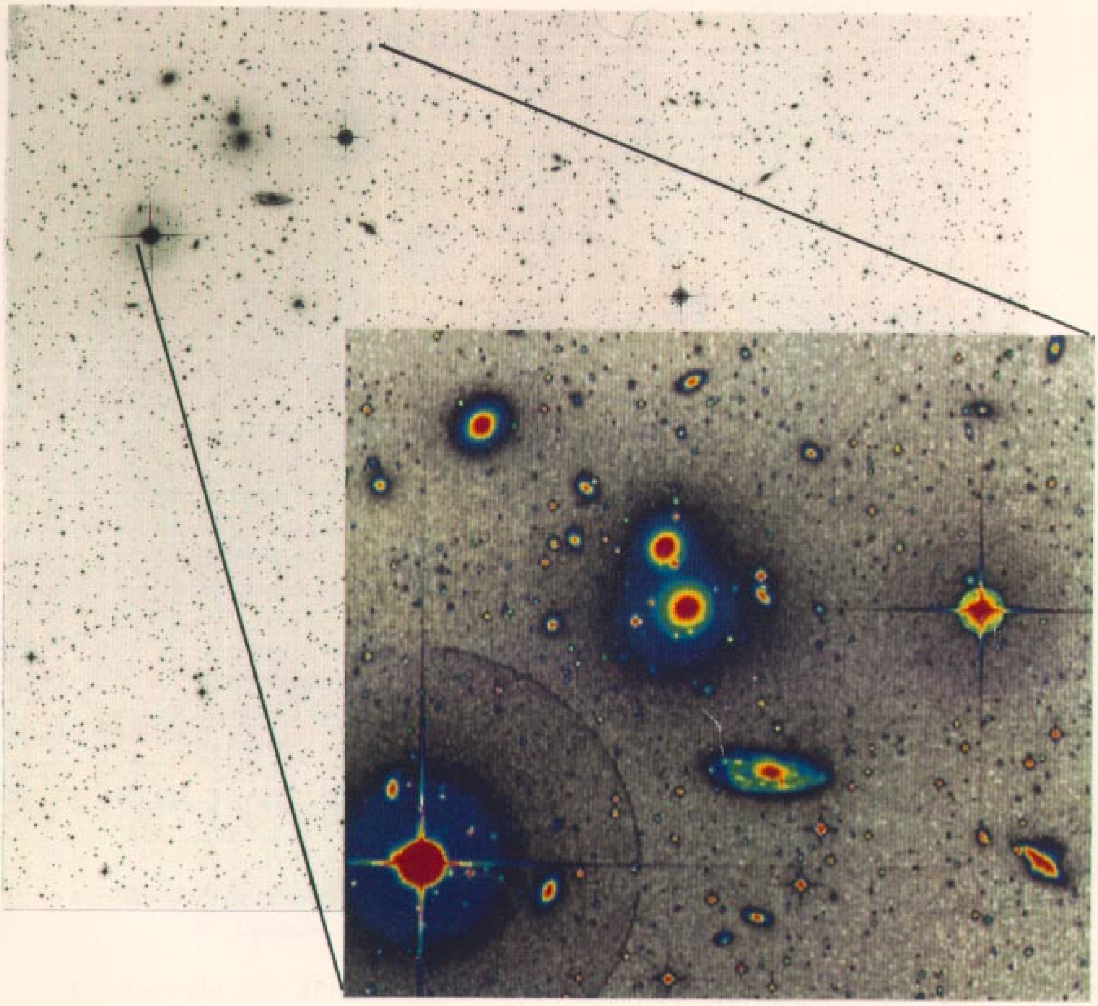
International Astronomical Union
Commission 9



Working group
on
"Wide-field imaging"

Newsletter 1

IAU WORKING GROUP ON WIDE-FIELD IMAGING

Newsletter No. 1

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Introduction:
The IAU Working Group on Wide-field Imaging

The new IAU Working Group (WG) on Wide-Field Imaging was established at the time of the 1991 IAU General Assembly in Buenos Aires. It belongs to IAU Commission 9 ('Instruments') and is the successor of the now defunct WG on Astronomical Photography, but it covers more areas, and also includes the functions of a proposed WG on Digitization, which are herewith taken care of within a broader context.

Photography has played a very important role in astronomy during more than one century and the photographic emulsion is a wonderful detector which has produced a wealth of discoveries and without which the rapid progress in our science would never have been possible. Thanks to the dedication of many astronomers turned photographers, photographers who developed into master observers, as well as chemical engineers whose ingenuity and joy of experimentation produced new and improved photographic methods and materials, the art of photography has steadily pushed our observational horizon outwards.

Soon after the revolutionary IIIa emulsions became available, the IAU WG on Photography was re-activated in 1976, and has since served to spread the know-how about the new tools and their optimal application. Improved sensitisation methods were invented and processing procedures were established which were more quantitive than those of earlier epochs. Great attention was paid to the efficient extraction of data by means of advanced microphotometers and to better reproducibility through accurate calibration. The results were excellent and photography experienced a renaissance in the 1970s and early 1980s.

However, the availability of new types of detectors, especially CCDs from 1980, has slowly reduced the territory of photography in astronomy, also because a certain technological stagnation has become apparent; no new emulsions, only minor improvements here and there, etc. I believe that the latest meeting of the IAU WG on Photography, in late October 1990 in Munich, Germany, rather clearly showed this development. This certainly does not mean that photography is no longer of great use in astronomy, on the contrary, it is unsurpassed for wide-field applications, but it has fewer followers than before. The Organising Committee of the WG on Photography therefore began thinking of some kind of reorganisation, the end result of which was the birth of the WG on Wide-Field Imaging three quarters of a year later. I am thankful to all involved persons, in particular the outgoing and incoming Presidents of Commission 9, Professors J. Davis and J.C. Bhattacharyya, for ensuring a smooth transition.

The new WG covers a wide field (no pun intended!) and will fill an important function in contemporary astronomy. Wide-field astronomy is a 'service' to many different types of research; the classical example is of course the very successful symbiosis between the Palomar 5 metre and Schmidt telescopes. By creating this WG, the various steps in the overall procedure in wide-field astronomy come together, from the observations to their archiving for the benefit of present and future generations of scientists; this is illustrated by the titles of the four WG sub-groups, now established:

1. Sky Surveys and Patrols;
2. Photographic Techniques;

3. Digitization Techniques, and

4. Archival and Retrieval of Wide-field Data.

An Organising Committee (OC) has been set up with the following members: Jean Guibert (Paris, France), Roberta M. Humphreys (Minneapolis, MN, USA), Keiichi Ishida (Tokyo, Japan), Barry M. Lasker (Baltimore, MD, USA), Hilmar Lorenz (Potsdam, Germany), Harvey T. MacGillivray (Edinburgh, Scotland, U.K.), David Malin (Epping, N.S.W., Australia), Neill Reid (Pasadena, CA, USA), Milcho Tsvetkov (Sofia, Bulgaria) and Richard M. West (Garching bei München, Germany). The chairpersons of the above mentioned sub-groups are West, Malin, MacGillivray and Lasker, respectively. The question of how future CCD surveys can best be accommodated within the WG structure still has to be solved.

The OC has decided to take a number of *initial actions* to start up the work of this WG, but it is of course very likely that quite a few more will materialize in due time:

- to issue a Newsletter (this is the first issue), probably twice a year, in which all contributions concerning the scientific and technical areas of the WG will be welcome, both from members and from other sides. Harvey MacGillivray has kindly agreed to be the editor;

- to organise a two-day meeting of the OC plus a small number of consultants, during which the future work of the WG will be thoroughly discussed and, if needed, some priorities set. This meeting will take place at the Space Telescope Science Institute in Baltimore, in response to the kind invitation from Barry Lasker, on April 13 – 14, 1992. The preliminary agenda will be found elsewhere in this issue and all WG members are herewith cordially invited to send me any ideas, comments, proposals etc., which you may have in this connection, so that they can be discussed by the OC. The outcome of the OC meeting will be described in the July 1992 issue of this Newsletter;

- to organise a full scale meeting of the WG in 1993, possibly in the first half of that year, and perhaps as an IAU Colloquium (if the Commission(s) and the IAU Executive Committee give their blessing), during which the entire subject area will be presented and discussed in depth;

- to give support to the Space Schmidt project, now (finally!) being realized in a collaboration that involves several European countries and possibly countries outside this area as well (Hilmar Lorenz is the contact person on the OC); and

- to prepare a computer-readable inventory of all wide-field plates extant in plate archives all over the world. Milcho Tsvetkov has started this enormous undertaking and has, as the article in this issue will show, already made good progress in collecting information from many observatories.

Now some numbers: on January 1, 1992, the WG had 165 members, of which 123 were 'full members' and 42 'consultants'. The difference is purely formal: according to IAU rules, only IAU members can be 'full members' of IAU Working Groups, and it certainly does not indicate any kind of discrimination! What counts is the active involvement of all members in the various field(s) of our Working Group.

The present members are located in 34 different countries: Argentina (1), Australia (6), Austria (2), Belgium (2), Brazil (1), Bulgaria (15), Canada (2), Chile (1), China (4), Czechoslovakia (6), Finland (1), France (22), Georgia (2), Germany (18), India (1), Indonesia (1), Israel (1), Italy (4), Japan (6), Latvia (1), Lithuania (1), Mexico (1), the Netherlands (3), New Zealand (1), Poland (1), Russia (4), Spain (1), Sweden (2), Switzerland (2), Thailand (1), UK (24), USA (24), Vatican City State (1) and Venezuela (1). (Four new countries of the former USSR have been listed individually in the expectation that they will soon join the IAU formally).

The distribution of interests is rather uniform. When asked to indicate on the earlier questionnaire which of the four sub-groups correspond to their field(s) of interest, the 165 WG members made 381 checks (2.3 per member); of these 98 (26%) were for sub-group 1 (Sky Surveys and Patrols), 83 (22%) for sub-group 2 (Photographic Techniques), 105 (28%) for sub-group 3 (Digitization Techniques) and 95 (25%) for sub-group 4 (Archival and Retrieval of Wide-Field Data).

The above statistics show that our WG has had a very good start indeed, both what concerns the coverage by geographical location and by subject. Nevertheless, I herewith kindly ask all members and especially those of you, who are 'isolated' in your part of the world, to make sure that other interested persons in your neighbourhood will be kept informed about present and upcoming WG developments, especially by passing on this and future issues of the Newsletter. Although the WG already has reached a substantial size, I would also welcome a few more active members, particularly in some of the IAU member countries not yet on the above list.

I wish all WG members a happy New Year 1992 and thank all of you in advance for your active collaboration. Let us try to make this WG a useful tool for all astronomers!

PS. I almost forgot to say that we still have to define what 'wide-field' means — $1^\circ \times 1^\circ$ or perhaps $2^\circ \times 2^\circ$, or even larger ? What do you suggest ?

Richard M. West
European Southern Observatory
Karl-Schwarzschild-Straße 2
D-8046 Garching bei München
Germany

Reports from the Sub-Sections of the Working Group

a): Sky Surveys and Patrols

In common astronomical terminology, *Sky Surveys* refer to observational programmes which aim at the *one-time recording* of a (significant) part of the sky, by (deep) direct or spectral exposures in different wavebands. The famous Palomar Observatory Sky Survey (POSS I) which covered the sky between declinations $+90°$ and $-30°$ is a typical example of this kind of work, although nowadays the term 'Sky Survey' is also used for radio-, IR-, X-ray and γ-ray programmes. Sky surveys are powerful tools when searching for particular types of astronomical objects, selected by morphological, colour or spectral criteria.

Sky Patrols are special surveys, which aim at covering a large part of the sky at *regular and frequent intervals*, in order to provide a continuous record of the sky and to document changes. Here, the long-term Harvard and Sonneberg Patrols first come to mind, each of which has produced several hundreds of thousands of photographic recordings. Because of the need to cover very large areas in a short time, patrols have been less deep than surveys, but have also led to innumerable discoveries, in particular of time-variable objects, such as minor planets, comets and variable stars. Sky Patrols also allow the investigation of objects retrospectively, for instance to learn how the luminosity of a recently discovered quasar has changed during the past century.

Sky surveys and patrols have eternal value, because we can never repeat an astronomical observation under completely identical circumstances: the epoch will always be different. By doing this kind of research, we pass on to future generations of astronomers an immense treasure of data, of which certain parts are bound to become very useful some day. However, we of course do not know which parts and for this reason, it is desirable that the data are as 'clean' as possible and they must in any case be extremely well documented and, wherever feasible, well calibrated.

It is exactly this unique mission of sky surveys and patrols that renders that type of work so valuable. To some it may appear rather monotonous, but experience shows that not only do the involved astronomers reap a bountiful harvest of discoveries now, they also do a great service to all our successors in the near and distant future. Just think about some of the labour-intensive surveys/patrols of the past, for instance the great Bonner Durchmusterung of the 19th century, which now provides an excellent check on various astrometrical measurements, or, to go further back in time, the careful record of historical supernovae and novae, collected over centuries by visual sky patrols in ancient China.

Clearly, it is our moral duty and in our own interest to continue such a tradition and to ensure that this kind of long-term work will not be forgotten amidst the natural enthusiasm for spectacular observations of one-time astronomical events and peculiar, individual objects. It must be admitted, however, and I think that it is quite understandable, that many younger astronomers are rather reluctant to embark upon this type of project at an early point in their careers!

We have at this moment arrived at a new crossroads in the development and execution of sky surveys and patrols. On the one hand, we master the art of producing the deepest possible sky surveys, witness the efforts in the USA and Japan in the north, and in Australia and Chile in the south. The progress is impressively demonstrated when comparing the first Palomar Survey (POSS I) with its successor, POSS II, now being produced. On the other hand, it is sad to record that recently the Harvard patrol was discontinued and that most probably also the Sonneberg patrol will soon be stopped, after many decades of continuous action. In both cases the decision seems at least partly to have been caused by the opinion of the respective funding authorities that the ever sparser funds may be better used than to support operations with well-tested, but no longer very modern equipment at less-than-optimal sites.

But this should not lead us to believe that sky patrols are no longer needed! On the contrary, I am convinced that the time has now come to reconsider this basic area of observational astronomy, in terms of instrumentation and strategy.

Enter the quantum efficient, but still rather small CCDs. How and when will they take over after the photographic plates which have been the unsurpassed detectors during more than 100 years of astronomical sky surveys and patrols? I have attempted to give a partial answer in a recent article (ESO Messenger, **65**, 45; September 1991), which was based on a talk given at the October 1990 meeting of the former IAU WG on Photography and to which the reader is referred for more details.

Briefly, I do not think that the time has come yet to equip the large Schmidt telescopes with CCDs. Even the biggest CCDs are still so small that a change would rob the Schmidt telescopes of their unsurpassed ability to produce high resolution imaging over a very wide field — and hence their usefulness for deep surveys.

However, I could imagine that it would now be reasonable to consider a rebirth of sky patrols, based on mosaics of large CCDs in medium-size, e.g. 2 m telescopes, since for this type of work, a somewhat lower angular resolution seems acceptable. Such 'patrol telescopes' would be fully dedicated to sky patrols in order to be efficient and reach the faintest possible limiting magnitudes. Two telescopes at the best possible sites, one in the North and one in the South, could patrol the entire sky down to the quite faint magnitudes, say once per month. This would secure a lasting record of the sky and, if powerful on-line reduction facilities are also set up, at the same time provide unequalled opportunities for discovery of 'interesting' objects some of which would then be further observed with larger telescopes, including those of the new generation of giants, the Keck, the ESO VLT, the Japanese 8-m, and possibly others.

I note in this connection the recent surge of interest in search programmes for Near-Earth Objects, as demonstrated by various new undertakings like the — for some time very active and successful — Spacewatch facility in the USA, the recent San Juan Capistrano Workshop sponsored by NASA, the Workshop NEO-91 in Saint Petersburg (formerly Leningrad) in Russia, the creation of IAU and NASA Working Groups on NEOs, and the plans for a dedicated European NEO search facility.

However, the NEO search techniques may not be optimally suited for full-sky patrols and there is of course always the critical question about how the enormous amounts of recorded data will be archived. This is a major problem in all current CCD work. But even if NEO facilities may be too special for sky patrols, it will clearly be very useful to establish close links with this community and to see how the various observational needs can best be taken care of.

The above thoughts are provisional only and serve to call attention to what I perceive as a compelling need for action. There may be different ways to proceed, and this theme will undoubtedly be further discussed within the WG on Wide-Field

Imaging.

In the meantime, I would be interested in receiving opinions from all interested persons, especially from the WG members. Are we ready to consider restarting regular sky patrols by means of wide-field, dedicated CCD telescopes? If so, which kind of telescope? What kind of CCD and in which configuration? To which limiting magnitude? Are there any groups or observatories who would like to embark upon such a project, or at least to carry through an first appraisal of the technical and organisational problems?

I look forward to your reactions!

Richard M. West
European Southern Observatory
Karl-Schwarzschild-Straße 2
D-8046 Garching bei München
Germany

b): Photographic Techniques

1 Introduction

I am very pleased to find that the interests of the astronomical photographic community have been incorporated into the Wide-Field Imaging Working Group. While the remit of 'Wide-Field Imaging' does not completely embrace all of photographic astronomy, this Group covers all the most active areas and is broad enough to include most applications of photography in our science. More important, the Group provides a potentially lively and conspicuous forum for those of us who believe that photography has something unique to offer the astronomical community. It is up to us to display our wares and exchange ideas.

So why should we persist with photography in the age of the CCD? It turns out that there are many reasons. The photographic emulsion is a detector with a DQE of a few percent over sensitive areas that are measured in large fractions of a square metre. This sensitive surface has astonishing uniformity and is covered with pixels that are small compared with those of most CCDs. Not only is this remarkable detector readily available, but it is relatively inexpensive and most existing telescopes are equipped to use it without modification. As well as being a rich source of scientific discovery, both serendipitous and statistical, the photographic plate is an excellent storage medium. Almost incidental to its scientific rôle, photography is able to produce pictures that are exciting to look at, a characteristic that other solid state detectors have yet to match.

Given these properties, it is not surprising that photography is extensively used for wide-field survey purposes, and a detailed discussion of its problems and potential compared to CCDs has been given by West (1991). A broader view of the future of astronomical photography and the reasons for its present state has been presented by Malin (1988).

2 New Activities

It was reported by Ken Russell (UKST) at the 'Digitised Optical Sky Surveys' meeting in mid 1991 that experiments with Tech Pan film based material in the UK Schmidt had proved very promising, at least from the image quality point of view, though this improvement is not obvious from simple inspection of the original films. It is evident that Tech Pan has considerably better spatial resolution and finer grain than the widely-used IIIa emulsions. These improvements come at almost no extra cost in exposure time and the contrast is about the same as IIIa-F. The initial tests imply that in good seeing, IIIa emulsions in the UK Schmidt are probably undersampling the image, and that the DQE of the film-based material must be considerably higher than the similarly sensitised IIIa-F.

The possibility of using this improved film-based material for Schmidt surveys (e.g. see the article by Phillipps and Parker in this newsletter – Ed.) immediately raises some interesting questions, some of which I hope the Working Group will be able to address. These are concerned with its spectral sensitivity and with the mechanical problems of using a film-based product.

The astronomical community acquired a new passband with the introduction of the IIIa-J emulsion 20 years ago. Though this emulsion revolutionised astronomical photography, an unwanted side-effect was that the long established B and V passbands languished, with only the older, relatively coarse-grained emulsions being available in the O and D sensitizings on which the B and V passbands were based. Tech Pan offers yet another passband, strongly peaked around 656nm, reflecting its origins as a solar flare patrol film. The Working Group must consider if the improved imaging properties of Tech Pan justify asking the manufacturer to make O, D or F sensitizings with Tech Pan-like imaging properties.

The second problem concerns the use of a film-based material at the strongly-curved focal plane of the large Schmidts. Persuading film to comply with this surface introduces non-uniform deformations which may not recover fully in the way that glass does, with obvious consequences for astrometry. Tests are planned to assess the seriousness of this problem.

One of the things that digitisation of images makes possible is the ability to combine many plates of the same field with consequent improvements in the signal-to-noise ratio. This is especially valuable where many plates of the same field already exist, as is often the case with Schmidt surveys. Similar image addition of large areas can be done more quickly in the darkroom, but the photometric information is lost in the output. Tests are about to be conducted which are intended to compare photographic and digital addition of identical plates. It may be possible to take advantage of the speed of the photographic approach and then recover the photometric information by digitising the final combined photographic image.

These activities underline the value of a group that brings together workers in all these areas. No doubt recipients of this Newsletter will have their own views on topics to be discussed and I would be delighted to hear from them.

References

[1] West, R.M., 1991. *ESO Messenger*, Issue **65**, September 1991, 45-50.

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D.F. Malin
Anglo-Australian Observatory
PO Box 296
Epping
NSW 2121
Australia

c): Digitization techniques

The past 10–15 years have seen considerable advances in the large-scale digitisation of photographic plates, which previously could only be digitised in very small parts or measured very tediously (and subjectively) by eye. It is good to see that there are now several groups around the world (or at least very soon will be) with the capability of systematically digitising the photographic sky survey material. Also, we can now realistically anticipate the availability of large amounts of this digitised material, as evidenced by the plan of the STScI to distribute the scans obtained under the Space Telescope Guide Star programme as well as the plans of the APS and COSMOS machine groups to release their catalogues of the Northern and Southern sky respectively.

With these large digitisation programmes, we are now at last gaining access to quantities of data hitherto undreamed of. Detailed studies of Galactic structure have been made possible, as have quantitative studies of the large-scale structure of the Universe from (for the first time) purely objective measurements of the distribution of galaxies and clusters. The second epoch sky surveys now well underway will allow other far-reaching studies to take place, such as the kinematics of the Galaxy and the halo system of star clusters and satellite dwarf galaxies, studies of the faint end of the stellar luminosity function and searches for brown dwarfs.

Some groups have demonstrated the possibility of digitally co-adding photographic plates, and we now see the very real promise of pushing photographic Schmidt material to magnitudes as faint as $B\sim 25$ (see the article by Hawkins in this Newsletter). Experiments with the use of fine-grain film on wide-field telescopes has shown that we have not yet reached the limit attainable with photographic material and provides further scope for new sky surveys based on these emulsions. Obviously, while we continue to use photographic materials for sky surveys, we continue to require digitisation devices and we must strive towards as accurate extraction of the information contained on the photographs as possible.

Digitisation of the photographic sky survey material is at the present time a very active field (as witnessed by the very important contributions presented at the 1991 conference in Edinburgh on 'Digitised Optical Sky Surveys'). Even if in the coming years the photographic medium is superceded by the use of CCDs for undertaking sky surveys, there is still a considerable wealth of information in the 1st and 2nd epoch sky surveys which must be extracted and made available as a legacy for future generations of astronomers.

I would like to hear the views of readers of this Newsletter. The questions I would like to raise are:- what should be digitised? do we only need to digitise the whole sky in a single passband for a single epoch, and only require multi-epoch, multi-colour scans for a small representative area? or should we digitise the entire sky survey material? should we digitise the objective-prism plates? should we digitise all of the good quality plates from all of the major Schmidt Telescope archives? Please, let me hear your views!!

Obviously, the enormity of an undertaking for bulk digitisation will mean that it is not practical for any single group to take the entire task upon itself. Local scientific interests of each group may drive them to scan a subset with a particular scientific goal in mind. I hope that we can set up some form of (informal) coordination of the digitisation activities. At the very least there should be exchange of information on scanning plans, and this has already been instituted through the meetings of the 'DOSS' community which will continue under the wider Working Group.

H.T. MacGillivray
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK

d): Archival and Retrieval of Wide-Field Data

As organizer of the IAU WGWFI's sub-section, 'Archival and Retrieval of Wide-Field Data', I am writing this first newsletter piece to ask our membership for their views on the programs of the sub-section. I regard our challenge as the identification of areas in which IAU-sponsored communication or even collaboration will advance our work, while simultaneously avoiding those topics in which formal structure will contribute little (and may actually inhibit) to good work at individual sites.

One may usefully regard our archival concerns as being motivated by two rather distinct types of data,

1. wide-field pixel data, and
2. catalog data.

At the last Digitised Optical Sky Surveys workshop (Edinburgh, 1991), we heard about a number of programs, both pilot projects and fully developed ones, addressing various aspects of each area.

The active approaches to the matter of wide-field pixel data involve full-plate scans, cutouts of identified images, and image compression on full-plate scans. It seems that each addresses a specific need and will be used by some investigators in the next several years. As the field matures, we may reasonably expect to need to exchange data in these formats; and this raises the issues of standardization. Regrettably, my expectation is that we already have one file format per data type per institution. Perhaps the situation is already too advanced to do much standardization, but if there is sufficient interest, the topic should be explored. As far as I can tell, the only common practice at present is a loose adhesion to FITS (without much thought about the keywords) as an exchange medium.

The storage of catalog data is an area where we are likely to see rapid progress in the next few years. Presently, small catalogs (10^5 to 10^6 objects) are well supported with powerful access tools, e.g. the SIMBAD facility, while larger ones (10^7 objects) are supported in accessible but less convenient ways with catalog-specific tools and structures. However, the situation is less clear for the larger catalogs (10^8 to 10^9 objects) which are currently under development at several institutions. How are we going to store them? to access them? to distribute them? Several promising ideas in various stages of development were reported at the DOSS workshop. At the minimum, we should use our facilities to give these efforts an appropriate level of informal visibility.

Comments on these topics before the end of February will be especially useful in preparing for the first meeting of the WGWFI's organizing committee in April, 1992. My E-mail addresses are scivax::Lasker (SPAN), lasker@stsci.edu (internet), and lasker@stsci (Bitnet/Earn).

Barry Lasker
Space Telescope Science Institute
Homewood Campus
Baltimore
Maryland
U.S.A.

Meeting of the Organising Committee

As mentioned in the introductory article, the Organising Committee of the WG on Wide-field Imaging will hold a two-day meeting in April 1992 to discuss a variety of scientific and technical as well as policy matters. For the moment, we have reserved April 13 and 14 for this purpose and the meeting will take place at the Space Telescope Science Institute in Baltimore, Maryland, U.S.A., at the kind invitation of OC member Barry Lasker. It is expected that all OC members will be present. The preliminary agenda are listed below for information. A full report on this meeting will be published in the next issue of the present Newsletter, which is scheduled to appear in July 1992.

The OC meeting will thoroughly discuss the areas of the WG and attempt to identify the most important issues to be dealt with during the coming years and up to the IAU General Assembly in 1994. If necessary, priorities will be set. It will also make the first preparations for the 1993 conference of the WG, to which all members and other interested persons will be invited. In particular, we shall try to fix the site, dates and overall programme of that conference, so that it would be possible to send in a formal application for IAU sponsorship, probably as a Colloquium, in time for it to be discussed by the IAU Executive Committee in September 1992. IAU sponsorship, apart from the prestige, would also automatically provide some IAU funds for travel support, etc.

In order to ensure the best possible interaction between the OC and all WG members, I herewith ask for your comments and suggestions, so that they can be duly taken into account by the OC. Do not hesitate to bring any matters which you consider to be of interest to our attention. For instance, are there any additional subjects which should be discussed? Please let me hear from you, not later than March 10, 1992. You can reach me as indicated in the list of OC members in this issue.

Meeting of WG WFI OC

Baltimore, April 13–14, 1992

Preliminary Agenda

1. *Welcome and Opening.* General Introduction to WG, its background and overall goals;

2. *Sky Surveys and Patrols.* Overview. CCD Surveys. Re-establishment of sky patrols. Space Schmidt project;

3. *Photographic techniques.* Overview. New emulsions. Interaction with suppliers of photographic material;

4. *Digitization Techniques.* Overview. Overlays for Sky Surveys;

5. *Archival and Retrieval of Wide-field Data.* Overview. Wide-field Plate Archive Data Base;

6. *Other Items.* Definition of 'wide-field'. Interaction with the CCD world. WG communications: Newsletter, electronic Newsboard (?). WG membership.

1993 Conference: site, time, programme, application for IAU sponsorship, other financial sources. 1994 IAU General Assembly (very preliminary).

Richard M. West
European Southern Observatory
Karl-Schwarzchild-Straße 2
D-8046 Garching bei München
Germany

Wide-Field Plate Archives

When the IAU WG on Wide-field Imaging was created in Buenos Aires last July, it was immediately decided that one of the tasks would be to establish a *computer readable file of all wide-field plates in plate archives all over the world.* This would provide a very powerful tool for future research. For instance, it would become possible to learn on which plates, in which archives, a particular object is present. That would enhance the astronomical value of the plates and make archival studies, e.g. of the earlier behaviour of particular objects, much easier.

I was asked to organise this and have since been busy communicating with observatories in many parts of the world. In a first Circular letter which was sent out in early September 1991 to more than 200 institutes, I asked about some preliminary information in order to establish the basic facts about the existing archives: where they are; how many plates they contain; which telescope they were obtained with; whether a computerized list exists, etc.

Up to now I have received positive answers from 44 observatories and institutes, representing 89 wide-field instruments in operation since the end of last century, as well as information on about 10 additional, separate plate archives at different observatories. In total, these plate archives contain information on about more than 1,200,000 plates/films. I also received 15 negative answers and 25 observatories which had active wide-field instruments did not answer so I have no information up to now about their plate archives.

I have prepared a first list of astronomical observatories/institutes, which have Wide-field Plate Archives (WFPA) with a number of entries, which I list here to give an impression of the information contained therein:

1. Location of observatory/institute and a description, mainly according to the list of observatories in the Astronomical Almanac (1990);
2. East longitude and latitude;
3. Elevation of the observatory/institute above sea level;
4. Telescope parameters: Clear aperture (m), diameter of mirror (m), focal length (m) and scale (arcsec);
5. Type of telescope(s): Schmidt, Astrograph, Camera or Reflector;
6. Field of the telescope (degrees);
7. Year of the beginning of operation or the time of possession of the plate archives;
8. Information about the type of archive; Plates, Films or Glass Copies of the original surveys;
9. Number of direct and objective prism plates/films;
10. Information about listings of the archived plates/films: in Table form, Computer readable form, or Table form and not complete computer readable form.
11. Name of the astronomer responsible for the plate archive or of the director of the institute/observatory.

I have a few general remarks about this work: 1) A similar compilation was initiated by Dr. B. Hauck some ten years ago and the resulting information was apparently stored at the 'Centre de Données Stellaires' in Strasbourg, France. This is now being looked into. 2) Another parallel project ('Archiving and Distribution of Spectroscopic Data'), including also wide-field objective prism photographs was recently started by the initiative of IAU Commission 29 (Stellar Spectra); this information was received from Dr. R. Viotti (Italy). I shall endeavour to coordinate our work with the spectroscopic people. 3) In some letters I have received there is the question about what is the size limit of 'wide-field'. A $1^\circ \times 1^\circ$ field seems a reasonable limit, but if there exist some comparatively big plate archives with smaller-field plates obtained with reflecting telescopes, I propose to publish a separate list with these data. 4) Many of the observatories/institutes and astronomers do not report about the plates obtained at other observatories which they now possess.

The main problem appears to be that so far only 9 archives are available in complete computer readable form, while 22 others are in the process of preparing and implementing this. This means that even after the plate archives have been identified and their contents surveyed, there will still be lots of work to do, before all plate data are in a global computer catalogue. I am looking into how this may best be done.

The next step will be to send in January 1992 a second Circular letter to all observatories. It will include the available information, as contained in the first list (see above), in order to check the details and also in the hope that other observatories and institutes which did not answer, but which are known to have wide-field instruments, will then react.

I shall report on the progress of this large undertaking in the next issues of the Newsletter. I also expect at a later date, perhaps by the middle of 1992, to make available to all WG members the complete list of archives, as described above. This will undoubtedly help to identify further plate archives not yet in the list.

Milcho Tsvetkov
Department of Astronomy
Bulgarian Academy of Sciences
Trakia Blvd. 72
BG-1784 Sofia
Bulgaria

Reproduction of the Palomar Observatory Sky Surveys

Since several institutions have announced plans to digitize the Palomar Observatory Sky Surveys, it is appropriate to summarize the issues of copyrights and of proper recognition of those who made the surveys possible.

1. The proper names of the two surveys from the 48-inch Oschin Telescope at the Palomar Observatory are:

   <u>The National Geographic Society–Palomar Observatory Sky Survey</u> (often referred to as NGS-POSS or POSS-I)

   <u>The Second Palomar Observatory Sky Survey</u> (often referred to as POSS-II)

2. Caltech and the National Geographic Society have waived their copyrights to the NGS-POSS survey, which is now in the public domain. We ask that scientific publications based on data from NGS-POSS include the following citation:

   > *The National Geographic Society – Palomar Observatory Sky Survey was funded by a grant from the National Geographic Society to the California Institute of Technology.*

3. The copyrights to POSS-II (and all derivative works) are owned by Caltech. Permission to reproduce portions of the survey for publication or distribution is routinely granted (without fee) for scientific and educational purposes (such as text books, monographs, research papers, public information articles, etc.). Permission will not be granted for use in connection with any commercial activity. Requests for permission to reproduce POSS-II images should be sent to:

   Photo Permissions
   Palomar Observatory 105-24
   California Institute of Technology
   Pasadena, California 91125

Publications based on data from POSS-II should include the following citation:

The Second Palomar Observatory Sky Survey was funded by grants to the California Institute of Technology from the Eastman Kodak Company, the National Geographic Society, the Samuel Oschin Foundation, the National Science Foundation grants AST 84-08225 and AST 87-19465, and the National Aeronautics and Space Administration grants NGS 05002140 and NAGW 1710.

R.J. Brucato
California Institute of Technology
Pasadena
California 91125
U.S.A.

Status of the ST ScI Scan-Distribution Program

1 Introduction

Our preliminary work on the compression of full plate scans and on its effects on astrometry and photometry is reported by White, Postman, and Lattanzi in the proceedings of the 1991 Edinburgh conference on Digitized Optical Sky Surveys. Also, a CD ROM, 'Guide Star Survey Sampler', containing compressed scans of eight plates has been prepared to demonstrate the properties of these techniques. This CD is being sent to all respondents to our 1991 questionnaire, and while the supply lasts, others requesting it.

Following these precepts and responding to expressions of community interest, we are currently embarking on a three year program to distribute the all-sky set of scans which have been made at the ST ScI. The southern fields are from the SERC J Survey and from an advance copy of the SERC Equatorial EJ Sky Atlas, and the northern fields are from the original NGS-POSS Sky survey. A pixel size of 25 microns with a 50 micron apodized aperture was used for all these scans.

The planned distribution will involve about 100 CD-ROMs if the survey is compressed, on average, by a factor of 10. The tentative schedule is to distribute the southern hemisphere at the end of the first year, the northern at the end of the second, and a calibration data base at the end of the third.

2 Status of the Second ST ScI Photometric Survey

A photometric survey is being conducted to extend the BV photoelectric calibrators in the Guide Star Photometric catalog (GSPC-I) to a fainter V band limit and to provide new data in the R band. The program is described in detail in the 1991 proceedings of the Edinburgh conference on Digitized Optical Sky Surveys, and the current status of the work is as follows:

- For each field, two (V and R) short and two long exposures are being acquired. The short exposures (2 minutes) will reach to V = 18 mag and the long exposures (30 minutes), to V = 21 mag. We are using the Kron-Cousins system. The short exposure survey is 95% complete (618 out of 651 fields observed) for fields north of the celestial equator. The long exposure survey is about 40% complete in the north. Of the fields that have been observed, about 65% have been reduced and calibrated.
- The southern hemisphere observations began last year when we obtained long-term status at CTIO and ESO. To date, the southern short exposure survey is about 20% complete and the southern long exposure survey is about 10% complete.

3 ST ScI Scanning Programs

Routine scanning of second generation plates (the southern SES and the POSS-II) in the configuration described in the Digital Optical Sky Surveys Workshop

(Edinburgh, 1991) will commence early in 1992. Briefly, the plan calls for full-plate scans with 15 micron pixels and for archiving of the raw images.

Scanning of the POSS-I E Survey also continues, with about half of the −18 degree zone and all zones north thereof completed.

Current production rates (per machine) are about five 25 micron scans or three 15 micron scans per week. A hardware enhancement program to increase these rates by a factor of 2–4 is currently in progress. The first step is to replace the PDS servo systems which, although a fair representation of technology from the mid 1970s, are obsolete, have become a maintenance problem, and require significant tuning efforts to approach optimum speed. The new servos will be driven more directly from the positional lasers with a HP 5527 laser transducer system, which replaces both the old laser receivers and the 'DCRS' system. At the same time, the M6800 control microprocessor is being upgraded to a VAXstation, with interfacing by IEEE-488 and CAMAC. Later steps in this development will involve upgrading the photometric amplifier and implementing a multi-channel capability.

Technical correspondence about the ST ScI programs should be directed as follows: photometric references and scan compression, Marc Postman (username postman); requests for the Sampler CD ROM, the GCS DIStribution Officer (username GSCdist); and the scanning programs, Barry Lasker (username Lasker). E-mail addresses for the ST ScI are of the form scivax::username (SPAN), username@stsci.edu (InterNet), or username@stsci (Bitnet/EARN).

Barry Lasker
Space Telescope Science Institute
Homewood Campus
Baltimore
Maryland
U.S.A.

Pixel Addition: Pushing Schmidt Plates to B = 25

In the late 1970s when the COSMOS measuring machine was being developed at the Royal Observatory, Edinburgh, and there was the promise of large numbers of plates from the UK Schmidt telescope at Siding Spring, the idea of co-adding a set of plates to go very deep was already being discussed. At that time, several approaches seemed promising. Firstly, there was the idea of photographic addition, where plates are progressively projected onto a film thus increasing the signal-to-noise. A measuring machine is only used at the end to analyse the final images. This technique has been developed by D. Malin to give a significant improvement in limiting magnitude, but the method does have some major drawbacks. Because there is distortion between plates taken at different hour angles or different centres, the whole field cannot be worked at one time, and must be cut up into small pieces. This adds a huge logistic overhead both to the addition procedure and to subsequent analysis, where the pieces must be matched together. Another problem concerns scattering of light in the emulsion during the addition process which appears to make star-like images grow as in a normal photograph of a bright point source.

First thoughts in the early 1980s about a machine based approach to plate addition were limited by the small size of computer back-up storage available at that time, and concentrated on a real time addition of measures. This approach was never really practical, and progress had to await the introduction of cheap mass storage at the several Gbyte level. This has now happened and the project to add whole Schmidt plates digitally has become feasible. The area of a UK Schmidt plate which can comfortably be used without problems of vignetting etc. is about 25×25 cm^2. Scanned at a sampling interval of 16 μm, this comprises approximately 250 million pixels, or 500 Mbytes. For cumulative pixel addition sufficient disc space is required to store the current added data, the new measure, and the new total. This means at least 3×500 Mbyte arrays, or 1500 Mbyte. Given that a fair amount of working space is also needed, the total required is around 2000 Mbytes.

The programming approach for combining the data uses sequential access to all the files. This gives greater flexibility in the types of mass storage which can be used, and a very fast running code. An important feature of the procedure is a transformation from each master pixel to the nearest corresponding pixel in the new data. It was found in practice that in the test cases a simple rotation translation and scale transformation was sufficient, but provision was made for a more sophisticated transformation to be used should circumstances warrant it. Having transformed the master pixel to the coordinate frame of the new measure, the bulk of the programme is concerned with ensuring that the relevant part of the dataset is in core so that the appropriate value can be chosen to add to the master pixel.

So far, the programme has been tested in two ways. In the first instance, two whole plate mappings were added using a single rotation, translation and scale transformation. Fields in the corner were examined, and no detectable misalignment of the star images was observed. The plates were however well matched, being on the same centre and taken at similar hour angle, and so it may be necessary in general to use a more sophisticated transformation.

The second test involved adding a one square degree area from a large number of plates, in two colours. The area contained a deep CCD sequence to enable calibration of the measures and an estimate of the depth attained by the co-addition. COSMOS measures are output as transmission values, but the measurement is dominated by noise in the emulsion i.e. fluctuation in density, hence the transmission values were converted to photographic density before addition. Since on the 'straight' part of the characteristic curve emulsion noise is essentially constant, independent of density, this ensures the correct weighting of each pixel value. Figure 1 shows a grey scale plot of a survey quality IIIa-J UK Schmidt plate in an area containing the sequence. Figure 2 shows the same area after 12 plates have been added together; the increase in depth is obvious, and amounts to a little over one magnitude. Figure 3 shows the result of adding 58 IIIa-J plates, the total number of acceptable quality currently available in Field 287. Figure 4 shows the result of adding the 61 IIIa-F plates available in the field.

In order to study the quality of the addition programme, the relationship between the number N of plates used and the sky noise σ_{sky}, the S/N ratio and the FWHM of the stellar images have been analysed by F. La Franca and L. Miller. They found that:

1. the decrease of the noise on the sky level is on average consistent with the relation $\sigma_{\mathrm{sky}} \propto \frac{1}{\sqrt{N}}$;

2. the increase of the S/N ratio in the stellar images is of the form $\mathrm{S/N} \propto \mathrm{N}^{\alpha}$, with $0.4 < \alpha < 0.5$;

3. the increase in the size of the images due to registration in the addition process is small, and tends to converge to values $< 10\%$ after 10 plates.

All these results are consistent with an increase in depth of the stacked plates of:

$$\Delta \mathrm{m} = 2.5 \log \mathrm{N}^{\alpha}, \quad \text{with} \quad 0.4 < \alpha < 0.5.$$

confirming that almost all the signal contained in each plate is transferred to the final co-added data.

In order to assess the depth, completeness, photometric accuracy and other properties of the co-added data, the COSMOS analyser was used in the ordinary way (with the image deblanding option) to detect and measure images in the field. These measures were calibrated using the CCD sequences, giving the calibration curve in Fig. 5. The number/magnitude relation for the field is shown in Fig. 6. From this it may be seen that for 58 plates, the completeness limit is about $\mathrm{B_J} = 24.0$. This corresponds to a B magnitude of about $\mathrm{B} = 24.5$ with images detected to $\mathrm{B} > 25$. The change of slope at around $\mathrm{B_J} = 22$ is due to the counts becoming dominated by galaxies which have a steeper slope than stars.

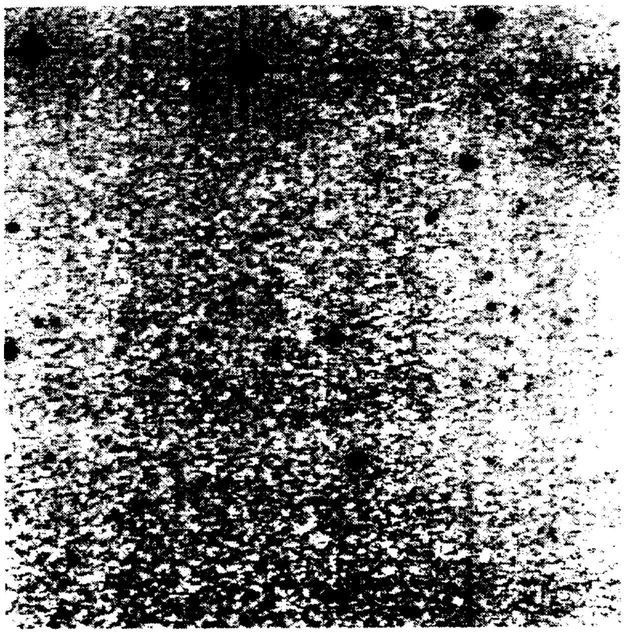

Figure 1.

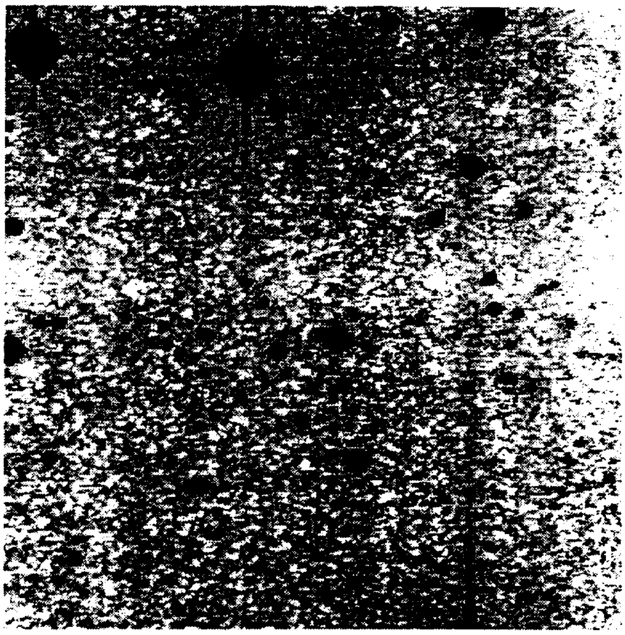

Figure 2.

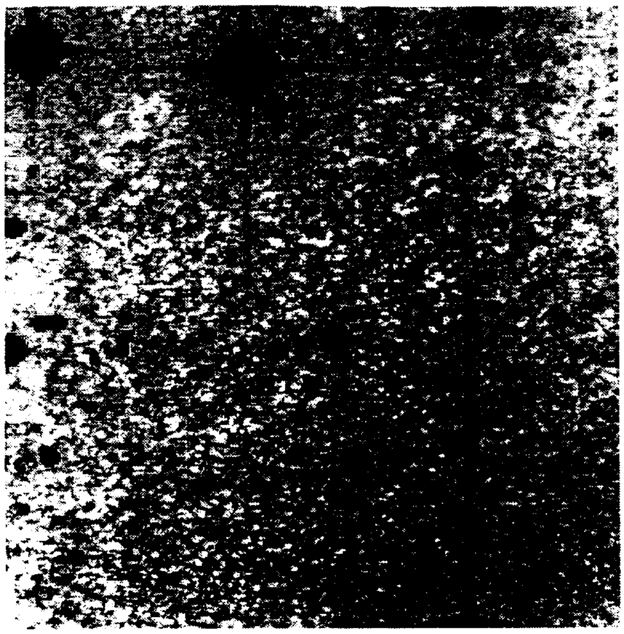

Figure 3.

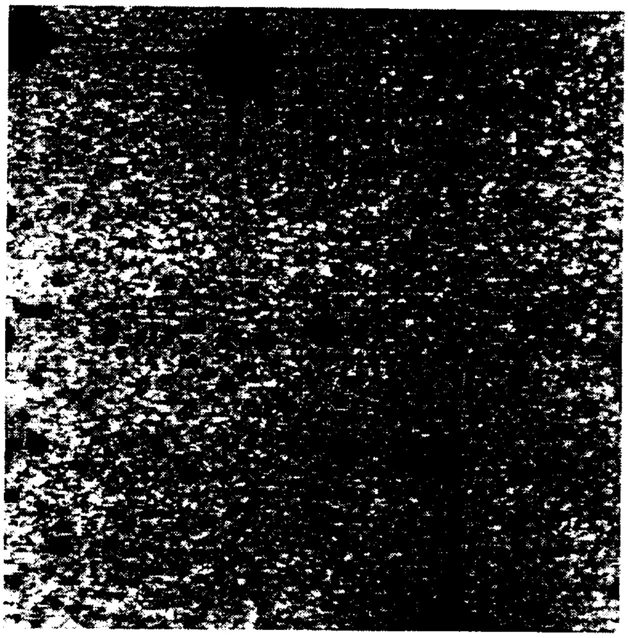

Figure 4.

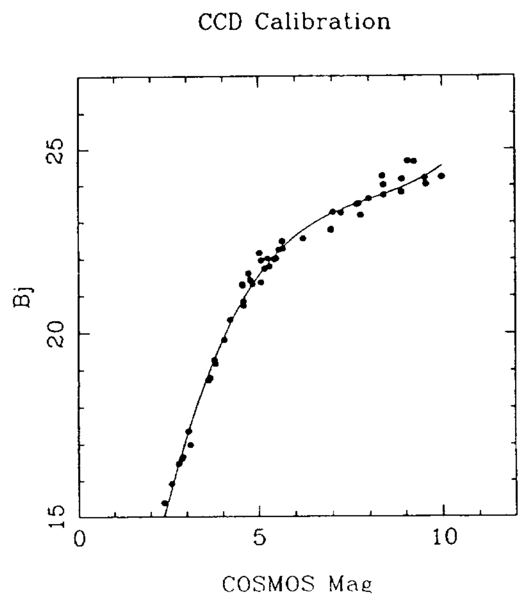

Figure 5.

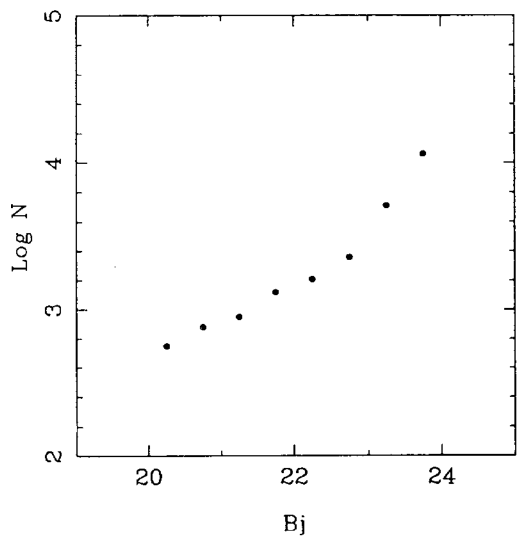

Figure 6.

The next step in this project is to add data for the full Schmidt plate area in the B and R colours discussed above, together with 30 I plate and 8 U plates. This should provide an unparalleled opportunity for a number of investigations which require great depth and wide angle coverage. These include the galaxy correlation function, the galaxy cluster distribution, searches for high redshift quasars and studies of the galactic halo. There are also many rare objects such as brown dwarfs and cool white dwarfs which should be detectable in the huge dataset which will result from co-addition of the full Schmidt area.

M.R.S. Hawkins
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK

Photometry with Estar Film

For the past 15 years or so, wide angle photographic surveys at red wavelengths have generally used Kodak IIIa-F emulsion on glass plates (with great success). Nevertheless newer photographic materials do exist and from time to time trials have been made in order to test their applicability for astronomical photography. A few years ago experiments were made at the UK Schmidt Telescope Unit, replacing the IIIa-F by Eastman-Kodak Estar 3415 emulsion. Although the emulsion was expected to provide higher efficiency, technical problems were encountered and the trials were discontinued. More recently, the UKSTU had made trials with the equivalent material as a film, now called Estar 4415 (see report by Ken Russell at the Edinburgh DOSS Meeting).

Visual inspection of these films suggested substantial gains in depth and resolution compared to normal IIIa-F plates, so we had two test films of an area in the Virgo Cluster scanned by COSMOS. (This involved mounting the films on a standard glass plate using a water/glycerin interface and sealing the edges so that they could be put in the COSMOS plate holder). These scans have enabled us to make some quantitative estimates of the effectiveness of these films for, in particular, galaxy photometry.

As a first test we scanned several 2048 by 2048 (half arc second 8μm) pixel areas centred on some relatively large but fairly low surface brightness galaxies (so there should be no problems of photographic or measurement saturation). We first converted the data from COSMOS transmission space to intensity space by way of measurements of the step wedges. We had available a CCD frame of one of the galaxies, so we were also able to directly check the effectiveness of the calibration curve by comparing the photographic and CCD intensities essentially on a pixel to pixel basis. We then determined intensity profiles for the galaxies by standard photometric techniques (using the GASP package). Repeating this for the second film we were able to check on the repeatibility of the measurements.

The profiles show excellent agreement with those from published work, but extend considerably further. For example, IC3374 is seen to have a profile which is closely exponential out to about 80″ along the major axis, whereas the published CCD profile by Gallagher and Hunter stops at 25″. Binggeli, Sandage and Tammann, in their Virgo Cluster Catalogue, quote a maximum observable radius of about 43″ on their photographic data from Las Campanas. Using the published data to absolutely calibrate our photographic profiles, we find that we can trace the profiles out to about 26.5 or 27 R magnitudes per square arc second (less than 0.4% of the sky background).

Note too that the sky noise per pixel is around 0.8%, so the observations are (at least) equivalent in depth to 5 to 10 minute observations with a standard CCD on a large telescope, but with the advantage of wide-field coverage. (For instance the AAT RCA count rate [in R] is quoted as 28 to 40 electrons per second per pixel for the sky, so has a Poisson noise of 0.8% after about 400 to 600 seconds; this of course ignores all other possible sources of noise in the CCD data).

Thus far, our photometry from the films indicate that they are indeed very suitable for galaxy photometry, having a high efficiency, which will enable us to see fainter objects than on normal photographic plates, and also low noise, which allows us to set lower limiting isophotes.

Steve Phillipps
Department of Physics and Astronomy
University of Wales College of Cardiff
PO Box 913
Cardiff CF1 3TH
Wales

Quentin Parker
UKST
Siding Spring Observatory
Coonabarabran
NSW 2357
Australia

ASCHOT — Astrophysical Schmidt Orbital Telescope

Summary

The need for a wide-angle UV Space Telescope for astrophysical investigations is outlined. Some of the main scientific goals are discussed, e.g. a full sky survey and a comprehensive study of UV emission of extragalactic and galactic objects, which may be achieved with the Astrophysical Schmidt Orbital Telescope ASCHOT, now under construction.

The concept of the telescope design, its optical system and the detectors, and its system of guidance are described. The limiting sensitivity of the telescope is about 24^m for stellar objects at 1500 Å.

1 Introduction

Sky surveys of celestial objects with wide-angle telescopes at different wavelength regions and the discovery of objects having certain peculiarities are among the main goals of observational astrophysics. Catalogues of a variety of objects have been compiled as a result of such surveys. The newly detected objects are then studied with the use of all possible observational means and methods.

Sky surveys and the investigation of the morphology of extragalactic objects in the far UV wavelength region, the discovery of young stars and the study of their distribution in space can be done most successfully with the use of fully reflecting Schmidt cameras.

The Astrophysical Schmidt Orbital Telescope (ASCHOT) project was started by the initiative of the Byurakan Astrophysical Observatory (Armenia, USSR) and the Central Institute of Astrophysics (Potsdam, Germany) in 1987.

The ASCHOT is a fully reflecting telescope for obtaining prime images and low dispersion spectra of all objects in a wide (2.°5) field of view. The virtues of such a telescope have been thoroughly debated within the astrophysical community for about two decades. ASCHOT advantageously differs from all launched telescopes for sky surveys. Firstly, it will be the largest telescope of this type. Secondly, the use of fully reflecting optics reduces the loss of far-UV radiation, which is crucial for the realization of many observations. At the same time the fully reflecting Schmidt optical system gives a very useful field of view with a high angular resolution.

The ASCHOT telescope will permit for the first time the study of weak (down to 24^m at 1500 Å) stars, galaxies and quasars in the vacuum ultraviolet (down to 1300 Å). This telescope will permit the study of galaxies and their details with the lowest surface brightness in visible light, because of the very low sky background level in orbital observations. A major advantage of the ASCHOT wide-field telescope is that a full-sky survey can be carried out. Thus, the ASCHOT telescope may play the same rôle for the HST as the 48″ Schmidt camera at Palomar did for the 5 m Hubble telescope.

2 The Scientific Goals

The ASCHOT telescope is designed for deep sky surveys in the vacuum ultraviolet by obtaining images of large areas of the sky and low resolution spectra of all objects in the field of view of the telescope.

The sky maps obtained by ASCHOT observations will be of great value for astrophysical research. They will serve as an important supplement to the maps obtained by ground-based telescopes in the visible wavelength region (e.g. Palomar, SERC and ESO surveys). Many important discoveries have been made using these maps and they will continue to serve astrophysics during many decades to come.

Low dispersion spectra of somewhat brighter objects will permit the study of the distribution of energy in the far-UV spectra of all observed objects. The importance of such observations is evidenced by the Byurakan objective prism sky survey which resulted in the discovery of over 2000 Markarian galaxies, many of which turned out to be active or starburst galaxies.

It will for instance be possible to observe images of distant galaxies with lower surface brightness than ever detected by wide-field ground-based telescopes. This is very important for solving problems such as the identification of weak radio sources and for cosmological studies.

The comparison of sky surveys in far-UV and in visible light made with the orbital Schmidt telescope opens many possibilities for interesting investigations.

3 The Optical System of the Telescope

The optical system of the telescope is of the fully reflecting Schmidt type (Fig. 1). The diameter of the main spherical mirror is 1.2 m. The diameter of the correcting mirror is 0.8 m. The focal length is 2.3 m. The field of view is 5°, of which 2.°5 will be used for science. The outer part of the field of view will be used for star trackers.

Stabilisation of the telescope pointing will be done by two axes with accuracies better than ±0.3 arcsec. Rotation of the field of view around the guiding star will be avoided to an accuracy of about 5 arcsec. Where the guiding star is near the edge of the guiding field, the image of the farthest star on the opposite side of the field will be increased due to field rotation only by about 2.5 μm or 0.2 arcsec. Thus the image size of point sources will vary over the field of view of the telescope and will be of the order of about 2 arcsec, or about 20 μm. The real angular resolution of the telescope will be 2–3 times larger. None of the wide-angle space telescopes launched for sky surveys, up to now, has ever had such a high angular resolution.

The optical system of the telescope also contains one diagonal flat mirror, by means of which the focal surface is placed outside the telescope tubus. This mirror is also used as one of two elements in the fine guiding system of the telescope. The location of the focal surface outside the tubus makes the change of detectors by crew members of the space station very easy.

All three mirrors will be coated by aluminium and magnesium fluoride, which have good reflection characteristics down to 1200 Å.

By 180° rotation of the diagonal mirror it will be replaced by a grating which will operate for convergent rays and allow low dispersion (1000–1500 Å/mm) spectra of all objects in the 2.°5 field of view of the telescope to be obtained.

The telescope construction guarantees the safety of its adjustment and normal functioning in orbit after the launch. The adjustment of the telescope optics will be done at conditions which eliminate deformations of the tubus and mirrors and any

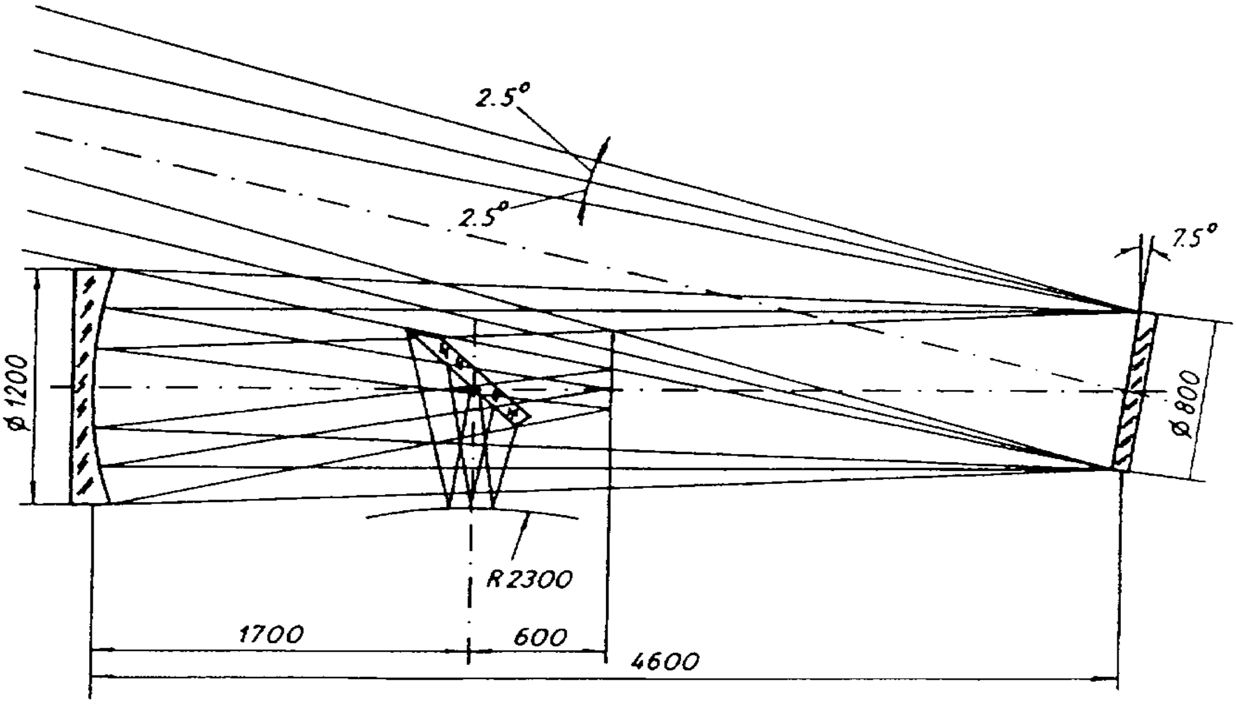

Figure 1: Optical system of the telescope ASCHOT.

relative displacements of the latter.

4 Detectors

The displacement of the focal surface out of the telescope tubus permits the use of several detectors for different purposes.

It is intended that two of the detectors will consist of multichannel intensifiers with cathodes made of CsI and TeCs, sensitive in the 1200–2000 Å and 2000–3200 Å regions respectively. The multichannel intensifiers may be coupled with CCDs using corresponding fibre optics to decrease the linear size of the field. Electron delay devices may have more perspectives. The diameters of the channels of microchannel intensifiers are about 8–10 μm and the resulting resolution of electron delay devices is about 25 μm, which just corresponds to the resolution of the telescope, including guiding errors.

An electronographic camera with CsI or TeCs cathode presents an interesting alternative as a detector. It has a better resolution, but its use with a space telescope is difficult, mainly because of the need to change films, which must be done during space walks.

With each of the UV detectors a set of interference filters will be used to determine the observational passband and to reduce the diffuse Lyman-α emission.

A film sensitive to the visible light will be used for the discovery of weak, low surface brightness galaxies. The length of the film in each cassette will be enough for about 300 photographs. In each frame its number, position of the centre of the photographed area, exposure and the date will be marked.

The cathodes of all detectors and the cassette for the film must have a surface whose shape corresponds to the curvature of the field of view.

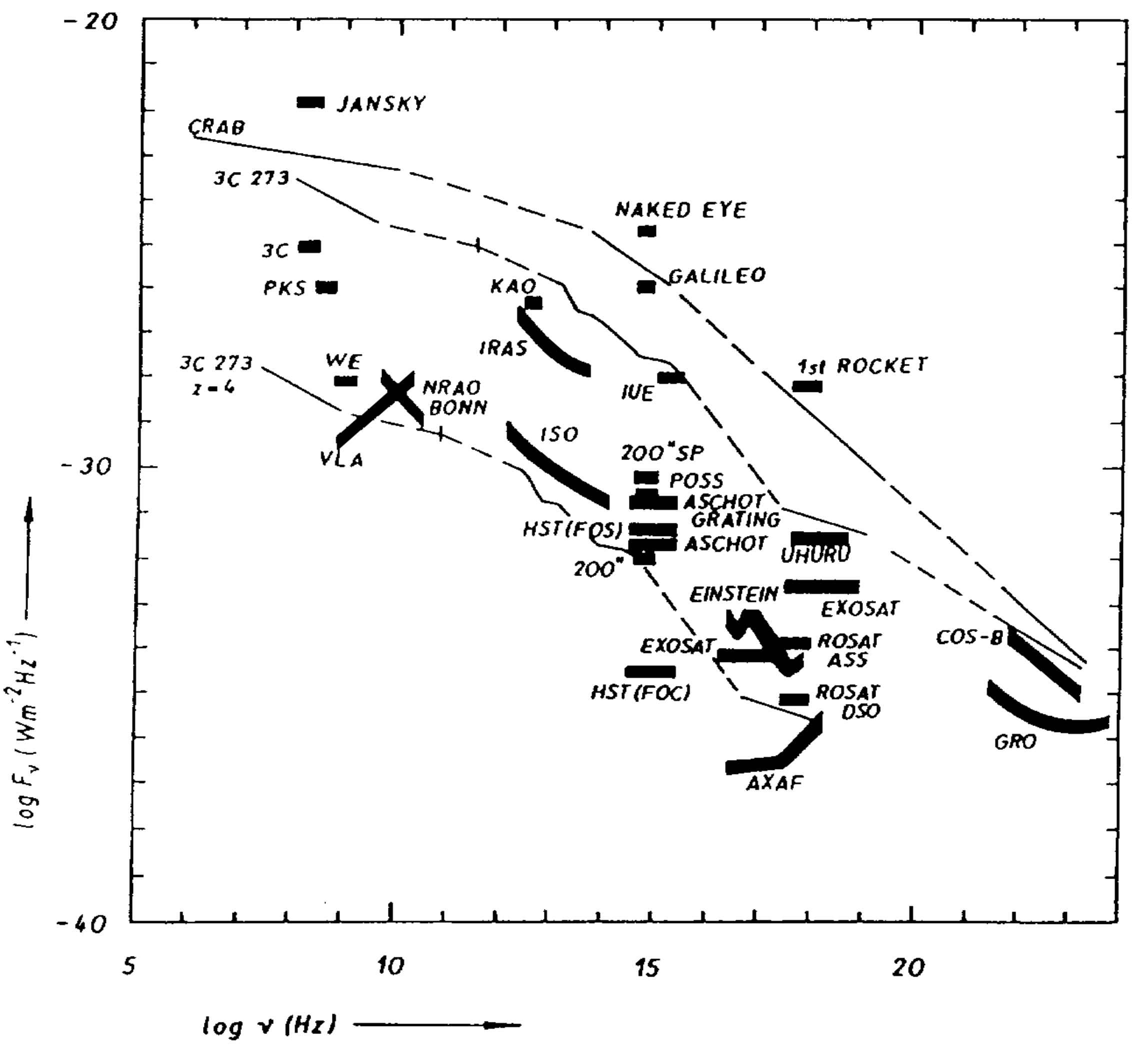

Figure 2: The sensitivity limits versus frequency for different telescopes and some projects, in order to compare the capability of ASCHOT. Most of the labels are self-explanatory, but a few should be explained: WE = Westerbork radio telescope, NRAO = National Radio Astronomy Observatory 91 m telescope, BONN = MPI Radioastronomy 100 m Effelsberg telescope, 200″ SP = Palomar 5 m telescope (spectrograph), HST (FOC) = Hubble Space Telescope (Faint Object Camera), KAO = Kuiper Airborne Observatory, 1st ROCKET = 1962 rocket discovering Sco X-1, ROSAT ASS = ROSAT All Sky Survey, ROSAT DSO = ROSAT Deep Sky Observations, GRO = Gamma Ray Observatory, the EGRET experiment only.

The registration with each of the electronic detectors may be done with exposures from 1 s to 30 min. Photographs on film may be taken with exposures of several minutes (up to 30 min). The change of cassettes with films will be made about once a month.

5 The Sensitivity of the Telescope

The sensitivity of the telescope has been estimated in the case of multichannel intensifiers coupled with CCDs as the main detector. The signal-to-noise ratio then depends on the statistics of photoelectron events and errors in the amplification and detection process. There are practical limitations from both. The uncertainty in the flux measurements is determined by the registered photoelectron events, including contributions from the objects and the sky background.

Taking into account the aperture of the telescope (80 mm), the bandwidth of the system (300 Å), and the losses (0.7^3) for reflections from three mirrors and a sky background of 300 photons $\mathrm{cm^{-2}s^{-1}str^{-1}}$ Å^{-1}, we obtain an estimate for the limiting magnitude m(1500 Å) $\approx 24.^m0$ for 30 min exposure time and $S/N = 10$. In the case of the maximum possible exposure times in one orbit this corresponds to about 26^m in V for unreddened OB stars.

Figure 2 shows the limiting sensitivity of the ASCHOT telescope compared to other ground-based and extraterrestrial surveys.

6 The Parameters of ASCHOT

Diameter of the main mirror	1.2 m
Diameter of the correcting mirror	0.8 m
Focal ratio	3:1
Field of view — of which for scientific observations	5° 2.5°
Scale: 1 arc sec =	12 μm
Accuracy of stabilization (made by stars brighter than $8.^m5$ in B)	$\pm 0.3''$
Angular diameter of a point source (80% of energy) including errors of guidance	$2''$
Limiting stellar magnitude ($\lambda = 1500$ Å, $\Delta\lambda = 300$ Å, exposure 5 min)	24^m
Low dispersion spectra	1500 Å/mm
Limiting stellar magnitude in the case of low dispersion spectral observations	$21.^m5$

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H. Lorenz
Sternwarte Babelsberg
Rosa-Luxemburg-Straße 17a
O-1590 Potsdam-Babelsberg
Germany

The Hitchhiker Parallel CCD Camera

A typical large telescope spends a large fraction of its time carrying out spectroscopy on or near to the optical axis. On the other hand, most large telescopes have fields of view much larger than those required by spectroscopic observers. The Hitchhiker camera (so called because it 'hitches a ride' on other peoples' observations) is a novel attempt to make more efficient use of costly large telescope facilities. Permanently installed on the William Herschel Telescope (WHT) at La Palma, Hitchhiker is a dual beam broad band CCD camera which works in parallel with spectroscopic instruments. The instrument was designed and built by the Cardiff group in collaboration with Craig McKay and Nick Rees at the Institute of Astronomy in Cambridge. Numerous members of the RGO staff in the UK and on La Palma assisted with the design and the mounting of Hitchhiker on the telescope. Hitchhiker has so far been used for a total of 12 weeks by various members of the Department of Physics and Astronomy at the University of Wales College of Cardiff, who are responsible for operating the instrument. In due course, we hope to completely automate the instrument control so that no observers actually need to be on site to run the camera.

Since Hitchhiker normally runs in parallel mode, we have no control over the fields of view, so we sample more or less serendipitously around the sky. The actual fields are 7 arc minutes from the object being viewed by the primary scheduled observer, Hitchhiker being operated most frequently in conjunction with the ISIS spectrograph. By use of a dichroic beam splitter and two separate CCDs we survey simultaneously in two bands (either B and R, B and I or V and I). Although the field of view is small in comparison with most other survey instruments (about 6 by 4 arc minutes) we make up for this in terms of the number of frames taken (corresponding to of order 1 square degree a year), the two simultaneous bands and the great depth to which the observations reach. Remember that we are observing in parallel with spectroscopic observers who frequently require extremely long exposure times. A two hour CCD observation on a 4.2m telescope (even with light losses from the additional optical components) enables us to detect objects easily to magnitude 25 in B. During an observing run data is collected at a rate of approximately 1000 Megabytes per week. Routinely reduced data will be stored in an archive (on Exabyte tape at present).

The camera is the first of its kind to be installed on a ground based telescope and we hope it can act as a prototype for a series of similar instruments on the new generation of large telescopes. Implementing similar systems on the new very large telescopes will ensure that the quality of background surveys keeps pace with the advances in telescope technology.

Jon Davies, Mike Disney, Simon Driver,
Ian Morgan, Steve Phillipps
Department of Physics and Astronomy
University of Wales College of Cardiff
PO Box 913
Cardiff CF1 3TH
Wales, U.K.

Address List for WG WFI Members
January 1992

Notes for guidance:–

a) An asterisk (⋆) prefixing the name indicates that the person is a member of the WG Organising Committee.

b) The letter in parenthesis after each name (i.e. M or C) indicates whether the person is a full Member (M) or Consultant (C) to the WG.

c) The numbers immediately following the e-mail address indicate the stated fields of interest of the person, i.e.

1= Sky Surveys and Patrols

2= Photographic Techniques

3= Digitization Techniques

4= Archival and Retrieval of Wide-Field Data

Additions or updates to this list are welcomed. Please send any alterations to the editor:-

Dr. H.T. MacGillivray
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK

Revised versions of the list will be distributed as appropriate.

1. Dr. D. Albanese (C)
Telescope de Schmidt
Observatoire de la Côte d'Azur
F-06460 Caussols
France
Tel.: 0033-93-42 62 70 (371)
Fax.: 0033-93-09 26 13
Mail: 17494::ALBANESE
2

2. Dr. G. Alcaino (M)
Casilla 8-9
Correo 9
Santiago
Chile
Tel.: 0056-2-217 2013
Fax.: 0056-2-217 2352
Mail:
2, 3

3. Dr. A. Alksnis (M)
Radioastrophysical Observatory
Turgeneva 19
226524 Riga
Latvia
Tel.: 0132-93 20 88 (SU)
Fax.: 0132-22 87 84
Mail: aspekt@lumii.lat.su for A. Alksnis
2

4. Prof. H.C. Arp (M)
Max-Planck-Institut für Astrophysik
Boltzmannstr. 1
W-8046 Garching
Germany
Tel.: 3299-3204
Fax.: 3299-3235
Mail: ASTRO@DGAIPP1S.BITNET
1

5. Dr. B.P. Artomonov (M)
Sternberg Institute
Universitetskij, 13
SU-119899 Moskau
Russia
Tel.: 939-22-45
Fax.:
Mail:
2,3,4

6. Dr. M. Azzopardi (M)
Observatoire de Marseille
2, Place Le Verrier
F-13248 Marseille Cedex 4
France
Tel.: 0033-91-95 90 88
Fax.: 0033-91-62 11 90
Mail: AZZO@FROMRS 51
1, 3

7. Dr. L. Muniz Barreto (M)
Observatorio Nacional
Rua General Bruce, 586
20921 Rio de Janeiro, RJ
Brazil
Tel.: 0055-21-580-7313 - Ext. 214
Fax.: 0055-21-580-6087
Mail: OGG 3@LNCC BR Bitnet
2,4

8. Dr. S.M. Beard (C)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK
Tel.: 0044-31-668 8223
Fax.: 0044-31-668 8264
Mail: REVAD::SMB
3

9. Dr. O. Bienaymé (M)
Observatoire de Besançon
B.P. 1615
F-25010 Besançon Cedex
France
Tel.: 0033-81-61 69 37
Fax.: 0033-81-61 69 44
Mail: Bienayme@Frobes51
2,3

10. Dr. A. Bijaoui (M)
Observatoire de la Côte d'Azur
B.P. 139
F-06003 Nice Cedex
France
Tel.: 0033-92 00 30 27
Fax.: 0033-92 00 30 33
Mail: EARN::"Bijaoui@Fronisi"
1,3,4

11. Dr. K. Birkle (M)
Max-Planck-Institut für Astronomie
Königstuhl 17
W-6900 Heidelberg 1
Germany
Tel.: 06221-5280
Fax.: 06221-528246
Mail:
2,3

12. Dr. F. Bonoli (M)
Dipartimento di Astronomia
Via Zamboni 33
I-40126 Bologna
Italy
Tel.: 0039-51-259 314
Fax.: 0039-51-259 407
Mail.: 38057::[Bonoli](Decnet)
1,2,3,4

13. Dr. Z.H. Borisov (C)
Sofia University
Dept. of Astronomy
Anton Ivanov Blvd. 5
Sofia
Bulgaria
Tel.: +359-2-662 324
Fax.: +359-2-463 589
Mail:
3

14. Dr. I.I. Brejdo (M)
Pulkovo Astronomical Observatory
SU-196140 St. Petersburg
(Leningrad)
Russia

Tel.:
Fax.:
Mail:
2

15. Dr. M. Bridgeland (M)
Royal Greenwich Observatory
Madingley Road
Cambridge CB3 0EZ
UK
Tel.: 0044-223-312511
Fax.:
Mail: UK.AC.CAM.AST.STAR::MTB1

16. Dr. Noah Brosch (M)
Wise Observatory
Tel Aviv University
Tel Aviv 69978
Israel
Tel.: 00972-3-413-788, or 3-545-0729
Fax.: 00972-3-642-9306
Mail: noah@Wise.tau.ac.il
1,3,4

17. Dr. R.J. Brucato (M)
Palomar Observatory 105-24
California Institute of Technology
Pasadena, CA 91125
USA
Tel.: 001-818-356-4033
Fax.: 001-818-568-1517
Mail: rjb@deimos.caltech.edu
1,2,3,4

18. Dr. G. Bruzual (M)
C.I.D.A.
Apartado Postal 264
Merida 5101-A
Venezuela
Tel.: 5874-791 202/792 660
Fax.: 5874-791 893
Mail: emsca!cida!bruzual@sun.com
1,2,3,4

19. Dr. R.D. Cannon (M)
Anglo-Australian Observatory
PO Box 296
Epping, NSW 2121
Australia
Tel.: 0061-2-868 1666
Fax.: 0061-2-876-8536
Mail: IN%"RDC@AAOEPP.OZ.AU"

1,2,4

20. Prof. M. Capaccioli (M)
Dept. of Astronomy
University of Padova
I-35122 Padova
Italy
Tel.: 0039-49-829 3435
Fax.: 0039-49-875 9840
Mail: CAPACCIOLI
ASTRPD.ASTRO.IT
2,3

21. Dr. Jian-sheng Chen (M)
Beijing Astronomical Observatory
Chinese Academy of Sciences
Beijing 100080
VR China
Tel.: 01-256 6698, 01-255 9201
Fax.:
1,3

22. Dr. D.G. Chipashvili (C)
Astrophysical Observatory
SU-383762 Abastumani
Georgia

Tel.: 883-237 5226
Fax.: 883-298 3853
2,4

23. Dr. Ch. Clement (M)
Dept. of Astronomy
University of Toronto
Toronto M5S 1A7
Canada
Tel.: 001-416-978-5186
Fax.: 001-416-971-2026
Mail: cclement@vela.astro.utoronto.ca
3,4

24. Dr. G. Comte (M)
Observatoire de Marseille
2 Place Le Verrier
F-13248 Marseille Cedex 4
France
Tel.: 0033-91-95 90 88
Fax.: 0033-91-62 11 90
Mail: EARN::"Comte@FROMRS51"
1,3,4

25. Dr. W.J. Couch (M)
School of Physics
University of New South Wales
P.O. Box 1
Kensington, NSW 2033
Australia
Tel.: 0061-2-697-4578
Fax.: 0061-2-663-3420
Mail:
WJC@NEWT.PHYS.UNSW.02.AU
1,2,3

26. Dr. Z. Ceplecha (M)
Ondrejov Observatory
251 650 Ondrejov
CSFR

Tel.: 0204-85201, 0204-85202
Fax.: 0204-85314
Mail.:

1,2,3,4

27. Dr. Ch. Coutures (C)
DAPNIA/SPP
CEN Saclay
F-91191 Gif-sur-Yvette
France
Tel.: 0033-1-69 08 72 00
Fax.: 0033-1-69 08 76 36
Mail: Coutures@FRSACS3
4

28. Dr. A.P. Cowley (M)
Dept. of Physics and Astronomy
Arizona State University
Tempe, AZ 85287
U.S.A.
Tel.: 001-602-965-2919
Fax.: 001-602-965-8011
Mail: cowley@pegasus.la.asu.edu
1

29. Dr. M. Crézé (M)
Observatoire de Strasbourg
11, rue de l'Université
F-67000 Strasbourg
France

Tel.: 0033-88 35 82 18
Fax.: 0033-88 35 01 60
Mail:
1,4

30. Dr. A.C. Davenhall (C)
Dept. of Physics and Astronomy
University of Leicester
University Road
Leicester LE1 7RH
UK
Tel.: 0044-533-522 522
Fax.:
Mail: LTVAD::ACD

31. Dr. E. Davoust (M)
Observatoire Midi-Pyrénées
14, Avenue E. Belin
F/31400 Toulouse
France
Tel.: 0033-61-33 28 68
Fax.: 0033-61-53 67 22
Mail: OMPTOB::DAVOUST
1

32. Prof. Chr. de Vegt (M)
Hamburger Sternwarte
Gojenbergsweg 112
W-2050 Hamburg 80
Germany
Tel.: 040-7252-4128/4112
Fax.: 040-7252-4198
Mail: ST00000@DHHUNI4.Bitnet
1,2,3,4

33. Dr. P.D. Delchev (C)
Computer Center of Physics
Bulgarian Academy of Sciences
Trakia Blvd. 72
Sofia
Bulgaria
Tel.: +359-2-756 089
Fax.: +359-2-757 053
Mail:
2,3,4

34. Dr. E.R. Deul (M)
Sterrewacht Leiden
PO Box 9513
NL-2300 RA Leiden
Netherlands

Tel.: 0031-71-275 880
Fax.: 0031-71-275 819
Mail: deul@maas.leiden.univ.nl
3,4

35. Dr. R.J. Dodd (M)
Carter Observatory
PO Box 2909
Wellington
New Zealand

Tel.: 04-472 8167
Fax.: 04-472 8320
Mail: ODDRJ@MATAI.VUW.AC.NZ
1,3,4

36. Dr. Mamoru Doi (C)
Dept. of Astronomy
University of Tokyo
Bunkyo-ku
Tokyo 113
Japan
Tel.: 81-3-5800-6800
Fax.: 81-3-3813-9439
Mail: LDOIXXX@C1.MTK.NAO.AC.J
1

37. Dr. O.D. Dokuchaeva (M)
Sternberg State Astronomical Institute
University Prospect, 13
SU-119899 Moskau
Russia
Tel.: 939 26 57
Fax.:
Mail:
1,2,3,4

38. Dr. F.V. Dossin (M)
Institut d'Astrophysique
5 Ave. de Cointe
B-4000 Liège
Belgium
Tel.: 41-37 35 84
Fax.:
Mail:
1,2,4

39. Dr. Pascal Dubois (M)
Observatoire de Strasbourg
11, rue de l'Université
F-67000 Strasbourg
France
Tel.: 0033-88-35 84 17
Fax.: 0033-88-25 01 60
Mail: dubois@simbad.u.Strasbg.fr
4

40. Dr. Ch. Ducourant (C)
Observatoire de Floirac
BP 89
F-33270 Floirac
France
Tel.: 0033-56-86 43 30
Fax.: 0033-56-40 42 51
Mail: Ducourant@FROBOR51.Bitnet
1,2,4

41. Dr. H. Duerbeck (M)
Astronomisches Institut
Universität Münster
Wilhelm-Klemm-Str. 10
4400 Münster
Tel.: 0251-83-3579
Fax.: 0251-83-3669
Mail:
1,3,4

42. Dr. J. Duerst (M)
Langwies
CH-Schoenenberg
Switzerland

Tel.:
Fax.:
Mail:
2

43. Dr. Richard Ellis (M)
Physics Department
South Road
Durham DH1 3LE
UK
Tel.: 0044-91-374-2163
Fax.: 0044-91-374-3749
Mail: RSE@UK.AC.DUR.STAR
1,4

44. Dr. Dieter Engels (M)
Hamburger Sternwarte
Gojenbergsweg 112
W-2050 Hamburg 80
Germany
Tel.: 040-7252-4136
Fax.: 040-7252-4198
Mail: ST20050@DHHUNI4.EARN
1,2

45. Dr. L. Federici (M)
Osservatorio Astronomico
Via Zamboni 33
I-40126 Bologna
Italy

Tel.: 0039-51-25 96 05
Fax.: 0039-51-25 94 07
Mail: ASTBO3::Luciana
3,4

46. Dr. R. Fong (M)
Dept. of Physics
University of Durham – Science Labs.
South Road
Durham DH1 3LE
UK
Tel.: 0044-91-374-2157
Fax.: 0044-91-374-3749
Mail: RF@UK.AC.DUR.STAR
1,2,3,4

47. Prof. L.W. Fredrick (M)
Leander McCormick Observatory
Box 3818
Charlottesville, VA 22903
USA
Tel.: 001-804-924-4905
Fax.: 001-804-924-3104
Mail: LWF@VIRGINIA.EDU
1,3

48. Dr. L.T. Gardiner (C)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK
Tel.: 0044-31-668 8392
Fax.: 0044-31-668 8264
Mail: UK.AC.ROE.STAR::LTG
1,4

49. Dr. T.B. Georgiev (M)
Rojhen NAO
P.O.B. 136
BG-4700 Smolian
Bulgaria
Tel.: 03021-356
2,3,4

50. Dr. Rumen G. Getov (C)
Rojhen NAO
P.O.B. 136
BG-4700 Smolian
Bulgaria
Tel.: 03021-356
2,3,4

51. Prof. E.H. Geyer (M)
Sternwarte Hoher List
W-5568 Daun/Eifel
Germany

Tel.: 06592-2150
Fax:
Mail:
1,2,3

52. Dr. L.B. Gilliam (C)
National Solar Observatory
Sacramento Peak
Sunspot, NM 88349
USA
Tel.: 001-505-434-7091
Fax.: 001-505-434-7029, 7098
Mail: lgilliam@sunspot.noao.edu
2,3

53. Mr. Ch. G. Goldsmith (C)
821 Boronia Cr.
Newmarket
Ontario L3Y 5J8
Canada

Tel.: 001-416-895-2935
Fax.:
Mail: goldsmit@aries.yorku.ca
1,3

54. Dr. John A. Graham (M)
Carnegie Institution of Washington
Dept. of Terrestrial Magnetism
5241 Broad Branch Rd., NW
Washington, DC 20015
USA
Tel.: 001-202-686-4403
Fax.: 001-202-364-8726
Mail: Span dtm::graham
1,3,4

55. Dr. R. Elizabeth Griffin (M)
Institute of Astronomy
The Observatories
Madingley Road
Cambridge CB3 0HA
UK
Tel.: 0044-223-33 70 91
Fax.: 0044-223-33 75 23
Mail: REMG@UK.AC.CAM.PHX
2,3

56. Dr. P. Grosboel (M)
European Southern Observatory
Karl-Schwarzschild-Str. 2
W-8045 Garching
Germany

Tel.: +49-89-32006237
Fax.: +49-89-320 23 62
Mail: pgrosbol@eso.org (on internet)
3

57. Dr. Jiri Grygar (M)
Institute of Physics
Czechoslovak Academy of Sciences
Na Slovance 2
CS-180 40 Prague 8 - Liben
CSFR
Tel.: +422-815-2660
Fax.: +422-858-4569
Mail:
1,2,3

58. ⋆ Dr. Jean Guibert (M)
Observatoire de Paris
61, Ave. de l'Observatoire
F-75014 Paris
France

Tel.: 0033-1-40 51 20 98
Fax.:
Mail:

59. Dr. Th. Gull (M)
Code 680
Goddard Space Flight Center
Greenbelt, MD 20771
USA

Tel.: 001-301-286-6184
Fax.: 001-301-286-8709
Mail: SPAN SMRS::GULL
1,3

60. Dr. H. Gursky (M)
Naval Research Laboratory
Space Science Division/Code 4100
4555 Overlook Ave., S.W.
Washington, DC 20375-5000
USA
Tel.: 001-202-767-6343/3363
Fax.: 001-202-404-7296
Mail: 11341::Gursky

61. Mr. Brian W. Hadley (C)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK

Tel.: 0044-31-668-8296
Fax.: 0044-31-668-8264
Mail: Photo@UK.AC.ROE.STARLINK
2

62. Mr. N.C. Hambly (C)
Dept. of Physics and Astronomy
University of Leicester
University Road
Leicester LE1 7RH
UK
Tel.: 0044-533-522 084
Fax.:
Mail: LTVAD::NCH
1,2,3,4

63. Dr. S.M. Haralambi (C)
National Astronomical Observatory
P.O. Box 136
BG-4700 Smoljan
Bulgaria
Tel.: 03021-357
Fax.:
Mail:
2,3,4

64. Dr. M.R.S. Hawkins (M)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK
Tel.: 0044-31-668 8393
Fax.: 0044-31-668 8264
Mail: REVAD::MRSH
1,3,4

65. Dr. M.L. Hazen (M)
Harvard College Observatory
60 Garden St.
Cambridge, MA 02138
USA
Tel.: 001-617-495-3362
Fax.: 001-617-495-7467
Mail: MARTHA@CFA3
1,4

66. Dr. Harry M. Heckathorn (M)
U.S. Naval Research Laboratory
Code 4104
Washington, DC 20375-5000
USA
Tel.: 001-202-767-4198
Fax.: 001-202-404-8445
Mail:
1,2,3,4

67. Dr. Karl G. Henize (M)
NASA Johnson Space Center
Code SN3
Houston, TX 77058
USA
Tel.: 001-713-483-5067
Fax.: 001-713-483-5347
Mail: SN::HENIZE
1,4

68. Dr. J.-L. Heudier (M)
Observatoire de Nice
BP 139
F-06003 Nice Cedex 5
France
Tel.: 0033-92-00 30 11
Fax.: 0033-92-00 30 33
Mail:
1,2,4

69. Dr. P.C. Hewett (M)
Institute of Astronomy
Madingley Road
Cambridge CB3 0HA
UK
Tel.: 0044-223-337 507
Fax.: 0044-223-337 523
Mail: PCH@STARLINK.ASTRONOMY.
CAMBRIDGE.AC.UK
1,3

70. Prof. B. Hidayat (M)
Bosscha Observatory
Lembang 40391, Java
Indonesia

Tel.: 62-22-28 6001
Fax.: 62-22-44-0699
Mail:

1,2

71. ⋆ Dr. R. Humphreys (M)
University of Minnesota
School of Physics and Astronomy
Minneapolis, MN 55455
USA
Tel.: 001-612-624-6530
Fax.:
Mail: roberta@aps2.ap.umn.edu

72. Dr. M.J. Irwin (M)
Royal Greenwich Observatory
Madingley Road
Cambridge CB3 0EZ
UK
Tel.: 0044-223-337 548 ext 7524
Fax.: 0044-223-337 548 ext 7523
Mail:
1,2,3

73. ⋆ Dr. Keiichi Ishida (M)
Institute of Astronomy
University of Tokyo
2-21-1 Osawa, Mitaka
Tokyo 181
Japan
Tel.: 0081-422-41-3741
Fax.: 0081-422-41-3749
Mail: lishida@c1.mtk.nav.ac.jp
1,2,3,4

74. Dr. P.V. Ivanov (C)
Computer Center of Physics
Bulgarian Academy of Sciences
Blvd. Trakia 72
Sofia
Bulgaria
Tel.: +359-2-756 089
Fax.: +359-2-757 053
Mail:
4

75. Dr. Derek H.P. Jones (M)
Royal Greenwich Observatory
Madingley Road
Cambridge CB3 0EZ
UK
Tel.: 0044-223-374 781
Fax.: 0044-223-374 700
Mail: DHPJ@UK.AC.CAM.AST-STAR
2,3,4

76. Dr. Noburu Kaneko (M)
Dept. of Physics, Fac. of Science
Hokkaido University
Sapporo 060
Japan
Tel.: 011-716-2111
Fax.: 011-717-9304
Mail:
1,3

77. Dr. L. Kresak (M)
Astronomical Institute
Slovak Academy of Sciences
84228 Bratislava
CSFR
Tel.: 427-375 157
4

78. Dr. D. Kubacek
Astronomical Institute
Slovak Academy of Sciences
Interplanetary Matter Div.
Dubravska Cesta
84228 Bratislava
CSFR
Tel.: 427-378 2902
3

79. Dr. L. Labhardt (M)
Astronomisches Institut
Universität Basel
CH-4102 Binningen
Switzerland
Tel.: 0041-61-271 7711
Fax.: 0041-61-271 7810
Mail: LABHARDT@URZ.UNIBAS.CH (internet)
1,2,3,4

80. Dr. Claes-Ingvar Lagerkvist (M)
Astronomiska Observatoriet
Box 515
S-75120 Uppsala
Sweden
Tel.: 0046-18-51 35 22
Fax.: 0046-18-52 75 83
Mail:
1,3,4

81. Dr. J.F. Lahulla (M)
Observatorio Astronomico Nacional
Alfonso XII, 3
E-28014 Madrid
Spain

Tel.: 0034-1-539 6055
Fax.: 0034-1-533 1158
Mail:
1,2,3

82. ⋆ Dr. B.M. Lasker (M)
Space Telescope Science Institute
Homewood Campus
3700 San Martin Drive
Baltimore, MD 21218
USA
Tel.:
Fax.: 001-301-338-5090
Mail: lasker@stsci Bitnet

83. Dr. Andris Lauberts (M)
National Defence Research Establishment
Dept. of Information Technology
PO Box 1165
S-581 11 Linköping
Sweden
Tel.: 0046-13-118 338
Fax.: 0046-13-131 665
Mail: andris@folke.se
1,3

84. Mr. Alain Lécart (C)
Kodak-Pathé
Allée du 1er Mai, B.P. 48
F-77423 Marne La Vallée Cedex 2
France

Tel.: 0033-1-64 61 21 41
Fax.: 0033-1-64 61 47 15
Mail:
2,3,4

85. Dr. R.S. Le Poole (M)
Sterrewacht Leiden
P.O. Box 9513
NL-2300 RA Leiden
Netherlands
Tel.: 0031-71-27 58 71
Fax.: 0031-71-27 58 19
Mail:
1,2,3

86. Dr. L. Leporati (M)
Laboratoire d'Astronomie Spatiale
Les Trois Lucs
F-13012 Marseille
France
Tel.: 0033-91-05 59 34
Fax.: 0033-91-05 59 66
Mail: L.Li@FRLASM51
3,4

87. * Dr. H. Lorenz (M)
Zentralinst. f. Astrophysik
Akademie der Wissenschaften
Rosa-Luxemburg-Str. 17A
O-1502 Potsdam-Babelsberg
Germany
Tel.: 0037-33-7620
Fax.:
Mail:

88. ⋆ Dr. H.T. MacGillivray (M)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK

Tel.: 0044-31-668 8381
Fax.: 0044-31-668 8264
Mail: 19463::HMG
1,3,4

89. Mr. C. Madsen (C)
European Southern Observatory
Karl-Schwarzschild-Str. 2
W-8046 Garching
Germany

Tel.: +49-89-32006 278
Fax.: +49-89-320 23 62
Mail:

90. Prof. P. Maffei (M)
Università di Perugia
Cattedra di Astrofisica
Via dell'Elce di Sotto
I-06100 Perugia
Italy
Tel.: 0039-75-58 53 0 42
Fax.: 0039-75-20632
Mail: SPAN 40195::MAFFEI
1,2,3,4

91. Dr. Hideo Maehara (M)
Okayama Astrophysical Observatory
National Astronomical Observatory
Kamogata-cho, Asakuchi-gun
Okayama 719-02
Japan
Tel.: 86544-2155
Fax.: 86544-2360
Mail:
MAEHARA@KIBI.OAO.NAO.AC.JP
1,4

92. ⋆ Mr. David Malin (M)
Anglo-Australian Observatory
PO Box 296 (167 Vimiera Road)
Epping, NSW 2121
Australia

Tel.: 0061-2-868-1666
Fax.: 0061-2-876-8542-36
Mail: DFM@AAOEPP.OZ.AU

1,2,3,4

93. Dr. Cedrick Martys (C)
Applecross
Wyedale Crescent
Bakewell
Derbyshire DE4 1BE
UK
Tel.: 0044-629-81-3234
Fax.:
1,2,3

94. Prof. S. Marx (M)
Karl-Schwarzschild-Observatorium
O-6901 Tautenburg
Germany

Tel.: 0037-7897-837
Fax.: 0037-7897-265
1,2,4

95. Prof. K. Mattila (M)
Helsinki University Observatory
Tähtitorninmäki
SF-00130 Helsinki
Finnland
Tel.: 00358-0-191 2947
Fax.: 00358-0-191 2952
Mail: Mattila@Finuha (bitnet)
2,3

96. Dr. Eric Maurice (M)
Observatoire de Marseille
2, Place Le Verrier
F-13248 Marseille Cedex 4
France
Tel.: 0033-91-95 90 88
Fax.: 0033-91-62 11 90
Mail: Maurice@FROMRS51
2,4

97. Dr. A.J. Maury (C)
Telescope de Schmidt
Observatoire de la Côte d'Azur
F-06460 Caussols
France
Tel.: 0033-93-42-62-70
Fax.: 0033-93-09-26-13
Mail: OCARO1::Maury
1,2,3

98. Dr. M.F. McCarthy (M)
Vatican Observatory Research Group
2017 E. Lee Street
Tucson, AZ 85719
USA
Tel.: 001-602-795-9866
Fax.: 001-602-326-0756
Mail: B:BOYLE@ARIZ
1,2,4

99. Dr. B.J. McLean (M)
Space Telescope Science Institute
3700 San Martin Drive
Baltimore, MD 21218
USA
Tel.: 001-301-338-4900
Fax.: 001-301-338-5090
Mail: SCIVAX::MCLEAN (SPAN)
1,3,4

100. Dr. Y. Mellier (M)
Observatoire Midi Pyrénées
14 Avenue Belin
F-31400 Toulouse
France
Tel.: 0033-61 33 28 24
Fax.: 0033-61 53 67 22
Mail: OMPTOB::MELLIER (SPAN)
1

101. Dr. M.-E. Sanabria Mihailov (C)
Sofia University
Dept. of Astronomy
Anton Ivanov Blvd. 5
Sofia
Bulgaria
Tel.: +359-2-662-324
Fax.: +359-2-463 589
Mail:

3,4

102. Dr. L. Miller (C)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK

Tel.: 0044-31-668 8378
Fax.: 0044-31-668 8264
Mail: REVAD::LAM,
UK.AC.ROE.STAR::LAM
1,2,3,4

103. Dr. B. Milliard (M)
Laboratoire d'Astronomie Spatiale
Trav. du Siphon
F-13012 Marseille
France
Tel.: 0033-91-05 59 42
Fax.: 0033-91-05 59 66
Mail: Millialrd@FRLASM51
1,4

104. Dr. C. Möllenhoff (M)
Landessternwarte
Königstuhl
6900-Heidelberg
Germany
Tel.: 06221-509 210
Fax.: 06221-509 202
Mail: E68@DHDURZ1
1,2

105. Dr. D.G. Monet (M)
US Naval Observatory
Flagstaff Station
P.O. Box 1149
Flagstaff, AZ 86002
USA
Tel.: 001-602-779-5132
Fax.: 001-602-774-3626
Mail: PERCY::DMONET (Span)

3

106. Dr. David H. Morgan (M)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK

Tel.: 0044-31-668 8327
Fax.: 0044-31-668-8264
Mail: DHM at
JANET:UK.AC.ROE.STAR
1,2,4

107. Dr. A.S. Mustafov (C)
Sofia University
Dept. of Astronomy
Anton Ivanov Blvd. 5
Sofia
Bulgaria
Tel.: +359-2-662 324
Fax.: +359-2-463 589
1,2,3,4

108. Dr. N.S. Nikolov (M)
Sofia University
Dept. of Astronomy
A. Ivanov Street 5
BG-1126 Sofia
Bulgaria
Tel.: 688 176
Fax.:

109. Dr. S.C. Odewahn (C)
Dept. of Astronomy
School of Physics and Astronomy
116 Church Street
Minneapolis, MN 55455
USA
Tel.: 001-612-624-0335
Fax.:
Mail: SCO@APSL.SPA.UMN.EDU
3

110. Dr. Sadanori Okamura (M)
Dept. of Astronomy, Faculty of Scien
University of Tokyo
Bunkyo-ku
Tokyo 113
Japan
Tel.: 3-5800-6880
Fax.: 3-3813-9438
Mail:
1,2,3,4

111. Dr. Q.A. Parker (M)
UK Schmidt Telescope Unit
Private Bag
Coonabarabran, NSW 2357
Australia
Tel.:
Fax.:
Mail:
1,4

112. Mr. M.J. Paterson (C)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK
Tel.: 0044-31 668 8247
Fax.: 0044-31-668 8264
Mail: UK.AC.COSMOS.MWP
3

113. Dr. R.L. Pennington (M)
Astronomy Dept.
University of Minnesota
116 Church St. SE
Minneapolis, MN 55406
USA
Tel.: 001-612-624-2582
Fax.: 001-612-626-2029
Mail: rlp@aps1.spa.umn.edu
4

114. Dr. A.G. Davis Philip (M)
1125 Oxford Place
Schenectady
New York 12308
USA

Tel.: 001-518-374-5636
Fax.:
Mail: AGDP@Union
1,3

115. Dr. S. Phillipps (C)
Dept. of Physics and Astronomy
Univ. of Wales College of Cardiff
PO Box 913
Cardiff CF1 3TH
Wales, UK
Tel.: 0044-222-874-000 ext. 5107
Fax.:
Mail: CARDIF::SXP (Starlink)
4

116. Dr. P. Pishmish (M)
Instituto de Astronomia UNAM
Ap. Postal 70264
Mexico D.F. 04510
Mexico

Tel.: 5-5 48 53 06, 548 53 05
Fax.: 525-548 3712
Mail: Pismis@unamoml
2,3,4

117. Dr. E.M. Pittich (M)
Astronomical Institute
Slovak Academy of Sciences
Dubravska cesta 9
842 28 Bratislava
CSFR
Tel.: 0042-7-375 157
Fax.: 0042-7-376 085
Mail: ASTROPIT.SAVBA.CS
2,3,4

118. Dr. V.N. Popov (M)
Dept. of Astronomy and National
Astronomical Observatory
72 Trakia Blvd.
1784 Sofia
Bulgaria
Tel.: +359-2-720 831 (ext 626)
Fax.:
Mail:
2

119. Dr. L. Prevot (M)
Observatoire de Marseille
2, Place Le Verrier
F-13248 Marseille Cedex 4
France
Tel.: 0033-91-95 90 88
Fax.: 0033-91-62 11 90
Mail: LPREVOT FROMRS 51
1,3

120. Dr. H. Oleak (M)
Sternwarte Babelsberg
Rosa-Luxemburg-Str. 17a
O-1590 Potsdam-Babelsberg
Germany
Tel.: 0036-33-7620
Fax.: 0037-33-76 23 09
Mail:
1,2,3

121. Mr. Ch. Pollas (C)
Télescope de Schmidt
Observatoire de la Cote d'Azur
Caussols
F-06460 St Vallier de Thiey
France
Tel.: 0033-93-42 62 70
Fax.: 0033-93-09 26 13
Mail: OCARO1::POLLASD
1

122. Mr. J. Québatte (C)
European Southern Observatory
Karl-Schwarzschild-Str. 2
W-8046 Garching
Germany

Tel.: +49-89-32006 310
Fax.: +49-89-320 23 62
Mail:
1,2

123. Prof. Dr. K.D. Rakos (M)
Institut für Astronomie
Türkenschanzstr. 17
A-1180 Wien
Austria
Tel.: 0043-222-34 53 60-1854
Fax.: 0043-222-34 53 60-16
1

124. ⋆ Dr. I.N. Reid (M)
Palomar Observatory
Caltech 105-24
Pasadena, CA 91125
USA
Tel.:
Fax.:

125. Dr. A.C. Robin (M)
Observatoire de Besancon
BP 1615
F-25010 Besancon Cedex
France
Tel.: 0033-81-66 69 41
Fax.: 0033-81-66 69 44
Mail: Robin@Frobess51, Obsbes::Annie
1

126. Dr. E. Roemer (M)
Lunar and Planetary Laboratory
University of Arizona
Tucson, AZ 85721
USA
Tel.: 001-602-621-2897
Fax.: 001-621-4933
Mail:
4

127. Dr. Ann Savage (M)
Schmidt Telescope
Private Bag
Coonabarabran, NSW 2357
Australia

Tel.: 0062-68-426 312
Fax.: 0062-68-842 298
Mail: ASA@AAOCBN
1,2,3,4

128. Prof. Th. Schmidt-Kaler (M)
Ruhr-Universität Bochum
Astronomisches Institut
Postfach 10 21 48
4630 Bochum 1
Germany
Tel.: 0234-700 34 54
Fax.: 0234-700 27 80
Mail:
1

129. Dr. W. Schoening (C)
National Optical Astronomy Observatory
950 N. Cherry Street
Tucson, AZ 85726
USA
Tel.: 001-602-325-9348
Fax.: 001-602-325-9630
Mail: schoen@noao.edu
2

130. Dr. G. Sedmak (M)
Osservatorio Astronomico
Via G.B. Tiepolo, 11
I-34131 Trieste
Italy
Tel.: 0039-40-3199 240
Fax.: 0039-40-309 418
Mail: 38439::SEDMAK (SPAN)
3,4

131. Dr. E.H. Semkov (C)
Dept. of Astronomy and National
Astronomical Observatory
Trakia Blvd. 72
BG-1784 Sofia
Bulgaria
Tel.: +359-2-758 927
Fax.: +359-2-755-019
1,3,4

132. Dr. J.L. Sersic (M)
Observatorio Astronomico
Laprida 854
5000 Cordoba
Argentina

Tel.: 0054-51-40613
Fax.:
2,3,4

133. Dr. T. Shvelidze (C)
Astrophysical Observatory
SU-383762 Abastumani
Georgia

Tel.: 883-237 5226
Fax.: 883-298 3853
2,3,4

134. Prof. K.R. Sivaraman (M)
Indian Institute of Astrophysics
Koramangala
Bangalore 560034
India
Tel.: 530672 to 76
Mail: vigyan!shakti!iiap!siva
2,3

135. Prof. A.G. Smith (M)
Dept. of Astronomy
211 Space Sciences Research Bldg.
University of Florida
Gainesville, FL 32611
USA
Tel.: 001-904-392-6135
Fax.: 001-904-392-5089
Mail: asmith@astro.ufl.edu
2,3

136. Dr. D.Y. Stavrev (C)
Dept. of Astronomy
Bulgarian Academy of Sciences
72 Trakia Blvd.
BG-1784 Sofia
Bulgaria
Tel.: +359-2-758 927
Fax.:
Mail:
3,4

137. Dr. Stepanian Jivan (M)
Special Astrophysical Observatory
Nczhnij Arkhyz
SU-357 147 Stavropol Territory
Russia
Tel.: 93-5-13 - 93-5-18
Fax.: (Tlx 123244 ZENIT SU)
Mail: JSTEP@SAO.STAVROPOL.SU
1,2,3,4

138. Dr. R.S. Stobie (M)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK
Tel.: 0044-31-668 8307
Fax.: 0044-31-668 8264
Mail: RSS@UK.AC.ROE.STAR
1,2,3

139. Dr. V. Straizys (M)
Inst. of Theor. Physics + Astronomy
Gostauto 12
Vilnius 2600
Lithuania
Tel.: 007-0122-613440
Fax.: 007-0122-618464
Mail: itpa.ma@ma-mii.lt.su
1,3

140. Dr. Hong-jun Su (M)
Purple Mountain Observatory
Academia Sinica
Nanjing 210008
VR China
Tel.: 25-306967
Fax.: 25-301459
Mail:
3

141. Dr. Jinghao Sun (C)
Beijing Astronomical Observatory
Chinese Academy of Sciences
Beijing 10008
VR China
Tel.: 861-256 1265
Fax.: 861-256 1085
Mail:
BMABAO@ICA.BEIJING.CANET.CN
3

142. Dr. L.G. Taff (M)
Space Telescope Science Institute
3700 San Martin Drive
Baltimore, MD 21218
USA
Tel.: 001-301-338-4799
Fax.: 001-301-338-4767
Mail: LGTAFF on SCI VAX

4

143. Dr. B. Takase (M)
National Astronomical Observatory
2-21-1 Osawa Mitaka
Tokyo 181
Japan

Tel.:
Fax.:
1

144. Dr. D. Teuber (C)
Astronomisches Institut
Universität Münster
Wilhelm-Klemm-Str. 10
4400 Münster
Germany
Tel.: 0251-83 9127, 3561
Fax.: 0251-83 36 69
3,4

145. Mrs. S.B. Tritton
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK

Tel.: 0044-31-668 8326
Fax.: 0044-31-668-8264
Mail: SBTat JANET:UK.AC.ROE.STAR
1,2

146. ⋆ Dr. M. Tsvetkov (M)
Dept. of Astronomy
Bulgarian Academy of Sciences
Trakia Blvd. 72
BG-1784 Sofia
Bulgaria
Tel.: +359-2-758 927
Fax.: +359-2-757 053
Mail:
1,4

147. Dr. K.P. Tsvetkova (M)
Dept. of Astronomy
Bulgarian Academy of Sciences
Trakia Blvd. 72
BG-1784 Sofia
Bulgaria
Tel.: +359-2-758 927
Fax.: +359-2-757 053
1,4

148. Dr. Va. Tsintsarov (C)
Rojhen NAO
P.O.B. 136
Bulgaria

Tel.: 03021-356
Fax.:
2,3

149. Dr. E. Valentijn (C)
Laboratory for Space Research
P.O. Box 800
NL-9700 AV Groningen
Netherlands
Tel.: 0031-50-63 40 11
Fax.: 0031-50-
Mail: valentijn@HGRRUG5
1,3,4

150. Dr. E.L. van Dessel (M)
Royal Belgian Observatory
Av. Circulaire 3
B-1180 Bruxelles
Belgium
Tel.: 0032-23 73 02 40
Fax.: 0032-23 74 98 22
Mail: evdes@astro.oma.be
4

151. Dr. W.F. van Altena (M)
Yale Astronomy Dept.
P.O. Box 6666
New Haven, CT 06511
USA
Tel.: 001-203-432-3020
Fax.: 001-203-432-5048
Mail:
VANALTEN@YALASTRD.BITNET
1,2,3,4

152. Ms. Yupa Vanichai (C)
Dept. of Physics
Burapha University
Bangsaen, Cholburi 20131
Thailand
Tel.: 038-376060
Fax.: 75509 SWU BS TH (Tlx)
Mail:

1,4

153. Dr. J. Duncan Waldron (C)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK
Tel.: 0044-31-668-8298
Fax.: 0044-31-668-8264
Mail:
PHOTO@UK.AC.ROE.STARLINK
2

154. Prof. Wan Lai (M)
Shanghai Observatory
Shanghai
VR China

Tel.: 438 6191
Fax.:
Mail:

1,2

155. Prof. A. Wehlau (M)
Dept. of Astronomy
University of Western Ontario
London, Ontario N6A 3K7
Canada
Tel.: 001-519-679-2111 x 6710
Fax.: 001-519-661-3486
Mail: AFWEHLAU@UWOVAX.Bitnet
1,3,4

156. Mr. N. Weir (C)
Caltech 105-24
Pasadena, CA 91125
USA

Tel.: 001-818-356-4987
Fax.: 001-818-568-1517
Mail: WEIR@DEIMOS.CALTECH.E

157. Prof. W.W. Weiss (M)
Institut für Astronomie
Türkenschanzstraße 17
A-1180 Wien
Austria
Tel.: 0043-1-34 53 60
Mail:Weiss@AVIA.UNA.AC.AT
1,3

158. ⋆ Dr. R.M. West (M)
European Southern Observatory
Karl-Schwarzschild-Str. 2
W-8046 Garching
Germany
Tel.: +49-89-32006-276
Fax.: +49-89-320 23 62

159. Dr. L. Winter (C)
Hamburger Sternwarte
Gojenbergsweg 112
W-2050 Hamburg 80
Germany
Tel.: 040-7252-4127
Fax.:
1,2,3,4

160. Dr. G. Wlerick (M)
Observatoire de Paris
F-92195 Meudon Cedex
France

Tel.: 0033-1-45 07 78 64
Fax.: 0033-1-45 07 78 78
1,3,4

161. Dr. R. Wolstencroft (M)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK
Tel.: 0044-31-668 8390
Fax.: 0044-31-668 8264
Mail:
1,3,4

162. Dr. A. Woszczyk (M)
Torun Astronomical Observatory
ul. Chopina 12/18
PL-87 100 Torun
Polen
Tel.: 0048-56-26018
Tel.: 0048-56-24602
Mail: AWASTR@PLTUMK11
2,4

163. Dr. T. Yamagata (M)
Royal Observatory
Blackford Hill
Edinburgh EH9 3HJ
UK
Tel.: 0044-31-668-8386
Fax.: 0044-31-668-8264
Mail: 19889::TY TY@STAR.ROE.AC.UK
1,3

164 Dr. N. Zacharias (M)
Hamburger Sternwarte
Gojenbergsweg 112
W-2050 Hamburg 80
Germany
Tel.: 040-7252-4128/4112
Fax.: 040-7252-4198
Mail: ST00000@DHHUNI4.Bitnet
1,2,3,4

165. Dr. W. J. Zealey (M)
Astronomy and Physics Group
Physics Dept., University of Wollongong
Box 1144
Wollongong, NSW 2500
Australia
Tel.: 0062-42-213-522
Fax.: 0062-42-213-151
Mail: WJZEALEY@UOW.EDU.AU
1,3,4

166. Mrs. O. Zichová (C)
Astronomical Institute
Czechoslovak Academy of Sciences
251 65 Ondrejov
CSFR

Tel.: 42-2724525, 20485201
Fax.: 42-20485314
Mail: