10^4 or more) is hard to cover with CCDs. One might be tempted to try to avoid the brighter stars; however, having got records of bright stars since the turn of the century, we should not now make the mistake of ending such a unique string of observations. On the other hand, the limiting magnitude of the Sonneberg Sky Patrol is only about 14^m in B (photographic magnitude) or 13^m in V (photo-visual magnitude), which is not sufficient for many important objects nowadays. It is therefore desirable to go to deeper magnitudes.

3. Scientific Justification of a CCD-based Sky Patrol

The detailed aims of a CCD-based sky patrol depend on the instrumentation in question. The deeper the patrol goes the more stars can be studied, but the frequency of monitoring decreases. A patrol cannot therefore serve all purposes simultaneously, and one has either to make a specific choice or to strike a happy medium.

In general we see two main branches of output:

1. *Recording of new events*: Novae, supernovae and CV outbursts, comets and asteroids (also NEAs),
2. *Monitoring of known objects* like variables in general, AGNs and solar-system objects.

More precisely, we envisage the following main targets of investigation:

1. Variable stars in general
    - *Cataclysmic Variables*: Long-term light curves; monitoring the duration and shapes of outburst and quiescence phases; studies of superhump phenomena; discovering new CVs (important because of the small probability of success) (see e.g. Canizzo et al. 1992).
    - *Novae*: Monitoring the sky for new novae down to 20^m or more. This would lead to a comprehensive picture of the real frequency of novae in our galaxy. Early discovery of nova outbursts gives a unique opportunity to study the prenova and initial rise. Lots of objects which are going to become novae could be studied before outburst on the basis of the archive.
    - *X-ray binaries*: Study of Polars and HZ Her stars, particularly the different active and inactive states in the light curve; coincidence with X-ray satellite observations; observation of X-ray burster counterparts.
    - *T Tauri stars*: Investigation of the long-term behaviour; quasi-periodic oscillations and quiescence phases; studies of colour-index variations (see Attridge 1992; Bouvier & Bertout 1989; Bouvier 1990).
    - *Flare stars*: Most outbursts of flare stars probably remain unobserved. A systematic sky patrol promises to yield unsurpassed statistics of flare events all over the sky.
    - *Multi-mode Pulsating Variables*: some RR Lyrae and δ Cephei stars exhibit multi-mode pulsations, a phenomenon that is not well understood. Detecting new stars showing that behaviour would be particularly important.
    - *Pulsating Variables with short periods*: Owing to the duration of about 20 – 60 minutes for a typical photographic exposure, stars with periods less than 3 hours tend not to get discovered through photographic patrols. The shorter exposure times with CCDs of a few minutes offer a better time resolution and therefore a higher probability of discovering this type of variable.
    - *Eclipsing binaries*: Studies of periods changing over long time-scales; searches for binaries with changing amplitude and conspicuous period changes as indicators of a third component or of mass exchange (see Azimov et al 1991; Fried, 1991; Lehmann, 1991; Mayer, 1990).

2. AGNs.
    - Long-term light curves are known of only a few objects. A patrol down to 20^m offers the possibility of investigating several hundreds or thousands of Markarian Galaxies, BL-Lacs, Quasars and related objects (see Carini et al 1990, 1991, 1992; Webb 1991).

3. Solar-system objects.
    - *Comets*: Early discovery, rediscovery and detection of faint comets.
    - *Near-Earth Asteroids*: Because of the rapid angular motion and the faint light of these objects, these are difficult to observe. But owing to the extensive data bases, NEAs may also be observed coincidentally.
    - *Saturn Trojans*: These objects, if they exist, may well be detected by chance.

- *Chiron-like objects and far asteroids/comets*: In view of the recent discoveries of 1992 AD and 1992 QB1, there are grounds for believing that more of these objects could be found.

4. Counterparts of Satellite Events.
   - Current satellite[1] events (variable sources, transient events) whose true nature remains a mystery are of great interest for parallel optical investigations (see Cheng Ho et al. 1992; Paciesas et al. 1992).

4. Instrumentation

The choice of instrumentation depends upon the projects for which the sky patrol is intended. The crucial quantities are the limiting magnitude and the total area of sky which has to be covered each night. The latter, plus the angular resolution, determines the frequency of monitoring.

We now give a rough estimation of the size, focal length and aperture of each instrument and the corresponding exposure times and number of cameras.

Let us define the following quantities:

m_C	limiting magnitude (for colour C)
$n(m)$	total number of stars per square degree down to magnitude m
$\Delta''(m)$, $\Delta_{px}(m)$	averaged distance of stars in arcsec and pixels, respectively
s	sampling (angular diameter mapped to one pixel)
n_{CCD}	CCD-size in pixels
p_{CCD}	linear size of one pixel
$l_{CCD} = p_{CCD} \times n_{CCD}$	linear size of the CCD-array
s_C	CCD sensitivity in given colour C
$d = s \times n_{CCD}$	fieldsize
D	aperture
f	focal length
$r = f/D$	focal ratio
n_c	number of cameras
t	exposure time
f_P	frequency of the patrol
Ω_N	number of square degrees seen from one site at night
Ω_O	square degrees to be covered when overlap included
T_N	length of the night

Starting with the limit magnitude m_C we can approximate the number of stars per square degree at 0° galactic latitude by[2]

$$n(m)=10^{(-3.89+0.544m_c-0.006m_C^2)} \qquad (1)$$

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[1] e.g. ROSAT, GRO

[2] This relation is derived from a table in Scheffler/Elsässer (1965) by simple quadratic approximation. We also assume that this number is independent of colour.

For uniformly distributed stars this yields in an averaged distance between them

$$\Delta''(m)=\frac{3600''}{\sqrt{n(m)}} \tag{2}$$

The sampling s needed to resolve (uniformly) crowded fields is related to this distance and to the crucial quantity Δ_{px}, which represents the distance between neighbouring stars in pixels:

$$s[''/px]=\frac{\Delta''}{\Delta_{px}}=\frac{3600}{\Delta_{px}10^{(-1.94+0.272m_C-0.003m_c^2)}} \tag{3}$$

Figure 1 shows this relation for $\Delta_{px}=\{3, 5, 10, 20, 50\}$. It gives the sampling s as a function of m for different Δ_{px}. It can also be read as the resulting difference Δ_{px} between neighbouring stars for a chosen sampling and limiting magnitude.

For the instrument we obtain from the sampling s and pixel size p_{CCD} its focal length (in m)

$$f[m]=0.21\frac{p_{CCD}[\mu m/px]}{s[''/px]}=f(m_C,p_{CCD},\Delta_{px}) \tag{4}$$

Because the data will mainly be used for photometry and only approximate positional information (in contrast to high angular resolution frames) a focal ratio between 3.5 and 5 would be convenient. So the aperture D is given by $D = f/r$, which means in practice that the telescope's optical design (f, D) is determined by the limiting magnitude to be reached. Figures 2 and 3 show focal length and aperture (for $r = 4$) as functions of m for different distances Δ_{px}. The horizontal lines indicate the respective sampling, where p_{CCD} is set to 15 µm.

An additional relation between aperture and limiting magnitude is given via the exposure time t and CCD sensitivity s_C (the integrated sensitivity over the colour range including absorption by filters):

$$m_C=m_0+2.5\log(D^2[m]t[min]s_C) \tag{5}$$

where m_0 is about 20. Together with equations (3) and (4), this yields an exposure time given by

$$t[min]=\frac{1}{D^2s_C}10^{0.4(m_C-m_0)}$$

$$=22.7\frac{r^2s^2}{s_C\,p_{CCD}}10^{0.4(m_C-m_0)}$$

$$=2.3\times10^4\frac{r^2}{s_C\,p_{CCD}^2\,\Delta_{px}^2}10^{(-0.144m_C+0.006m_C^2)} \tag{6}$$

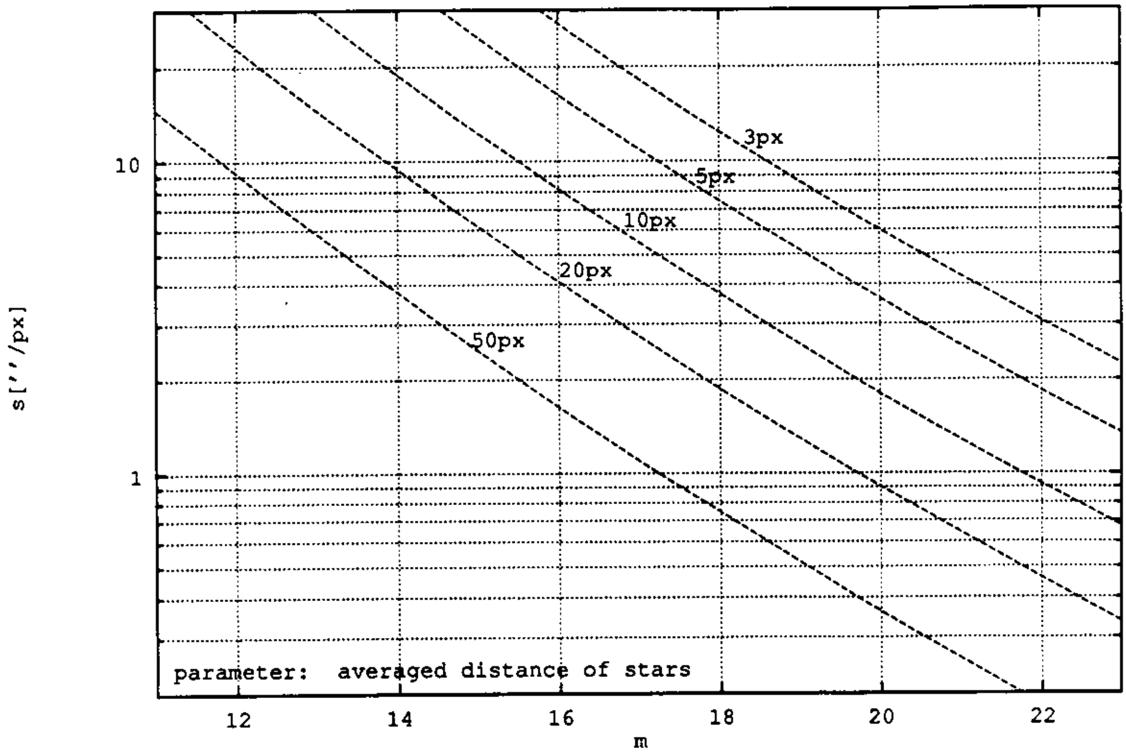

Figure 1. Sampling $s[''/px]$ as a function of limiting magnitude m for different distances of stars.

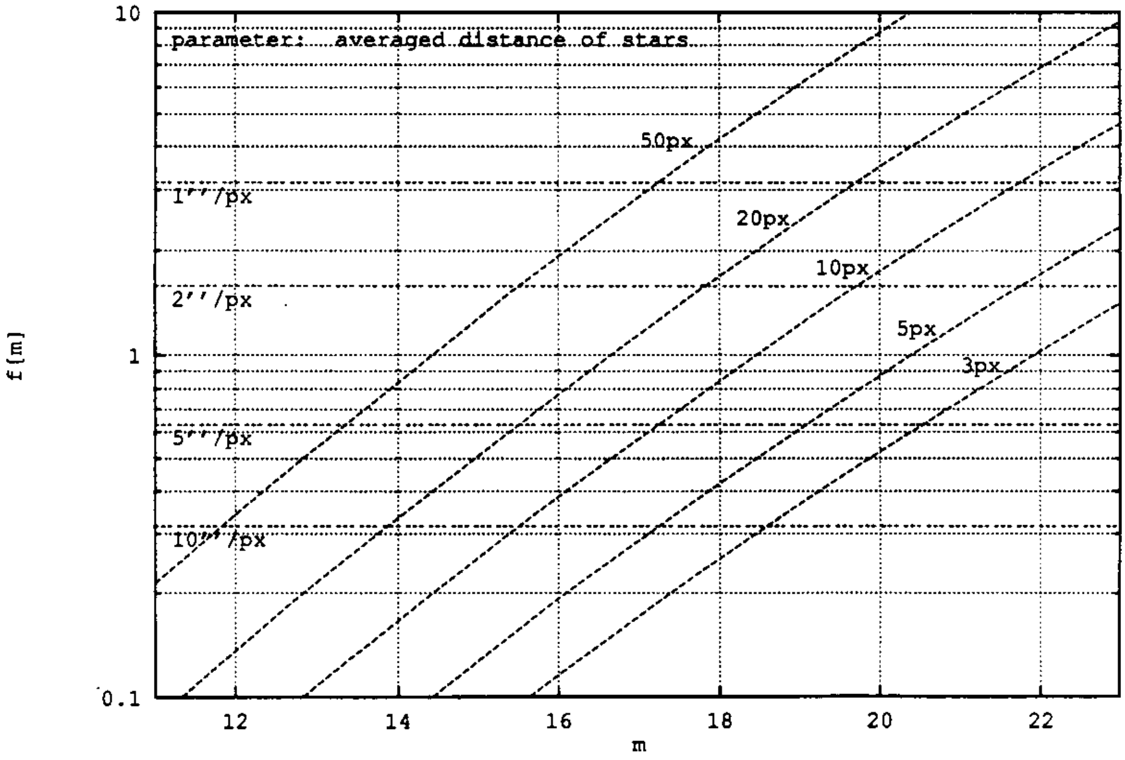

Figure 2. Focal length $f[m]$ as a function of limiting magnitude m. The sloping lines show the relation for different distances Δ_{px}, and the horizontal lines indicate different samplings s.

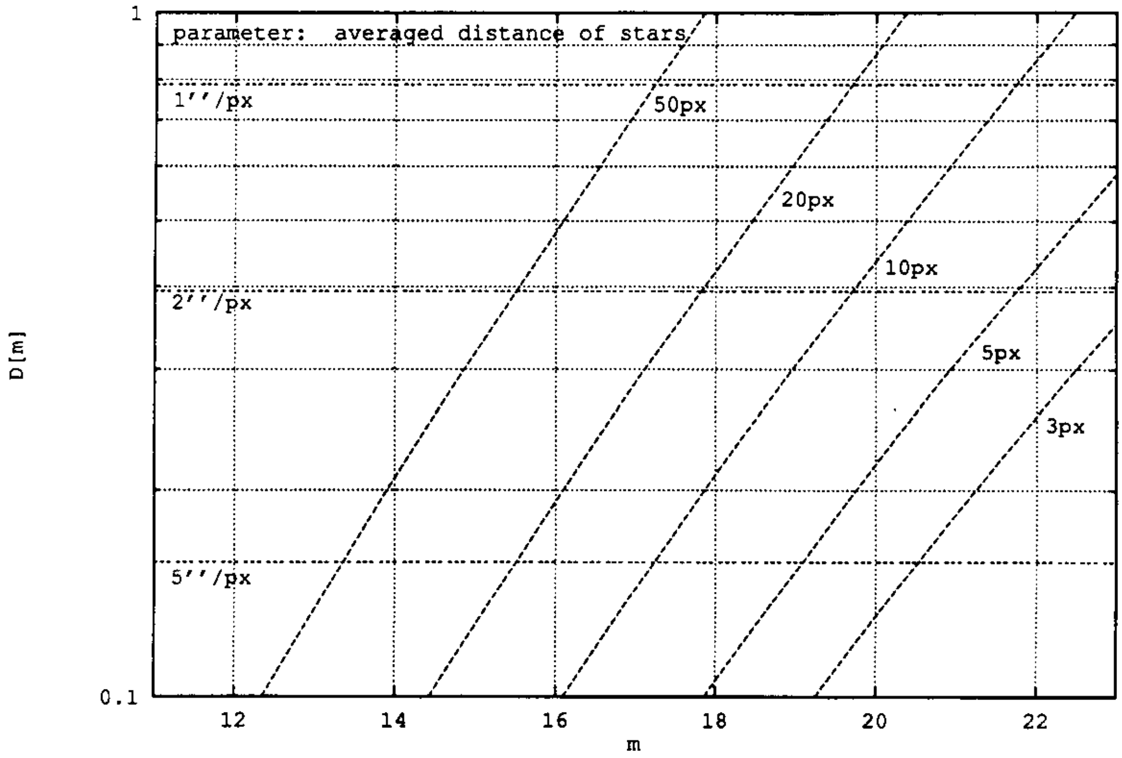

Figure 3. Aperture $D[m]$ as a function of limiting magnitude m for fixed focal ratio $r = 4$. The sloping lines show the relation for different distances Δ_{px}, and the horizontal lines indicate different samplings s.

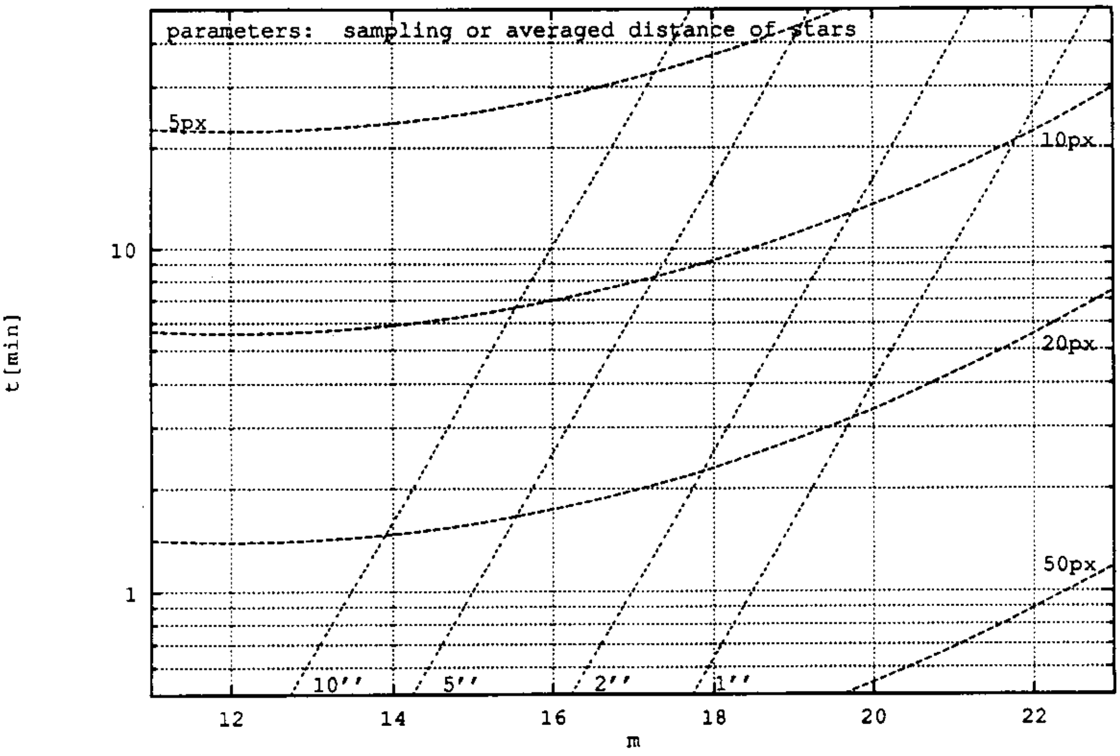

Figure 4. Exposure time $t[min]$ as a function of the limiting magnitude m for different distances Δ_{px} (curved lines) and different samplings s (sloping lines).

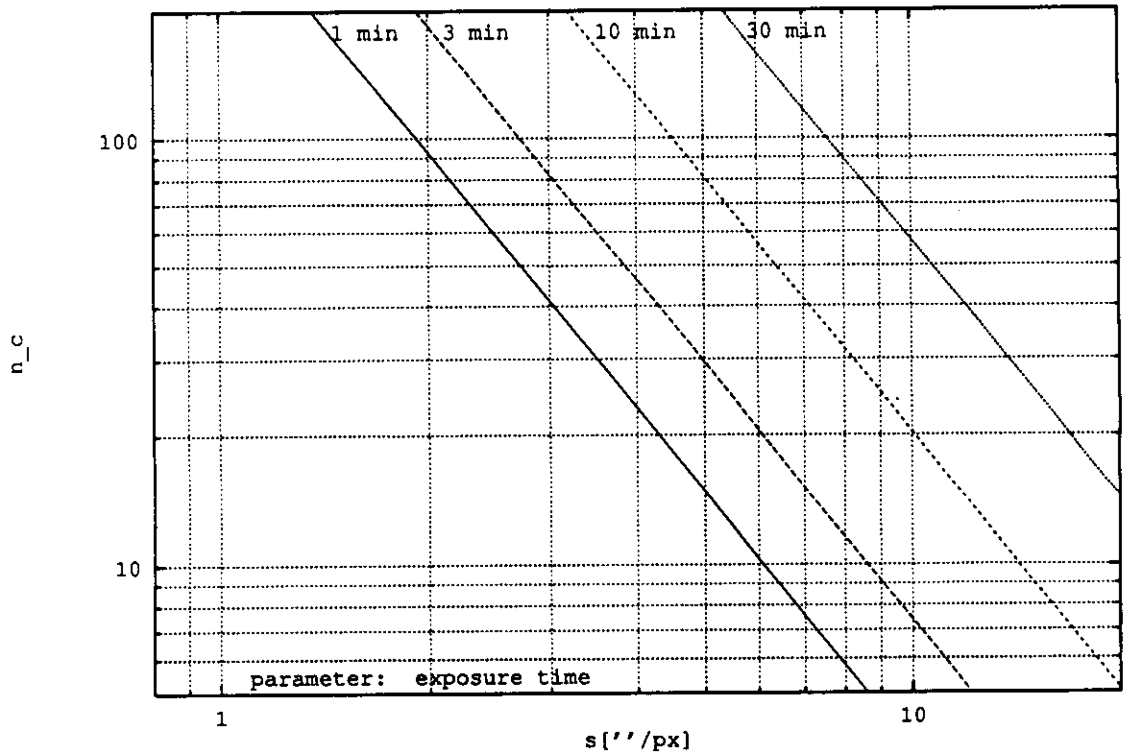

Figure 5. Number of cameras n_c for a patrol frequency of one per night as a function of the sampling s for different exposure times t. The read-out time t_r is taken to be 1 min. and the CCD array is assumed to have 2048 x 2048 pixels.

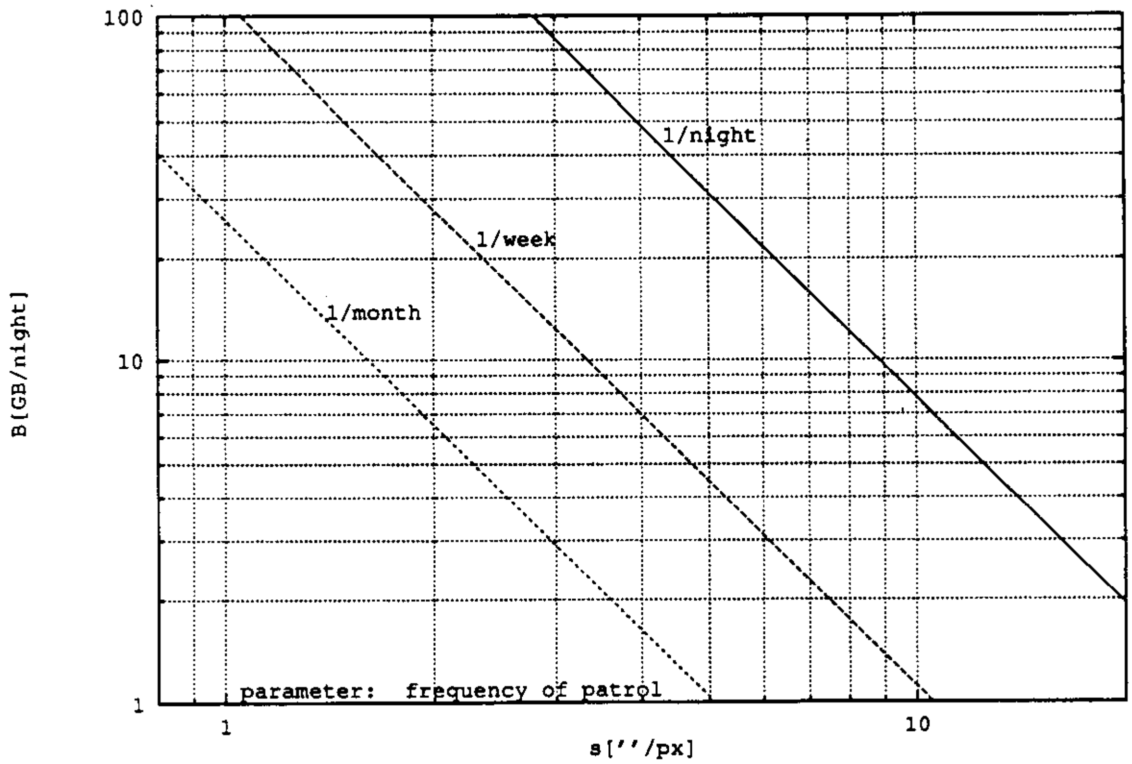

Figure 6. Data in Gbytes produced per night as a function of sampling s for different frequencies f_p of the patrol.

We have plotted the exposure time in Fig. 4 as a function of limiting magnitude for different distances Δ_{px} (curved lines) or different samplings s (sloping lines). The sensitivity and the focal ratio are assumed to be 40% and 4, respectively. One may be surprised to find that the larger the sampling, the longer is the exposure time, but that results from the telescope design being fixed by limiting magnitude and focal ratio.

The area of night sky which can be seen from one sight, Ω_N, depends on the geographic latitude and the length of the night, T_N. We estimate those quantities as 25,000 □° and 500 minutes, respectively. If the cameras operate a field-by-field coverage we have to take into account the overlap, which may be 10% – 20%. This yields an effective sky size, Ω_O, of about 30,000 □°. Each camera covers d^2 square degree. In addition, we must take into account the read-out time t_r which is relevant for small exposure times, i.e. the total time for taking one exposure is $t + t_r$. We then obtain the following total of cameras:

$$n_c = f_P \frac{\Omega_O}{d^2} \frac{(t+t_r)}{T_N} = 60 f_P \frac{(t+t_r)[min]}{d^2[\square^{\circ}]} = 7.8\times10^8 f_P \frac{(t+t_r)[min]}{(s[{}''/px])^2 n_{CCD}^2} \tag{7}$$

A graphical representation is given in Fig. 5, where we have set $n_{CCD} = 2048$ and $t_r = 1$ min. For a patrol frequency of one per night, it shows the number of cameras as a function of the sampling for different exposure times. One should notice that for larger CCDs the number of cameras decreases significantly.

5. Data Processing

An important consideration concerns the processing of the huge amount of information produced every night. In fact, the total of data per night, B, depends on the sampling s and the effective size of sky, Ω_O, giving the number of individual pixels to cover the sky. Taking into account the data depth b in bytes and f_P, we obtain

$$B[GB] = 0.013 f_P\, b \frac{\Omega_O[\square^{\circ}]}{s^2[\square'/px]} = 390 \frac{f_P\, b}{s^2[\square'/px]} \tag{8}$$

This relation is plotted in Fig. 6, where the data (in Gbytes) are shown as a function of the sampling for different frequencies f_P = {1/night, 1/week, 1/month}. b is assumed to be 2 bytes.

Owing to the size of the data bank, the processing represents an essential part of the project. Here we hope to learn from the LITE project how to deal with several Gbytes per night. Since a main goal of a sky patrol is the discovery of new objects and conspicuous events, the data have be to preprocessed immediately after each exposure. Fast computers and convenient detection algorithms are therefore required.

For archiving one should use some sort of compression algorithm, thus decreasing considerably the amount of bytes needed to be stored. However, since we can expect it to take several years until this project is realised, it should not represent a serious problem to store several Gbytes daily on a stable and reliable medium.

6. Proposal for an Actual System

The above study of the instrumentation of a sky patrol leads now to a proposal for a real specification. The system as a whole should consists of two components: *Low Resolution Sky Patrol* (LRSP) down to 16^m once per night and *Deep Sky Patrol* (DSP) down to 20^m which covers the total sky once per month.

The following table shows the essential quantities of both components. We have chosen the pixel size to be 15 μm, the CCD size to be 2048 x 2048 and the read-out time to be 1 min.

	Low Resolution Sky Patrol	**Deep Sky Patrol**
limiting magnitude	16^m	20^m
number of stars per □°	1,900	38,900
Δ″	83″	18″
sampling	5″/*px*	2″/*px*
Δ_{px}	17	9
field size	2.°8	1.°1
focal length	0.6 m	1.6 m
aperture (r = 4)	0.15 m	0.4 m
exposure time	3 min	16 min
frequency of patrol	1/night	1/month
number of cameras	30	26
data per night	31 GB	6 GB

This rough estimation only considers one colour, and each field is only taken once per cycle. To achieve more reliable results (e.g. detection of cosmic-ray events and other artifacts) simultaneous observations might be more effective. That would either increase the number of cameras or decrease the frequency. Observations in at least two colours (B and V, with respect to CCDs sensitivity) would also be very advantageous. In the case of the LRSP, with double the number of cameras each field could be taken simultaneously in different colours.

Doubling the cameras seems to be ruled out for the DSP, although observations in two colours would be interesting too. Observing the sky down to 20^m once per month is excellent for a long-term archive. But the low frequency has the disadvantage that moderately fast-moving objects (too slow to yield a trace on a single exposure) might not be detected. That suggests that one should tune the mode of operation so that the same field is taken again one or more nights later. The decision about how to operate the DSP depends critically upon the particular aims, and it will not be easy to find that happy medium.

Although the DSP goes only 4 mag deeper and its frequency is one thirtieth of that of the LRSP, the differences in instrumentation are rather considerable. While one or several mountings with a total of 30 small cameras is relatively easy to build, it might be much harder to find funding for a battery of 26 medium-sized telescopes. However, the cost of the CCDs would be comparable, and that part of the project may consume most of the money. In addition, because the LRSP produces more than 30 Gbytes per night, the processing of that amount of data therefore requires more computer power than the DSP. It is therefore probable that the total costs, including staffing and operating costs, will be similar for both components.

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LITE: the Large Imaging Telescope

Abstract

We describe a new German–French project aimed at a very deep CCD survey in the southern hemisphere. It is based on a 2.5 m class telescope with a field of 1.5 degrees or more, dedicated to high-resolution, deep CCD imaging. This telescope is intended to become a complement to the ESO VLT and to be installed in the Paranal area. The operations should start in 1999.

It was realized very early in the development of the ESO 16-metre equivalent Very Large Telescope (VLT) that wide-field imaging is too complicated and costly to implement on the VLT itself and should be done with a smaller telescope.

Accompanying imaging observations are essential for the optimal use of the VLT. Let's take an example. For large scale structure studies, the VLT allows the measurement of redshifts in a 30 arcmin field-of-view of galaxies of magnitude 23 or even fainter. They are too faint to be reliably detected on Schmidt plates, so the input observation catalog must be obtained from deep CCD imaging. In this example, outstanding image quality is needed to make a clear separation between faint galaxies and stars. The best compromise for obtaining such images is a middle size telescope of about 2.5 m diameter and equipped with a wide field CCD camera.

These considerations have led the French astronomical community to propose the construction of such a special telescope. The definition of this project, now referred to as the Large Imaging Telescope (LITE), started in Spring 1992 with the establishment of a consortium of several French laboratories, including Observatoire de Meudon, Institut d'Astrophysique de Paris, Observatoire Midi Pyrénées, Observatoire de Besançon, Observatoire de Marseille, and led by the Department of Astrophysics and Particle Physics in Saclay. At the same time, a German group from Sonneberg Observatory, Tautenburg Observatory and the Institute of Astrophysics in Potsdam were working on a project of a second generation Schmidt telescope to pursue the type of research which has long been done at these institutes. Richard West and Ray Wilson of ESO, who were aware of both projects, acted as the go-betweens of the two groups who, in a meeting held at the ESO Headquarters in Garching in December 1992, decided to join their efforts. The telescope is the responsibility of the German group, while the CCD camera and its acquisition system will be designed and constructed in France.

While this project was originally designed for observations of mainly cosmological interest, it has the technical capability to cover a much broader range of astrophysical problems. The consortium is now working on several programs, e.g.:

1) galactic structure and low mass star luminosity function and proper motion on a 10 year time scale;
2) study of variable stars;
3) properties of nearby galaxies;
4) luminosity function and morphology-density relation of galaxies;
5) survey of emission line galaxies and quasars;
6) large scale structures combined with redshift measurements with the VLT;
7) gravitational lensing effect due to dark matter distribution on very large scale;
8) very deep multicolor survey to study galaxy evolution on cosmological time scale;
9) detection of supernovae up to $z = 0.5$;
10) a second generation experiment for detection of brown dwarfs by micro-lensing effects on stars in the Magellanic Clouds.

Three types of observational programmes are envisaged:

1) a multicolour astrometric and photometric survey in individual fields selected according to Galactic structure and stellar program;
2) a multicolour and slitless, low resolution spectroscopical survey of typically 100 square degrees for cosmological observations and supernova research;
3) observations in front of the Magellanic Clouds for detection of brown dwarfs.

All of these programmes require very good image quality.

The scientific requirements call for LITE being a telescope of 2.5 m diameter with a mean image quality, including seeing, of 0.8 arcsec (or better) over a field of 1.5 degrees (or more). This can only be achieved with good sampling of the image PSF by the CCDs. For a typical pixel pitch of 15 microns, 0.3 arcsec pixels are achieved with 10 m focal length; this corresponds to an f/4 aperture ratio. We first designed a quasi Ritchey–Chrétien system with a Gascoigne corrector, but we have finally adopted a new optical concept worked out at the Tautenburg Observatory, with the assistance of Ray Wilson from ESO. It is a modified version of the 3 mirror Paul-Baker telescope which provides a plane focal surface at the 'prime focus' location, behind the secondary mirror. A preliminary design study has shown that for a telescope with 2.5 m diameter and focal ratio f/4, and image quality of 0.4 arcsec can be obtained at the edge of a 2.5 degree field, and significantly better towards the centre. Compared to the initial Cassegrain solution, this design has two important advantages, the absence of chromatic aberrations because there are only reflecting mirrors, and a very easy baffling system to suppress stray light.

As a baseline, the CCD camera will be organized around thin, back–side illuminated Thomson CCDs, each with 2048 x 2048 pixels and 15 micron length. These CCDs are being developed for the VLT, and the thick version should become available in 1993 and the thin one in 1994. The three-side buttability allows to make strips of 2 CCD width. A 1 square degree surface can be covered with 36 CCDs. Readout time of the whole array will be as low as 30 seconds, thanks to a parallel acquisition system. Cryogenic temperatures will be provided by a closed cycle cooler in order to simplify the operations.

The natural site for this telescope is near the VLT, in the Paranal area, where it may take advantage of the excellent seeing and the large number of photometric nights as compared to the other Chilean sites. Discussions will take place with ESO to study this possibility.

The definition phase of the project will be undertaken in 1993. We must still settle the details of the German-French collaboration, work out the relationships between the consortium and ESO, and obtain the funding. The actual start of the project is expected in 1994 and the beginning of the observations in 1999. In the present status of the project, nothing has been absolutely fixed and new groups are welcome to join. If you are interested, please do not hesitate to contact us. We expect to make a first presentation of the project at the IAU Symposium in Potsdam in August.

Projects similar to ours are under development, in particular the Sloan Digital Sky Survey (SDSS) in the USA. We wish to emphasize the differences between our project and the SDSS. The main goal of the SDSS is to make a survey over a large fraction of the entire sky ($\sim \pi$ steradian), both in photometry and in spectroscopy, and with the same telescope. However, the use of the SDSS 2.5 m telescope for spectroscopic measurements will naturally limit the observations to moderately faint galaxies only. The necessity of the all sky survey pushes towards the largest possible field, but at the detriment of image quality, and to a transit instrument which simplifies the operations.

In our case, the spectroscopic observations are planned with the much larger VLT, which, of course, can reach much deeper. Due to the increasing number of objects at fainter magnitudes, we cannot expect to cover a large fraction of the sky. On the contrary, we shall only be able to obtain images significantly deeper than the SDSS by limiting the sky coverage. For LITE, the priority of optimization is then image quality first, and field-of-view second. In addition, the pointing mode of operation is more suitable for very deep imaging than a transit mode. While many scientific areas are common to both instruments, the trade-offs are different, and the scientific programmes will be different too.

We believe that the combination of the VLT and LITE will offer a unique capability of probing the deep sky and will become a prominent instrument for future cosmological studies.

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Linking the Sonneberg Field Patrol to Project LITE[3]

1. Introduction

A quarter of a century ago, a paper was published with the title 'Structure of the Galaxy Investigated by Means of the Variable Stars of the Sonneberg Field Patrol' (Richter 1968; Bräuer & Fuhrmann 1992). The time is ripe: like the Prince who breaks the spell on Sleeping Beauty, LITE with its European wide-field telescope of the 2.5 m class can revive the issue at stake in that paper.

Variable stars are clearly defined groups of objects, easy to recognize and with well-determined properties, such as mass, luminosity, spectral type, age, population membership and metallicity, which are correlated with kinematic and dynamic characteristics. Because of those qualities, variable stars are particularly suitable for studying the structure and evolution of the Galaxy. Work on galactic structure by means of variable stars was carried out by Payne-Gaposchkin, Kukarkin, Parenago, Sherwood and Plaut in their classical papers (Payne-Gaposchkin 1954; Kukarkin 1949; Kukarkin & Parenago 1963; Plaut 1965; Sherwood & Plaut 1975), by Richter (1968) in Sonneberg and by others (see Ch. 7 in Hoffmeister et al. [1984]).

The Sonneberg Field Patrol (SFP) is a photographic programme brought into being by Cuno Hoffmeister in 1923 with the aim of discovering and classifying variable stars in 41 fields of 100 square degrees each and with a limiting magnitude of 17.5 – 18 pg, in order to collect a homogeneous sample for statistical use (Hoffmeister 1938) (see also Richter 1992). Field size and limiting magnitude are mutually dependent; on the one hand, since bright objects are rare, it is obvious that a large area must be covered in order to obtain a statistical sample of a useable size, while on the other hand the limiting magnitude must not be too faint lest the area density should be too high and the star images overlap.

Now at first sight the LITE telescope with its field of 1 degree (or little more) and limiting magnitude of 26 would seem to be of little use for such statistical studies. But the situation is not quite what it seems. The increase in surface density (i.e. the concentration of stars on the globe) will grow with magnitude in geometric progression only as long as the spatial density remains constant. In reality, owing to the finiteness of the Galaxy the size of that increment generally goes down as the

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[3] The Large Imaging Telescope, a joint project..., October 23, 1992 (Draft Edition)

magnifying power goes up. The remaining increase in surface density is offset by the resolving power of the telescope, and at the same time — together with the gain in volume due to deeper penetration into space — makes good the loss due to the smallness of the field of vision. (To be precise, the gain in surface density at first overcompensates the loss, but on reaching its maximum, which depends on the luminosity and concentration towards the galactic plane, falls off more or less abruptly). In that way LITE promises to be appropriate for resuming, on a higher level, the statistical investigation carried out at Sonneberg in 1968.

At high galactic latitude, stars fainter than 20th magnitude and brighter than $M_V = +4$ or $+6$ (depending on population) will only occur in small numbers. Thus, as early as 1966, Kinman et al. (1966) estimated that, at high galactic latitude and in the range between 18^m and 20^m, the number of RR Lyr stars per square degree is about 0.05 – 0.12. Therefore, beyond 20^m, the only variables to be found in larger numbers will be of low luminosity, that is, they will be variable white dwarfs, including dwarf novae ($M_V = +7 - +13$ in quiescent state) and flare stars. To detect objects of the latter type, the ten-minute exposures of LITE subproject 2.9 (2.9.2) will be sufficient.

In the opinion of Kinman et al. (1966) the galactic halo extends far beyond the Magellanic Clouds, that is, farther out than 50 kpc. Saha (1982) and Hawkins (1984, 1985) reported the existence of far-off RR Lyr stars. LITE will therefore contribute to the exploration of the whole system, Galaxy + Magellanic Clouds.

The present state of research will be described in Section 2, and in Section 3 we show how, without extra burden on its observational programme, LITE can help solve problems of variable star statistics and thereby shed new light on the structure of the Galaxy.

2. State of Research and the Sonneberg Results

The Sonneberg paper (Richter 1968) has the advantage that its analysis was made on the basis of a large homogeneous sample. It was preliminary, though, in that the astrograph then used (400/1600 mm, limiting magnitude 18 pg; in operation since 1935) was confiscated in 1945 (C. Hoffmeister called the day it happened "the blackest day of my life") and the work had to be based mainly on exposures made with a triplet lens 170/1200 mm of limiting magnitude 16.5 pg. The sample consisted of 2350 variable stars. The principal results published in that paper were numerical details on the spatial density (in galactocentric coordinates), total numbers of variables in the Galaxy, and duration of the states of variability for several subclasses of Miras, red irregulars and semiregulars, RV Tau, δ Cep, W Vir, and RR Lyr stars, novae, dwarf novae, and eclipsing binaries. In a recent book (Hoffmeister et al. 1984) Richter and Wenzel compared the results with those of other authors, whose material, however, was less homogeneous.

Of course the SFP cannot expect to provide the unique solution to every problem, particularly those concerning variables of faint luminosity, cataclysmic variables (CVs) in most cases. Flare stars, whose brightness variation is too rapid to be detected with much certainty on those old long-exposed Field Patrol Plates, are not included in the sample. Several interesting questions also remain unanswered. For instance, dwarf novae are a subclass of CVs; according to Richter (1968) there is a steep gradient of their concentration towards the galactic plane, which is typical of the disk population, but Kopylov (1957) finds that the gradient is small, which is typical of extreme population II. In addition, novae, which are also CVs, are encountered in the extreme halo of galaxies (Meinunger 1971), and that seems to favour Kopylov's findings. However, should Richter's values prove correct, one would have to infer that novae are a CV subclass that is completely different from the dwarf novae, a concept which would not be compatible with current CV models. As mentioned above, there is also uncertainty about the extreme extension of the galactic halo, where RR Lyr stars can be used as optical tracers. It is time to sound the charge and tackle such problems with new projects.

In the meantime, thousands of new variables of magnitude down to 17.5 pg have been detected on the plates in the Sonneberg vault (mostly by C. Hoffmeister; the number of fields monitored had been raised from 41 to 81). They are an excellent homogeneous sample from which to proceed as envisaged in the 1968 paper, and LITE now offers that unique opportunity of extending one of the targets of the SFP to objects down to magnitude 26 pg.

3. Sonneberg's Participation in LITE

Comfortably enough, obtaining the raw data necessary for our purposes does not require extension of the observational strategy as it was outlined in the LITE Draft Edition of October 1992, or of the parameters agreed upon by the informal meeting at the ESO headquarters in Garching on December 11 1992, save perhaps for a request to the technicians to make the field size as large as possible.

Our plans are as follows:

1. First of all, we hope to make use of the data expected from subproject **2.9 Searches for Supernovae at High Redshift (J. Rich)**, which will, as a by-product, register down to 23^m a large number of variable objects such as CVs and flare stars, and RR Lyr stars in the extreme halo in addition to supernovae. The RR Lyr stars should enable us to study the gravitational distortion of the shape of the halo by the Magellanic Clouds.

2. Further, to attack the same problem, we would like to make use of data to be obtained in subproject **2.3 Searches for Unseen Galactic Objects via Gravitational Microlensing (J. Rich)**. The search will uncover many new variables and, provided the number of observations is large enough, permit the determination of their types. These objects are likely to give a sample suitable for statistics.

3. Finally, by-products of subproject **2.8 Systematic Survey of Faint Stellar Objects with Emission Lines (G. Mathez, D. Kunth, P. Boissé)** will be about 120,000 low-resolution spectra of faint stars. Objects found to have particular spectra, if bright enough and appropriately situated in the sky, can then be investigated on SFP plates and Tautenburg Schmidt plates.

   The most promising candidates for observation on Sonneberg plates are the late K and M stars with H_α emission lines (dMe stars), or Balmer emission-line stars without He II emission lines (CVs with weak mass transfer, which are potential dwarf novae). In dMe stars or flare stars the variation in brightness may amount to 5^m, so they can become visible on Sonneberg astrographic plates at short exposures even if the brightness at quiescence is only about 20^m. Dwarf novae, which have eruption amplitudes of perhaps 5 or 8 or even more magnitudes, might become visible on Sonneberg plates even when they are, at quiescence, out of reach of LITE, though these will be rare cases; for example, the dwarf nova V 592 Her is 12^m at maximum light, but fainter than 22^m at minimum (Duerbeck 1992).

   CVs with clearly visible He II emission lines are objects either with strong mass exchange (postnovae, recurrent novae) or with column accretion (polars). They have only small brightness variations and may only be observed on Sonneberg astrographic plates if they are brighter than about 17.5 magnitude.

Of those three LITE subprojects, the one mentioned first (2.9 of J. Rich), appears to be the most suitable for linkage with the SFP on account of the limiting magnitude and the frequency of one observation per week. In each case, however, it will be worth arranging for as many fields as possible to lie within the Sonneberg fields, in order to achieve a smooth transition at least in some areas. This question will have to be solved by internal agreements with the authors of the subprojects.

Acknowledgements

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Scanning Activities at Sonneberg Observatory

Sonneberg Observatory operates the world's second largest archive of photographic plates, presently containing more than 240,000 (Bräuer & Fuhrmann 1992). Scanning them will be an essential part of future activities. Some tests have recently been carried out with a new dedicated CCD line-scanner (Bräuer & Kroll 1992). The scanner was developed in collaboration with the *Lehr- und Forschungsbereich Theoretische Astrophysik, Universität Tübingen* and has recently been lent to Sonneberg for several months. The device as a whole consists of the following components:

- base, plus lighting unit of 30 x 30 cm^2 working area with 3 high-frequency, colour-neutral, fluorescent daylight lamps;
- OPTOSCAN CCD line-camera with 5100 pixels, line movable on a carriage over 7200 steps. Data depth is presently 8 bits; 12 bits will be available shortly;
- UNIX-workstation of Silicon Graphics Inc. (IRIS 4D/20);
- software 'POLYSCAN' developed by SCIENCE+COMPUTING GmbH, Tübingen;

- exabyte Cassette Drive 8500 for permanent storage.

For more details, see Kroll & Neugebauer, 1993.

The scanning process takes about 3 minutes for a 5000 x 5000 pixel frame. For a typical plate of 12 x 12 cm^2 (Sky Patrol) or 30 x 30 cm^2 (Field Patrol) the scan of the whole plate with a resolution of 10 µm should take about 30 min (or 3.5 hours, respectively), yielding about 225 MB (or 1.3 Gbytes), uncompressed.

The main focus of interest at Sonneberg Observatory is the light variation of variable stars. Traditionally the plates were inspected visually using a simple microscope or a plate comparator. The experienced investigator manages to produce 300 estimations per day, so it would take 100,000 years for one 'manual' investigator to deal with the whole Sonneberg archive (assuming 50,000 star images per plate).

In automatic mode, one aims at a determination of the brightness of all the objects on the scanned frames. The necessary software was developed by Neugebauer (see Kroll & Neugebauer, 1993), and is based on an eight-parameter fit of a Gaussian distribution of density within an image. The logarithm of the volume within the Gaussian distribution constitutes a good measurement of magnitude, and the method yields a photometric accuracy of about $0.^m05 - 0.^m08$.

At present the scanner is employed for digitising the neighbourhood (object and comparison stars) of carefully chosen objects on all plates of a particular field (e.g. HZ Her on 746 plates, BL Lac on about 500 plates) to get long-term light curves.

Although we hope one day to digitise the whole plate archive the present scanner is not appropriate for such a purpose. A new device with 12-bit output, stabilised cold-light unit, moving table and a faster computer (IRIS Indigo 4000) may possibly be available after April 1993.

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Report from the Space Telescope Science Institute

1. Measuring Machine Modifications

The program of modifications to the ST ScI scanning microdensitometers, as reported in the previous Newsletter has continued. For the first of the two machines, all elements of the new servo system and the upgraded data-acquisition and control elements have been integrated, and systemic tuning is now in progress, with recommissioning planned for January, 1993. The same modifications will be installed in the second machine later this year.

In parallel with this work, a new set of optics has been prototyped and is being prepared for installation. The major features of this are laser illumination, which provides sufficient flux to permit short pixel times even at high densities, and which enables acousto-optic (AO) beam steering. The integrated light outside the main spot is below 10^{-4}, so that high photometric integrity is maintained. The AO deflector, driven from a linear function of the y-servo error, will remove residual 'chopping' due to y-servo unbalance introduced by irregularities in the ways, and it will also be stepped to provide multi-channel capabilities. These elements will be installed in the summer.

2. Scanning of Second Epoch Survey Plates

Scanning of both the POSS-II and SES plates has been continuing on one PDS while the modifications to the other have been in progress. The plates are being scanned as 23040 x 23040 rasters with 15-micron (1.0 arcsec) pixels; about a hundred plates were scanned in 1992. Production rates will increase as the modified machine is commissioned and then again when the multichannel system comes on-line.

3. Guide Star Catalogue

In August, version 1.1 of the GSC incorporating a number of improvements over the original publication was released to the community on CD-ROM. The Tycho Input Catalogue (Egret et al. 1992) was used to supplement the GSC plate measurements by providing information on bright stars which are either missing from GSC 1.0 or poorly measured from the Schmidt plate material. In addition a new photometric calibration algorithm was applied to the GSC, improving the reliability of the extrapolation beyond the magnitude range of the GSPC-I sequence stars.

A large number of non-stellar objects on the halos and spikes of the brightest stars were identified as probable image artifacts. These were reclassified in the GSC, as were a number of blended pairs of stars. In addition, all reported misclassifications of individual objects were repaired.

Work is continuing on improving the GSC, with an all-sky astrometric recalibration based on the subplate reduction method (Taff et al. 1990) currently in progress. This version (GSC 1.2.1) will be completed by summer.

4. Second HST Guide Star Photometric Catalogue

Work on this catalogue (Postman et al. 1992) to provide faint CCD photometric standards for the standard survey fields is still underway. To date, approximately 62% of the northern fields have been reduced and accepted as satisfactory. Small subsets of the prepublication data may be available for comparison to other standards as a quality check. If interested, please contact Marc Postman at ST ScI.

5. Image Compression and Distribution

Compression of the digitized scans that have been made for HST operations continues with the goal of distributing them to the community over the next 3 years. The data include the Palomar POSS-I E plates in the north and the SERC J plates in the south. The plates were all scanned using modified PDS microdensitometers as 14000 x 14000 rasters with a pixel size of 25-microns (1.7 arcsec). These data are being compressed by about a factor of 10 and will be distributed on a set of about 100 CD-ROMs.

The project work is being carried out with NASA funds based on the results of a recent ST ScI survey of potential institutions that would be interested in obtaining a CD set by sharing the costs of mastering and duplication of the discs. As of the end of December 1992, 30% of the southern sky has been compressed, with completion of this hemisphere planned for May 1993. Additional information on the distribution of the data will be announced in the near future.

6. Optical Identification of ROSAT Sky Survey X-ray Sources

B. McLean, R. Burg and R. Giacconi are continuing a project to find optical counterparts of sources in the northern hemisphere detected during the ROSAT X-ray Sky Survey. The images from the optical disk archive around each X-ray source are being automatically extracted, the optical objects detected, positions, magnitudes and classifications are derived (McLean & Burg 1991) and delivered to the ROSAT project at MPE. All of this information is providing a sample of clusters for the ST ScI group in collaboration with Huchra and Bohringer to study the luminosity function of galaxy clusters with follow-up imaging and spectroscopy. A preliminary list of 400 candidates in the 9–17h range has been derived based on a minimum flux, hard spectra and extended size parameters. These have been examined on the survey plates images and a subset have been observed with both the MMT and the 48″ telescopes at Mt. Hopkins for redshifts and deep CCD imaging. Initial results show a high detection rate (>75%) and a significant number of clusters that were not identified by Abell. We plan to continue this work for the next several years, refining the X-ray selection criteria and obtaining ground-based observations in order to compare the morphology, spatial distribution and luminosity functions of these clusters. The deep X-ray imaging by ROSAT at the ecliptic poles is producing a list of very faint, extended sources that require optical identification. Initial results (Burg et al. 1992) seem to indicate the presence of a moderate redshift supercluster in this area.

7. The ST ScI Archive for Proper Motions

The ST ScI scanned POSS/Quick-V archive is useful for the determination of reliable relative proper motions down to $0.''03$/yr in the visual magnitude range 10–18. D. Jack MacConnell and W. James Roberts are completing an analysis of the proper motions in two plate regions, one centered on the North Galactic Pole, and one at a lower latitude toward the bulge. Their results will be compared with other available results for the NGP region, and they will demonstrate the uses and limitations of their method for galactic kinematic studies. The faintness of our magnitude range, which begins near where the PPM (Position and Proper Motion) Catalog leaves off, enables us to sample bulge and halo proper motions at considerable distances from the Earth.

8. Image Simulation

A collaboration between the ST ScI (M. Lattanzi and B. Lasker) and Osservatorio Astronomico di Torino (L. Pividori and L. Lanteri) is directed to the improvement of centroiding algorithms for images on Schmidt plates. The first step of this program, implementing a test environment for centroiders, has been completed; this is based on an image simulator (including a noise model) which produces excellent approximations to images from the UK Schmidt and the Palomar Schmidt over the entire usable magnitude range. Experiments with the classical centroiders (center-of-gravity, Gaussian), as well as various correlation approaches, are currently in progress.

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The Hamburg Schmidt Survey

The Hamburg Observatory is currently carrying out an objective prism survey on Schmidt plates taken at the Spanish–German Astronomical Center (DSAZ) on Calar Alto/Spain (Engels et al., 1988). The Schmidt telescope was moved in 1980 from Hamburg to Calar Alto. The telescope is an f/3 instrument with a mirror diameter of 120 cm and a free aperture of the correction plate of 80 cm. We use a 1.7 deg objective prism providing unwidened spectra with a dispersion of 1390 Å/mm at H_γ on hypersensitized KODAK IIIa-J plates. The field size on the 24 x 24 cm plates is 5.5 x 5.5 deg, giving a scale of 12 μm/arcsec on the plate. Under conditions of good seeing the FWHM of the images is 30 μm (plate resolution) giving a spectral resolution of 45 Å at H_γ. For each field two prism plates are taken to identify spectra of interesting objects with higher reliability. Additionally a direct plate is taken to determine accurate positions, and to recognize overlaps and extended objects. The current coverage is shown in Fig. 1. A complete coverage of the fields with $\delta > 0^\circ$ and $|b| > 20^\circ$ is planned until 1996. Until the end of 1992 we obtained 735 prism and 490 direct plates in 450 fields, covering about 12,000 deg^2 of the sky.

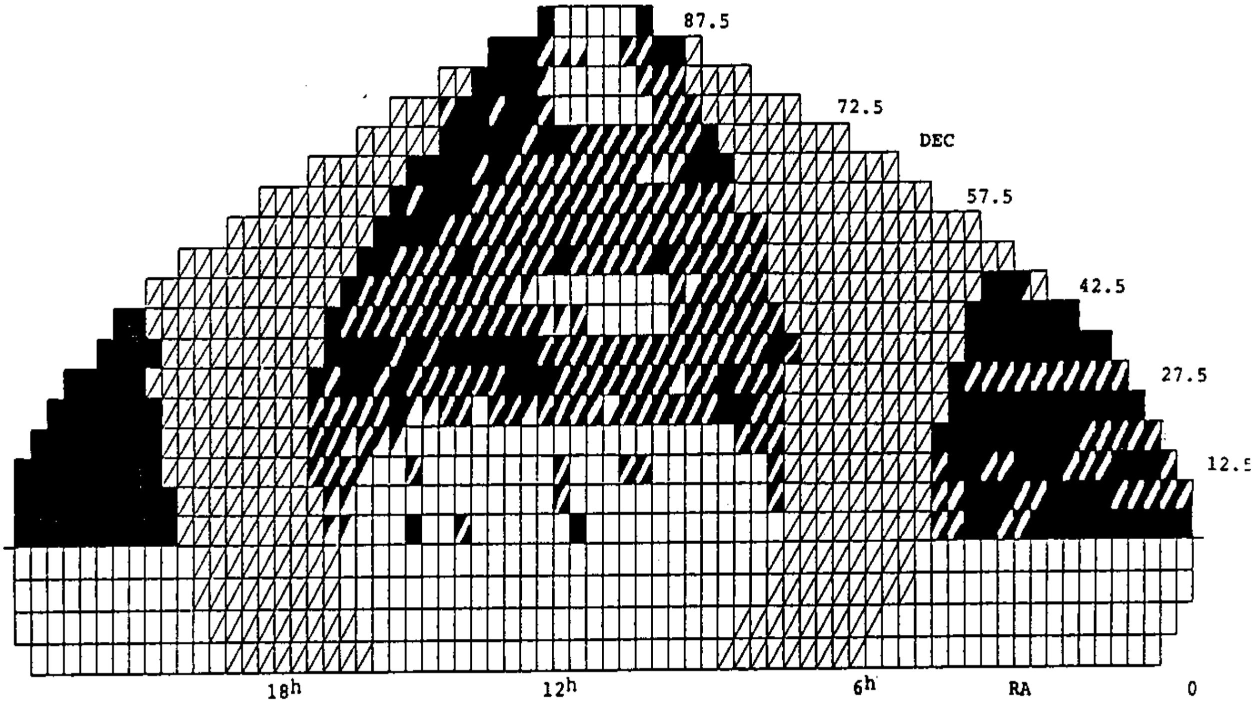

Figure 1. Coverage of the Hamburg Schmidt Survey until the end of 1992. Half colored fields have one, while full colored fields have two prism plates.

The Schmidt plates are digitized in Hamburg by a PDS-Microdensitometer 1010G. The densitometer is controlled by a KWS computer and a new software package was developed to digitize the plates with high speed. Currently the prism plates are scanned in 3 hours in a low resolution mode, while the direct plates are scanned within 9 hours with full resolution. An algorithm to remove the background is applied on-line to keep the data storage space small. This set-up allows the handling of several hundred plates in a reasonable amount of time.

The digitized data base of objective prism spectra is used for several purposes. The Hamburg Quasar Survey (HQS) aims for the discovery of bright QSO ($B < 17.5$). Already several extraordinary bright QSO were found (Reimers et al. 1989; Groote et al. 1989; Hagen et al. 1992). In collaboration with the MPE Garching we identify ROSAT X-ray sources on the Schmidt plates (Bade, Engels et al. 1992; Bade, Dahlem et al. 1992). About 6000 X-ray sources were analyzed on 4600 deg^2 until the end of last year. Hot stars are searched for in collaboration with the Universities of Kiel and Bamberg (Heber et al., 1991).

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A Technique for Stacking Digitized Photographic Plates

Abstract

With the advent of fast scanning microphotometers and inexpensive digital mass storage, there has been a resurgence of interest in performing deep ($B \leq 25$) panoramic surveys by co-adding large numbers (~ 10^2) of digitized photographic plates. While the Kodak IIIa emulsions are highly linear recorders of photographic grain density, we demonstrate that the threshold and saturation levels which restrict the dynamic range of the emulsion can distort the higher statistical moments of the grain density fluctuations (variance, skewness, etc.) along the linear part of the characteristic curve. The variance of the grain fluctuations is only additive between digitized plates that preserve the Poissonian grain noise. In order to compensate for the statistical distortion, we derive the necessary pixel weighting for five scanning aperture sizes (2 µm, 4 µm, 8 µm, 16 µm, 32 µm) as a function of the grain density.

1. Introduction

Wide-field photographic plates continue to play a crucial rôle in astronomical surveys (West 1991; Irwin 1992). In an age of rapidly evolving electronic detectors, plates still retain the unique ability to record high-density photometric information over fields of view exceeding a few degrees with a spatial resolution limited only by the seeing. Recent improvements in the performance of fast scanning microphotometers (e.g. COSMOS) now make it possible to extract ~ 10^9 data pixels from a plate in a matter of a few hours. This has allowed various groups to compile objective catalogues of very large numbers of galaxies. In the Edinburgh/Durham Galaxy Survey, Heydon-Dumbleton et al. (1988) scanned 60 overlapping plates that cover almost one steradian of the southern sky in order to compile a catalogue of roughly one million galaxies down to a limiting magnitude of $B_J \approx 20$. Rapid plate scanning also affords the opportunity to co-add or 'stack' a large number of photographic plates in order to increase detection limit sensitivity over a wide field. Tsvetkov (1992) reports that there are at least 1.3 million wide-field plates in archives throughout the astronomical community. Roughly speaking, this means that each square degree is covered by $30\,f^2$ plates, where f is the average field size in degrees, although these archives are heavily biased towards certain regions of the sky largely in the northern hemisphere. Moreover, a fair proportion of the plate archives will have been taken under less than ideal conditions, and hence will be of little use.

Malin (1988) has demonstrated that the plate limit improves by about two magnitudes when 36 UK Schmidt plates are co-added using traditional laboratory techniques. More recently, Hawkins (1991) used the COSMOS microphotometer to scan 58 plates of a common field; these were added in density space to form an image whose completeness limit was $B_J \approx 24$ mag with some images going a magnitude fainter. The importance of this result is exemplified by the number-magnitude relation for field galaxies: an improvement in the limiting sensitivity from $B_J = 22$ mag to $B_J = 24$ mag increases the detection rate of field galaxies by an order of magnitude.

2. The Statistics of Photographic Plates

For a given aperture size, the central limit theorem ensures that the density fluctuations obey Poissonian or Gaussian statistics (Marriage & Pitts 1956), even in the limit that the scanning aperture size is of order the emulsion grain size (Trabka 1969). However, it is clear from Fig. 1a that the width of the grain noise statistics does not conform to a simple Poissonian ($\sqrt{N}$) model. This is underscored by Fig. 1b which shows that there is a systematic trend in the skewness of the density fluctuations with increasing grain density. In the following section, we present a statistical treatment that attempts to explain the basic behavior in Figs. 1a and 1b. Any departure from Poissonian statistics has important consequences for co-adding digitized photographic plates.

When we add together separate images with mean signal s_1 and s_2, it is normally assumed that the noise in both images, n_1 and n_2, obeys Poissonian statistics. If $n_1 = \epsilon_1 \sqrt{s_1}$ and $n_2 = \epsilon_2 \sqrt{s_2}$, the

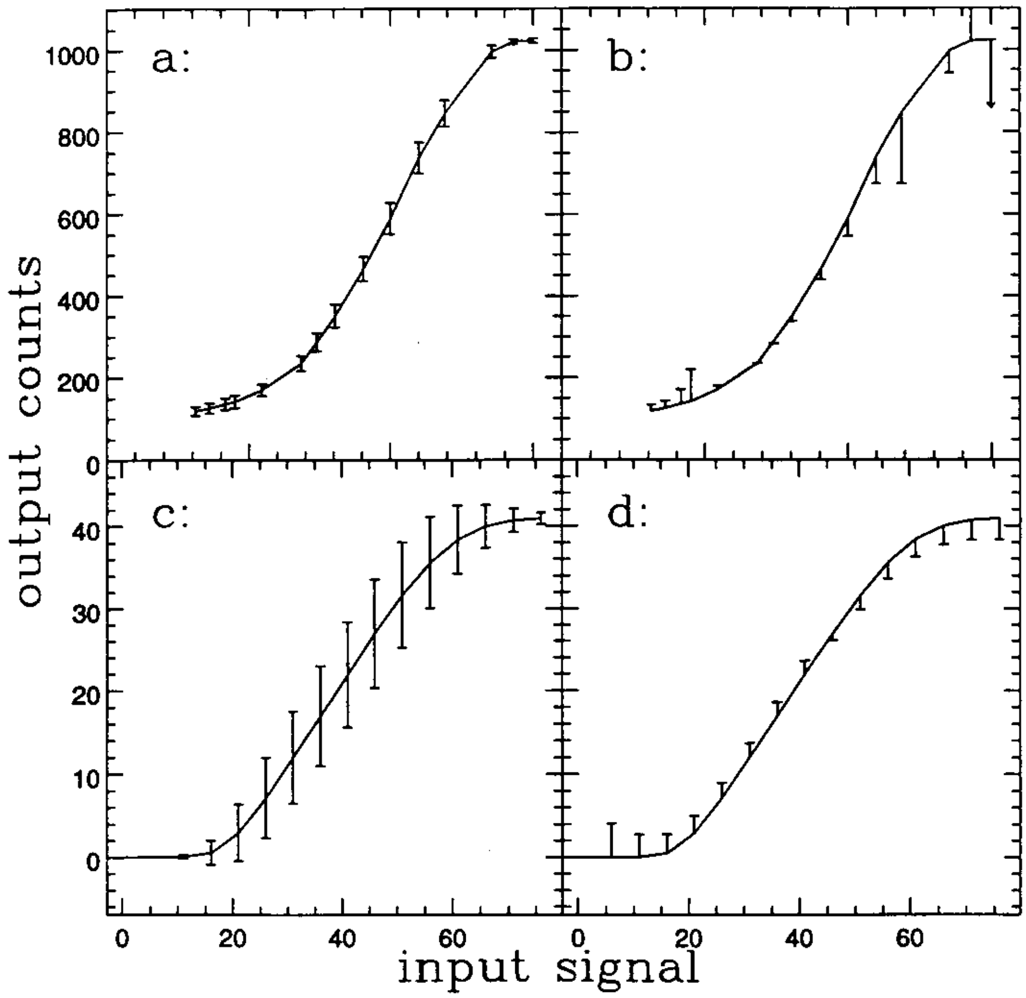

Figure 1. a, b. The characteristic curve (or μ) for a scanned IIIa-F photographic plate measured from the density step wedges. In **a**, the error bars correspond to ±1σ, and in **b**, the vertical bars indicate the magnitude and sign of the skewness, κ. **c, d.** The output response to a linear detector in the presence of saturation and threshold levels. When the linear response is restricted to a finite dynamic range, both moments deviate from their true Poissonian values.

variance of the noise in the summed image is simply the sum in quadrature of the original variances, i.e., $\sqrt{n_1^2+n_2^2}=\sqrt{\epsilon_1^2 s_1+\epsilon_2^2 s_2}$. Therefore, in summing images, we are making at least two general assumptions: n_1 and n_2 are statistically independent and are governed by Poissonian noise such that $\epsilon_1 = \epsilon_2 = 1$. The first assumption is discussed by Shopbell, Bland-Hawthorn & Malin (1992) and reduces to showing that the weight of the covariance term, w_3, is negligible, viz.

$$\sigma_S^2=w_1 n_1^2+w_2 n_2^2+w_3 n_1 n_2 \tag{1}$$

where $w_1 = \epsilon_1^{-2}$, $w_2 = \epsilon_2^{-2}$, and σ_S^2 is the variance of the summed image. For the second assumption, if the noise distributions deviate from Poisson statistics, the correction factors w_1 and w_2 need to be applied to the individual variances. These weights are derived below.

3. The Restricted Poissonian Distribution

The photographic plate is a highly linear recorder of photographic density. After Dainty & Shaw (1974), we demonstrate that the measured density fluctuations in Figs. 1a and 1b can be understood with a relatively straightforward model. For ease of illustration, consider a linear *photon* detector comprising an infinite number of recording cells that is uniformly exposed with an average number of p photons per cell. The photon distribution over the cells will be governed by Poisson statistics such that the proportion of cells receiving r photons will be $p^r e^{-p}/r!$. In practice, there are minimum (threshold) and maximum (saturation) exposure levels that a detector can register. Assume that the first $(t - 1)$ photons do not generate counts whereas the tth photon registers one count. Assume further that s or a higher number of photons register exactly s counts. The mean number of counts over all cells is then

$$\mu = E(p) = \alpha(1 - \beta e^{-p}) \tag{2}$$

where $\alpha = s - t + 1$ and

$$\beta = \frac{1}{\alpha} \sum_{k=t-1}^{s-1} \sum_{r=0}^{k} \frac{p^r}{r!} \tag{3}$$

We have used the form of the expectation, E, to determine higher moments of the distribution, viz.

$$E(p^2) = \alpha^2(1 - \gamma e^{-p}) \tag{4}$$

$$E(p^3) = \alpha^3(1 - \delta e^{-p}) \tag{5}$$

where the summation terms are given by

$$\gamma = \frac{1}{\alpha^2} \sum_{k=t-1}^{s-1} \sum_{r=0}^{k} (2[k-t+2]-1)\frac{p^r}{r!} \tag{6}$$

$$\delta = \frac{1}{\alpha^3} \sum_{k=t-1}^{s-1} \sum_{r=0}^{k} (3[k-t+2][(k-t+2)-1]+1)\frac{p^r}{r!} \tag{7}$$

Equations (4) and (5) provide information on the variance, σ^2, and the skewness, κ, of the distribution, since

$$\sigma^2 = E(p^2) - \mu^2 \tag{8}$$

$$\kappa^3 = E(p^3) - 3\mu\sigma^2 - \mu^3 \tag{9}$$

For an ideal linear detector with infinite dynamic range, the expected values of the mean, standard deviation and skewness for a Poisson distribution are easily derived. In the presence of detector limits, all three statistical moments deviate from their true Poissonian values; the induced 'statistical distortion' is illustrated in Figs. 1c and 1d. Intuitively, as the value of p approaches either detector limit from the linear section of the curve, one tail of the distribution measuring the statistical uncertainty in p starts to disappear. A comparison of Figs. 1a and 1b with Figs. 1c and 1d respectively reveals that the restricted Poissonian model explains the major trends in the scanned density step wedges.

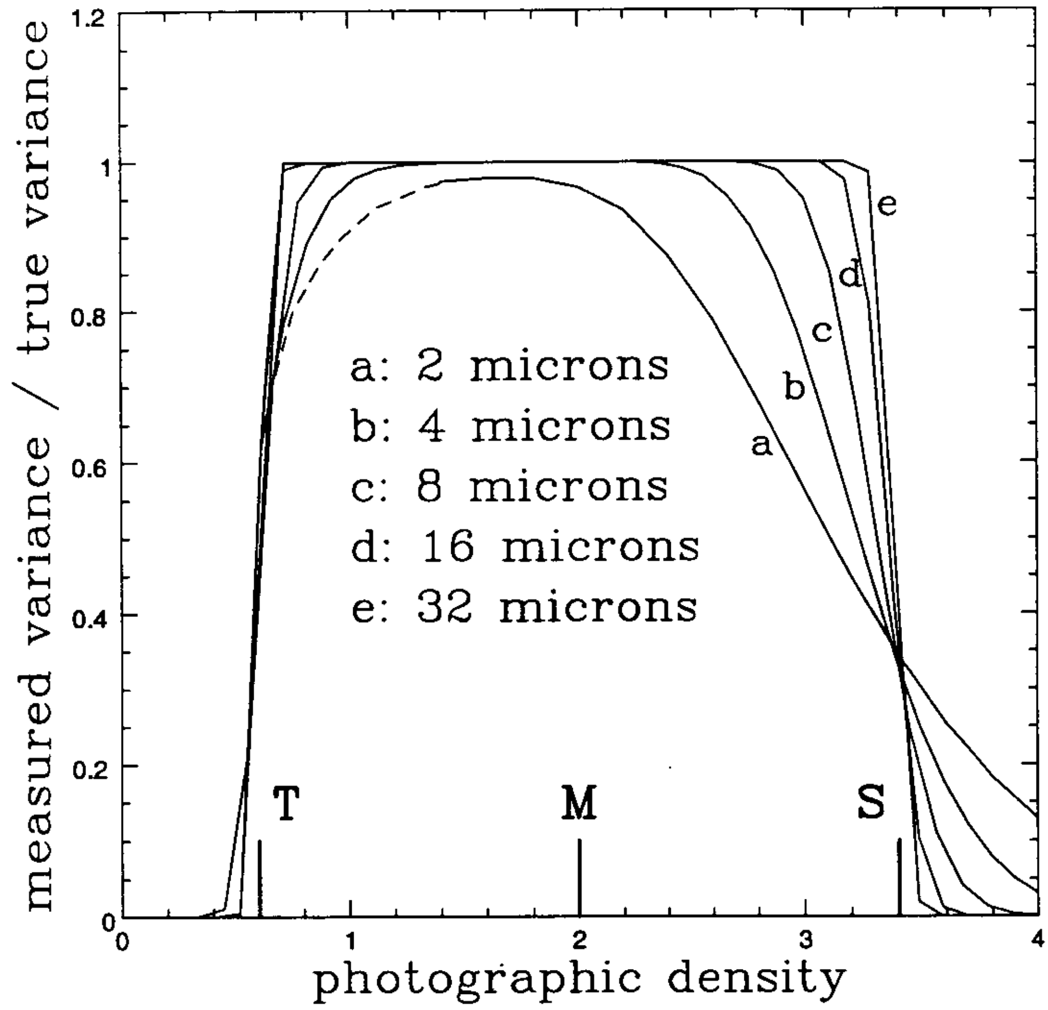

Figure 2. A plot that shows how the measured variance differs from the Poissonian variance as a function of photographic density and scanning aperture size. The values along the vertical axis are inversely related to the corrective weights (see text). The statistical distortion is clearly more important at high density and for small scanning apertures. The dashed line is an extrapolation as the numerical method fails in this region.

4. Discussion

In order to simulate the response of the grain density fluctuations to the presence of threshold and saturation levels, we determine the linear dynamic range that produces the fluctuation level at some intermediate (midpoint) value along the straight section of the characteristic curve. We note in Fig. 1 that the maximum statistical dispersion occurs roughly at the midpoint of the linear ramp. Since the threshold and saturation levels can only reduce the statistical dispersion, it follows that the grain density for which the statistical response is most likely to exhibit Poissonian behavior is that which produces the largest grain dispersion. Furenlid, Schoening & Carder (1977) have calibrated the grain density fluctuations, σ_D, on the linear part of the characteristic curve for a range of photographic emulsions. They find that under a wide range of conditions, there exists a unique relationship between σ_D and grain density, D: for the Kodak IIIa emulsions, we adopt $(\sigma_D/D) = (0.64/a)$ where a is the square aperture dimension in microns. We compute statistical models which attempt to simulate the grain density response for five aperture sizes; 2, 4, 8, 16, 32 µm. The expected grain density fluctuations are 32%, 16%, 8%, 4%, 2% respectively. For all five models, the positions of the threshold (T), midpoint (M) and saturation (S) levels remain in a fixed ratio with respect to the linear scale defined by a zero density (Z) and a peak density (P). We adopt the following representative density values in each of the simulations: Z = 0.0, T = 0.6, M = 2.0, S = 3.4, P = 4.0. An important boundary condition in our model is that the density fluctuation falls to zero at zero density. However, in reality, we note from Fig. 1a that there will be finite background noise at both extremes of the density range. The results are summarized in Fig. 2. It is clear that the statistical distortion is particularly severe for the smaller apertures and tends to restrict the linear density response, particularly to higher densities. For a scanning aperture of 4 µm, notice that the higher statistical moments are truly Poissonian for only about half of the straight section of the characteristic curve.

In practice, one corrects for the statistical distortion by dividing out the form of the measured to true variance in Fig. 2. The necessary pixel weights, w_1 and w_2, are functions of density and are essentially the reciprocal of the values plotted in Fig. 2. The first statistical moment is handled by the density-to-intensity transformation; the third and higher moments are unlikely to have much influence. In stacking N digitized plates, with the proposed corrections, we would expect the magnitude limit to improve in proportion to $2.5 \log \sqrt{N}$. Thus, a hundred co-added plates could in principle increase the sensitivity limit by an order of magnitude everywhere within the full field.

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Inventory by the Wavelet Transform

1. The Astronomical Image Inventory

Large astronomical plates are today analyzed with fast scanners leading to images with about 10^9 pixels. This amount of information leads the astronomers to examine sets of computer vision techniques in order to get an available inventory of the contained objects.

The detection is the first kind of the desired results. It is important to be aware of the miss and false alarm probabilities. The principal information lies in the position and in the magnitude of the detected objects. We want to get the most accurate values, with the less bias. We have also to recognize the objects (stars, galaxies, asteroids, etc.) hence we need to get available pattern parameters leading to a nice separation between classes.

In order to get the required information we need a *vision model*. Many kinds of such models have been implemented, the one resulting from the wavelet transform corresponding to a new approach.

2. Some Typical Vision Models in Astronomy

The classical computer vision for robotic and industrial vision is based on the detection of the edges. We have first applied this model to astronomical imagery (Bijaoui et al. 1978). We choose the Laplacian of the intensity as the edge line. As this function is the sum of the second partial derivatives of a noisy function, we need to smooth and to threshold it. The results are independent of large scale variations, such that the ones due to sky background. The resulting procedure is very fast, requiring small memory sizes. No previous background mapping is necessary leading to real time analyses. Many false detections exist if we do not want to miss real objects. The accuracy of the magnitudes is not sufficient. But the main disadvantage lies in the difficulty of getting an available object classification: astronomical sources can not be recognized from their edges, but from their intensity profiles.

Many reduction procedures have been built using a model for which the image is the sum of a slowly variable background with superimposed small scale objects (Stobie, 1986; Slezak et al. 1988). The first step requires the construction of a background (Bijaoui, 1980). For that purpose we need to introduce a scale: the background is defined in a given area. Many statistical estimators derived from the local histogram of intensity are used: mode, median, resulting from a model, etc.

The resulting background map is subtracted. Each pixel which has a significant intensity is considered to belong to a real object. A cross-correlation with the star profile is done, in order to optimize the detection of these objects. A threshold is computed from the distribution of the intensity pixels. An image labelling is performed (Rosenfeld, 1969), bringing positions, magnitudes and pattern parameters.

Generally, this procedure leads to quite accurate measurements, with an available detection and recognition. The computations are fast and require only small computer memory. The model works very well for poor fields, if it is not the case, a labelled field may correspond to many objects. The background map is done at a given scale: larger objects are removed. The smoothing is only adapted to the star detection not to larger objects. The analysis does not take into account the wings of the objects. The classification allows us to separate stars from galaxies but not to recognize the galaxy type.

An improvement of the previous model is done with the introduction of the radial profile of each source (Le Fèvre et al. 1986; Slezak et al. 1988). An astronomical object is associated to a point-like structure. We have thus only to detect the local maxima. Its radial profile contains the main information on the source. The method is similar to the previous one up to the image labelling which is replaced by a maxima detection followed by the determination of the radial profiles. The quality of the measurements is increased, and the derived pattern parameters permits a gain in the separation between the stars and the galaxies.

The defects of this procedure lie in the impossibility of describing complex structures. The method is adapted to quasi stellar sources, on a slowly varying background.

3. A Vision Model with the Discrete Wavelet Transform

In fact the three vision models we used on many sets of images failed to bring about a complete analysis because they are based on a single scale for the adapted smoothing and for the background mapping. The observation of sky images furnishes lots of examples for which we see a small star embedded in a larger structure, itself embedded in a larger one, and so on. A multiscale analysis permits to get a background adapted to a given object and to optimize the detection of different size objects. It is the reason why we were interested in the use of the Wavelet Transform.

Morlet-Grossmann's (Grossmann & Morlet, 1985) definition of the continuous wavelet transform for a $1D$ signal $f(x) \in L^2(R)$ is:

$$W(a,b)=\frac{1}{\sqrt{a}}\int_{-\infty}^{+\infty} f(x)g^*(\frac{x-b}{a})dx$$

z^* designs the conjugate of z. $g^*(x)$ is the analyzing wavelet. a (> 0) is the scale parameter. b is the position parameter.

It is a linear transformation which is essential for numerical algorithms, statistical computation and understanding of the results. The wavelet transform is covariant under translations: the analysis does not depend on the origin of the coordinate frame. It is the general property of convolution operators. It is also covariant under dilatations: this is the property which gives its originality to the wavelet transform. We get a mathematical microscope the properties of which do not change with the magnification.

Our vision model is based on the splitting of the image into scale space allowing us to detect objects of different sizes. The discrete wavelet transform can be processed by many algorithms (Bijaoui 1991). The constraints we put on the transform result from the chosen strategy. Stars, and generally astronomical sources are quite isotropic sources, no direction is privileged. Thus we choose an isotropic wavelet. We need to connect fields from different scales. The redundancy is not critical, but we need to restore an image from the transform. At last, we need also to have a fast algorithm. These constraints led us to use the *Algorithme à trous* (Bijaoui, 1991; Holdschneider et al. 1989) resulting from the difference between two B-spline interpolations. $B_3(x)$ is close to a Gaussian function and the results are quasi-isotropic. With $B_5(x)$ the discrepancy to the Gaussian is very faint, and the interpolation and the wavelet can be considered as isotropic.

4. The Object Definition and the Partial Reconstruction

After applying the wavelet transform on the image, we have to extract, to measure and to recognize the significant structures. The wavelet space is a $3D$ one. An object has to be defined in this space.

In the first step, we do an image segmentation scale/scale in the wavelet space. An object could be defined from each labelled fields, without taking into account the interscale neighbourhood. We can restore an image of these objects from the known wavelet coefficients, but this restoration does not use all the information.

Secondly, we link the labelled fields from a scale to the following one. That leads to building a tree of neighbourhoods, from the largest scale to the smallest one. After this operation we can say if a large scale field contains smaller ones which contains smaller ones, and so on.

The image is a set of connected trees, corresponding to different objects. We could define an object as one tree, but it appears that we reduce in a too high manner the number of objects. A small star may belong to a small nebula, the tree corresponds to the nebula, and we do not consider the star if we take into account only the connected tree. It is the reason why we define an object as a subtree resulting from the image segmentation in the wavelet space.

Let us consider now an object, such as it was defined. It corresponds to a field D in the wavelet space. It is fully determined from its wavelet coefficients $w_0^{(i)}(k,l)$. We have to restore an intensity distribution $c^{(0)}(k,l)$ such that its wavelet transform has the same coefficients in D. The restoration algorithm is an extension of the classical Van Cittert's deconvolution algorithm (Burger & Van Cittert 1932).

This algorithm provides an image for each object. It is easy to compute from each of them any kind of parameters: mean position, total intensity, pattern parameters, etc. Now, our experiments show us that the quality of the detection is very nice in this procedure. A recent experiment on SA57 field gives us a dispersion of less than 0.08 for the magnitudes of about 23–24 compared to another careful interactive processing. Using a very different approach, Coupinot et al. (1992) showed that they get accurate measurements from the wavelet transform.

5. Conclusion

The vision model resulting from the wavelet transform permits us to detect, to measure and to recognize an object as complex as available. We have not done enough experiments to claim that the resulting measurements would be more accurate than the ones derived from other models. The procedure does not introduce any prior information on the stellar profile or on the scale of the background variations. This is very important for automated procedures.

The main disadvantage lies in the number of used data. The algorithm *à trous* leads to an increase in the data by the number of scales. In our experiments we used 4 – 5 scales. The increase is too high for large astronomical images. We are examining now a way to reduce this data amount with a pyramidal transform.

This vision model may be improved using the stellar profile. In the wavelet space, we can recognize the wavelet images connected to star-like objects. The procedure is more complicated and we used it only for the image restoration (Starck & Bijaoui 1992).

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Tech-Pan UKST Films: Some Preliminary COSMOS Data Comparisons

Summary

Following on from the reports in the previous WFA Newsletters on the introduction of Kodak Tech-Pan 4415 emulsion at the UKST (Phillipps & Parker, 1992a; Parker & Malin, 1992) we present some preliminary findings on object parameter comparisons obtained from pairing COSMOS machine scans of 4415 film and equivalent glass plate exposures in both the 'R' and 'U' photometric pass-bands. The results indicate that Tech-Pan 4415 can effectively replace IIIa-F 'R' and IIIa-J 'U' exposures for most purposes. The image properties are well behaved and there appear to be no serious film-plate colour terms or systematic effects between repeat 4415 exposures. The enhanced imaging properties and significantly reduced emulsion noise of Tech-Pan offers the opportunity for increased scientific gains. Concerns over the astrometric reliability of the 4415 estar-substrate also appear to be unfounded.

1. Introduction

Kodak estar-base Technical Pan 4415 emulsion is an extremely fine grained, high resolution, panchromatic negative film with extended red sensitivity. Although available for quite some time (Kodak 1981), and used successfully for many years by amateurs (e.g. Martys 1991), its use as a serious astronomical emulsion on large Schmidt telescopes has only recently been demonstrated (Russell et al. 1992; Phillipps & Parker, 1992a, b; Parker & Malin 1992; Parker 1992). This is partly because the technical difficulties of mounting large format film satisfactorily in the telescope with perfect focus (together with effective hypering and processing) have only recently been overcome. Tech-Pan film is now in routine use at the UKST for most follow-up exposures of transient phenomena and for increasing numbers of research applications aimed at taking advantage of the emulsion's better imaging capabilities and lower emulsion noise. To date, ~ 160 UKST exposures have been taken on 4415 emulsion since its first use in March 1991.

However, before a general switch to 4415 film from glass plates can be sanctioned for certain exposure types there is still a pressing need for more quantitative assessment of the astronomical image characteristics produced by 4415 film when compared with the more traditional IIIa-F and IIIa-J exposures. The integrity of object positions, photometry and other general properties must be demonstrated. This can be effectively achieved by comparing measuring machine scans of film and equivalent plate exposures. Phillipps & Parker (1992a, b) have already shown that the 4415 emulsion is excellent for wide-field, low surface brightness, galaxy photometry when COSMOS mapping mode data is used (a straight pixelation of the original film). Here we look at more general object comparisons through the use of COSMOS IAM data (image analysis mode data, MacGillivray & Stobie 1984) which produces parameterised object information.

2. COSMOS IAM Data Comparisons

2.1 Scanning the films in COSMOS

Due to their flexible nature, 4415 films have been mounted in COSMOS on glass backing plates using a water/glycerin interface and more recently using 'Nonane' which has a refractive index much closer to that of glass and is somewhat easier to handle than water/glycerin. These techniques have yielded excellent COSMOS data. A proper film holder for use with the forthcoming SuperCOSMOS machine is anticipated to get around the current time consuming film mounting process.

2.2 4415 — IIIa-F 'R' exposure comparisons

For this work, 4415 and IIIa-F 'R' exposures of ESO/SERC Survey Field 443 were scanned with COSMOS in IAM mode at 16 µm resolution using standard scanning parameters. Image deblending software was also employed (Beard et al 1990). Derived COSMOS RA and DEC values were used to pair-up detected objects from each scan which are typically accurate across a field to within an arcsecond for glass plates. Top quality exposures with each medium are required to minimise the effects of seeing variations on the derived COSMOS image parameters.

Figure 1a gives a direct comparison of 4415 and IIIa-F 'R' COSMOS magnitudes of paired objects from Field 443. The IIIa-F data come from a COSMOS scan of an 'A' grade survey plate. The 4415 film exposure was also assessed to be of good quality. A 1-in-10 sampling of the paired data from across the entire field was used to produce the figure (~ 8000 objects plotted). As one would expect from the similarity between the 4415 and IIIa-F emulsion sensitivity curves (Kodak, 1987), there is excellent agreement between the calibrated 4415 and IIIa-F COSMOS magnitudes (given as magnitudes above the sky background) with no significant colour terms evident. A best fit regression line gives a gradient of 1.05 whilst the mean square deviation about the line is 0.11 magnitudes. No corrections of any kind have been applied to the COSMOS data.

2.3 Repeat 4415 OR exposure comparisons

Figure 1b is the comparison of the COSMOS magnitudes of paired images on two good quality 4415 film exposures of a field in VIRGO. Excellent consistency in the COSMOS data was found indicating no exposure-to-exposure systematic effects in the image parameters. The magnitude relationship is highly linear with the best fit regression line producing a gradient of 1.009 and a mean square deviation about the best line of only 0.049 magnitudes. This was achieved without the application of any zero-point offsets or other corrections. For all three 4415 films scanned from both the VIRGO and 443 fields, no magnitude or image area positional effects were found such as would be expected if there were any de-focusing in the film across the field.

2.4 4415 — IIIa-J 'U' exposure comparisons

'U' exposures at the UKST are normally taken with IIIa-J or IIa-O emulsions through the UG1 filter. Some test exposures have recently been taken with the UG1 filter and 4415 emulsion of ESO/SERC Survey Field 502 to try to take advantage of the superior imaging qualities and cheaper cost of the film. Unfortunately neither the film nor IIIa-J plate taken for the comparison were in good seeing. Nevertheless, COSMOS data from the matched U-film and U-plate gave very good agreement of general object properties. The crucial point for the 4415 'U' exposure is that, since the 4415 emulsion sensitivity extends to 690 nm (unlike IIIa-J), there were concerns about the severity of a red leak through the 4415+UG1 combination. COSMOS data of the equivalent IIIa-F 'R' survey plate was matched with the U plate and the reddest 3% of stars selected from an R, (U-R) colour-magnitude diagram. These red stars were plotted on a magnitude-binned $U_{plate} - U_{film}$ versus U_{plate} diagram in Fig. 2. The error-bars are the σ values associated with magnitude differences in each bin. The plot shows that there is no obvious difference between these red stars and all stars in the field thus indicating a negligible red leak. Furthermore, the small number of objects which appeared much brighter on the film than on the plate were found to be evenly distributed in colour in the colour-magnitude diagram. These are probably variables or image deblending errors.

3. COSMOS RA-DEC Positional Comparisons

Van Haarlem et al. (1992) have demonstrated that film copies made from glass positives retain essentially the same astrometric accuracy as the original plate. However, concerns have been expressed over the astrometric reliability of 'original film exposures' because of the effects of possible non-uniform deformations of the film when in the telescope. The thick estar-base on which the 4415 emulsion is deposited does have excellent toughness and rigidity properties (Kodak 1970) and our own experience at the UKST with using 4415 film exposures to provide sub-arcsecond positions for transient phenomena such as for comet Grigg-Skjellerup (Russell & McNaught — private communication) indicated that very good astrometry could be achieved. Tolerances of only 1.5 arcsec were necessary to achieve ~ 85% pairing success for the two VIRGO 4415 exposures down to the plate limit. The mean difference between derived COSMOS object RA and DEC co-ordinates from

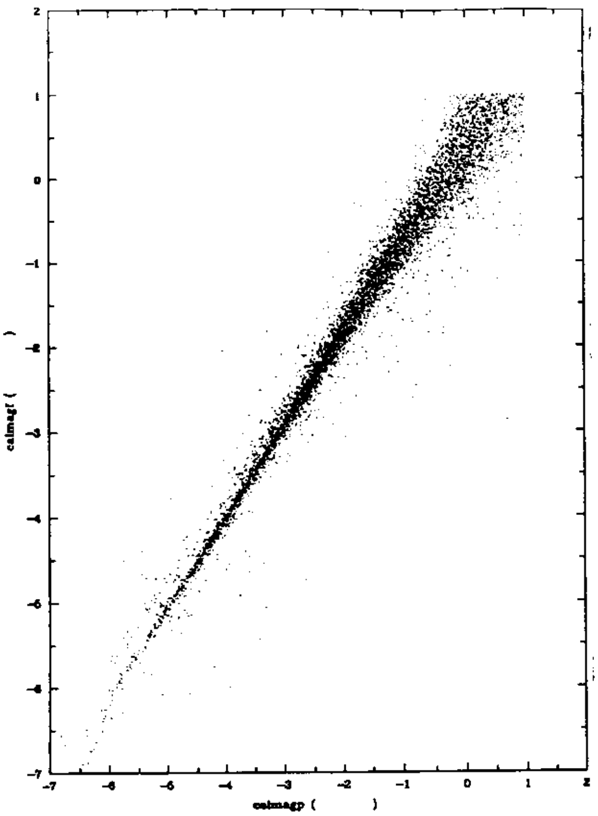

Figure 1a. F443 4415 – IIIa-F COSMOS magnitude comparison.

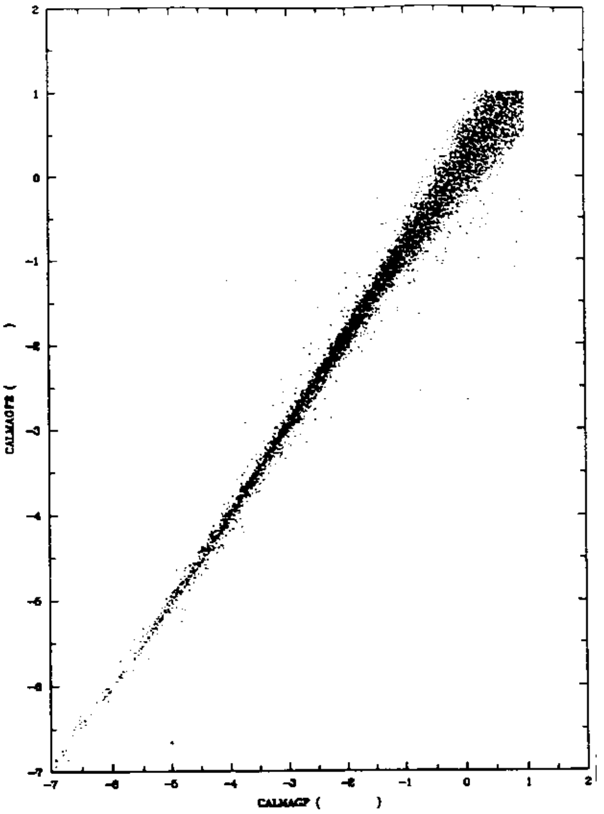

Figure 1b. VIRGO 4415 –4415 COSMOS magnitude comparison.

film pairs was only 0.125 arcsec with $\sigma = 0.36$ arcsec. This compares with differences of ~ 0.24 arcsec with $\sigma \sim 0.67$ arcsec from the 443 film-plate pair.

The article by Dafydd Evans in this Newsletter puts more stringent constraints on the film astrometry from APM scans of 4415 via a more sophisticated astrometric analysis. Without recourse to such sophisticated analyses the standard COSMOS RA and DEC positions obtained from fits to standard stars in each field provide agreement of object positions between plates and film to within 0.5 arcsec. This is more than adequate for most work.

4. Conclusions

The preliminary investigation outlined above indicates that COSMOS data obtained from 4415 film scans is sufficiently reliable and repeatable to replace COSMOS data from IIIa-F 'R' and IIIa-J 'U' glass plate exposures in most instances. The superior imaging properties of the emulsion, the very low noise and the speed of the hypered product give significant information gains over the IIIa-equivalent exposures and should yield new scientific results. A more detailed description of the work outlined above is being prepared for publication.

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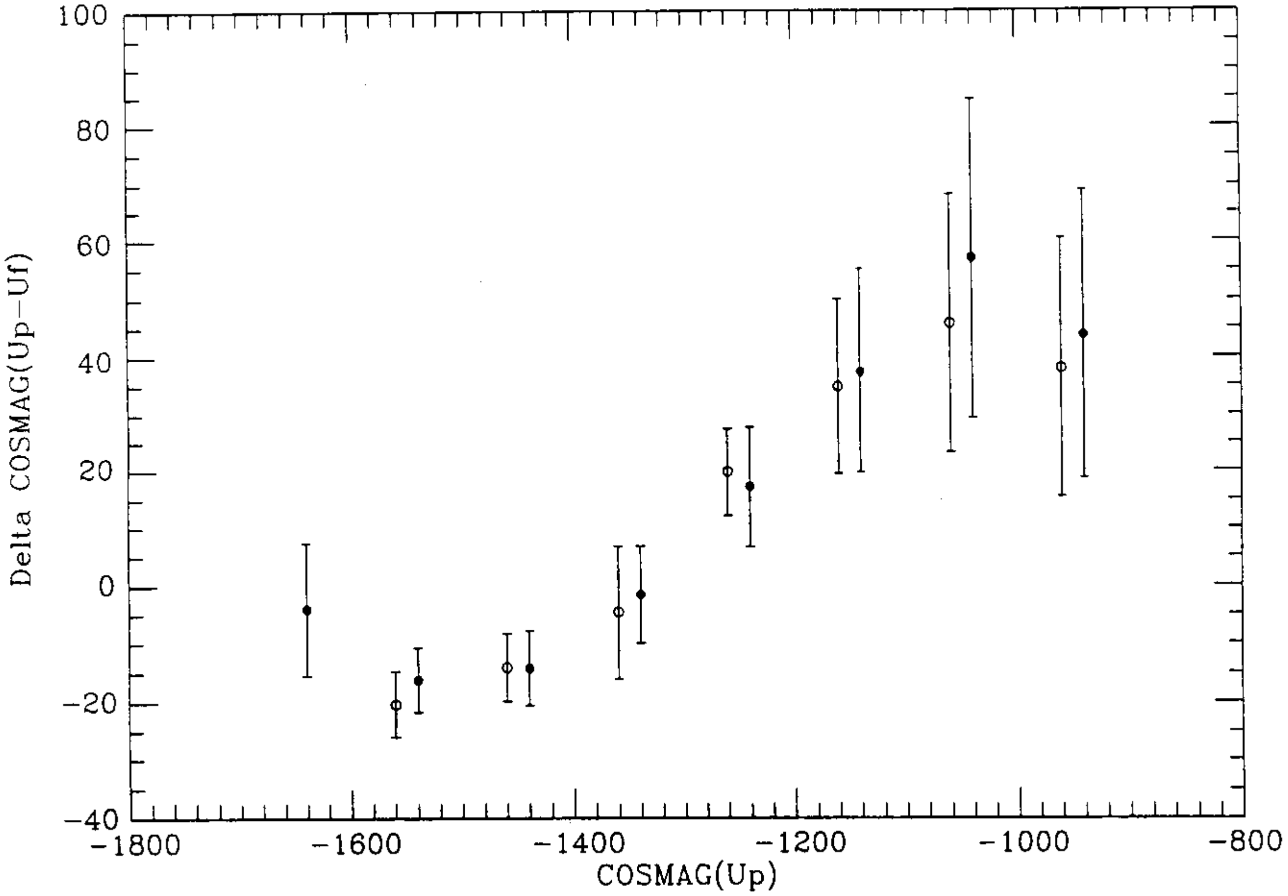

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An Astrometric Comparison Between Glass and Film Negatives on the UKST

1. Introduction

The intention behind this comparison is to see if there is any astrometric difference between using film or glass as the primary recording medium in the UK Schmidt Telescope (UKST).

The main comparison was carried out in UKST field number 386 using plates OR14216 (glass) and OR14387 (film). This field has Galactic coordinates $(l,b) = (330°, 20°)$ and is thus in an area with a very high star density. The difference in epoch between these plates is about 3.5 months.

The 'control' field that was used was the 8 Hour Field used in Evans (1988). The plate material used was J6644 and J6814 (both glass originals). This field has Galactic coordinates $(l,b) = (210°, 35°)$. The difference in epoch in this case is about 3 months.

2. The Data Reductions

All plates were scanned by the APM (in both 0° and 180° orientations) and various reduction procedures were applied to the data in order to remove any systematic effects present in the data caused by either the process of producing the plates or the scanning. These procedures are described in detail in Evans (1988).

The main systematic effect is caused by differential atmospheric refraction (see Wallace & Tritton, 1979) and distortion of the plates. These errors are accounted for by applying a map of these distortions to the data, i.e. making the assumption that no **average** shift in the positions as a function of the plate position can be a result of an astronomical effect. Note that by using galaxies as an absolute reference frame the global proper motion, and its gradient across the plate, is reinstated.

For the plates OR14216 and OR14387 the zenith angle is quite small (~ 9°) and hence the size of the differential atmospheric refraction will be small. Thus any remaining effect will be due to distortions caused by the plates. Figure 1 shows the map used between the 0° scans of OR14216 and OR14387. The larger distortions are of order an arc second. Of course, these distortions could be present in either the glass or the film plate. It is also possible that a small amount of these errors are caused by the scanning.

3. The Comparison

An important point about the selection of the plates used in these comparisons is that the epoch difference between the plates should be small. This is to minimize the effect of proper motions on the distributions. An estimate of the size of the effect for the 8 Hour Field plates (the control) is an additional dispersion of about 0.002 arcseconds. If added in quadrature to the measured widths it can be seen to be negligible.

Due to the crowded nature of the field a larger number than normal of mismatches occur. This leads to a number of outliers being present in the distributions of the positional comparison. Because of this, 4 different sorts of width estimator for the distributions were used:

(1) Gaussian fit to the histograms of the distribution;
(2) Interquartile estimator (scaled to a Gaussian width);
(3) Standard deviation;
(4) Standard deviation with an a priori cut of 1 arcsecond.

Probably (1) is the best estimator to use in order to measure the width of the core of the distribution and not be affected by the outliers. This is what was used in the following results.

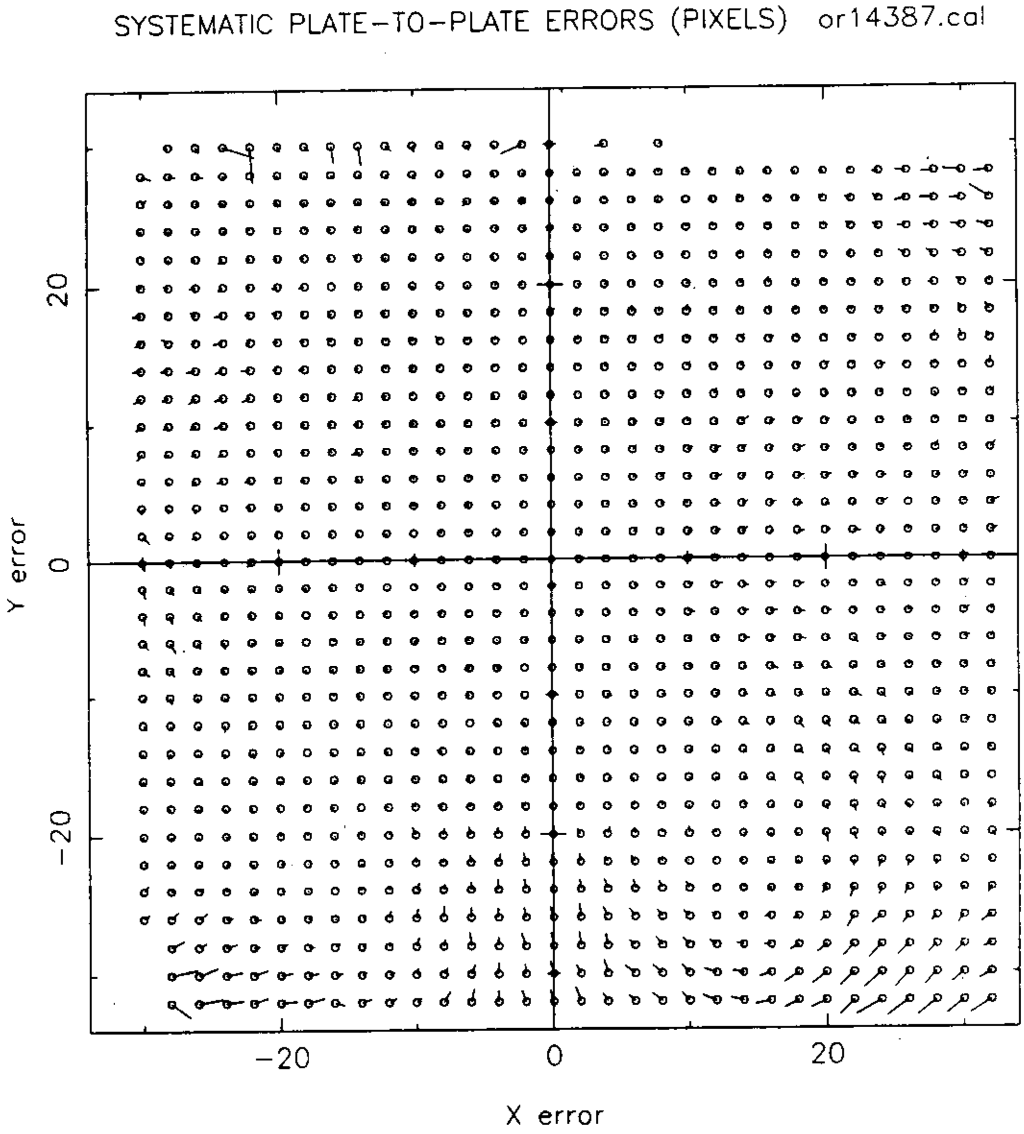

Figure 1. This diagram shows the size of the systematic effects present between the 0° scans of OR14216 and OR14387. The position of the circles represent positions on the plates. The whole plot roughly represents a UK Schmidt plate (about 6° x 6°). The average error at a particular position is indicated by the length of the line starting at each circle. The scale for these lines correspond to those of the axes, which is in scanning machine pixels. A pixel is approximately 0.5 arcsecond. It should be noted that in producing these plots a linear six plate constant transformation has already been applied to the data.

The basic comparison was carried out using the averaged (of the 0° and 180° scans) positions from the glass and film plates. The widths of the distributions were

	x	*y*
Glass vs. Film (av.)	0.086″	0.084″

x and *y* correspond roughly to the axes of right ascension and declination.

If you compare the 0° and 180° scans of the glass plate OR14216 you obtain widths of

	x	*y*
Glass 0° vs. 180°	0.050″	0.063″

This will be √2 times the error due to scanning, which is of order 0.5 μ per plate measure.

For an averaged difference distribution the width will be given by

$$\sigma=\sqrt{2\sigma_p^2+\sigma_s^2}$$

where σ_p is the error due to the plate and σ_s is that due to the scanning. This is assuming that plate errors and all the scanning errors add quadratically i.e. they are independent random errors. The reason we treat the plate and scanning errors differently is that there are 4 scans which contribute to the difference distribution and are averaged while the plate errors are not really combined 4 times since there are only 2 different plates. (Note that if you don't average the distributions over the 0° and 180° scans the width is given by $\sigma=\sqrt{2\sigma_p^2+2\sigma_s^2}$.)

Therefore the average (assuming glass and film to be the same) individual plate error is

	x	y
Plate error	0.055″	0.050″

This corresponds to around 0.75 μ.

As a check on these values it can be seen if a similar result can be obtained by comparing just the 0° scans, i.e. the distributions are not averaged. These measurements yield

	x	y
Plate error (from only 0° scans)	0.060″	0.056″

As a control, scans of two glass plates (J6644 and J6814) from the 8 Hour Field of Evans (1988) were compared. The width of the distribution of the differences between the averaged positions on these two plates was

	x	y
Glass vs. Glass (av., 8 Hour)	0.085″	0.094″

In order to obtain σ_s for these scans the 0° and 180° scans for one of the plates were compared. These yielded widths (= $\sqrt{2}\sigma_s$) of

	x	y
Glass 0° vs. 180° (8 Hour)	0.042″	0.067″

Thus we can calculate the plate errors for just glass plates:

	x	y
Plate error (8 Hour)	0.056″	0.057″

4. Conclusions

From the plates that have been scanned and analyzed for this work the conclusion is that there is not much difference (if any) between the astrometric results from film and glass plates.

It must be stressed that this is very much a **preliminary** result. No formal error estimates have been given for the values of the widths of the distributions since it is unclear that a formal error analysis would be appropriate or useful. An **estimate** of the error would be ~ 10%. This comes from comparing the x and y plate errors and comparing the averaged with the 0° results. Since film is only part of the plate pair combination we can probably say that a film is within ~ 20% of the accuracy of glass.

Naturally, the way to progress from here is to analyze more films and see how the results differ. In particular, since we have already characterised both the systematic and random errors present for glass vs. glass comparisons the next step is to do film vs. film comparisons on the same field. After all, the finer grain size of the film should lead to improved astrometric results at least for the random component of error. Theoretically a factor of 2 improvement is possible.

Acknowledgements

Other people were involved with this work. Ann Savage (AAO) took the plates in Field 386 and initiated this project. Mike Irwin (RGO) did the scanning at the APM. Dafydd Evans did the data reductions and analysis.

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Using the FK5 Extension on the B1950.0/FK4 System to Test the AGK3U

The purposes of this note are to relate our bringing the FK5 Extension onto the FK4 system and to use the result on the context of the AGK3U (Bucciarelli, Daou, Lattanzi & Taff 1992). This independently verifies the system of the AGK3U and the quality of the AGK3U positions and proper motions. This kind of independent confirmation is especially important as the AGK3U is the only astrometric catalog to use Schmidt plates.

To place the FK5 Extension, at B1950.0 epoch of place and equinox, on the FK4 system means correcting for all the systematic differences between the new I.A.U. system of constants and the old ones as well as applying the FK5/FK4 systematic differences to the positions and separately to the proper motions. Each of these steps was performed using the method of infinitely overlapping circles twice (see Taff, Bucciarelli & Lattanzi 1990; Bucciarelli, Daou, Lattanzi & Taff 1992). There are two different steps involved because the FK5 Extension has no overlap with the Basic FK5. First consider doing the computations for the positions.

We calculated, by the method of infinitely overlapping circles, the FK5/FK4 systematic differences, in the sense FK5 minus FK4, at B1950.0. This computation was necessarily executed at the position of each of the 1535 FK stars. Next we fixed on a single FK5 Extension star and found every Basic FK star within a small circle of radius 9.25 deg of it. (A small circle of this size contains, on the average, 10.62 ± 3.79 Basic FK5.) Then we computed the systematic difference between the FK5 and FK4 systems, at the position of the FK5 Extension star, again using the weight formula of the infinitely overlapping circle method. (This is the second application of the technique.) No magnitude or color index terms were included. This entire procedure was then repeated except instead of positional differences we formed proper motion systematic differences.

We used our new version of the FK5 Extension to verify both that the AGK3U is on the FK4 system and that its quoted mean errors are substantially correct. (The AGK3U is comprised of the AGK2 and the AGK3 positions, corrected for known systematic effects, and updated with positions taken from a re-reduction of the Hubble Space Telescope Guide Star Catalog 'Quick V' Schmidt plate collection.) The AGK3U represents the first attempt to combine astrometrically reduced Schmidt plate data with that from astrographic plates.

Six hundred and twenty-six FK5 Extension stars north of declination -3 deg and fainter than magnitude $6.^m5$ were successfully matched in position — within $5''$ — and magnitude — within ±0.75 mag — with stars in the AGK3U catalog. Using the version of the FK5 Extension at B1950.0 produced as indicated above, but without the FK5/FK4 systematic differences applied, the average difference between the equatorial coordinates for these 626 stars are on the left-hand side of the top line in Table 1.

Table 1. AGK3U/FK5 Extension Positional Systems

$\Delta\alpha\cos(\delta)$ (arc secs)	$\Delta\delta$ (arc secs)	$\Delta\alpha\cos(\delta)$ (arc secs)	$\Delta\delta$ (arc secs)
without FK5/FK4 systematic differences		with FK5/FK4 systematic differences	
-0.0172 ± 0.2636[a]	-0.0308 ± 0.2096	0.0193 ± 0.2650	-0.0180 ± 0.2111
0.0161 ± 0.1908[b]	-0.0309 ± 0.1970	0.0183 ± 0.1934	-0.0180 ± 0.1983
0.0187 ± 0.2648[c]	-0.0179 ± 0.2108	0.0177 ± 0.1932	-0.0179 ± 0.1981

[a] All 626 stars in common. [b] 9 outlier stars removed. [c] Double area smoothing.

Redoing the computation, but first applying the FK5/FK4 systematic positional differences to the B1950.0 version of the FK5 Extension, the results are on the right-hand side of the topmost line in Table 1. It is obvious that the two catalogs are on the same positional system and that the results are just slightly better when the FK5 Extension is completely placed on the FK4 system. The standard deviations about the mean are about twice what would be expected from the formal AGK3U error estimates alone (i.e. $0.''118$ per equatorial coordinate [Bucciarelli, Daou, Lattanzi & Taff 1992]; the FK5 Extension positional errors are a minor contribution to the standard deviation of the combination [FK5 Extension minus AGK3U] coordinate differences). The cause of this discrepancy is, in fact, 9 outlier stars (clearly visible in Figs. 1a and 1b).

If these 9 stars, which differ in one of their equatorial coordinates by more than $1''$ in amplitude, are removed and the computation repeated the new results are in better accord with our expectations; see the second line of Table 1. Remembering that the stars in the AGK3U which successfully matched the FK5 Extension stars are among the brightest stars in the AGK3U, so that their positions from the Hubble Space Telescope Guide Star Catalog 'Quick V' Schmidt plates are among the poorest (see Taff, Lattanzi & Bucciarelli 1990; Taff et al. 1990), this is not surprising. Plots of $\Delta\alpha\cos\delta$ and $\Delta\delta$ versus magnitude are shown in Figs. 1a and 1b.

Although we chose $R = 9.25$ deg (or 10 stars per enveloping circle), we have also done computations with circle sizes the square root of two larger (i.e. 20 stars per circle). These results are in the third lines of Tables 1 and 2 (but the FK5 Extension circle still had a 9.25 deg radius; only the FK5/FK4 catalog-to-catalog differences utilized the larger circle). Note the stability.

The same type of computation for the proper motion components yielded the results shown in Table 2 (which has the same format as Table 1). Clearly the right ascension proper motion systems are better aligned than the declination proper motion systems but there is also no doubt that the declination systems are substantially identical. The formal error in an AGK3U proper motion component is $0.''58$/cy so that the bulk of the standard deviations about the mean are a consequence of the AGK3U proper motion errors. This can be double checked by repeating these calculations with the 9 outlier stars removed; see the second line of Table 2. Figures 2a and 2b show the variation in the proper motion component differences with V magnitude.

Table 2. AGK3U/FK5 Extension Proper Motion Systems

$\Delta\mu_\alpha\cos(\delta)$ (arc secs/cy)	$\Delta\mu_\delta$ (arc secs/cy)	$\Delta\mu_\alpha\cos(\delta)$ (arc secs/cy)	$\Delta\mu_\delta$ (arc secs/cy)
without FK5/FK4 systematic differences		with FK5/FK4 systematic differences	
0.0037± 0.606[a]	0.0799 ± 0.675	-0.0260 ± 0.602	0.0784 ± 0.671
0.0043 ± 0.607[b]	0.0835 ± 0.673	-0.0253 ± 0.604	0.0817 ± 0.669
-0.0272 ± 0.601[c]	0.0778 ± 0.671	-0.0264 ± 0.603	0.0812 ± 0.669

[a] All 626 stars in common. [b] 9 outlier stars removed. [c] Double area smoothing.

We can deduce several different, strong, conclusions from this work. We start with the assumption that the FK5 Extension is a very good catalog. First examining the standard deviations in the Tables, and seeing that they remain essentially constant before and after the application of the FK5/FK4 systematic differences, we can say that the method of infinitely overlapping circles is introducing no additional noise. Still examining the standard deviations, and taking the mean errors in the FK5 Extension at face value, we can also conclude that the formal error estimates given in the AGK3U are substantially correct. Finally, from the small values of the averages in the Tables, we can validate that the AGK3U it is on the FK4 system. Another deduction one can make from the numerically small magnitudes of the means is that we have been successful in astrometrically reducing Schmidt plates by the method of subplate overlap (Taff 1989) and then integrating the results with those from the AGK2 and 3 astrographic plate material.

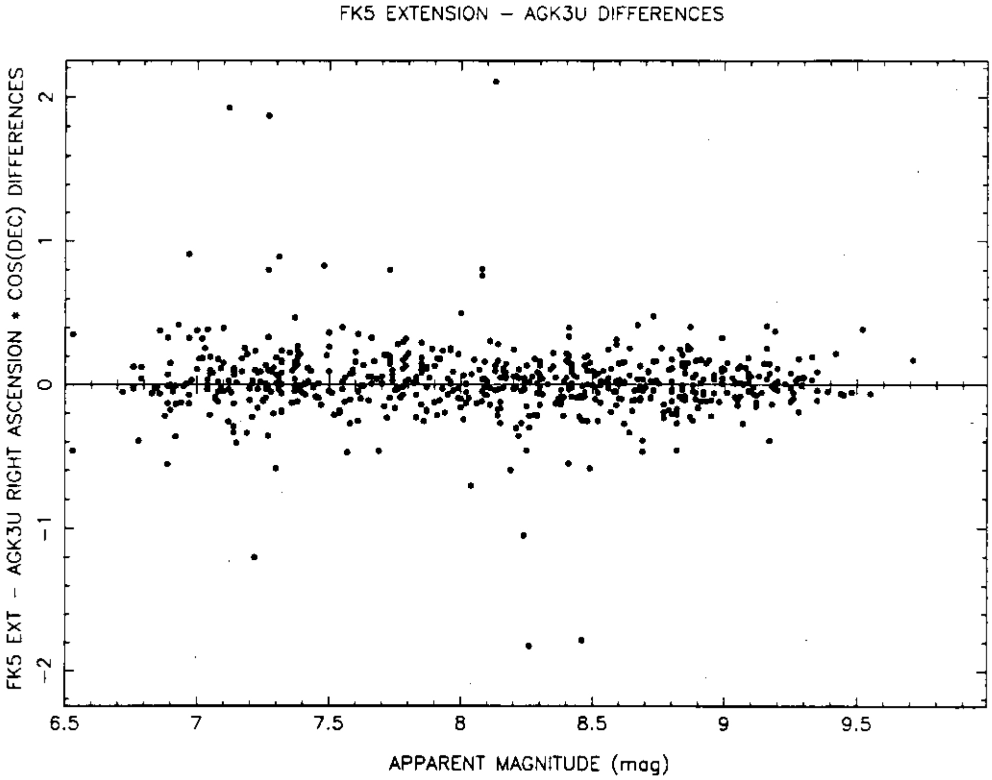

Figure 1a. Right ascension differences in arc seconds, on a great circle, between the FK5 Extension (on the FK4/B1950.0 system) and the AGK3U vs. *V* magnitude. Note that there is no magnitude dependence nor any sizeable bias.

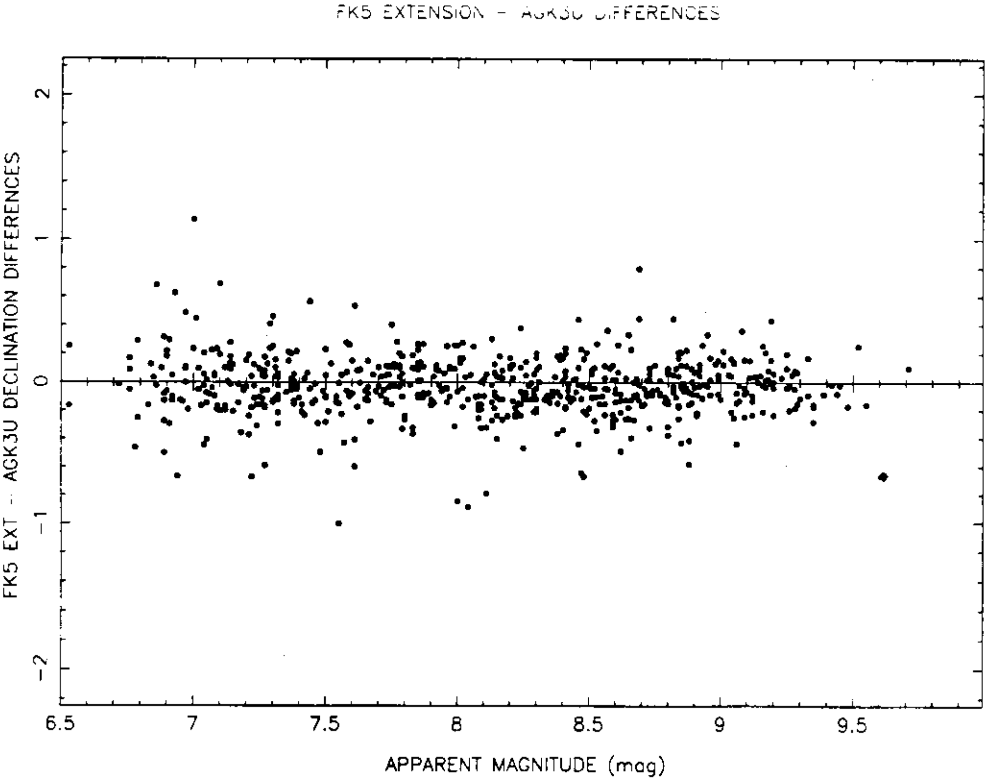

Figure 1b. Same as Fig. 1a but for declination.

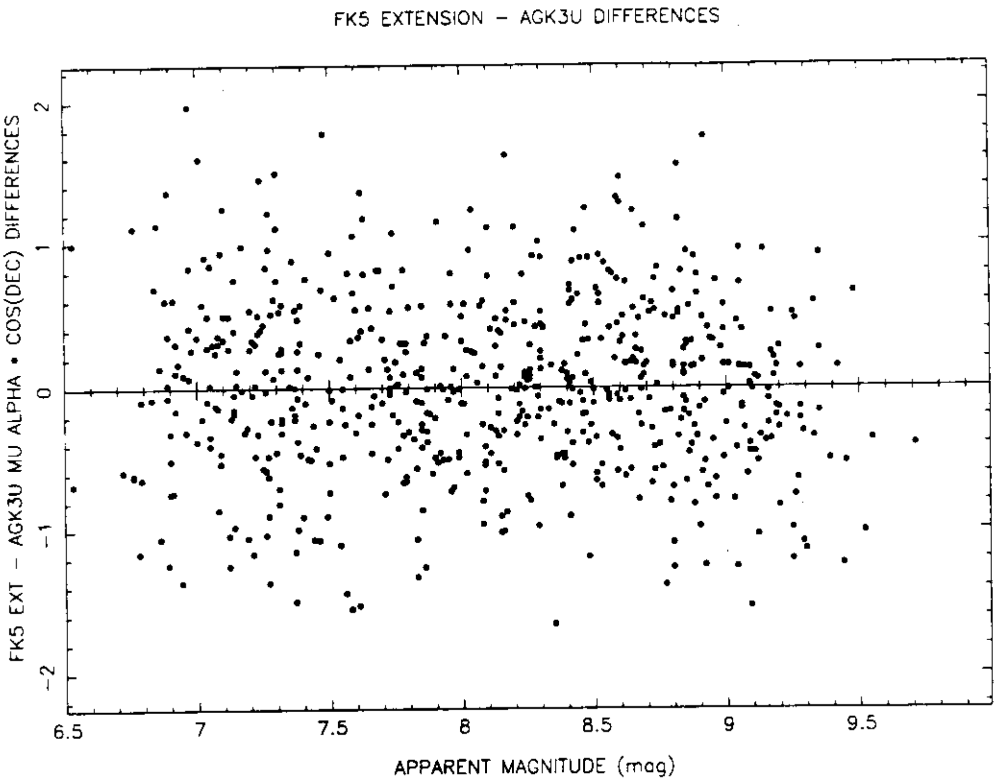

Figure 2a. Same as Fig. 1a but for the right ascension proper motion differences on a great circle ("/yr).

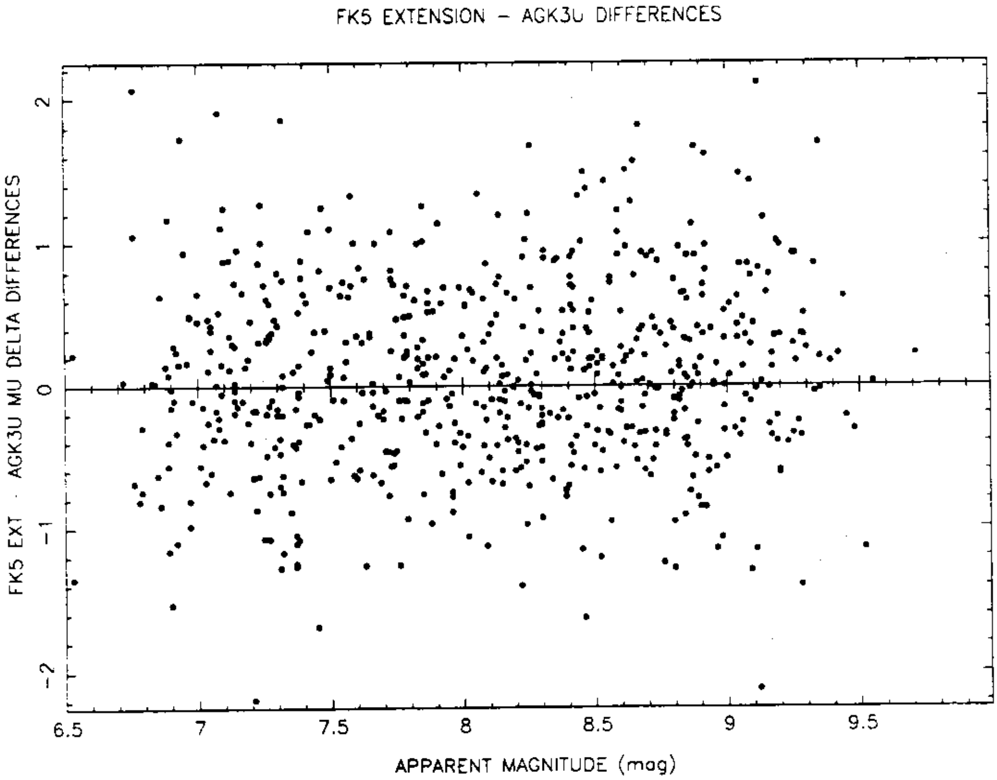

Figure 2b. Same as Fig. 2a but for the declination proper motion differences.

Acknowledgments

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News about the Wide-field Plate Archive Database

Since the last information about the Wide-field Plate Archive Database in Newsletter No. 2 (Tsvetkov 1992), we have received a lot of letters and e-mails with useful new information and corrections. We would now like to inform you in a systematic way about these remarks, suggestions and contributions by arranging them according to the following topics:

- new information about the WFPA list;
- development of the WFPA Database;
- future plans — digitisation of the WF plates;
- some general comments and remarks.

1. New Information about the WFPA List

Additional information has been received about some observatories which were not included in the first WFPA list of observatories with WFPA. It is given in Table 1, which contains the name of the observatory (with the country indicated), the number of the wide-field plates available there and the name of the astronomer who reported the information:

Table 1. New data to be added to the WFPA list

Observatory	**Country**	**No. of WF plates**	**Reported by**
Bamberg	Germany	40,000	R. Hudec
Dushanbe	Tajikistan	...	N. Bochkarev
Hoher List	Germany	11,000	M. Geffert
Klet	Czech Rep.	8,300	I. Ticha
Konkoly	Hungary	12,000	L. Balazs
Odessa	Ukraine	90,000	R. Hudec, R. Gershberg
Ondrejov	Czech Rep.	100,000	R. Hudec
Siding Spring (AAT)	Australia	1,000:	D. Malin
Vienna	Austria	1,140	A. Schnell

Ph. Ianna (Leander McCormick Observatory, Charlottesville) has again called attention to the fact that data is missing for several observatories in the USA: U.S. Naval Observatory (Flagstaff, Arizona), Van Vlek Observatory (Middletown, Connecticut), Yale University Observatory (New Haven, Connecticut), Yerkes Observatory (Williams Bay, Wisconsin) and NASA Observatory (Washington DC). The problem is in the lack of any answer from these places to the WFPA circular letters. All help to establish contact with the archivists in these observatories will be most appreciated.

A. Klemola (Lick Observatory) wrote that the 13 cm camera listed at the Lick Observatory actually belongs to the Mt. Wilson Observatory. It was on loan to the Lick Observatory for several years around 1955-1960 and was returned to Mt. Wilson. The plate data of the 13 cm Mt. Wilson Observatory camera is published in the introduction to the Lick Sky Atlas. 5,000 plates of the Alger Observatory (Algeria) were incorrectly listed as belonging to the Bordeaux plate archive. The number of the plates received with the Bordeaux Astrograph (half of them from the Carte du Ciel programme) was specified by J. Colin (Bordeaux Observatory) as 4298. The correct number of the plates received with the Leander McCormick 0.67 m refractor is 145,000 according to Ph. Ianna (Leander McCormick Observatory).

Susan Tritton (Royal Observatory Edinburgh) has a proposal to list also information about the date of discontinuation of operation of an instrument. This has already been done in the case of the Sonneberg Observatory plate archive (Bräuer & Fuhrmann 1992). For example the Brorfelde Schmidt Telescope according to K. Augustesen (Copenhagen University Observatory) no longer produces wide-field plates and has been permanently equipped with a 1024 x 1024 NASA JPL CASSNI CCD chip. In such cases, it is very important to mention the final date of operation of the telescope as a wide-field instrument.

The second edition of the WFPA List will be available at the WG WFI meeting in Potsdam later this year.

2. Development of the Wide-field Plate Archive Database

While developing the WFPA DB in Sofia at the Bulgarian Academy of Sciences, we received the possibility to use ORACLE RDBMS (Version 6.0) to manage the WFPA information. The ORACLE RDBMS is available at the Centre of Informatics and Computer Technology thanks to a grant received via the TEMPUS Programme of the European Communities (EC). The WFPA database will be one of the main projects there. The ORACLE RDBMS system is installed on a TELMAT TR 5000 computer (processor RISC/MC88000) and under the operating system of UNIX V (Release 4.0).

13 computer-readable plate archives are now available in Sofia. They contain information about more than 101,000 plates (Table 2).

Table 2. WFP catalogues in computer-readable form in the WFPA Database — SOFIA. Status in January 1993

No	Catalogue Name	Telescope (cm)	Observatory	No. of plates	Astronomer responsible	Note
1	ASIAGO50.CAT	40/50/100	Asiago Obs.	18378	R. Barbon	
2	ASIAGO90.CAT	67/92/215	Asiago Obs.	15245	R. Barbon	
3	BEIJING.CAT	60/90/180	Beijing Obs.	1509	S. Lan	1
4	BRUCE.CAT	40/ /203(2x)	Heidelberg Obs.	8800	G. Klare	2
5	ESO.CAT	100/160/306	ESO, Garching	9434	R. West	
6	KISO.CAT	105/150/325	Kiso Obs.	6798	Y. Nakada	
7	BGNAO50.CAT	50/70/172	Rozhen Obs.	6427	A. Mutafov	
8	BGRCNAO.CAT	/200/160	Rozhen Obs.	1950	K. Stavrev	
9	PALOMAR.CAT	122/183/307	Palomar Obs.	1037	R. Brucato	3
10	SONN-A.CAT	17/ /120	Sonneberg Obs.	7976	H.-J. Bräuer	
11	SONN-GA.CAT	40/ /160	Sonneberg Obs.	1658	H.-J. Bräuer	
12	TAUTENBG.CAT	134/200/400	Tautenburg Obs.	8187	R. Zinner	4
13	UKSTU.CAT	124/183/307	UKSTU	13940	S. Tritton	3

Notes: 1. The archive contains the plates obtained up to 1987. The diskette was sent by J. Wang.
2. The data for the first 970 plates is absent in the file on the diskette.
3. Computer readable version of the catalogue obtained from R. West.
4. The catalogue was obtained from S. Marx.

During the coming months we plan to put all these catalogues into the SQL form in order to manage them with the ORACLE RDBMS.

Some observatories have also collected the WFPA catalogues from their observational activities or from other observatories and use them for different projects.

Sonneberg Observatory WFPA Database: According to the paper of Bräuer & Fuhrmann (1992) and private information received during our visit to the Sonneberg Observatory last October, a total of 201,703 plates from the Sonneberg archive is already in a computer-readable form. This is more than 85% of the entire Sonneberg Plate Archive. The very useful programme, written for PC XT/AT on Turbo Pascal 6.0 manages the information of this great plate archive.

Lowell Observatory WFPA Database: According to B. Skiff, the computer plate files of the Lowell Observatory include the POSS I and POSS II sky surveys, the 0.6 m Asiago Schmidt telescope, the Lowell and Indiana archives and part of 10,000+ films taken by G. and C. Shoemaker with the 0.46 m Palomar Schmidt telescope. There is a computer programme at the observatory which will search plate catalogues to find instances where a certain asteroid should be present on the plate.

3. Future Plans — Plate Digitisation

On the way to collecting preliminary information for the already digitised plates, we have started to prepare a list of them. Up to now this list contains data from the already digitised wide-field plates collections of ST ScI (Guide Star Catalogue — 1518 plates [Lasker et al 1990]) and of the Muenster Astronomical Institute (Flare Star Project, 200+ GPO plates [Tsvetkov et al. 1992]). For this purpose, we hope to collect more data about already digitised plates from the Royal Observatory Edinburgh (COSMOS), ST ScI, Paris Observatory (MAMA), Muenster Astronomical Institute (two PDS 2020 GM+), Kiso Observatory, etc. All help will be very useful.

We propose in the future to copy from the files of the digitised plates only the information in the headers (in FITS format or another) and to produce a separate list of them.

We would also like to mention M. Irwin's work (Royal Greenwich Observatory) who reported about 600 (6.2° x 6.2°) digitised glass copies of POSS I O and E survey plates presented as APM Northern Sky Catalogue (Irwin 1992).

Bräuer & Kroll (1992) and Kroll & Neugebauer (1993) have reported about a project to digitise the plates in the Sonneberg Plate Archive using the method of the brightness determination on photographic plates with a CCD line scanner. The development of such modern methods will be very useful for the future digitisation of as many as possible wide-field plates, or at least parts of them.

4. Some General Comments and Remarks

4.1 The importance of networking

During the work on collecting WFPA data, we have become convinced once more of the importance of the availability of network contacts and exchange of the new information. The collaboration and exchange of information via network with SIMBAD, STARCAT, NSSDC, Goddard Space Flight Center Database, etc., will be very necessary for this project. Until now we have established access only to SIMBAD (thanks to M. Crézé) and ESO/STARCAT (thanks to ESO).

As an example for future useful contacts via electronic network we would like to mention the e-mail information received from M. Iliev (Center for Informatics and Computer Technology, Bulgarian Academy of Sciences) during his recent visit to the Bordeaux University about the paper by C. Kraybill (Planetary Image Facility, University of New Mexico) about Pioneer Database Project (managed on DECstation 5000/120). More than 18 catalogues including some astronomical and additional information are available via **pioneer.umn.edu@linx.unm.edu (Colby Kraybill)**. A. Klemola pointed out that some catalogues of the Lick Observatory are available in the Data Center of the Goddard Space Flight Center (especially for Lick/Mount John Observatory Southern Sky Survey under the catalogue designation ADC-6031; 212 records), but still we have no access to any of the USA databases.

We have also started to prepare a separate list of e-mail addresses (respectively FAX numbers) of the persons responsible for the plate archives in different observatories for easier communication and exchange of information.

4.2 Plate storage and quality

Estimation of the plate archive quality, how the plates are stored, their availability, etc., are only some of the very important questions which we must attempt to clarify. At the Organizing Committee meeting in Baltimore (ST ScI), one of us (M.T.) was asked (MacGillivray 1992) to collect this information and we shall appreciate any support in this direction from the astronomers responsible for the plate archives. At present we would like to suggest to put additional information (in an extra column of the WFPA list) which comments on how the plates are stored and about their quality.

4.3 Converting WFPA into the Computer-Readable Form

The biggest problem at this moment is that many observatories/institutes have no plans and funds to convert existing archives into computer-readable formats. As a result of the remarks of several astronomers, the total number of the catalogues in computer-readable form which was listed before has actually decreased! We received the corrections from the Harvard, Lick, Haute Provence and other observatories. Martha Hazen (Harvard College Observatory) pointed out that they have only card catalogues (except for the original record books). At the moment almost none of the data are in computer-readable form. They have started putting the information on a disk file but with so many plates (more than 450,000) it will take many many years. A. Klemola (Lick Observatory) explained that only about 3,000 plates from their plate archive are now in computer-readable form. The Lick Observatory does not make resources available to convert the records of the remaining plates to the machine-readable form. In the Tuorla Observatory, according to L. Takalo, there are no plans to convert the listing of the plate archive into computer-readable form. For the plates obtained after 1949 up to 1987, there is not even a list. In the Haute Provence Observatory P. Véron wrote they have only a card catalogue of the observatory plates.

This is a general problem which must be discussed during the next meeting of the WFPA WG in Potsdam this August.

We would like to mention the support of B. Hauck (Lausanne University, president of the IAU Commission 5 [Documentation and Astronomical Data]) who first initiated international plate archiving work and who has expressed his full support of the WFPA project. He proposes to publish some information about this project in the next issues of the IAU Commission 5 Newsletter.

J. Garcia (University of Buenos Aires, Argentina) and N. Vogt (Catholic University of Santiago, Chile) have expressed their great interest in participating in the WFPA project and their help in collecting more information for the Southern wide-field plate archives will be very useful. N. Vogt is preparing an international project for research on long term variability of stars for which the WFPA DB will be very useful.

We would like to express our full agreement with the basic philosophy formulated by E. Griffin (1992) in her review 'Spectroscopic Data Archives: A Study in Harmony' presented as a summary of the Vatican Workshop on Archiving and Distribution of Spectroscopic Data:

THE ORGANIZATION OF ARCHIVING OF ASTROPHYSICAL OBSERVATIONS HAS AN IMPORTANCE WHICH DESERVES AND REQUIRES URGENT INTERNATIONAL RECOGNITION AND ATTENTION.

We shall appreciate if more astronomers working on the WFPA establish and maintain contact with the Bulgarian archiving group and help us in updating and complementing the wide-field plate archiving data.

Finally we would like to express our deep thanks to all astronomers who are supporting the WFPA project and sending us information for their WF plate archives, especially on diskettes or in table form.

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Wide-field Plate Archive Database: a Management System for Personal IBM XT/AT Computers

As useful experience on the way to developing the Wide-field Plate Archive Database project (Tsvetkov 1992a, b) a set of programmes aimed at data management and reduction of the computer readable version of the 50/70 cm Schmidt telescope log book at the Rozhen National Astronomical Observatory, Bulgarian Academy of Sciences (Mutafov et al. 1993) was created.

The programmes were written for the most commonly used personal computers in Bulgaria — that of IBM XT/AT or compatible. The software package was written in Turbo Pascal 6.0.

The programmes have a user friendly menu-driven interface with any-time-available context orientated help information. They allow us to edit, append and print the necessary data information from any Wide-field Plate Archive (WFPA) catalogues. There are also some statistical tools like frequency analysis. Search and parametric search programmes help us to find in the Plate Archive any useful information.

The logical structure of the management system gives the ability to work with different data types — an easy way to manage other catalogues of the WFPA. The physical structure and the data format chosen by us lessens approximately three times the space normally occupied by ASCII representation of a given catalogue. In spite of the flexible logical structure the programmes need some tuning procedures to work with more than one archive at a time.

Using this software package the detailed analysis of the 50/70 cm Schmidt telescope plate archive will be made after the final reduction of the data.

The programme package will be available at the IAU Symposium 161 'Astronomy from Wide-field Imaging' in Potsdam where it will be demonstrated and distributed among the interested participants.

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Observations Catalog for the 2 m RCC Telescope at NAO-Rozhen

The first part of a computerized catalog of the observations obtained with the 2 m Ritchey-Chrétien-Coudé telescope of the National Astronomical Observatory at Rozhen has been completed. It contains the data for the direct-photography observations. The second part, now in preparation, will contain the spectroscopic observations. Our aim is to encourage by the help of this catalog the repeated use of observations stored in the observatory plate archive.

Since 1980 when the 2 m Rozhen telescope started operating nearly 2000 plates have been obtained, ⅘ of them with angular dimensions 1° x 1° (30 x 30 cm, resolution 12.9 arcsec/mm). The catalog of plates contains information for: equatorial coordinates of the plate center, object designation, photographic emulsion, band filter, plate dimensions, observation date and time, exposure time, observer and notes (sky quality, plate quality, etc.).

The analysis of the plate catalog data allows the tracking of the 2 m telescope usage for 13 years of operation. Figure 1 shows the yearly number of plates for the period 1980–1992. The gap for 1987 is due to the repair and test operations connected with the change of the telescope mirror by Carl Zeiss Jena. The decrease of the obtained number of plates for the period 1988–1992 compared with 1980–1986 is obvious. It is caused mainly by the increased application of electronic detectors in the recent years, and maybe partly by the worsened weather. We expect that this tendency will continue. If so, the wide field of the 2 m Rozhen telescope, which is one of its major advantages, will not be effectively used.

Figure 2 shows the number of obtained plates versus the type of observed objects. More than 85% of the 2 m telescope direct plates for which the object type has been identified are photographs of star clusters, (near) galaxies and clusters of galaxies, i.e. the wide field of the 2 m telescope has been actively used by the observers.

The information for the plate quality and the plate availability is of major importance for the potential user of the plate archive. Unfortunately, many plates from the plate catalog are of unknown quality. As for the availability, most of the observers have not kept the proprietary period of 3 years.

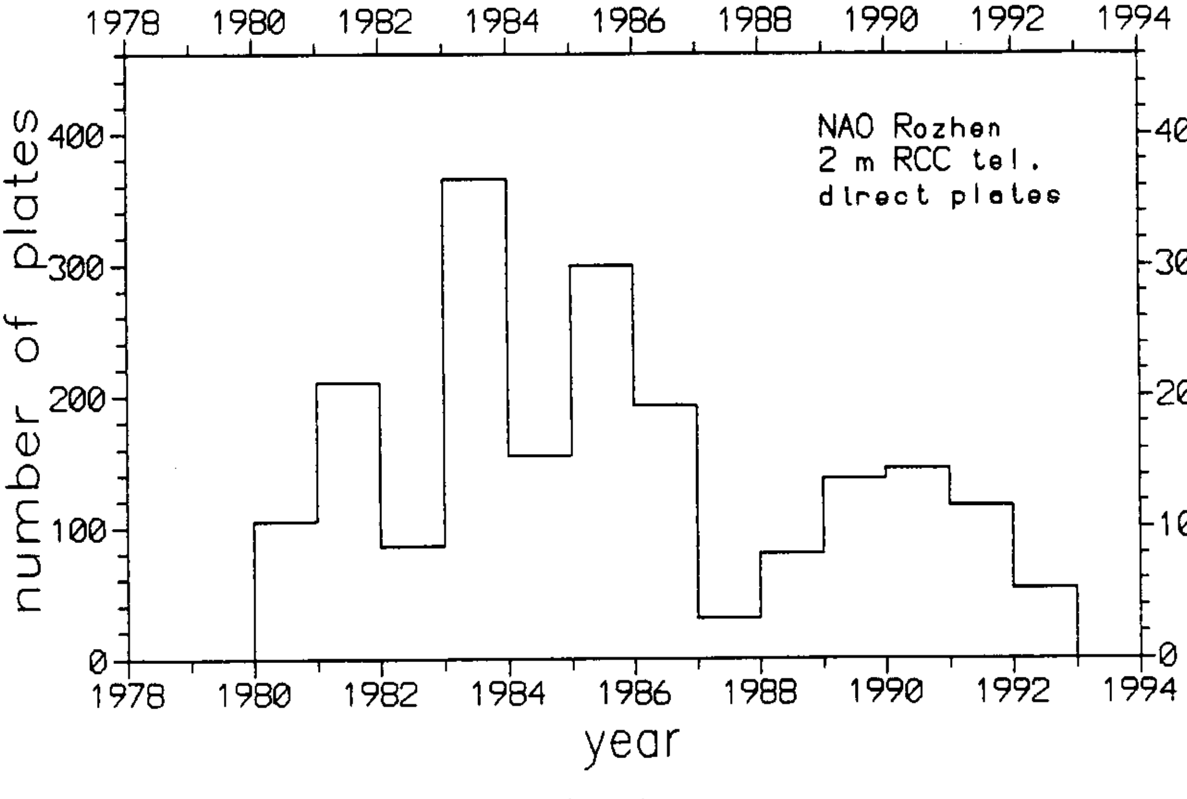

Figure 1.

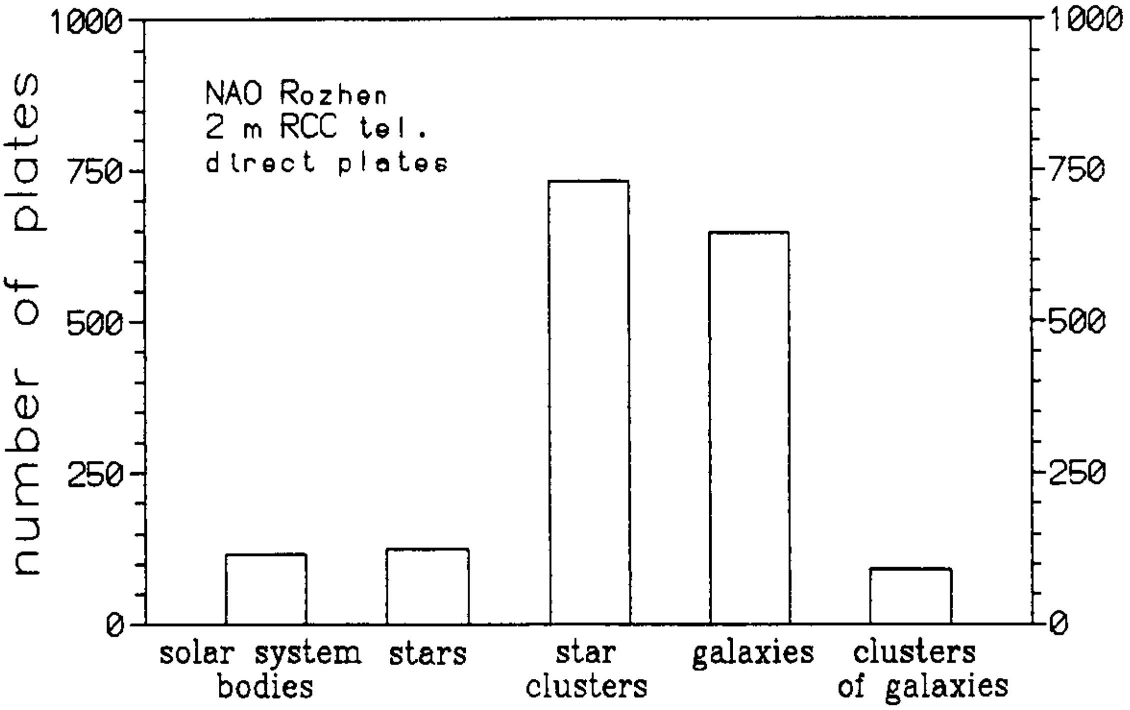

Figure 2.

We have a request to all observers possessing plates from the 2 m Rozhen telescope to return them for storage at NAO-Rozhen if they do not need the plates any more.

The catalog of plates for the 2 m RCC telescope at NAO-Rozhen will be included in the Wide-field Plate Archive Data Base (Tsvetkov 1992) which is now in preparation. In this way the data for the Rozhen direct plates will become accessible on line through the international data networks.

References

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Flare Stars Database

At present in the Galaxy there are more than 1500 known flare stars (UV Ceti type variables) discovered mainly during the last 30 years. All flare star discoveries are practically the result of the long term monitoring work with Wide-field telescopes. As a product of the endeavour and efforts of many astronomers we now have some catalogues of flare stars in stellar aggregates, as well as in the Solar vicinity.

A standard data-processing package of programmes for the existing catalogues of flare stars in computer readable form in the field of the stellar aggregates Orion M 42/43 (Natsvlishvili 1991), Pleiades (Tsvetkov et al. 1993), Praesepe (Tsvetkova et al. 1992), Cygnus (Tsvetkov & Tsvetkova 1990), Coma Berenices cluster (Erastova 1981), in the Solar vicinity — N.I. Shahovskaya (1978), Pettersen (1976), Semkov et al. (1988) and the subcatalogues of flare stars from the General Catalogue of Variable Stars (Kholopov 1985), subsequent Name-lists of Variable Stars and the New Catalogue of Suspected Variable Stars (Kholopov 1982) is prepared.

The programme package is realised for personal computers IBM XT/AT or compatible in Turbo C 2.0++. It gives flexible environment for easier access to the data, consisting of the characteristics of the flare stars and the literature describing them.

The following functions are realized:

- editing a record of a chosen catalogue;
- sorting the records by a chosen flare star characteristic;
- extracting of records of fixed indication;
- addition of new records;
- deletion of records;
- printing of records.

The input of new data for processing with the software package is realized in interactive mode and convenient form for the users.

It is permitted to delete an existing catalogue, if different reasons require to remove it.

The reported database will be at the disposal of astronomers during the meeting of the Working Group in Potsdam this year.

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Tsvetkova, K., Tsvetkov, M. and Jankovics, I., 1991. Preprint of the Astronomical Institute Münster, Poster Paper at the General Assembly of the IAU, Buenos Aires.

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Astronomical Glass Plates Made in Germany

For 60 years photographic glass plates for scientific and technical imaging have been produced in Wolfen (Germany), and during the past 30 years or so, glass plates with special emulsions for the astrophotography were also made here.

This tradition is now continuing under the trade mark **ORWO** (i.e. **ORiginal WOlfen**).

Based on their high sensitivity and simultaneously favourable Schwarzschild behaviour these plates give excellent results, especially for long-time exposures at the lowest radiation energies. The high signal-to-noise ratio and the medium and high spatial frequency ranges guarantee a maximum of astronomical applications.

The opti-float glass is of the best quality and has an anti-halation coating on the rear side.

Types available

There are presently four types of plates for astrophotography and two types for production of copies with different spectral sensitivities available:

Plate type	**Sensitization**	**Sensitivity range**
Plates for astrophotography		
Astro Plate ZU	unsensitized	230 - 520 nm
Astro Plate ZP	panchromatic	230 - 680 nm
Raman/Astro Plate RO	orthochromatic	230 - 600 nm
Raman/Astro Plate RP	panchromatic	230 - 650 nm
Plates for copying		
Diapositive Plate DU	unsensitized	230 - 500 nm
Topo Plate TO	orthochromatic	230 - 600 nm

Type	Sensitivity[1]	**base plus fog density (maximum)**	**contrast γ**	**granularity RMS**	**resolving power (lines/mm)**
ZU	1 nJ/cm^2 at 420 nm	0,30	1,6	27	70
ZP	65 µJ/cm^2 at 660 nm	0,30	1,5	29	55
RO	4 µJ/cm^2 at 420 nm	0,18	1,1	23	65
RP	110 µJ/cm^2 at 600 nm	0,18	1,4	23	65
DU	40 nJ/cm^2 at 420 nm	0,08	1,4	20	85
TO	50 nJ/cm^2 at 420 nm	0,10	2,6	14	125

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[1] when exposed to D = 0,6 above base plus fog density.

The ORWO plates are being offered in all usual sizes. One package contains 12 plates, respectively 6 plates for sizes equal to or larger than 24 cm x 24 cm.

Development

The special developer A 71 S of the German producer Calbe Fotochemie GmbH (D-O-3310 Calbe, Germany) is recommended for the Z- and R- plates. Other developers with metole and hydroquinone can also be used. For the D- and T- plates, the contrast of the copies is very much influenced by the selected developer and the developing time.

Storage

The guaranteed period is 12 months. The storage conditions should be cool (max 4°C) and dry (50 to 60% relative humidity).

Further information

Users of astronomical plates who are interested in more information about the mentioned plates, are welcome to contact ORWO at the address indicated below.

A. Ohnesorge
Filmfabrik Wolfen GmbH
D-O-4440 Wolfen
Germany

Tel.: (03494) 63 61 37
Fax.: (03494) 63 61 72
Telex: 319 170 film d

Computer-Readable Version of the Rozhen Schmidt Telescope Plate Log Book

Since August 1991 in connection with the Wide-field Plate Archive project (Tsvetkov, 1992a, b) we started to prepare a computer-readable version of the observational log book of the 50/70/172 cm Schmidt telescope at the Rozhen National Astronomical Observatory, Bulgarian Academy of Sciences.

Our purpose was to lose minimum information with maximum record compactness. Thus the next fields were included:

1. Plate current number in the log book;
2. Additional letter for the plates with identical current number;
3. Plate size;
4. Sequential number of exposure in the case of two or more different exposures;
5. Date;
6. Beginning of the exposure in local time (GMT + 2h);
7. Object/field name;
8. Plate centre coordinates — Right Ascension and Declination from the log book;
9. Multiplicity of the exposure;
10. Duration of the exposure;
11. Emulsion (Kodak, ORWO, etc.);
12. Filter;
13. Objective prism indication;
14. Method of exposure (M — multi-exposure, T — stellar track, F — focus, U — adjustment, C — calibration);
15. Humidity during the exposure;
16. Temperature (Cx);
17. Plate quality (T — technical problem, C — plate control and check up, A — meteorological problem, F — out of focus, S — hypersensibilization, G — guiding problems, M — Moon during the exposure, E — problems during the exposure);
18. Image quality;
19. Plate location (O — observatory, A — observer/author of the programme);
20. Observer (initials of name);
21. Notes.

We used in our work the archiving experience of the Kiso Observatory (Ishida 1989).

At present the complete computer-readable version of the log book of the Rozhen Schmidt telescope contains data for more than 6400 plates (December 1992). A specialized software package in Turbo Pascal 6.0 for input, editing, analysis and statistical processing was created (Michailov & Borisov 1993).

The computer readable version of the Rozhen Schmidt telescope log book is available on 3.5"/5.25" diskettes in ASCII format. The analysis of the log book will be presented at the IAU Symposium No. 161 in August 1993.

Table 1 shows a sample listing of the first page of the computer readable version of the Rozhen Schmidt telescope plate archive.

Table 1. Sample listing of the Rozhen 50/70 cm Schmidt telescope log book computer-readable version.

1 2	34	5	6	7	8	9	10	11	12	1314	15	16	17 18	19	20	21
0001A	AA	19790606	0245.	Alpha Lyr	1836 +3847	08	000.20	RP1	N	N	U	+09		A	MTs	TEST
0002A	AA	19790606	0330.	Draco	1623 +6130	09	000.30	RP1	N	N	F	+09		A	MTs	TEST
0004A	AA	19790810	0100.	Alpha Lyr	1836 +3847	20	000.30	RP1	N	N		+17		A	Ms	TEST
0005A	AA	19790825	0136.	V1057 Cyg	2057 +4403	01	020.00	ZU2	N	N		+13		A	MTs	TEST
0006A	AA	19790905	0210.	Alpha Cyg	2041 +4516	20	000.30	RP1	N	N		+09		A	MTs	TEST
0007A	AA	19790918	0230.	Pleiades	0346 +2400	06	010.00	ZU2	N	N		+02		A	MTs	
0008A	AA	19790918	0345.	Pleiades	0346 +2400	06	010.00	ZU2	N	N		+02		A	MTs	
0009A	AA	19790918	2222.	Cygnus A*	2052 +4300	01	045.00	ZP3	N	N		+08		A	MTs	
0010A	AA	19790918	2332.	Cygnus A*	2052 +4300	06	010.00	ZU4	N	N		+09		A	MTs	
0011A	AA	19790919	0045.	Cygnus A*	2052 +4300	06	010.00	ZU21	N	N	M	+09		A	MTs	
0012A	AA	19790919	0210.	Pleiades	0346 +2400	06	010.00	ZU2	N	N	M	+08		A	MTs	
0013A	AA	19790919	0328.	Pleiades	0346 +2400	06	010.00	ZU2	N	N	M	+08		A	MTs	
0014A	AA	19790919	0444.	Pleiades	0346 +2400	01	045.00	ZU3	N	N		+08		A	MTs	
0015A	AA	19790919	2215.	Cygnus A*	2052 +4300	01	045.00	ZU21	N	N		+11		A	MTs	
0016A	AA	19790919	2314.	Cygnus A*	2052 +4300	06	010.00	ZU2	N	N	M	+11		A	MTs	
0017A	AA	19790920	0133.	Cygnus A*	2052 +4300	06	010.00	ZU2	N	N	M	+12		A	MTs	
0018A	AA	19790920	0146.	Pleiades	0346 +2400	06	010.00	ZU2	N	N	M	+11		A	MTs	
0019A	AA	19790920	0304.	Pleiades	0346 +2400	06	010.00	ZU2	N	N	M	+10		A	MTs	
0020A	AA	19790920	0415.	Pleiades	0346 +2400	06	010.00	ZU2	N	N	M	+10		A	MTs	
0021A	AA	19790920	0525.	Pleiades	0348 +2400	01	031.00	ZU21	N	N		+10		A	MTs	
0022A	AA	19790920	2123.	Cygnus A*	2052 +4300	06	010.00	ZU2	N	N	M	+12		A	MTs	
0023A	AA	19790920	2234.	Cygnus A*	2052 +4300	06	010.00	ZU2	N	N	M	+11		A	MTs	
0024A	AA	19790920	2346.	Cygnus A*	2052 +4300	06	010.00	ZU2	N	N	M	+11		A	MTs	
0025A	AA	19790921	0103.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+10		A	MTs	
0026A	AA	19790921	0215.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+10		A	MTs	
0027A	AA	19790921	0330.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+10		A	MTs	
0028A	AA	19790921	0443.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+10		A	MTs	
0029A	AA	19790921	2112.	Cygnus A*	2052 +4300	06	010.00	ZU2	N	N	M	+13		A	MTs	

1 2	34	5	6	7	8	9	10	11	12	1314	15	16	17	18	19	20	21
0030A	AA	19790921	2222.	Cygnus A*	2052 +4300	06	010.00	ZU2	N	N	M	+11			A	MTs	
0031A	AA	19790922	0052.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+10			A	MTs	
0032A	AA	19790922	0203.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+10			A	MTs	
0033A	AA	19790922	0321.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+10			A	MTs	
0034A	AA	19790922	0445.	Cygnus A*	2052 +4300	06	010.00	ZU2	N	N	M	+10			A	MTs	
0035A	AA	19790922	2051.	Cygnus A*	2052 +4300	06	010.00	ZU2	N	N	M	+13			A	MTs	
0036A	AA	19790922	2201.	Cygnus A*	2052 +4300	06	010.00	ZU2	N	N	M	+13			A	MTs	
0037A	AA	19790922	2313.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+12			A	MTs	
0038A	AA	19790923	0040.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+12			A	MTs	
0039A	AA	19790923	0158.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+12			A	MTs	
0040A	AA	19790923	0134.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+13			A	MTs	
0041A	AA	19790923	0429.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+12			A	MTs	
0042A	AA	19790923	0544.	Pleiades	0348 +2400	01	020.00	ZU2	N	N		+12			A	MTs	
0043A	AA	19790924	0029.	Alpha Cyg	2025 +4120	06	010.00	ZU2	N	N	M	+14			A	MTs	
0044A	AA	19790924	0145.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+13			A	MTs	
0045A	AA	19790924	0258.	Pleiades	0348 +2400	06	010.00	ZU2	N	N	M	+13			A	MTs	

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Erratum:

Clarification of the Minutes of the 1st Meeting of the WFI WG Organising Committee (Newsletter No. 2, p. 16)

Section 8.19 gives the impression that a meeting is planned at the University of Minnesota for 1995. Since I did not endorse any suggestions on the sites of future meetings (e.g. Minnesota) and their topics or commit to organize a meeting, I was surprised that Minnesota is listed as the next meeting site.

Unfortunately, a meeting at the University of Minnesota is no longer feasible. I had received a large financial commitment for support from the University administration for the planned 1993 meeting. This included a personal commitment from the Dean to raise private funds which is no small matter. Consequently, I cannot ask for this kind of support again for many years.

Therefore the statement that a meeting is to be arranged at the University of Minnesota for 1995 is incorrect.

Roberta M. Humphreys
University of Minnesota

Availability of KODAK Astronomical Plates

We have heard from Eastman Kodak that they are having serious difficulty preparing emulsion types IIa-O, 098-04 and 156-01 (IIa-D) as well as the 103a series. This announcement was made by Gordon P. Brown, from Kodak's Professional Photography Division at the recent (January 1993) AAS meeting in Phoenix and repeated in a recent fax to David Malin.

This confirms earlier information from observatories that they were experiencing long delays in supply of these emulsion types. Apparently, these products were formulated many years ago using gelatins that are now in short supply because the animals from which they were derived are protected or no longer available. All emulsion types of interest to astronomers are threatened, though a 'temporary fix' keeps IIIa-J and IIIa-F available for the moment. Note that there is now no Kodak emulsion suitable for the fundamental astronomical B and V bands.

This situation is potentially very serious, and though Kodak have advised that they will attempt to solve the problem, aspects of it may require "an extensive research program that these products cannot support". In any case, the investigation will take some time.

It is evident that this problem has caused Kodak to review the demand for spectroscopic plates, and, at the same AAS meeting, Gordon Brown issued a questionnaire asking for information on the usage of a range of Spectroscopic Plates. Apparently, the questionnaire has only been directed to participants at the AAS meeting. Since many users of Spectroscopic Plates would not be present, with Gordon Brown's agreement, we reproduce the questionnaire in this Newsletter.

On the reverse of the questionnaire was another page inviting comments. Specifically, it said: "Please use this side for any comments that you may have regarding: plate availability, ordering, shipping, new opportunities, plate testing, etc."

If you have any interest whatsoever in the continued availability of Spectroscopic Emulsions, I strongly encourage you to take advantage of this opportunity to let Eastman Kodak (through Gordon Brown) know how their demise will affect your scientific program.

Please include in your reply your name, your institute and its full address as well as telephone and fax contact numbers, if available.

The questionnaire and comments should be returned as soon as possible to:

Gordon P. Brown
Coordinator: Scientific Products
Professional Imaging - MEC
Eastman Kodak Company
343 State Street
Rochester, New York 14624-0811
U.S.A.
Fax.: +1 716-724-0457

David Malin
Anglo-Australian Observatory
PO Box 296 (167 Vimiera Road)
Epping, NSW 2121
Australia

Availability of KODAK Astronomical Plates — Questionnaire

For a number of reasons, we currently are unable to manufacture some of the astronomical emulsions on glass plates. Our problems are related to certain gelatin formulations which are no longer available. We are testing to determine alternate sources of supply, but progress is not promising. We may be able to improve the situation slightly after testing for a period of 6 to 8 months. In other cases it is doubtful that we will be able to make the emulsions at all.

The situation is particularly crucial since we believe that some of the ingedients — we don't know which without an extensive research program that these products cannot support — were responsible for the sensitivity of the plates.

The plates that we are currently having difficulties with are:

KODAK Spectroscopic Plate, Type IIa-O

KODAK Special plate, Type 156-01/02 (formerly IIa-D)

KODAK Special plate, Type 157-01/02

KODAK Spectroscopic Plates, Type 103a-O, 103a-F, 103a-G, and 103a-D

KODAK Special Plate, Type 098-01/02/04

KODAK Spectroscopic Plates, Type 649-O, 649-F.

Others that we have had problems with that currently have temporary fixes in place are:

KODAK Spectrum Analysis Plates, SA-1

KODAK Spectroscopic Plate, Type IIIa-J

KODAK Spectroscopic Plates, Type IIIa-F.

Gordon P. Brown
Coordinator: Scientific Products
KODAK

Questionnaire for WG on WFI members: KODAK Spectroscopic Plates

KODAK Plate	Do you use it?		Reasons that you use it
	Yes	No	
Spect. Analysis #1			
T-MAX 100			
Process			
IIa-O			
Proj. Sl. Contrast			
101-05			
IIIa-J			
IIIa-F			
Spect. Analysis #3			
I-N			
103a-G *			
103a-O *			
649-F *			
Proj. Sl. Medium *			
Technical Pan			
IV-N *			
103a-D *			
Holographic 120 *			
649-O *			
103a-F *			
I-Z *			
IIa-D *			
Other:			
Other:			

Name:	Institute:
Mail Code:	Address:
City:	State/Province:
Country:	Postal Code:
Telephone:	Fax:

Please use other side for comments.

*Candidates for discontinuance

Questionnaire for WG on WFI members: KODAK Spectroscopic Plates

Please use this side for any comments that you may have regarding: plate availability, ordering, shipping, new opportunities, plate testing, etc.

Please return this questionnaire to:

Gordon P. Brown
Coordinator: Scientific Products
Professional Imaging — MEC
Eastman Kodak Company
343 State Street
Rochester, New York 14624-0811
U.S.A.

Telephone (716) 724-0635
FAX: (716) 724-0457