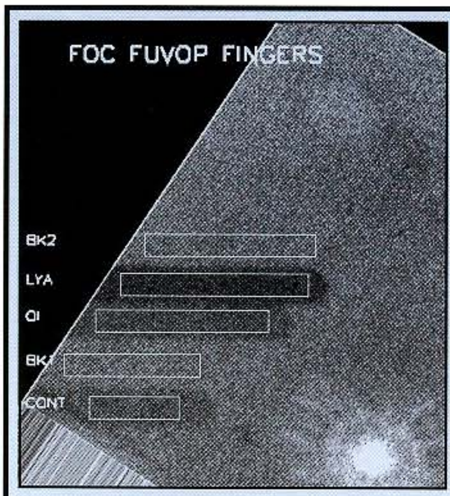
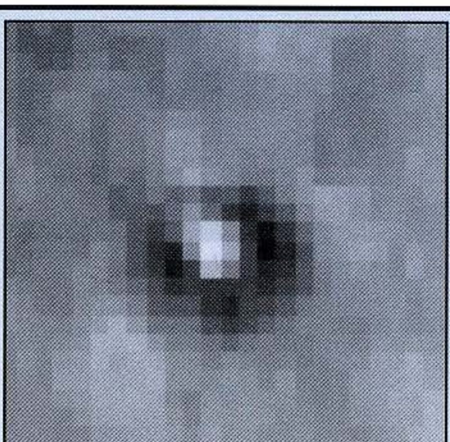
Number 19 February 1993

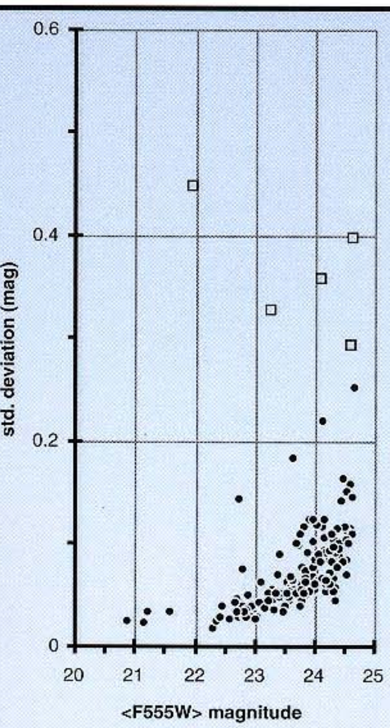
ST-ECF Newsletter

Space Telescope — European Coordinating Facility

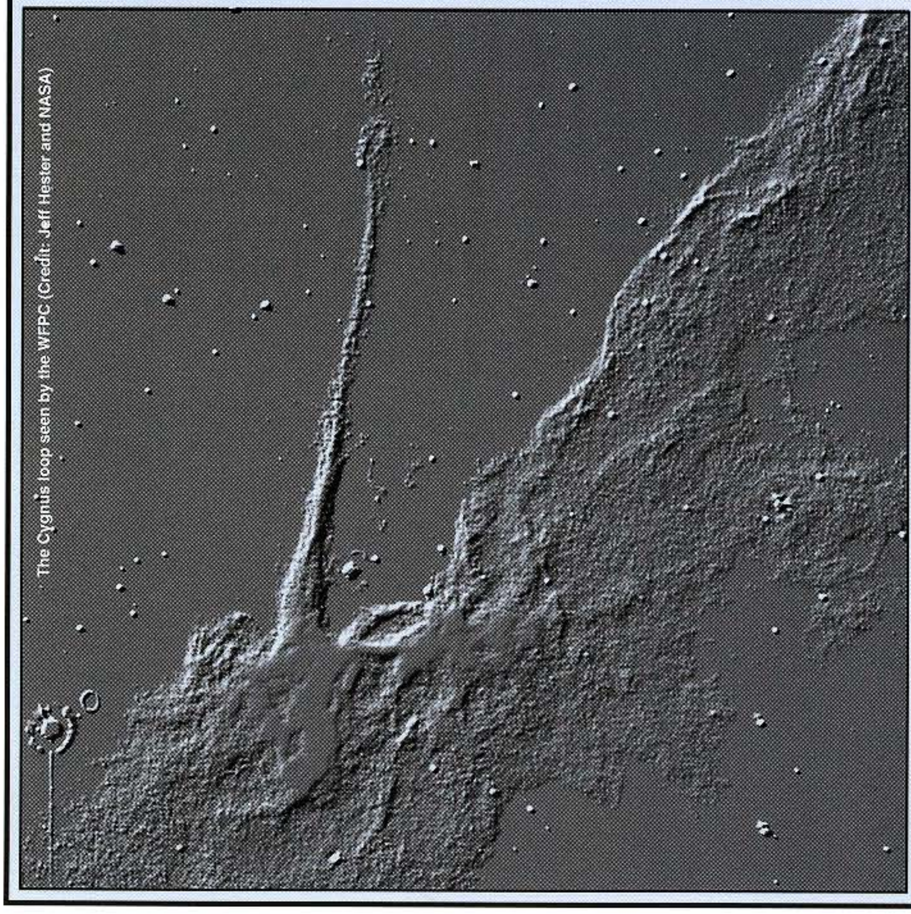




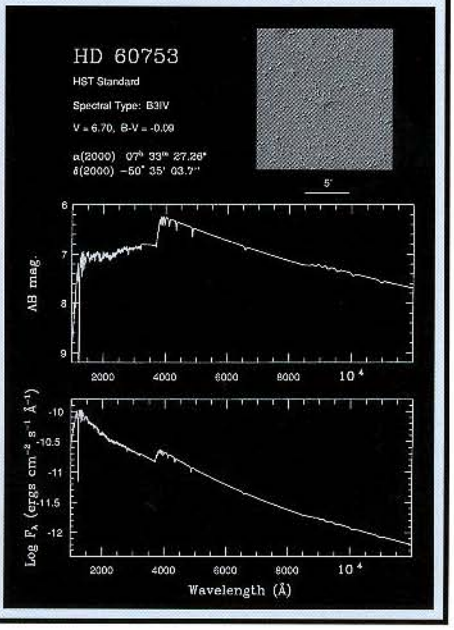
A protoplanetary disk in Orion — WFPC
(Credit: Bob O'Dell and NASA)

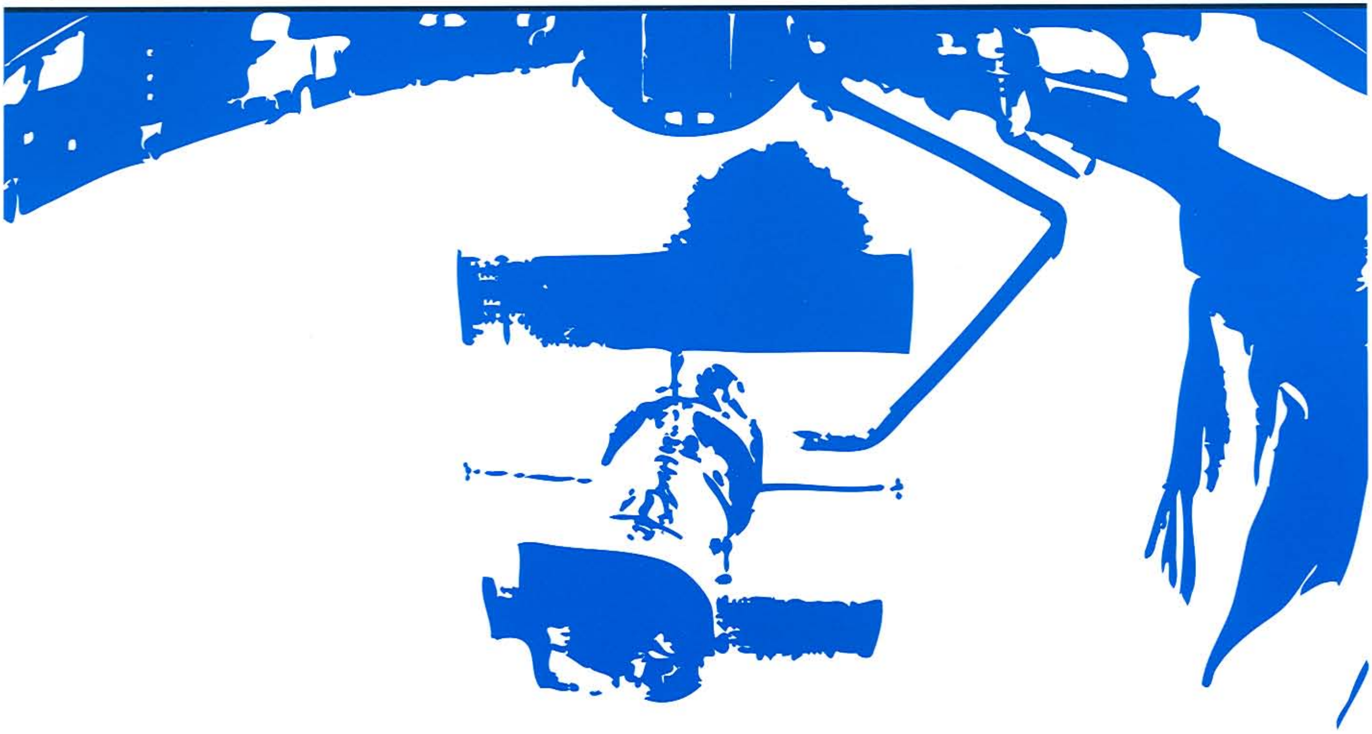


Above: Cephied variables (open squares) in IC 4182 detected from multiple WFC frames (see page ?)



The Cygnus loop seen by the WFPC (Credit: Jeff Hester and NASA)





The Hitch Hiker's Guide to HST observing

Robert Fosbury & Daniel Golombek[†]

It can be done; you've seen the NASA/ESA press releases with pictures and spectra. But how can you do it yourself? It is, to be sure, a rather daunting prospect and so you would appreciate a little help. You could start by wading through the 'Grey Books' but why not start here and get some ideas about the kind of topics which need special attention amongst the avalanche of information. Our aim is not to summarise them but rather to highlight some of the important decisions to be made along the way and to point to places where you might be able to find succinct and germane help.

First a few remarks about the telescope. It has some important characteristics other than spherical aberration and most of them are a lot more useful. The primary is 2.4 m in diameter with about a 14% central obscuration. That means that a zeroth magnitude star gives you about 37 million photons/s/Å in the V-band times the efficiency of two reflections. The telescope throughput as a function of wavelength from 1,000 to 10,000Å is given in the OTA (Optical Telescope Assembly) handbook—one of the grey ones. How this changes with time—particularly in the far-UV—is a question being given considerable attention but it appears to be quite stable.

The spherical aberration is well understood both in cause and effect (for simple descriptions see ST–ECF Newsletters No. 14 p4 & No. 15 p2) and the prescription derived from both laboratory and in-orbit measurements is being used to design corrective optics. The first of these will fly with WFPC 2 and COSTAR in the first maintenance and refurbishment mission (M&R) in December 1993.

The OTA is pointed using a whole hierarchy of devices starting with a magnetic compass and ending with the interferometric Fine Guidance Sensors (FGS; see the FGS Handbook). You can point anywhere on the sky although not always at a given time since you have to avoid the Sun, Earth and Moon. A pair of zones on the sky at the orbital poles are accessible continuously—they are called the 'continuous viewing zones' (CVZ) and they precess around the celestial poles through the year (Sherrill, T.J., 1982. J. Spacecraft, 19, 228). The pointing is done with respect to a pair of guide stars which are acquired by two of the three FGS. The stars are selected from the Guide Star Catalog (GSC). This contains about 20 million objects ($m \leq 14.5$) whose positions are known with an rms error of about three tenths of an arcsecond. This is actually a fantastic story, available in a new release—version 1.1—on the NASA label on CD-ROM (your institute can request a copy from the GS Distribution Office, c/o Patty Reeves, at STScI; see also A.J., 1990, 99, pp 2019, 2059 & 2081). The complete scans, from which the catalogue was derived, will soon be available on CD-ROM as well: 100 discs with 10 times compression and 10 discs with 100 times compression (see ST–ECF Newsletter No. 16 p3).

The FGS work in two modes. Coarse Track uses a kind of 'quadrant diode' simulator—the star is moved in a circular path over 4 photomultipliers which generate a position error signal—and works robustly with a precision which is a decreasing function of guide star magnitude and is typically 20 milliarcseconds (mas) or so. The interferometric Fine Lock mode takes somewhat longer to set up but can give a tracking precision of 3–4 mas in 'quiet' periods, independent of guide star brightness down to about 13.5 where they run out of photons. Fine Lock is less

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robust, is affected in subtle ways by spherical aberration and can be lost when the spacecraft is shaken by thermal shocks—caused particularly by the current solar arrays which wobble when the Sun is switched on and off by Earth occultation. The story of this tracking precision—which is pretty remarkable if you think about it—is told in a fascinating STScI document called: "Results of the HST Jitter Test" by Pierre Bély et al. (seriously, this is really worth reading; it reports the use of the High Speed Photometer, with a bright star on the edge of its aperture, to measure spacecraft motions up to high mechanical frequencies independently of the FGS).

Due largely to the low Earth orbit (about 600 km) and regular passage through the South Atlantic Anomaly (SAA), the scheduling of observations is a complex process (see ST–ECF Newsletter No. 13 p12, reprinted in STScI Newsletter 7, No. 3, 24). This means that almost all observations are completely preplanned, since real-time contact is very expensive in communication resources—HST uses the TDRS satellites for communication with the ground. The necessity to do this pre-planning results in you having to complete a 'Phase II' proposal if you are successful in having your scientific case approved after the technically simpler 'Phase I' application. Phase II is far from trivial and you will almost certainly need some help. This is the point where you really have to worry about details and think the process through to final data analysis.

Imaging the sky from space

The sky is quite a bit fainter in space than at a good groundbased site: about two magnitudes through most of the visible but up to three or so in the near infrared where HST is above the OH airglow (see O'Connell, R.W., 1987, A.J., 94, 876). The UV sky is dominated by Geocoronal Lyman-α and OI $\lambda\lambda$1304, 1356Å airglow (see the FOC background article in this issue). The sky in the V filter gives about 100e$^-$ in the 0.1×0.1 arcsec^2 pixels of the WFC in a one-orbit (~40min) exposure. This all has to be calculated in order to decide about splitting exposures for cosmic ray event discrimination etc.

The pixel sizes in the cameras are, of course, smaller than typical groundbased instruments and so the readout noise in the CCD of the WFPC (13e$^-$ rms in the current WFPC, about 7e$^-$ in WFPC 2) dominates short exposures and thermal dark current can be significant for narrow bands and regions of low CCD sensitivity. If you expect that your source or the background will fall below about 8e$^-$/pixel during a short exposure, it will be wise to 'preflash' the observation to avoid loosing very faint objects.

The FOC, on the other hand, is readout noise free but it does have a thermal background which is at least three orders of magnitude less than its maximum allowable count rate per pixel. This is mostly, although not exclusively, harmless.

Now that you have figured out what you want to do and how to do it, how does the telescope 'see' your target? There are three basic modes of target acquisition: blind, onboard and interactive. The cameras use the blind acquisition type as you generally only need reasonably accurate coordinates to point and take a picture. The spectrographs require the use of the onboard acquisition. This means that the instrument will be pointed where you indicate, but it will try to accurately locate the target using a series of measurements programmed into the onboard computers. For this mode you need to know the magnitude and colour of your target. Special targets and complex fields will need to use the interactive acquisition mode. In this case, you will first get a picture with the WFPC to identify your field and measure the coordinates of your target and then use this information to point the spectrographs—generally weeks or months later. It works and there is now a good deal of experience but, for some observations, eg, spectroscopy with small apertures in crowded fields with a background, it can be very time-consuming and complex to plan. If you want to acquire a bright star with the GHRS it is not too difficult. If you want to snap a feature on the surface of a rotating planet, it needs more work! Do not hesitate to contact or visit the ST–ECF and/or STScI if you think you need help. There is also a description in the Target Acquisition handbook.

For some observations, it may not be necessary to go through the guide star acquisition procedure at all. The 'snapshot' mode has been developed to make scientific use of short periods during which it would not be possible to fit in a full, guided, observation. Short exposures with the WFPC can be taken tracking only on gyros which have a drift rate of about 1 mas/s. There may be other possibilities you can think of.

There are opportunities to obtain observations—usually images—in 'parallel mode'. This means running two instruments simultaneously. This is useful for surveys of generic fields. As a parallel observer, you will be told some months in advance when a suitable opportunity for your programme will occur.

An example of a more subtle point may serve to illustrate the kind of consideration you need to give to the specification of the observations themselves. Let us say you want to build up deep (multi-orbit) exposures of a single Wide Field Camera (WFC) field in several filters. The observations will not necessarily be scheduled consecutively (unless you specifically ask for this) but they may all be done in the same week. Because of the requirement to keep the solar arrays fully illuminated, the spacecraft roll-angle for a particular pointing will sweep 360° a year—about a degree a day. This means that a sequence of spacecraft pointings at the same target would normally be slightly rotated and may also be slightly shifted with respect to one another—you have to make a specific request in Phase II to avoid it and there is some freedom to roll the HST away from the optimum angle. Now the WFC severely undersamples the Point Spread Function (PSF) of the OTA—even with spherical aberration—and so the combination of non-congruent images is difficult (quite a range of meanings can be read into the word 'difficult' in this context). There are certainly some advantages to be gained from having a series of slightly displaced images. It can alleviate the effects of undersampling and help with the flat-fielding problem although it complicates the process of cosmic ray event identification and removal. But you may want to choose a set of non-integral pixel shifted images yourself and avoid the rotation problem (see the article by Hook & Lucy in this issue).

The choice of particular instrument set-ups and exposure times is a subject which is well-covered in the 'Instrument Handbooks' and so we won't go into it here. If you know that your set-up is fairly standard then you should not have any serious calibration concerns (see the STSDAS Calibration Guide). For things like unusual filters or, particularly, filter combinations, check to see if you need to specify your own calibration observations. For the spectrographs, consider the various sub-stepping strategies and observation modes which will produce the best quality data.

The coupling of observation design with data analysis strategy is an important message which we would like to emphasize. There can be substantial differences in the quality and quantity of your final dataset resulting from, sometimes subtle, changes in the choice of procedure and instrument setup. Remember that you will generally not be able to change the rest of your exposures after you have realised that the first one was badly designed. The use of simulations is very valuable for this purpose and there are tools available to help you (see Mignani & Murtagh in this issue).

Another difference from groundbased observing is in the complexity of the data structures you will receive on your 'GO Tape' when the observations are done. The files are in FITS format of course but the file naming conventions are not blessed with an excess of intrinsic self-clarity. Try looking at ST–ECF Newsletter No. 15, p15 to see what we mean.

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High-level tools for proposal preparation

This complements the previous article in pointing out some tools to assist in the task of proposal preparation.

Roberto Mignani[†] *& Fionn Murtagh*

In preparing an HST observing proposal and using the Phase I formatter or RPSS, there are some tools and software packages which may be of help. This is a brief introduction to some of them. We show where the software and documentation are to be found at the ST–ECF and how to access them.

Synphot

One of the critical problems in planning an observation with HST is that of calculating correctly the exposure times for a particular instrument given the observing configuration and the characteristics of the source being observed. This may be calculated manually as described in the Instrument Handbooks. The manual calculation of the source count rate and the response of the instrument can be tedious and time consuming. The SYNPHOT package in STSDAS (which supersedes XCAL, see below) is a very powerful tool because it can readily simulate the results of an observation for any particular instrument configuration and observing mode.

To perform such simulations, SYNPHOT requires some reference files (instrument throughput tables, graph and component tables, stellar model data etc.) which are not usually distributed with STSDAS mainly because of the disk space they occupy (over 60 MB). However, these files can be copied via ftp from the directory: /software/stsdas/refdata/synphot of STEIS and installed on your own machine.

In the same directory you can find all the basic information in the README file. In addition a TeX and PostScript guide, with the instructions for the installation of the reference files, are also provided. Other reference files are in the directory: /software/stsdas/refdata. Again, follow the instructions in the README file.

At the ST–ECF, SYNPHOT is available in the local installation of STSDAS.

Focsim

While SYNPHOT is of general use, a specific exposure time simulator has been developed by Y Frankel and F Paresce (STScI) for the FOC. This program, named FOCSIM, computes automatically the exposure times depending on the FOC observing configuration and the physical characteristics of the astronomical source to be observed.

FOCSIM is very easy to use and, for this reason, may be preferred to SYNPHOT in calculating FOC exposure times. Unfortunately the program cannot presently be distributed outside STScI and it is installed only on STScI computers such as the Icarus, Nemesis and TIB Sun-SPARCstation clusters, SCIVAX and FOCA (VAX/VMS systems). However, any user interested in using FOCSIM may submit a request to set up a temporary account on one of these machines in order to run FOCSIM remotely. Requests may be sent to Dan Golombek at STScI: email: golombek@stsci.edu, phone: 410-338-4974. You will be given a temporary account on one of the STScI machines (probably Nemesis or Icarus) for a period of about a week.

Once you have an account set up you can telnet to STScI and use FOCSIM remotely as follows:

☐ telnet icarus.stsci.edu or 130.167.1.109 (for example)
☐ Username:
Password:
☐ cd iraf
(FOCSIM is part of the IRAF package)
☐ cl
☐ to start the program simply type: focsim

A first version of the "FOCSIM Beginner's Manual" (April 1992) written by Warren Hack (STScI) is now available; anyone interested in a copy of this manual should contact W. Hack or R. Mignani (c/-STDESK at ST–ECF): hack@stsci.edu, or stdesk@eso.org. A copy (in PostScript) is also now available by anonymous ftp from the machine ecf.hq.eso.org (134.171.11.4) in directory pub/doc.

GASP & GSSS

The two CD-ROMs of the Guide Star Catalog (currently version 1.1) are accessed by the stsdas.gasp package. These CD-ROMs use some features which are not supported by SUNOS, which must therefore be patched before the disks are mounted. The instructions necessary to install this patch are available in the directory: software/stsdas/gasp of STEIS in the file README_CD. Note that this patch to the kernel requires superuser (root) privileges. Once you have retrieved and installed this patch on your Sun you can use gasp to access the GSC.

An introduction to the GSC structure is available on both CDs in the file README.TXT.

The following is an example of the first steps to read the GSC with gasp (useful for beginners).

☐ Copy the GSC index table (the file regions.tbl in the directory tables) from CD-ROM to disk with the task: stgindx
☐ Scan the list of guide star tables in GSC to select those overlapping a particular sky region with the task: sgscind
☐ Select a subset of stars from the selected guide star tables using regions
☐ Finally, you can produce a sky map with the selected stars using stplot.skymap

A set of user notes on gasp is currently in preparation and will be available soon.

Pickles, a Macintosh package which also supports the GSC, is available. It originates at the University of Texas at Austin (contact Barbara McArthur, mca@astro.as.utexas.edu).

TinyTim

TinyTim can generate PSFs for the HST WFPC, FOC *f*/48, FOC *f*/96, WFPC 2, and COSTAR-corrected FOC cameras. It is written in C and is portable to most 32 bit systems.

Version 2.1 of the TinyTim HST PSF generator is available on STEIS (anonymous ftp to stsci.edu, look in the software/tinytim directory). TinyTim is not an official product of the STScI, but John Krist (krist@stsci.edu) will support it insofar as time and conditions allow.

Locally, the TinyTim executables and documentation are available in directory /home/ns3c/tinytim.

Xcal

The Cross-Calibration Software, XCAL, models the spectral response of all the HST observing modes, both photometric and spectrophotometric. A brief introduction to XCAL together with the installation procedures may be found in the README file in the directory /software/tim of STEIS. The only version of XCAL available so far is that running on VMS machines. Further questions about XCAL may be addressed to Keith Horne (horne@stsci.edu).

XCAL has been superseded by the equivalent SYNPHOT package (see above) installed in STSDAS (source: STScI Newsletter, Dec. 1990, p16).

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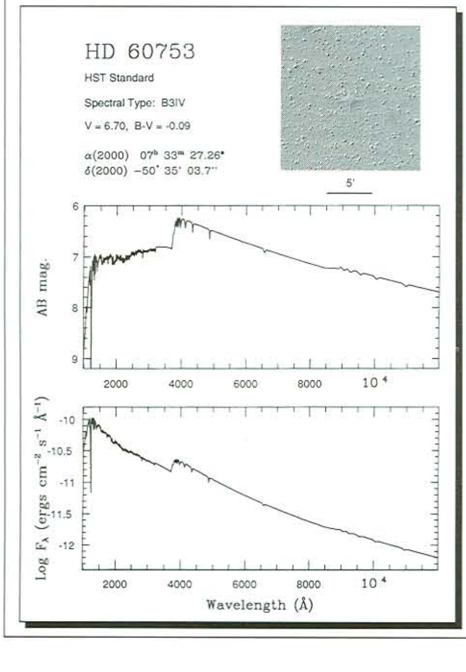
The HST spectrophotometric standards

Jeremy Walsh

Photometric and spectrophotometric standards have been set up by the HST project in order to ensure adequate calibration of HST images and spectra in the UV and optical (see Turnshek et al. 1990). For the spectrophotometric standards, fluxes for 27 stars are available from around 900Å to 12,000Å and were formed by combining IUE and ground-based data with the addition of stellar atmosphere models in some cases. Associated with this project, Oke has observed 25 stars in the optical (3200–9200Å) and fluxes have been tabulated at wavelength intervals of 1–2Å over this range (Oke, 1990). Both sets of data are available through the STScI Anonymous ftp account (/software/stsdas/refdata/flux_stds for HST standards and /software/stsdas/refdata/oke_data for the Oke standards) as FITS files. The Oke data are tabulated in AB magnitudes whilst the HST standards are in F_λ units.

The data files have been reprocessed at the ECF into a single format with entries for wavelength, F_λ and F_ν. These ASCII files can easily be converted into MIDAS tables compatible with previous tables for spectrophotometric standards. The files are available through the ST–ECF Anonymous ftp account under the directories pub/standards/okestan for the Oke data and pub/standards/hststan for the HST standards (see Hook & Murtagh, 1992 for details of access to this account). In addition, a MIDAS command procedure for converting the ASCII files into MIDAS tables is provided. The data files may of course be manipulated for other data reduction requirements and files compatible with the FIGARO spectrophotometric standard star tables have been produced and will be available through the Starlink STADAT database. If other tabulations are required they can be accommodated on request. In addition to the data files, an explanatory text together with entries for all the HST and Oke spectrophotometric standards is available (see figure). For each star the position and magnitude are listed, the variation of flux and AB magnitude with wavelength is plotted and a finding chart given.



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The 5th ESO/ST–ECF Data Analysis Workshop

ESO, Karl–Schwarzschild–Straße 2
W–8046 Garching, Germany
April 26–28, 1993

The aim of the Workshop is to provide a forum for discussions of astronomical software techniques and algorithms. It is held annually during the spring (April/May) and centres on a different astronomical area each time. The Workshop will be held at the ESO headquarters where there is room for 100 participants only. We may therefore have to reject some people and recommend that you register well before the deadline (1993, March 1) either through normal mail or email.

The topic for the 1993 Data Analysis Workshop is the analysis of direct imaging. The scientific section of the meeting will consist of three sessions each starting with a main talk after which papers of approximately 10 minutes duration can be presented. The last day is reserved for the MIDAS user's meeting and special sessions. The tentative agenda is as follows:

Analysis of Direct Imaging Data

April 26:	14:00–18:00	Surface photometry
April 27:	09:00–12:30	Point source photometry
	14:00–17:00	Time series analysis
	17:00–18:00	European FITS committee
April 28:	09:00–12:30	MIDAS users' meeting
	13:00–14:00	European FITS committee
	14:00–17:00	User Interfaces and Data Acquisition

We especially welcome contributions on algorithms and techniques for: time series analysis of non–equally sampled data, calibration of photometry, and shapes of extended objects. We encourage people to present their work in these areas even if they are only ideas. After each introductory talk, there will be a more informal discussion where such contributions can be made. There will also be a poster session where people can present short contributions. The special session on Graphical User Interfaces and Data Acquisition will also include instrument control and on–line processing. Proceedings of the scientific sessions will be published.

The scientific organizing committee includes:
P Grosbøl (Chairman), P Benvenuti, D Baade, S D'Odorico, R H Warmels

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Co-adding images with different PSFs — III

The Richardson/Lucy-based iterative co-addition algorithm is a powerful method with wide-ranging applications for data-combination. In this third article of the series, a method is described which is applicable to array detectors that intrinsically undersample the image. By using component images which are shifted by sub-pixel steps, it is possible to recover a substantial part of the resolution and astrometric precision appropriate to the sampling grid spacing rather than the detector pixel size.

Richard Hook & Leon Lucy

Introduction

In the earlier articles in this series (Lucy 1991, Hook & Lucy 1992a) we described a method for co-adding images with different point spread functions (PSFs) which retains the resolution of the best images or spectra whilst utilising the flux from all of them. Some early results with both simulated and real (ground-based and HST) data were also presented. Our implementation is based on the Lucy-Richardson iterative restoration algorithm and lends itself to normal image and spectral restoration tasks as well as co-addition.

We have now upgraded the software to incorporate several new features and considerably enhanced the speed by both using accelerated algorithms and faster Fourier transforms. A version running in the MIDAS system is now also available. The major changes are described here along with details about how the software may be obtained.

Acceleration of the algorithm

Speed is always an important consideration with image restoration. When co-adding one is often combining multiple large images and using several hundred iterations, so the time required is often very long even on a fast modern workstation. One way of reducing the time required is to employ some form of fast vector processor such as the i860-based system described in an earlier article by Hans-Martin Adorf (1992, see also this issue). We have taken the complementary approach of modifying the algorithm to provide faster convergence. There are several ways this can be done and these have been recently reviewed (Adorf et al., 1992). The method used in our co-addition code is based upon multiplying the correction array added to the restored image at each iteration by a number λ greater than one. Because flux conservation requires that the correction array has zero total flux, an arbitrary multiple of this array can be added to the previous iterate without affecting flux conservation, so the multiplication retains this. In order to choose the optimum value of λ, an iterative search, using the Newton-Raphson method, is made for the change which leads to the largest increase in the likelihood. It is, however, often also necessary to constrain λ to ensure that the resultant restored image remains non-negative.

This acceleration scheme is quite easy to implement and does not require a significant increase in the time required for each iteration. It is also found that the iterative search converges rapidly. For typical HST restorations—using a few tens of iterations—average acceleration factors of about three are obtained, ie, the result after 10 accelerated iterations is similar to that after 30 normal iterations. This is a valuable, but not spectacular improvement, resulting in a significant reduction in the amount of computer time required. When co-adding images it is often desirable to get close to the 'maximum likelihood' result by using large numbers of iterations. In such cases the gain from the accelerated algorithm becomes greater as the iterations proceed and allows the converged solution to be reached in a practical number of iterations.

This acceleration algorithm is now part of the co-addition software and may be turned on or off as required. However, it is strongly recommended that it be used in general since there appear to be no significant undesirable side-effects and it always results in a useful speed gain. More discussion of the advantages and uses of acceleration are given in Hook & Lucy (1992b).

Interleaved sampling

Astronomical images and spectra are rarely over-sampled. In some cases they are undersampled by a large factor—about four times for the WFC in the visible. This results in many deleterious effects on the quantitative measurements made from the data as well as producing an unpleasing 'pixellated' appearance. These issues are described by Lucy & Baade (1989). The undersampling makes data combination difficult and generally precludes high quality image restoration. Some improvement is obtained by restoring to an output on a finer pixel grid than the input. As long as the PSF is available on a suitable fine grid, the co-addition software can be used to combine sub-pixel shifted undersampled images to recover a substantial part of the resolution inherent in the optical PSF.

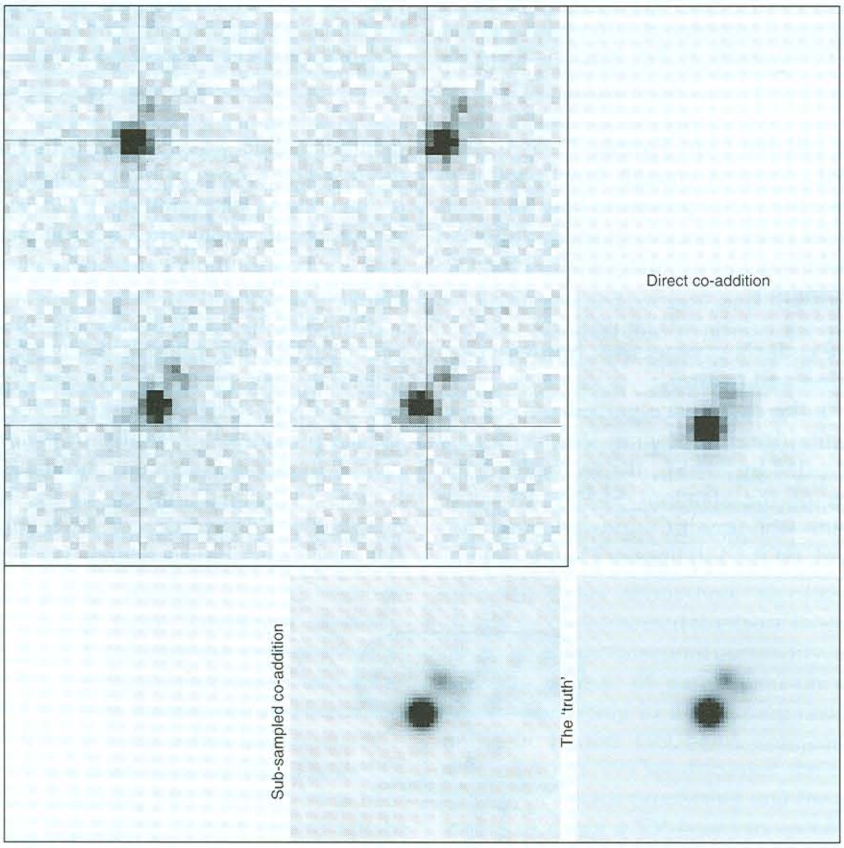
Shifted images

It is common for images which need to be co-added to be mis-aligned. In the most general case this lack of registration may be a shift, a scale change and a rotation (possibly with a non-linear component as well). However a particularly common, and readily tractable, case is where there is a simple shift between the input images. As such images are neither likely to be well sampled nor shifted by an integer number of pixels relative to each other, it is not possible to register them using conventional interpolation methods without some undesirable loss of information during the re-sampling. However, in an iterative co-addition, the problem may be transferred from that of displacing the data to displacing the PSFs. If the PSFs can be shifted by the appropriate amounts relative to each other, the convolutions which are part of the co-addition may be used to effectively shift the data by any desired amount (normally small compared to the frame size) and hence produce an output co-added image with the images accurately aligned. This option is particularly suitable for cases where analytical PSFs may be used since these can easily be produced with a given centre and scale.

Cameras which use CCDs to image wide-fields often have to resort to undersampling the PSF with the pixel array in order to maximise the field of view and photometric sensitivity of the resulting images. A familiar example of a severely under-sampled imaging camera is the Wide Field Camera of HST. The important consequences of this undersampling have been discussed in an earlier article (Adorf 1990). It is possible to restore much of the fine spatial information to such undersampled images if multiple exposures can be made with shifts of fractions of a pixel between them. The co-addition code described here is a convenient way of optimally combining such sub-stepped data, although it is demanding in computer power.

An example

To illustrate the value of these new facilities a simple simulation has been performed and is shown in the figure. The object is a triple star and it is shown in its true guise (on a finely sampled grid) at the bottom right. This object is 'observed' four times on a coarser grid with shifts between the exposures of 2.5 pixels and the results are shown in the four images at top left. In this case the PSFs are identical for all four images but they could equally well be different. When these are co-added on the coarse grid the result is shown at centre right. This is the result of 100 accelerated iterations with the co-addition algorithm. This is acceptable but still has a rather 'pixelated' appearance. When the co-addition is performed onto a finer grid (bottom centre) the result appears to the eye to be superior and closer to the 'truth'.



Implementation

The first version of this software was implemented using the F77/VOS FORTRAN interface to IRAF. However, it was also felt that a version using the MIDAS system would also be very valuable to the many European users of this system. In order to ease maintenance and minimise the amount of extra code required it was decided to try to base both implementations on the same core FORTRAN code. This proved to be quite simple as the facilities offered by the F77/VOS and the MIDAS environment interfaces are quite similar, particularly when only the basic facilities are used, as is the case here. A small library was written which emulated the F77/VOS calls using MIDAS interface routines and a UNIX shell script prepared to make the few additional modifications that were needed automatically. These included changing the named COMMON array used for global storage (MEMD in F77/VOS and VMR in MIDAS), adding the calls to STSPRO and STSEPI which MIDAS needs etc. It is now possible to modify the F77/VOS original and then, when required, automatically build a MIDAS compatible version. This is a convenient way of maintaining a relatively simple (ie, no graphics, no catalogue access etc.) code in the two systems and may be used in future for other programs.

Another minor enhancement is the adoption of a new Fast Fourier Transform code. The early versions of this program used the Numerical Recipes FFTs which are both slower than some alternatives and impose a power of two constraint on array sizes. The new version removes this constraint and is about twice as fast. This program (Version 1.2D) is now available in V1.2.2 of STSDAS, a patch release is available from the STScI's anonymous FTP (STEIS). The MIDAS version is available in the November 1992 release. In STSDAS, the task name is stsdas.contrib.acoadd and in MIDAS, the commands are COADD/IMAGE and DECON/FLUCY in a new context IMRES. The two MIDAS command names emphasise the two aspects of the program (image co-addition and secondly image restoration using the Lucy method). The IRAF version may still be obtained directly from our anonymous FTP archive on the machine ecf.hq.eso.org (134.171.11.4) in the directory pub/swlib/coaddition.

Future plans

This program has already been modified and extended many times and now has most of the features required of such an image co-addition and restoration 'engine'. However, it is clear that there are still many other possibilities which we are considering for future enhancements. Among these are the development of ancillary software to assist the preparation of suitable PSF images from real data frames; the enhanced handling of misaligned data; an IDL implementation and the addition of regularization to the algorithm to reduce artifacts in low signal-to-noise extended features.

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The Richardson-Lucy algorithm — now on a vector processor

The standard Richardson-Lucy restoration algorithm for space-invariant point-spread functions has been implemented on an Intel i860™ -based vector processor and seamlessly interfaced to the IDL image processing system. The vectorized RL-algorithm performs about 7 times faster than the equivalent algorithm on a Sun SPARCstation-2.

Hans-Martin Adorf

The restoration of distorted HST-images, undoubtedly a compute-intensive undertaking, has now become almost routine (see Adorf 1993a for a recent review). While the restoration of FOC-images with its space-invariant point spread function (SI-PSF) appears quite manageable on a 1993 state-of-the-art workstation, WFPC image restoration is hampered by the WFPC's *space-variant* PSF (SV-PSF) inhibiting the use of efficient global restoration methods. Moreover, the severe undersampling of the WFPC PSF by the CCD pixel array calls for subsampled restoration which results in a substantially increased number of pixels.

For SI-PSFs, the standard Richardson-Lucy (RL) algorithm (Tarasko 1969, Richardson 1972, Lucy 1974) is expressible on the abstraction level of image frames (Adorf 1990). Thus it is readily vectorizable, opening the possibility of accelerating the restoration with the help of vector processing hardware. Several European astronomical sites, including Cambridge, Liège and Garching, have already begun to exploit the power of relatively low-cost vector processors in order to cope with the actual or expected computational load of heavy-duty image processing. While being our primary motivation, the restoration of HST images is not the only compute-intensive task that merits vector processing (see Box 1).

Vector processing hard- and software

After a survey of contemporary parallel computing options (Adorf 1991), the ST–ECF launched a parallel processing initiative in order to provide some guidance to European astronomers interested in vector processing. Following an initial assessment (Adorf & Oldfield 1992, Adorf 1992), the 'MemSys i860™ Accelerator' board, distributed by Cambridge/UK-based MaxEnt Solutions Ltd. (MESL), was ordered and upon arrival installed in an S-bus slot of a standard Sun™ workstation without problems.

The 'MemSys i860™ Accelerator' is accompanied by a subroutine library, the *MESL Hostmode Library™* (HML, MESL 1992), comprising procedures for programme and data management, basic numerical arithmetic, special function computation, etc. (see Box 2), roughly on the completeness level of Fortran-77. All procedures are vectorized, of course, and are callable from Fortran-77 or C. The HML contains enough functionality to make the vector processor hardware useful for image processing and permits the implementation of many whole-frame algorithms.

Box 1

Ground-based optical astronomy of the 1990s is likely to produce data volumes 10 to 100 times higher than those regularly seen today and at rates that are again factors higher than current ones. A case in point is an image dissecting spectrograph which is proposed for one of the later ESO-VLT units; it is supposed to cover 4x4 arcsec^2 of the sky at a spatial resolution of 1/10 arcsec and with 10,000 pixels in the spectral dimension (Wampler 1992, pers. comm.). At a sampling rate of 2 pixels per resolution element and 16 bits = 2 byte depth per pixel, a single frame will have a data volume of 1,600 x 10,000 x 4 x 2 byte = 128 Megabyte. These data volumes, each equivalent to one sixth of a digitized Schmidt plate (assuming 20 kilopixels squared, with two bytes per pixel, ie, 800 Mb), will have to be analyzed automatically with robust and reliable algorithms

The coder's perspective: implementation and testing

With the experience gained last year in Cambridge and a program template kindly provided by MESL, the re-implementation of the standard SI-PSF RL-algorithm—this time in C—proved straightforward. Of the 130 lines of C-code in total, at most 35% can be considered essential code, the other 65% or so is overhead (mainly memory management).

A considerable fraction of the implementation time was spent in debugging the low-level *memory management* part of the code.[1] Debugging the F77/C-code is non-trivial; often, when a problem occurs, the board simply hangs and has to be restarted.

In order to facilitate the use of the vectorized RL-algorithm, it was interfaced to the IDL image processing system, whose CALL_EXTERNAL foreign function interface provides the facility to *dynamically link* and execute pre-compiled F77/C-code (a 'shared' object) to the IDL executable. Construction of the required IDL-to-C interface procedures was facili-

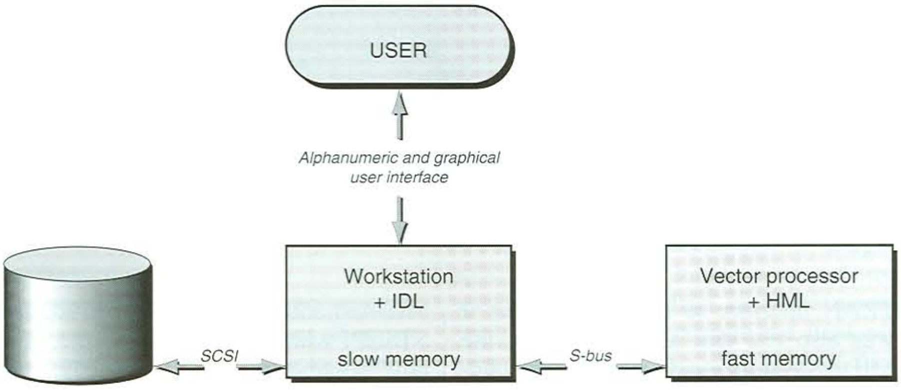

Figure 1: Hard- and software architecture for vector processing. Under the control of the user interfacing to the image processing system on the scalar host, data are being read from the external disk into host memory; alternatively data may already be resident in host-memory from a previous processing step. Data are subsequently transferred to the memory on-board the vector processor, where processing takes place. Results are transferred back to the host memory for visualization and/or further processing and/or storage onto an external disk.

Box 2

The MESL Hostmode Library™ for the Intel i860™-based vector processing board is a 'vectorized', mathematical/numerical, Fortran- or C-callable subroutine library, comprising management procedures for

- ☐ board initialization and on-board memory allocation and deallocation,
- ☐ program and host-to-board/board-to-host data transfer,
- ☐ on-board data movement (ie, copying or swapping), data spreading (ie, initializing a vector with a scalar), and linear ('ramp') filling.

Supported mathematical functionality includes routines for

- ☐ basic real or complex arithmetic,
- ☐ signum and square-root, exponentiation and logarithm,
- ☐ standard and hyperbolic trigonometric functions and their inverse,
- ☐ arithmetic mean and sum of squares,
- ☐ scalar ('dot') product,
- ☐ several real or complex fast Fourier transforms (FFTs), operating on power-of-two dimensioned arrays,
- ☐ conjugate symmetric multiplication, occurring within convolution/correlation, and
- ☐ random number generation, timing and board status inquiry.

A recent addition to the Hostmode Library™ comprises the min and max operators.

tated by two templates kindly provided by Research Systems, Inc. The calling sequence of the RL-algorithm was deliberately kept compatible to that of the native (ie, scalar) IDL-code. The resulting overall hardware/software architecture is depicted in Figure 1.

The user's perspective: performance and ease-of-use

The i860™-based RL-algorithm carries out a 40-iteration restoration on a standard 512 × 512 frame in 85 seconds (wall-clock time). This is about 7 times faster than a Sun SPARCstation-2 using native IDL.

When seamlessly interfaced to a high-level, vectorized image processing language such as IDL, the VP is *easy to use*. Indeed, the user response so far has been quite positive, since the speed of the VP-board re-introduces interactivity into restoration work without increasing the complexity on the user's part.

The VP-solution achieves a reduction of overall turn-around time by raw (compute) power. As such it has to compete with recent more 'intelligent' developments to accelerate the convergence of the RL-algorithm in software (Adorf et al. 1992 and refs. therein, see also the article by Hook & Lucy in this issue).

A real-time visualization of computational progress, which would have been quite impressive, turned out to not be feasible with the i860™ add-on board due to the architectural (host-to-board interface) bandwidth limitation.

Discussion

As opposed to a massively parallel machine (see eg, Cobb et al. 1991), a special-purpose VP-board, as described here, is not only available now, but also affordable by many astronomical institutions: when variable overhead costs are neglected, the MESL i860™-board can be considered 'low-cost'.

The implementation of the vectorizable standard RL-restoration algorithm for SI-PSFs was—apart from some Unix problems—relatively straightforward and resulted in a usable and used (!) piece of code. However, as expected already at the time of purchase, the limited memory size (8 MB) restricts the range of image processing algorithms which can sensibly be implemented and used on sizable frames.

The considerable overhead for programming the VP appears tolerable for algorithms which can stay untouched for a long time. However, the overhead is large enough to discourage experimentation with new *ad hoc* algorithms in response to problems surfacing during a typical data analysis session.

The advent of the VP has triggered some thoughts about how algorithms should be implemented to ensure longevity and cross-architectural portability, and what the impact of parallelism on scientific computing in the coming decade might be (Adorf 1993b). A companion article (Adorf 1993c) discusses the cost aspects of vector processing and the potential of using a VP-board to speed up fine-grained image processing operators.

Acknowledgments: Thanks are particularly due to Dave Chittim (ESO), Richard Hook (ST–ECF) and Carlos Guirao Sanchez (ESO) for their support.

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[1] It has recently been emphasized (Nassi 1992) that memory management should *not* be left to the application programmer, since "memory management bugs are among the most common and difficult errors in static programming languages." Moreover, it has been required for the new dynamic language Dylan™ that "there should be no machine-level pointers".

Observations of the sky background from space

This article reports the results of a novel method of measuring the three dominant components of the sky brightness from the HST orbit. The shadows cast by an occulting finger in the Faint Object Camera field dispersed with a UV objective prism are separated into Lyman-α, neutral oxygen and 'red' continuum components which can be measured as functions of relevant angles in the spacecraft-earth-sun geometry.

Adeline Caulet & Richard Hook

We report measurements of the Geocoronal Ly-α and neutral oxygen airglow emission lines in the far ultraviolet and the—predominantly zodiacal light—continuum above 3000Å. The observations were made using the Faint Object Camera (FOC) aboard the Hubble Space Telescope. The bright and strongly variable space background was measured from 50 FOC exposures taken through the *f*/96 far-UV prism (FUVOP) during the two years following HST launch. The majority of the images belong to Peter Jakobsen's GTO program #1235. Typical exposure times were around 900 seconds.

The measurements are compared with predictions derived from atmospheric models presented in the FOC Instrument Handbook and satisfactory agreement is found when the revised *f*/96 detector quantum efficiency is used with the models. The zodiacal light is well within the expected range 70–210 S10 units for the observed ecliptic coordinates. The Ly-α emission background is 25% lower than expected for all solar zenith angles. There is an excess of OI emission for solar zenith angles less than 100°.

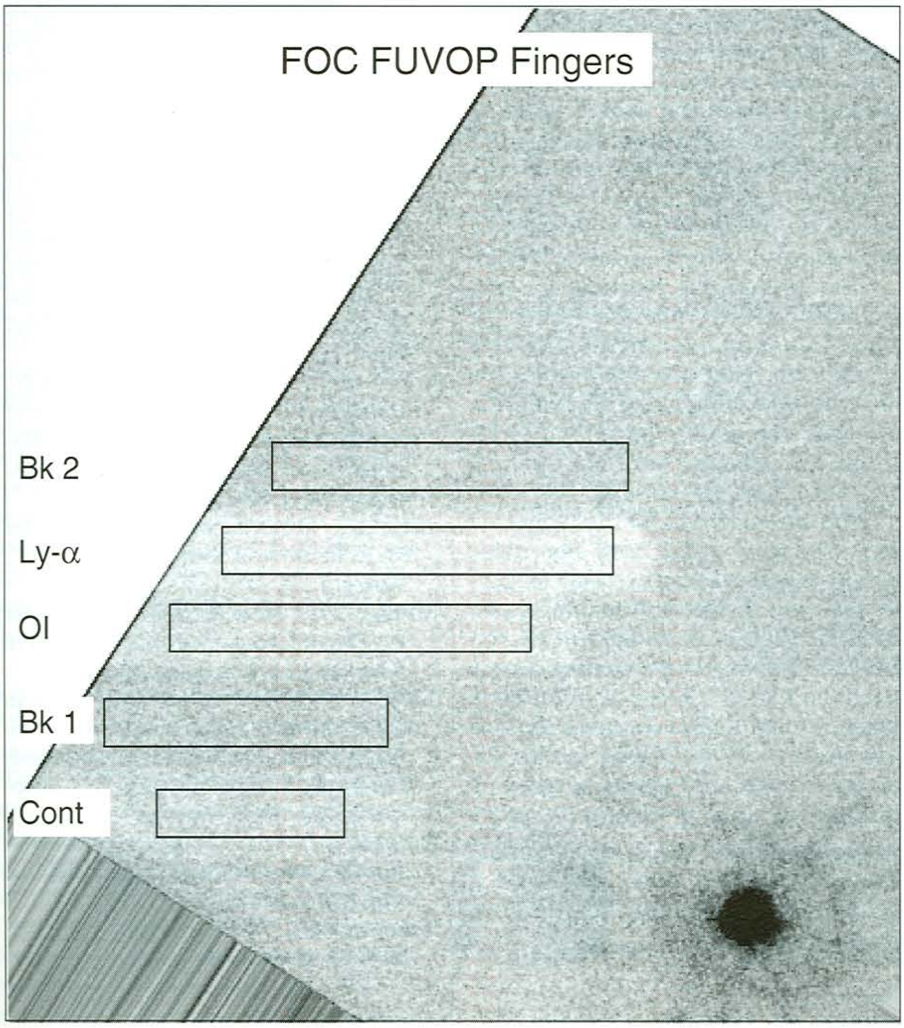

Figure 1: A FOC exposure taken through the f/96 far-UV objective prism (FUVOP). The stellar spectrum appears in the lower right-hand corner—but is apparently undispersed because of the dominance of the red light. Three shadows of the 0".8 occulting finger are projected onto the background: these correspond to Ly-α, OI and the red continuum. The boxes used for measuring the mean counts inside and outside the shadows are shown. See the front cover of ST–ECF Newsletter No. 17 (February 1992) to see the layout of the f/96 FOV.

Introduction

It has been estimated that the sky seen from a space observatory is much darker than from the ground at all wavelengths (O'Connell 1987). At the orbital altitude of 610 km, the HST sky background is dominated by two strong, variable airglow emission lines, Geocoronal Ly-α (1216Å) and OI (1304, 1356Å), the diffuse galactic light (DGL) below 2500Å from Galactic starlight scattered by dust grains in the interstellar medium and, longward of 2500Å, the zodiacal scattering of sunlight. Although these components are understood and reasonably accurate predictions of the sky background are available, eg, in the HST instrument handbooks, few observations of the sky background from space have been published. Here we present such measurements using a series of FOC objective prism exposures. We use them to separate the main contributors and to study their dependence on various angles.

Method, data reduction and results

The method and data reduction are summarized here: we refer to our previous article in the proceedings of the Sardinia workshop (Caulet & Hook 1993) for more details. The results have been explored further since the conference and are now compared to models which take into account new estimates for the DQE of the *f*/96 relay (Sparks 1991).

The 0.8 arcsec FOC finger occults the field of the *f*/96 camera, projecting a shadow against the background light. Because of the dispersion of the far-UV objective prism, this shadow consists of three features: a Ly-α shadow, an OI shadow and a shadow from the continuum in the red (Figure 1). The diffuse galactic light component appears too faint to be measured using this technique. The dataset consists of 50 FUVOP objective prism spectra taken between November 1990 and August 1991. All reseau marks were removed from the images. The contributions of the Ly-α, OI and red continuum

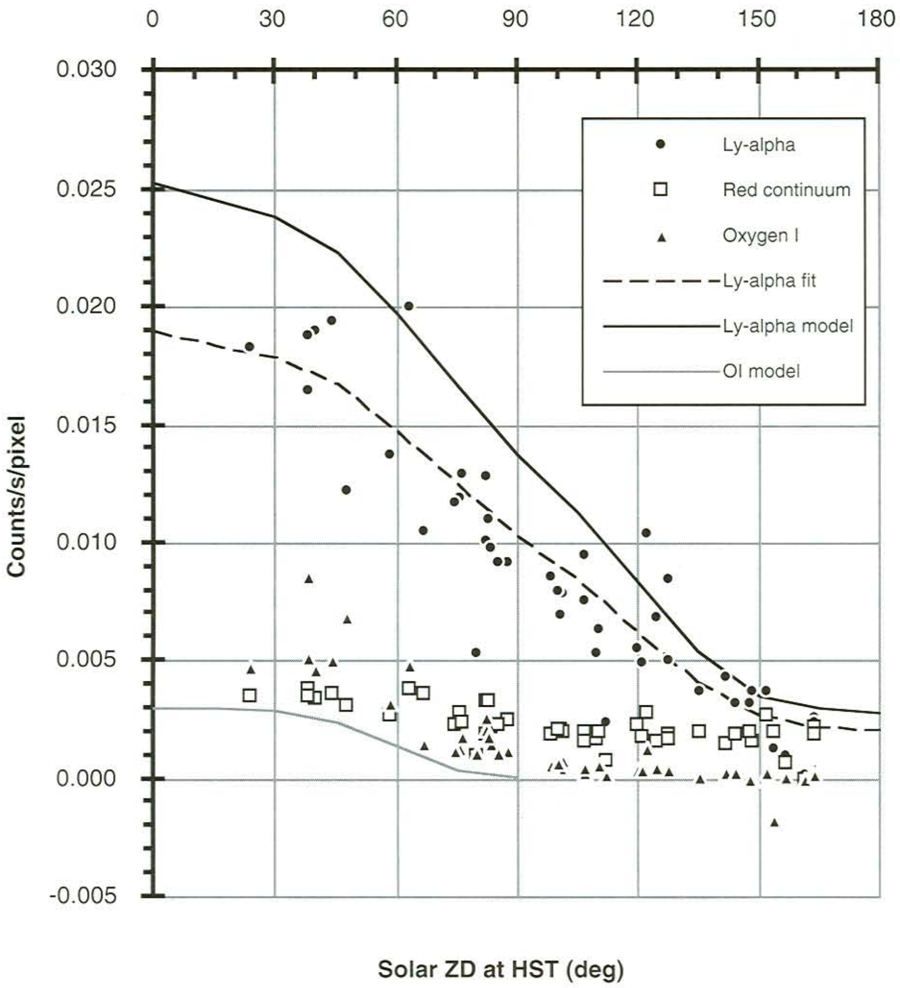

Figure 2: The measured airglow contributions to the FOC background corrected for filter transmission. The values are counts/s/pixel as a function of solar zenith distance measured at mid-exposure. Also shown are the red continuum measurements (see Figure 3). Model predictions are shown as lines. The dashed line is the Ly-α model reduced by 25%: this gives the best apparent fit to the data.

emission were obtained by subtracting the mean count of each shadow from the mean count of the nearest box outside the shadow, which includes all light and detector noise near the wavelength of that point. The results were reduced to counts per second per normal (unzoomed) detector pixel and corrected for the known throughput of the FUVOP prisms in the filter transmission curve database (46% at Ly-α, 58% at OI and 94% for the red continuum between 2000 and 6000Å).

Ly-α and OI airglow: The measured Ly-α and OI intensities are strongly correlated with the solar zenith angle (ZD) as expected (Figure 2). The Ly-α background increases from 0.002 counts/s/pixel at ZD = 180° to about 0.02 when the Sun is at zenith. OI emission vanishes for a solar zenith distance greater than 115°, ie, when the Sun goes below the horizon seen by HST, since the excitation of this atomic line occurs during the daytime only. The observed scatter is not large and may be due to a weaker dependence of the intensity on the target zenith angle. There was an additional blocking filter in the beam for a few frames. We did not correct for the transmission of that filter.

The model predictions given in the FOC Instrument Handbook (V3.0, 1992) are the same as those plotted in the previous version (V2.0, 1990) which used the old FOC camera response functions. From Table 12 of the handbook (1992), we derive for the overall OTA+FOC absolute quantum efficiency of the $f/96$ relay Q (Ly-α) = 0.0169 and Q (OI) = 0.0256 counts/photon. The old values were 0.0253 and 0.036 counts/photon at Ly-α and OI respectively. Using the new DQE values, the agreement between the data and the models is good. The discrepancy between the Ly-α measurements and the predictions has been reduced from 50% as presented in our previous article to 25% in this Newsletter (dashed line, Figure 2). The Ly-α space measurements remain 25% lower than expected, but this could be due to a combination of uncertainties in the atmospheric models and in the far-UV response of the camera (10%). It could, possibly, be related to the level of solar activity in 1990/1. The OI data agree approximately with the predicted OI counts but we note an excess of the observed counts for solar zenith angles less than 100°.

The zodiacal light: The results for the red continuum are the same as those in our previous paper. The observed counts in the red continuum are found to be well explained by the contribution of the zodiacal light. The data are plotted in Figure 3 as a function of the ecliptic longitude of the objects with different symbols corresponding to different ranges of observed ecliptic latitude. The observed counts were converted into absolute intensities by:

$$I_{zod} = \text{measured counts} \times 90 / (0.94 \times 1.684\times10^{-3}) \text{ in S10 units}$$

The factor $1.684\times10^{-3}/90$ represents the integral of the zodiacal light contribution to the FOC background counting rate with no filters in place as a function of wavelength with an input of one S10 unit. The data lie within the expected range of values derived for these ecliptic latitudes. Overall, the calculated residuals are between 10 and 20% with no correlation with ecliptic latitude or longitude.

Units

One S10 unit is a surface brightness equivalent to one tenth magnitude solar-type star per square degree.

A rayleigh (R) is 10^6 photons emitted in all directions per cm^2 vertical column per sec:

$1 \text{ R} \equiv 1.58\times10^{-3}/\lambda(\text{Å}) \text{ erg/cm}^2\text{/s/sr}$ at the zenith.

Absolute intensities of the airglow lines and conversions to other commonly used units: It is useful for future reference to convert the FOC observed counts into true intensities.

For Ly-α:

$$I(\text{Ly-}\alpha) = \text{measured counts} \times 1647 \text{ kilorayleigh}$$

and for OI:

$$I(\text{OI}) = \text{measured counts} \times 1087 \text{ kilorayleigh}$$

The measured counts are again the observed counts with no filters in place. One kilorayleigh is 3.1×10^{-14} erg/cm^2/s/arcsec^2 at Ly-α and 2.8×10^{-14} at OI. From Figure 2, it is seen that that Geocoronal Ly-α varies from 3 to 20 kilorayleigh. The highest value is of the same order as that expected from a Ly-α aurora above the limb of Jupiter.

For the zodiacal light, one S10 (V) = 27.78 mag/arcsec^2 in the V-band (O'Connell 1987). So the background due

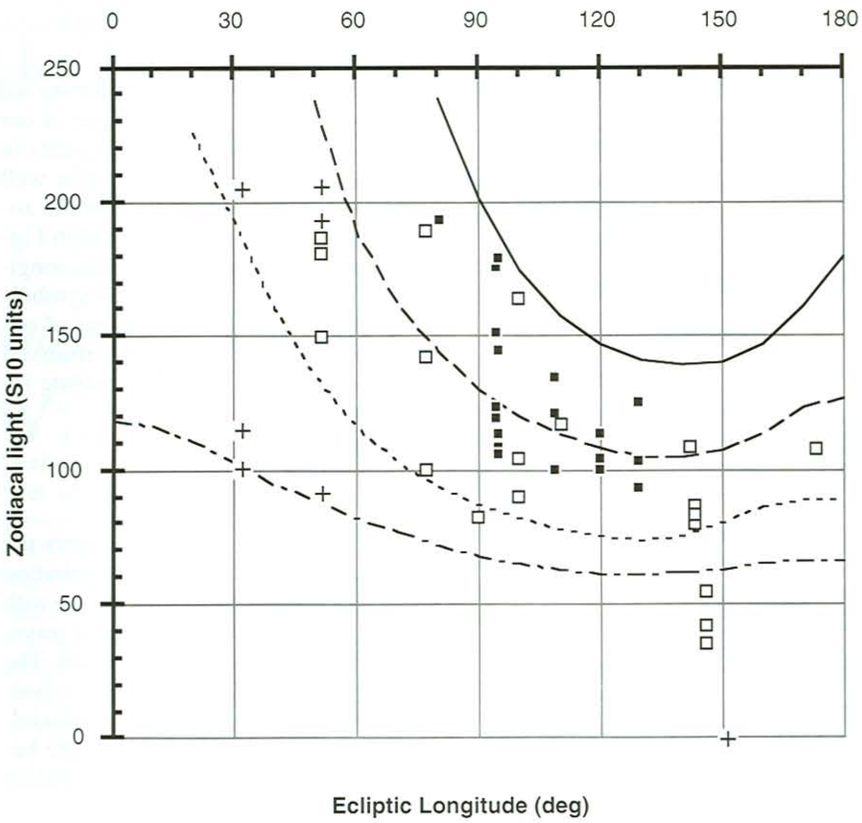

Figure 3: A comparison of the measured 'red' continuum strength with a model of the Zodiacal Light. The lines give the model predictions as a function of ecliptic longitude for different ecliptic latitudes. The measurements (expressed in S10 units—see box) are divided into different ranges of ecliptic latitude.

to the zodiacal light is between 23.5 and 22 V–mag/arcsec^2 in our data set. This can be compared with the night-sky brightness at a good ground-based site which is ≤ 22 mag/arcsec^2 at all visible wavelengths at high ecliptic latitudes (Figure 1 of O'Connell 1987).

The general form of the backgrounds we have measured agree well with the models presented in the FOC Instrument Handbook. The absolute values for the zodiacal light are in good agreement but the Ly-α values are somewhat fainter and the OI background slightly brighter than expected.

Acknowledgment: We thank Peter Jakobsen and the FOC IDT for permission to use the FUVOP data for this investigation.

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The proceedings of the workshop, containing all contributions, the poster papers and a report of the final round table, will be published by ESO in the Conference Proceedings Series.

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Photometry from Wide Field Camera images

This report of the analysis of the data obtained for one of the major WFC photometric programmes gives a clear picture of the techniques that are required for this kind of work.

Lukas Labhardt[†], Hans Schwengeler[†] & Gustav Tammann[†]

During the first quarter of 1992, a long series of images of the faint spiral galaxy IC 4182 was taken with the Wide Field Camera (WFC). The immediate aim of the investigation team—led by Allan Sandage—is the precise determination of the Cepheid distance to this galaxy. Since IC 4182 is also the site of the well-observed type Ia supernova 1937C, this first step of a continuing HST project will, free from absorption effects, calibrate the SNe Ia for the (re)determination of H_0.

The datasets

During 20 epochs, spaced over seven weeks, a total of 44 WFC observations were secured. The target was a field northwest of the center of IC 4182, covering about one third of the visible part of the galaxy as well as the adjacent sky region (see the illustration on page 14 of ST–ECF Newsletter No. 18, July 1992). The latter contains only very few foreground stars because of the high galactic latitude of the target (b = +79°). Visual inspection indicates that there are many stars, nebulosities, and HII regions on all four images (WF1 to WF4). Some star clusters/associations are visible in the most crowded part of the frames (WF3 and WF4). At every epoch, two exposures were taken in succession through the F555W filter (similar to V) and at two epochs, an additional pair of F785LP (similar to I) exposures. The typical exposure time was 35 minutes for every single observation which resulted in an estimated S/N ratio of about 10 to 45. Only one bright star ($m_V < 18.5$) was affected by saturation. The pointing capability of HST is most impressive: corresponding frames were found to match within 0 to 2 pixels, the maximum difference amounted to four pixels.

The reduction procedure

The raw science data were processed by the calibration pipeline program at STScI, using the latest version of reference files available at the time of processing. The resulting frames looked remarkably flat and showed no ghosts. The subsequent steps of data reduction consisted of:

- ☐ removal of the many cosmic ray events (CR) and hot spots,
- ☐ modification of imperfectly registered columns,
- ☐ co-addition of the two frames belonging to the same epoch,
- ☐ determination of the point-spread function (PSF),
- ☐ generation of a mask based on several co-added frames and used to locate and photometer all sources brighter than a specified limiting magnitude,
- ☐ PSF-fitting photometry measurements at all epochs,
- ☐ homogenization of the photometry obtained from all datasets in order to eliminate systematic variations,
- ☐ determination and application of the photometric zeropoint.

Data analysis dealt with the systematic search for variable stars—by picking up those star-like sources which show significant magnitude variations between any two epochs, period-finding of the Cepheid candidates and construction and calibration of the period-luminosity relation. As a by-product, we constructed a deep colour-magnitude diagram. Finally, the transformation to standard (V, I) photometry was done in order to allow direct comparisons with previous work.

Two small teams independently reduced and analysed the preprocessed images at different sites (Baltimore and Basel) by utilizing different software (DoPHOT and MIDAS/ROMAFOT, respectively). A letter announcing the results obtained at STScI has appeared (Sandage, Saha, Tammann, Panagia & Macchetto, 1992. Ap.J. 401, L7). The final reductions combine the efforts undertaken by the two groups and will be reported in the archive paper in preparation (Saha et al. 1993). Here we would like to briefly discuss some of the problems encountered by the Basel group on its way to obtain reliable photometry of all sources bright enough to be measured at all epochs.

The CR and hot-spot removal

A direct comparison of the two frames taken in repeated observations (split mode) led to the detection of unwanted signals. Most CR leave a signature on the chip that is sharply defined and has a width of one or two pixels. They can be automatically recognized and removed. Our procedure (see Box) took the difference to the minimum of two corresponding images and looked for pixel values greater than 15 DN ($\sim 10\,\sigma$). The affected pixel(s) were rejected in the one frame and replaced by the lower value of the corresponding pixel of the companion frame. Typically some 4000 pixels affected by CR and hot-spots were detected and replaced on every single image.

The point spread function

We decided not to undertake any image restoration because this would have been very time-consuming and could affect the photometric quality. Thus far, there is no tool available to perform optimum crowded-field photometry in the aberrated HST images. We had to build on our experience and procedures developed for the measurement of ground-based data. The ROMAFOT package as implemented in the MIDAS environment neither supports the use of an empirically defined PSF nor allows the PSF to vary across the

MIDAS procedure fragment for CR and hot spot removal

```
! the two input images are called p1 and p2
! the cleaned images are called p3 and p4
! p5 is the threshold value

compute/image clean = min({p1}, {p2})      ! minimum of input images 1 and 2
compute/image diff = {p1}-clean            ! difference frame 1
replace/image {p1} {p3} diff/{p5}, >=clean
compute/image diff = {p2}-clean
replace/image {p2} {p4} diff/{p5}, >=clean
```

[†] Astronomical Institute, University of Basel, Switzerland

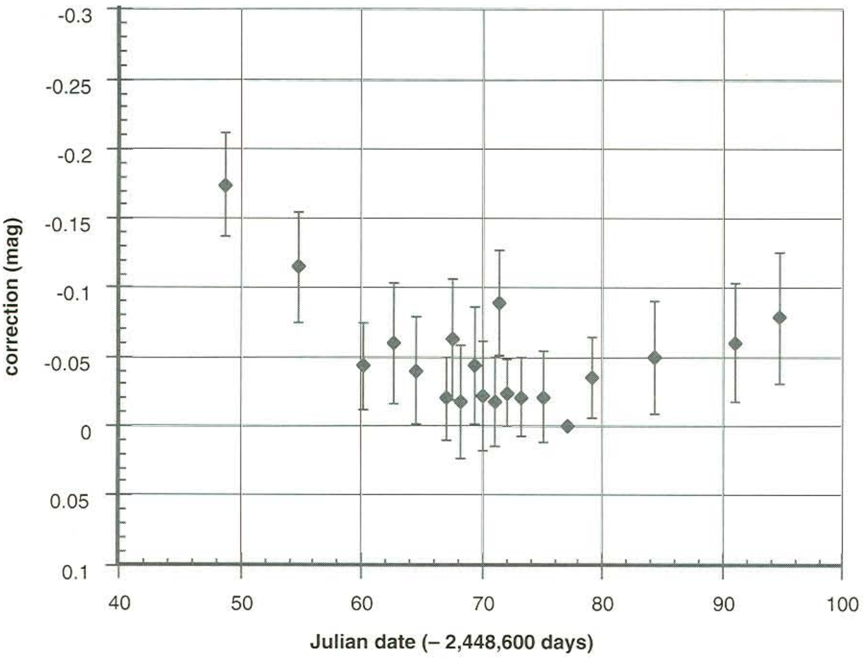

Figure 1: Magnitude corrections relative to the epoch with the highest count rates. Each point represents the average of 25 bright stars from WF1+F555W images.

field. However, it proved very powerful in fitting the diffraction limited core of the severely undersampled WFC PSF. Due to extreme crowding in WF3 and WF4 it was impossible to locate a sufficient number of bright, isolated stars suitable for defining the PSF. Consequently, we determined only one 'best' PSF for each filter from the average of many stars and kept it stable for all epochs. The fixed parameters describing the uniform Moffat function were $\beta = 4.0$, σ (F555W) = 2.20 pixels, and σ (F785LP) = 2.40 pixels. The sky level was allowed to vary but no sky tilt was used.

As a first attempt, PSF-fitting was performed for a total of only some 600 objects that were selected by hand from a stacked frame corresponding to a six hour exposure. This saved us from measuring and analysing a multitude of spurious detections in the extended structure around the sharp peaks of image cores. For every single measurement the quality of the resulting fit was carefully checked and improved whenever possible.

The homogenization

Before any Cepheid candidates were selected on the basis of their variability, we had to consider spatial and temporal variations and chip-to-chip differences of the PSF. Plotting the instrumental magnitudes of individual stars versus time (ie, epoch) revealed a general fluctuation pattern. Reasons for this pattern are (i) temporal changes of the PSF caused by telescope jitter during the exposure, (ii) history of decontamination events that change the characteristics of the flat-field. Based on a sample of bright, intrinsically non-variable stars we determined for every image and epoch the magnitude offset relative to the epoch with the highest count rate. The resulting corrections ranged from 0 up to 0.175 mag (Figure 1). They were applied to all instrumental magnitudes and thus yielded homogeneous photometric data.

The photometric zeropoints

In the case of IC 4182 there is no available top-quality external photometric calibration for V and I which covers the area and range of the WFC images. This forced us to rely on the zeropoints given in chapter 12 of the WFPC Final Orbital/Science Verification Report (1992). It is important to know that any sensitivity differences between the four involved CCD chips are accounted for in the pipeline flat-fielding procedure. Thus the O/SV Report gives a uniform photometric zeropoint for each passband referring to the flux measured through a big aperture of 40 pixels radius in order to contain virtually all the measurable light. This created the additional complication for us to actually determine what fraction of light from a source was not covered by the PSF. A detailed analysis of the growth curves of the (few) bright, isolated stars on images of WF1, WF2, and WF3 allowed the measurement of the aperture correction. Figure 2 shows the WF1 image of epoch 3. Figure 3 illustrates the profile and the corresponding growth curve of one of the brightest stars in Figure 2. From such curves, the following average aperture correction, ie, the offset between the magnitude returned by ROMAFOT and the star's integrated magnitude collected in a circular aperture of 40 pixels diameter was determined:

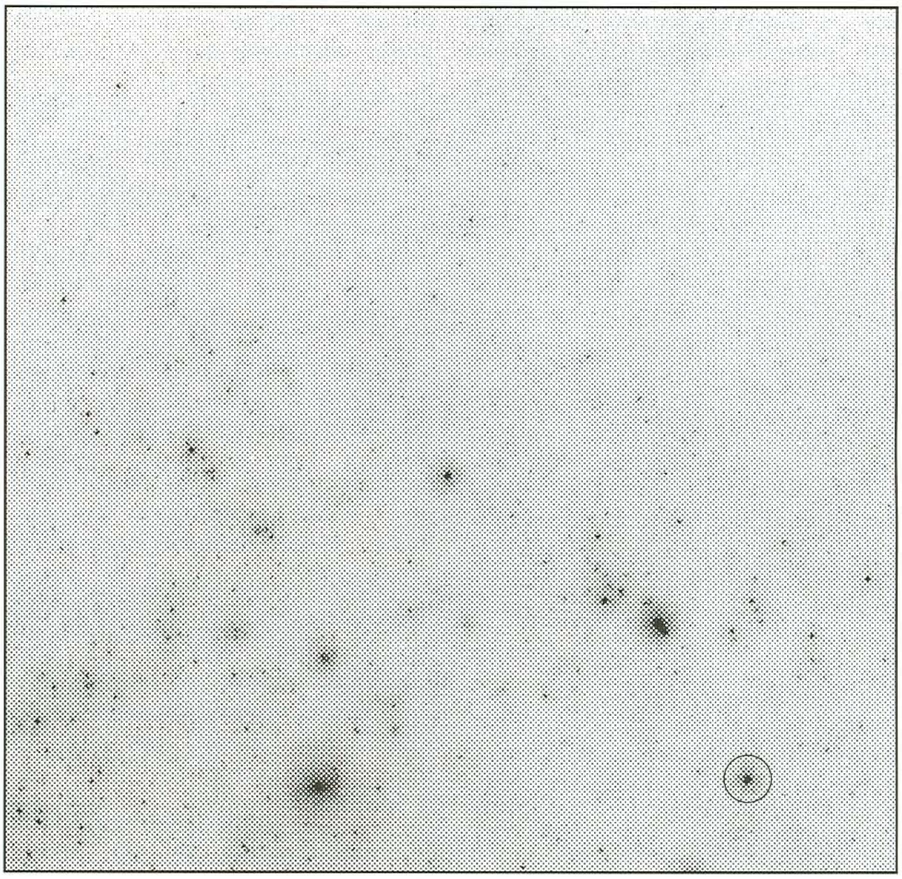

Figure 2: The WF1 image of epoch 3 depicts the outer part of IC 4182. The exposure time was 2 × 35 minutes. The bright, isolated star in the lower right corner is shown in Figure 3.

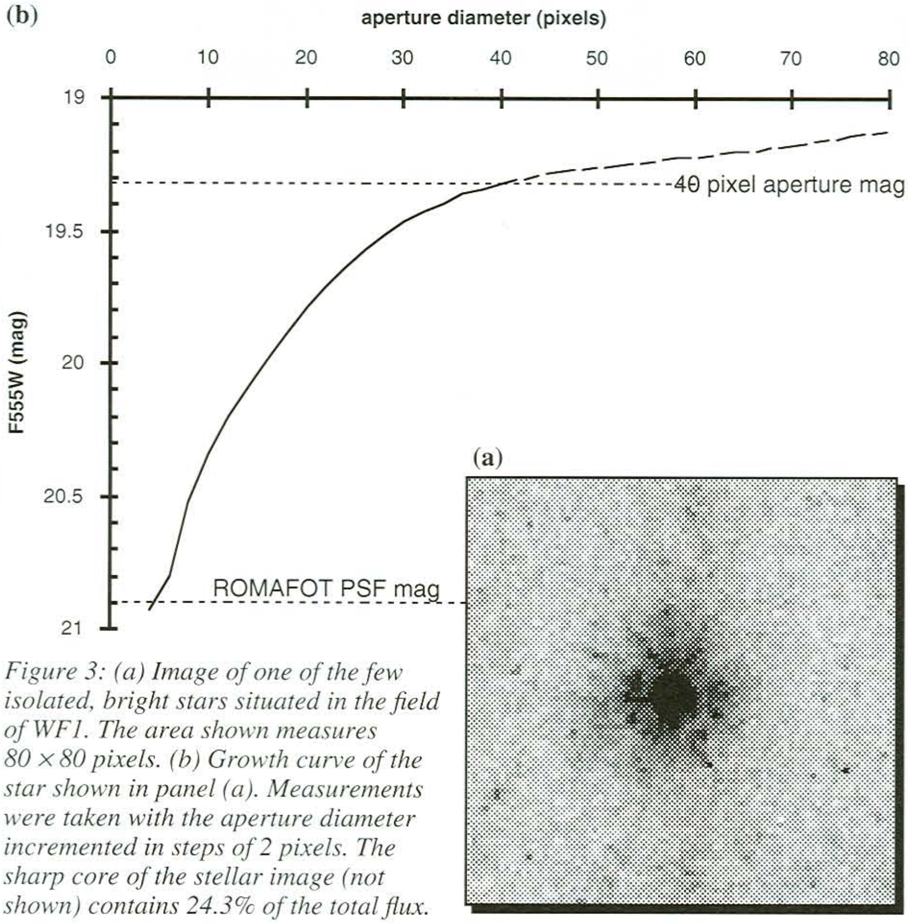

Figure 3: (a) Image of one of the few isolated, bright stars situated in the field of WF1. The area shown measures 80 × 80 pixels. (b) Growth curve of the star shown in panel (a). Measurements were taken with the aperture diameter incremented in steps of 2 pixels. The sharp core of the stellar image (not shown) contains 24.3% of the total flux.

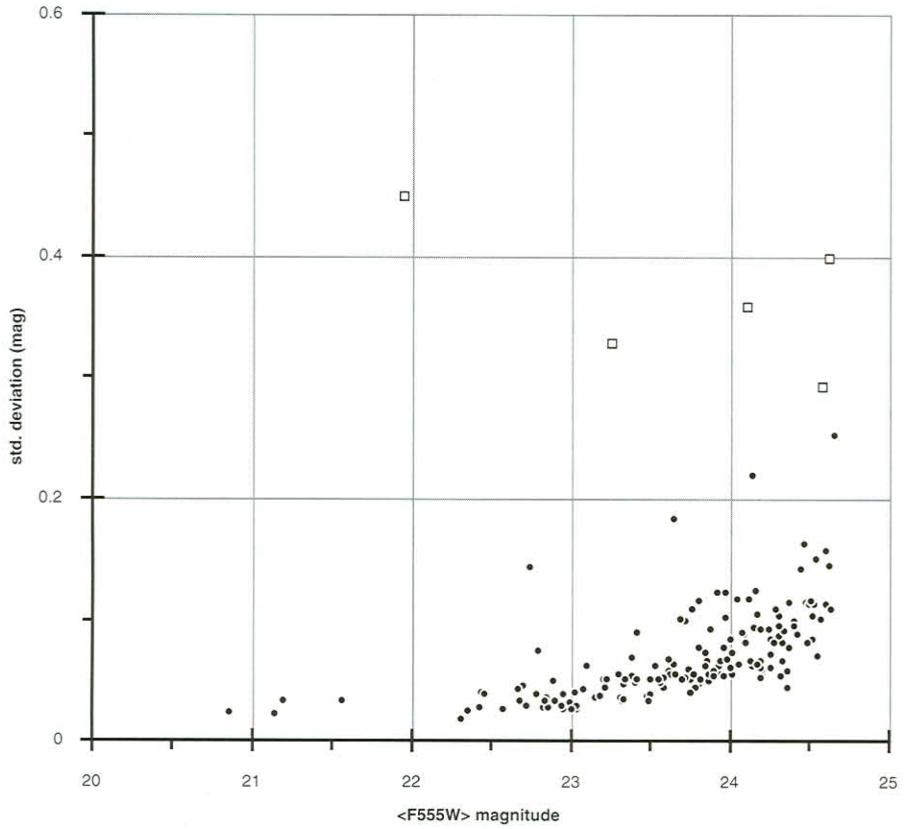

Figure 4: The statistical error of the F555W magnitudes, averaged for 20 epochs, is plotted as a function of the mean magnitude. The diagram contains about 180 stars measured on WF1 images. Note how well variable stars and confirmed Cepheids (open squares) can be distinguished from the normal stars.

1.537 ± 0.008 mag for the F555W filter and 1.764 ± 0.003 mag for F785LP. We measured only within 40 pixels to avoid running into neighbouring stars. The remaining aperture corrections from 40 pixels diameter to full aperture were again taken from the O/SV Report. We were not successful in establishing the same offsets by modelling the PSF with the Tiny Tim package.

The photometric errors

For all epochs, a matching procedure combined the valid instrumental magnitudes belonging to the same individual object. The resulting data pool was subjected to a search for significant brightness variations of its elements. The standard deviation of the mean <F555W> could directly be used as an indicator for variable star candidates. Its dependence on the mean instrumental magnitude is shown in Figure 4. This plot not only very nicely illustrates the clear separation of variable stars—especially the ones that turned out to be Cepheids. It also indicates the photometric error affecting our measurements. However, it should be stressed that the uncertainty introduced by the pipeline calibration procedure and application of the nominal zeropoint correction adds up to an overall inaccuracy of 0.1 magnitudes. This is acceptable for our scientific aims but might be too much in the case of other projects utilising HST WFPC data.

Conclusions

The work reported could only be realised because of a well designed observing strategy which included optimised sampling of a large range of Cepheid periods, maintaining the field-orientation for all epochs, and making use of the CR-split mode. Our reduction procedure evolved from those developed for ground-based data. PSF-fitting of the diffraction limited core yields very reliable photometry down to limits imposed by photon statistics. Photometric calibration poses severe problems if there are no bright, isolated stars in the field. The availability of a photometric sequence would be desirable to confirm the value of the ‘cookbook’ zeropoint and to detect and handle field effects and/or temporal changes which might still affect the images processed by the calibration pipeline. Efforts should be undertaken to overcome the limitations of the colour range of the transformations to standard magnitudes given by Harris et al. (1991. A.J. 101, 677).

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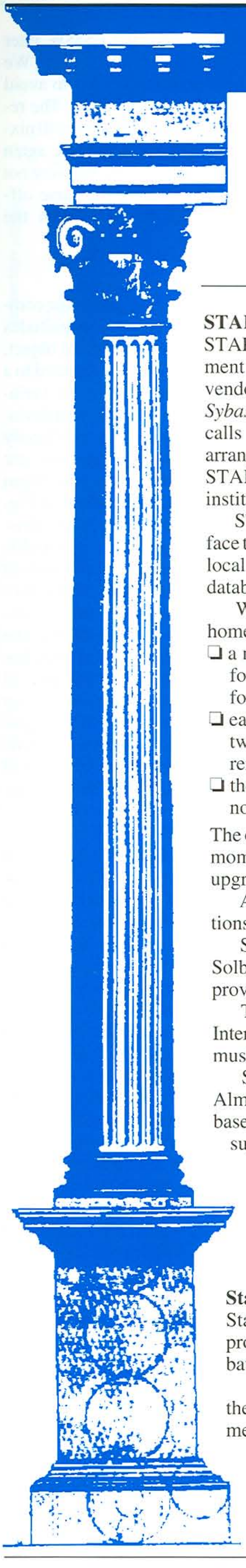

The Archive column

A number of new facilities and forthcoming events are reported. It is now possible for some sites to run STARCAT on their own machines, greatly improving the response of the user interface.

Benoît Pirenne & Miguel Albrecht[†]

STARCAT is now available for remote distribution

STARCAT interacts with the ESO/ECF database management system (*Sybase*, a commercial DBMS) via a set of vendor-supplied interface routines in a client-server mode. *Sybase* has waived any license fee on products that include calls to these routines. The practical consequence of this arrangement is that we are now in the position of making the STARCAT program (executable) available to any scientific institution that wishes to install it on their own system.

STARCAT is however only the astronomical user interface to the database system, ie, installing STARCAT on your local computer does not mean you install the 3 Gigabyte of databases as well.

What are the advantages in running STARCAT from the home institute rather than remotely at ESO/ECF?

- ☐ a much more responsive user interface: rather than wait for the reaction to a keystroke, the result is now immediate for operations not involving database retrieval.
- ☐ each record retrieved from the database is transmitted twice as fast to the user's terminal compared with the remote login solution.
- ☐ the output files are created in the user's home directory: no need to copy them across the network.

The only drawback of this solution that we can foresee at the moment is that the STARCAT program might need to be upgraded from time to time, requiring a new installation.

At the moment, only the following computer configurations are supported:

SPARC compatible computer, ie, Sun 4, BriteLite, Solbourne etc. We now support SunOS 4.1.x and intend to provide support for Solaris 2.x in the near future.

The STARCAT host computer *must* be connected to the Internet network. The command '/usr/etc/ping 134.171.11.1' must return a positive message after a few seconds.

STARCAT needs a windowing system for the PreView. Almost all those that run on the SPARC platform (X11-based interfaces: OpenWindows, OpenLook, Motif) are supported.

A (pre-)registration form is printed overpage. If you are interested and think the requirements are satisfied at your site, just return a copy of the form to Susan Hill, ESO/ST–ECF archive. You will then receive installation instructions.

StarMail is now available.

StarMail is a new facility at ESO/ST–ECF that will process STARCAT batches over email. To send a starmail batch you need to follow these steps:

First, prepare an email message in which you enclose the STARCAT batch commands as the only text of the message (see the example below).

Then, just send the message to starmail@eso.org and wait for results.

In order to obtain any results you *must* include in your batch the 'outfile' command so that information is extracted from the database onto a file. Beware that only ASCII and LaTeX outputs can be transferred back to you via email (NO Midas and FITS formats).

Should you require the latest Starcat documentation please send in a request to: Susan Hill (shill@eso.org or ESO::SHILL).

Attention—command name change

The command 'Output_file' in the query menus of STARCAT has been renamed to 'OutFile'. This change was prompted by the need to make the command name shorter in order to reduce the number of lines in the Query menu. This change is particularly important for those of you using the batch mode of STARCAT or using StarMail. Please change your existing batch files accordingly.

An example of a STARCAT batch

```
!Query command
Catalogs
!Catalog name
hr
! Select all objects within 1 degree of 18 00 00 -
      29 30
Center
J2000.0 18 00 00 -29 30.0
 1 00 00
! Extract the data onto a file
OutFile
! ... as an ASCII file
ASCII
!Use extension .tab for tab-separated columns
! Filename (default extension .lis)
my-hr-objects
!##OutputFileName>> my-hr-objects.lis
! Select Fields: { FieldName | Clear | Exit }
Clear
hr
_ra
_de
vmag
bmv
! Exit Select Fields
Exit
! Exit OutFile
Exit
Scan
! Exit Catalogs
Exit
! Exit Starcat
Exit
```

[†] The ESO archive group

New catalogues in 1992

- ❑ Burbidge89: New Optical Cat. of Quasi-stellar objects, 4383 entries.
- ❑ Fairall91 : catalogue of 'Southern Redshifts', 12844 entries
- ❑ GCVS91: 4th edition of the Variable Stars catalogue, 28480 entries.
- ❑ GSC1.1: Version 1.1 of the Guide Star Catalog. 25281306 entries.
- ❑ HIC: The Hipparcos Input Catalogue. 118208 entries.
- ❑ IRAS_FSC: the IRAS Faint Source Catalog, 173044 entries.
- ❑ IUE91: now with preview of all ULDA Spectra!
- ❑ Michigan: Catalogue of 2D spectral types for HD stars(IV), 33301 entries.
- ❑ PPM_S: Positions and Proper Motions (South), 144787 entries.
- ❑ SStar: A General Catalogue of S Stars, 741 entries.
- ❑ Veron91: Catalog of Quasars and Active Nuclei (1991), 7998 entries.

HST issues

SendRequest/Reqstatus commands
As mentioned in the 'HST guide', a command call 'SendRequest' is available in STARCAT to submit a list of selected files to the ECF Request Handler. The command has been changed recently to replace the previous 'email' implementation by a direct database insert for each file in the request. This not only accelerates the service but it also allows for the existence of a brand new command called 'ReqStatus' in the 'Utility' menu. This last function gives a quick overview of the status of a particular request. It suffices to enter an abbreviation of your archive username and STARCAT will automatically produce a summary listing of the statuses of the various files in the request. The list is always up-to-date. The command can be used repeatedly to enquire the ECF archive on the progress of a request. Try the 'help' command and the topic 'util' 'req' for a complete explanation.

DADS
The DADS project (Data Archive and Distribution System) that NASA is planning to use for storing and distributing HST observations will reach a major milestone in the course of 1993. It means a substantial number of changes to the archive, especially to the catalogue. Our intention is to render these changes as painless as possible to STARCAT users. In other words, the HST screens in STARCAT will still look familiar when going from the current database structure to the new one later this year. In order for this transition to be smooth, we are planning to get a test version of the new database structure by the end of the winter for assessment and early transition tests.

HST data reprocessing now complete.
The STScI has reprocessed 1990 and 1991 observations from all instruments and has re-archived them. The object of reprocessing was to re-calibrate the data (apply better calibration files) and to correct the file header keywords and hence the catalogue. The exercise was very successful. Only a few re-calibration problems were noticed and will be taken care of in the near future. This obviously improves the quality and homogeneity of our archive.

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Remote STARCAT pre-registration form

STARCAT will be made available to Astronomical Institutes in the near future. However, a number of technical conditions have to be met. See the 'STARCAT News' article for a description.

Yes, we are interested in running STARCAT at our institute. We are planning to install STARCAT on a SPARC compatible computer having access to the Internet network.

Site: ______________________________

Address: ______________________________

City: ______________________________

Country: ______________________________

Contact Person in charge of STARCAT at the site: ______________

Email address of the contact person: ______________

Have you ever used STARCAT before? : ______________

Computer type: ______________________________

Operating System version: ______________________

TCP/IP number of the computer: ______________________

Internet address of the computer: ______________________

Applicants will receive installation instructions shortly.

Two years of HST Archive operation — first conclusions

Benoît Pirenne

The ST–ECF archive officially started the re-distribution of HST data on the 1^{st} of January 1991 after having accumulated data since launch. Just a few months later, the first 'ERO' (Early Release) and 'SAO' (Science Assessment) observations started to become publicly available. After almost two years of increasing activity, we can now discuss the first real figures, show trends, draw conclusions and plan for the short and long term future of the ECF archive activities.

We will discuss here the different aspects of the ST–ECF archive, which—like any respectable scientific archive—consist of four major parts:

- ❑ the user interface,
- ❑ the bulk data,
- ❑ a database management system,
- ❑ human expertise on scientific aspects of the data.

Obviously, the latter point can hardly be quantified. It can only be judged by the level of satisfaction of users having had their particular problems answered by the experts, ie, the ST–ECF staff. So we will present what happened in the past two years with emphasis on two aspects: the user interface/database usage and the distribution of data.

The usage of STARCAT
STARCAT has been serving as a user interface to various types of astronomical information over the past five years. From standard catalogues describing various sorts of astronomical objects at all wavelengths to remote databases and to vari-

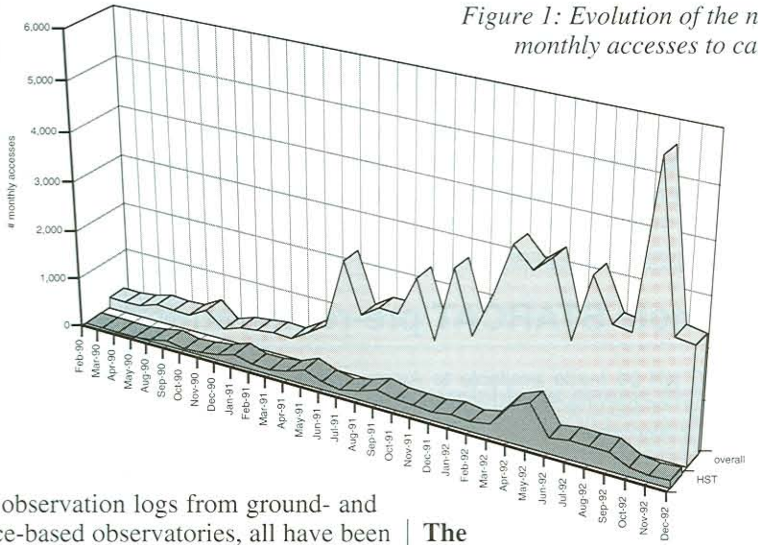

Figure 1: Evolution of the number of monthly accesses to catalogues.

ous observation logs from ground- and space-based observatories, all have been made available to users through STARCAT. The latest important addition has been the access to the ESO archive log.

To better grasp the evolution of STARCAT usage over the past few years we present in figure 1 a graph where the evolution of the number of accesses to catalogues per month is presented. The separate evolution of the HST part is also shown.

Note that the big success of 'astrocat' (all the astronomical catalogues) is essentially due to the Guide Star Catalogue being used on-line at the La Silla observatory to help users prepare their finding charts and guide star sets... (See also the STARCAT News article in this issue on the new version of GSC recently installed).

Other special users have prepared substantial numbers of STARCAT batch files to search the Guide Star Catalogue and other catalogues in the hope of finding visual counterparts of sources discovered at different wavelengths. Recently, the long-awaited 'StarMail' facility (see the STARCAT News article) was finally released. It will allow even more users to get a remote, yet extremely quick, STARCAT service.

Figure 2 presents the evolution of the number of different users accessing our services each month. This shows that the interest in STARCAT is increasing. The future distribution of STARCAT to external sites will most certainly change the shape of this trend dramatically.

Finally, the number of records retrieved per month is probably the most revealing figure. It seems to be now the rule rather than the exception that, on the average, over half a million catalogue entries are retrieved from our databases every month.

Even though the figures seem high, we cannot say that the database management system is overwhelmed by queries. As a matter of fact a much larger amount of data could still be retrieved before real performance problems begin to arise.

The usage of the off-line data archive

How does the archive data distribution work: To better understand the statistics and comments presented, we think it is necessary to give an introduction on the data distribution method.

As of the time of writing, the archive contains over 1.9 million files on 425 2 Gigabyte optical disks. This is almost entirely HST data. (Our archive system also serves requests for 30,000 ESOLV data files). Those disks are stored in a locked cabinet in a secure computer room to isolate them from both fire hazard and ill-intentioned people—since many of these data are still under proprietary restriction.

The software system used to manage the data is called the 'Request Handler'. The Request Handler was developed at the ST–ECF and is now also in use (in different implementations) at the Canadian Astronomy Data Centre and at the Space Telescope Science Institute.

Let us now examine what is happening when data are requested by users. User requests are entered in the Request Handler database directly from STARCAT. This saves a lot of time for the operator and consequently accelerates the service. Thereafter, an automatic procedure warns the operator of the presence of a pending request which can immediately be processed. The process consists of a number of distinct operations:

1. Get the necessary optical disks from their respective locations on the shelves, according to the list provided by the Request Handler,
2. Feed the optical disk drives with the required disks on prompts from the reading software, one after the other. The reading software takes each individual file in the list of pending requests and copies them onto a staging disk.
3. When all the files from a request have been read from the various optical disks, a tape reservation process is started. This process computes the number of tapes of the desired type (and their length) necessary to write all the files that have been retrieved from the optical disks.
4. Then the operator can start a tape copy process to move the files from their staging area onto the final medium. The process also converts all the files from VMS GEIS format to FITS format 'on the fly'.
5. The operator can finally print the labels, put the tapes into an envelope and mail it.
6. The last operation is a finalisation of the request executed through a procedure which informs the user by email about the completion of the request.

Request service time estimation: All these operations take time and the close monitoring of operational activities has helped us to identify the bottlenecks in the entire process and pointed to improvements.

From these figures, we can deduce the turnaround time for typical requests from the four major HST instruments (Figure 3). The typical request consists of a few datasets (say five) with calibrated and raw data included. The table lists the various parameters pertinent to such template requests.

The actual service time estimation must also take into account the temporary load of the operator/database. If a large num-

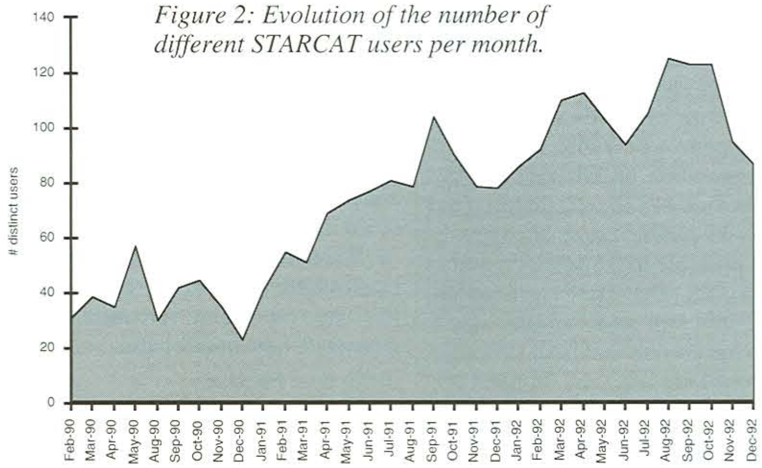

Figure 2: Evolution of the number of different STARCAT users per month.

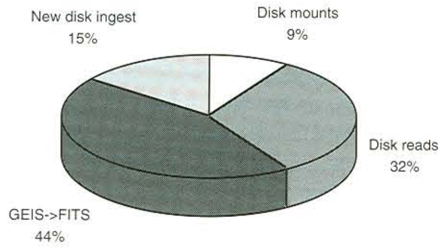

Figure 3 Time spent on each request-handling sub-task.

Inst.	# files	size (MB)	O.D. time	Read time	Conv. time	Tot. time
			(min)			
WFPC	20	73.5	2.4	9.8	31.3	45
FOC	20	30.0	2.4	4.0	12.8	20
FOS	30	2.2	2.4	0.3	0.9	6
GHRS	30	0.6	2.4	0.2	0.5	5

Table: Parameters pertinent to the servicing of requests. Note that sizes may vary depending on instrument configurations. Mount times are selected assuming that the five datasets can be found on three disks; the total time also takes into account the database interaction time.

ber of requests is pending, the service time will be somewhat longer.

Distribution statistics: Figure 4 compares the evolution of the number of HST datasets re-distributed to archive researchers—in-house and externally—with the distribution rate for public datasets.

If we compare the values displayed in Figure 4, it is easy to see that the ECF archive alone has already circulated over 45% of public HST observations to the community. These values are constant with time and it is encouraging to see how much interest there is in archive data within the community.

How will we perform in the future? To conclude this brief study, we will try to address a few problems like 'what will it take to support an increasing request load?'.

At present, the ECF archive is regularly distributing data at a rate of 1 GB/month with a maximum of 3 GB. The figures presented above show that the current efficiency of all aspects of the system (hardware, software and of course manpower) allows us to serve roughly 3 GB of data per month with two optical disk drives and a half time operator—the second half of our operator (*'s time — ed.*) is used by the ESO archive. If we start to receive requests exceeding 4 GB/ month, we will have problems serving users efficiently. The solutions that we are investigating at present concern all aspects of the archive system:

Hardware: although hardware solutions involving optical disk jukeboxes or optical tapes exist and are technically sound, this simple 'pour money in and that'll do' type of solution cannot really be considered at this point for the following reasons: a jukebox can hold roughly 100 disks or 200 gigabytes. We already have nearly 500 disks. Combining several jukeboxes would simply turn an expensive solution into an unaffordable one. Going to higher density media like the 6.5 GB disks that DADS will produce will only divide the number of disks by three and HST will continue to produce data…

The optical tape (where each reel can hold up to 1 Terrabyte) is a very elegant solution. But the price of the equipment and the limited experience of installed units makes it too risky at the moment. And still this solution would not bring all HST observations on-line since we are facing the prospect of much more than one TB of data. We would not be able to spare an operator either since we would have to copy all the optical disks coming from the STScI onto this new medium.

Software: we are currently in the process of streamlining all the operator request-handling procedures. This is done by covering the individual procedures with a window-based graphical user interface. It should ease the manipulation of requests, allow a quicker learning curve for operators and facilitate the control of several optical disk drives. It is expected that this new interface will remove some of the task switching dead times and somewhat enhance the overall throughput.

Manpower: since no new hardware solution is planned for the reasons explained above, we will have to compensate for any increase of workload beyond the current production capacity by manpower. The solution currently under consideration involves an additional half-time operator working in shifts, preferably in the evening, since experience has shown that users usually send their requests in the late afternoon.

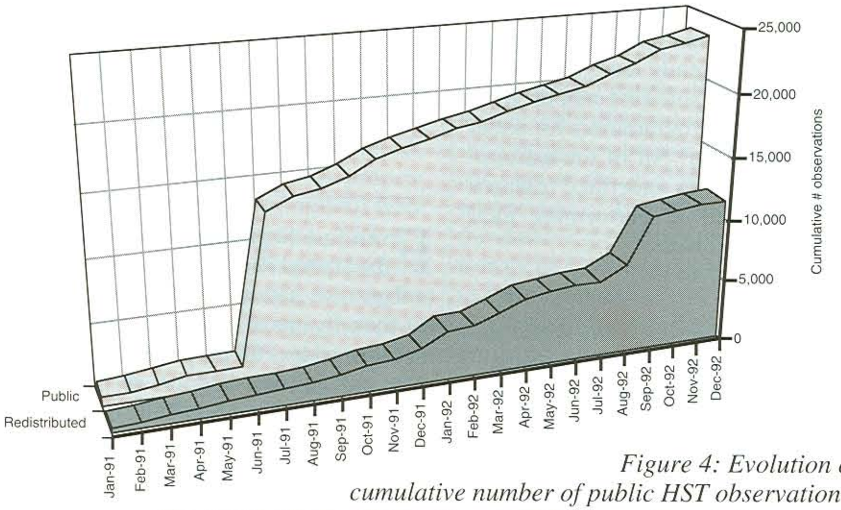

Figure 4: Evolution of the cumulative number of public HST observations and the cumulative re-distribution of HST observations to the community.

The question is now: when do we need to increase our production potential? The answer can be computed in the following way. Assuming that the rate of increase of HST observations released to the public remains constant next year (approximately 600 new obs./month) and considering that our archive has kept the redistribution rate of public data to an average of 40% over many months, we can expect an increase of data to re-distribute of roughly 0.2 GB/month in 1993. This predicts a saturation point (3 GB/month) towards the end of the summer of 1993.

Conclusion

We have presented the evolution of all aspects of the ECF archive activities over the past couple of years. A steady increase of the use of the database (catalogues and observation logs) through the STARCAT user interface has been noted as encouraging. The latest developments in the user interface (StarMail—wide distribution of STARCAT) will probably result in a further increase in the number of records retrieved and attract still more users of the system.

The bulk data distribution during the past two years has confirmed the feasibility of the operation—even with limited resources. We have analysed the present re-distribution figures and used the technical response times to extrapolate our future load and hence our potential expansion needs. The various ways of responding to throughput problems have been presented with their respective advantages and drawbacks and a practical solution has been suggested. With the advent of DADS, 1993 will be a year of changes. We have to consolidate our efforts and prepare for throughput limits being reached.

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The Canadian Astronomy Data Centre

Dennis Crabtree[‡]

The Canadian Astronomy Data Centre (CADC) is located within the Dominion Astrophysical Observatory (DAO), which is just outside Victoria, British Columbia. The DAO is a component of the Herzberg Institute of Astrophysics, which itself is a Division of the National Research Council of Canada. The CADC was formed to provide access to the HST data archives for Canadian scientists and to promote involvement in space astronomy research. Canada is not a partner in the HST mission, but NASA has agreed to provide the CADC with a copy of non-proprietary HST data. The CADC must pay for the incremental costs—which are covered by the Canadian Space Agency—of producing the copy.

The following personnel are currently part of the CADC project: Daniel Durand and Stephen Morris are astronomers with strong computing backgrounds. Severin Gaudet is our software project leader who is assisted by programmer/analyst Norman Hill. Wes Fisher spends half his time as CADC archivist/librarian. Wes is also assistant systems administrator for the whole DAO. Dennis Crabtree is an astronomer who currently leads the CADC group. We also get software support from University co-op programmers for about 8 months each year. All of the astronomers are expected to undertake research programs as well as performing their CADC functional rôles.

HST Archive

Unlike the ST–ECF which receives a 'duplicate' optical disk from STScI containing all of the data, the CADC receives a slightly smaller subset of the data on optical disks which are produced approximately one year after the data are archived in Baltimore. CADC-produced software, named CADCOD, runs on the DMF VAX at STScI to produce the optical disks which are sent to Victoria. CADCOD works by scanning the HST database for public datasets which the CADC does not yet have. These datasets are then copied to an output optical disk and the datasets are then flagged as copied. Incidentally, CADCOD has been designed so that it can serve other (future) HST archive sites as well.

All of the CADC's archiving activities in Victoria are SparcStation-based. Sybase 4.8 runs on a SparcStation 2 while a SparcStation 1+ serves as an optical disk (OD) server. The OD machine currently has two LMSI drives and one Sony WD-600 series drive connected and a Sony 931 soon to be connected. We also have a microVAX II which is used to debug CADCOD and other software which runs at the STScI.

Our copy of the HST database is updated nightly over the network using software called DBsync which we developed. This compares the STScI database with ours and normally copies over new tuples on a table-by-table basis. If there has been any change in the structure of a table (eg, a new field) then our copy of the table is dropped, the table is recreated using the new definition and then the data are downloaded. This procedure has also been used to synchronize our copy of 'astrocat' with the ECF's.

STARCAT

The CADC is currently running the same version of STARCAT as the ST–ECF. In fact, we have been involved in STARCAT development for several years and have recently established procedures for collaborative development within the ST–ECF STARCAT directory tree. We now have the ST–ECF tree NFS mounted in Victoria and scripts allow us to do remote checkouts, checkins, etc. of modules. A local copy of the tree which is updated daily is used for all compilations, linking, testing, etc., as the NFS mount is over a slow 56 Kbps link.

Most of our STARCAT users will be using client/server STARCAT over CAnet so we are interested in developing X11-based tools for STARCAT such as the new PreView feature. We would like to have an X11 Doc tool which uses documentation stored in the database. This would allow us to add or modify documentation without requiring users to download any files to their site. We will be working with the ECF on other STARCAT developments such as the new graphics server and services server.

CFHT Archive

The CADC is also archiving data from the CFHT. We are writing data to Sony optical disk in Hawaii in the DMF format. The FITS headers are copied over the network and used to update the CFHT catalog. Archiving officially started on September 18 but there is still much work to be done before we have a working archive. The CFHT Archive will be accessible through STARCAT in much the same way as the ESO archive.

[‡] Dominion Astrophysical Observatory, Canada

The UK HST support facility

Nial Tanvir[†] *& David Robinson*[†]

From last September, astronomers in the United Kingdom have had access to their own national HST Support Facility, the only one of its kind within the ESA member states. Its purpose is to supplement the existing support services provided by STScI and ST–ECF, by offering a more local source of help with HST applications, data analysis, status information and archive use.

The Facility, which is situated in Cambridge, consists of two members of staff—the authors—together with a well appointed hardware system based around two desk-top SPARC-stations. Such a national facility has several benefits. Firstly, it provides an efficient vehicle for handling user queries, which may either be answered directly or referred back to the appropriate experts at STScI or ST–ECF. Secondly, it performs a rôle in disseminating important status information to the community. Thirdly, the lower cost of national rather than international travel makes it easier for users to visit Cambridge than it would be to travel to Baltimore or Garching. Similarly, it allows the staff members to travel to other institutions to provide specific assistance and also address the wider community by way of general HST seminars and 'roadshows'. Finally, it can tailor its operations to the particular requirements of the UK community, such as the computing systems and software packages which are in common use.

Thus, a significant aspect of the support rôle is to provide assistance with the analysis of HST data, which may include collaborative research. The staff members have particular experience in some of the areas of data reduction, such as image reconstruction and crowded field photometry, which are frequently applied to HST data. Being based in Cambridge also means easy access to locally available expertise on the analysis of data from the HST science instruments.

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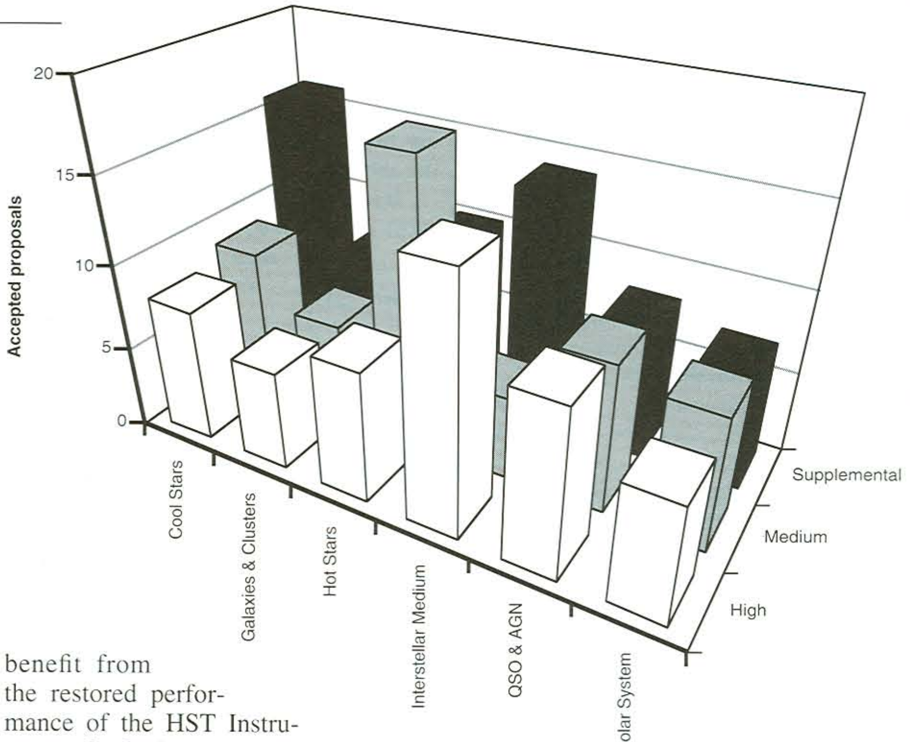
HST Cycle 3 European allocations

Piero Benvenuti

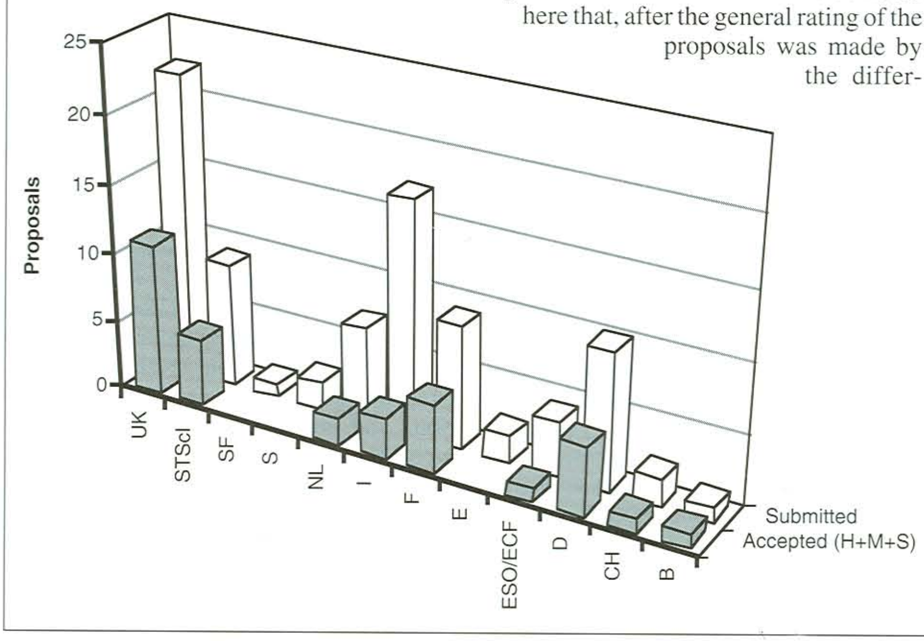
Proposers for the third Cycle of HST Observations should by now have been notified by the STScI about the outcome of their proposal. The allocation process took place last November when the members of the six discipline panels and of the Telescope Allocation Committee met in Baltimore to review the 406 proposals which were received for Cycle 3. As for previous cycles, their task was difficult because of oversubscription with high quality applications.

Just to make things more complicated, this time there was uncertainty about the actual duration of Cycle 3 due to doubts about the exact date of the Shuttle servicing mission planned for next December. For many proposals, the difficult question had to be faced: would it be better to postpone these observations until the installation of COSTAR and WFPC 2?

To accommodate these uncertainties, the STScI took two decisions: the first was to moderately oversubscribe Cycle 3 in such a way that HST could continue to operate were the M & R mission to be delayed by few months. Indeed the approved proposals for Cycle 3 are divided in three categories: *High priority* , which will normally be executed, *Medium priority*, which may be executed and in particular should help in filling gaps in the HST schedule and *Supplemental*, which come into play only if the Shuttle mission is postponed. The second, related decision was to bring forward to March the Cycle 4 call for proposals—the first cycle to benefit from the restored performance of the HST Instruments. Cycle 4 proposals will also be processed faster than previously in order to have a new observing programme ready before the M & R mission and the subsequent busy commissioning period.



At the end of the process, 170 proposals (about 43% of those submitted) were accepted for Cycle 3: of these, 32% are rated High priority, 32% Medium and the remaining 36% Supplemental. Among the approved proposals, 34 have a European PI: this corresponds to 20% of the total—exceeding, as in previous cycles, the agreed 15% threshold. It should be noted here that, after the general rating of the proposals was made by the different discipline panels, the European ones were evenly distributed in the rank order, indicating the absence of any geographical bias in the evaluation process. The percentage of European participation in the observing programme increases if the European Co-Investigators are pro-rated in the computation.



The partition of all (not just European) proposals among the different disciplines is shown in the top figure: note that this year, in order to achieve a more even distribution among the panels, the previous groups *Stellar Astrophysics* and *Stellar Populations* were replaced by *Cool Stars* and *Hot Stars.*

The geographical distribution of the submitted and accepted proposals in the ESA Member States is shown in the lower figure.

By now the European PIs have been contacted by the ST-ECF in order to plan for the Phase II proposal preparation, the deadline of which is February 15, 1993.

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Reflections on the second Astronomical Data Analysis Software and Systems conference

Hans-Martin Adorf

A rainy early November Boston hosted the second conference on “Astronomical Data Analysis Software and Systems”. Excellently prepared by its scientific organizers Carol Cristian (UC Berkeley), Dennis Crabtree (DAO), Bob Hanisch (STScI), F.R. Harnden, Jr. (SAO), George Jacoby (NOAO), Dick Shaw (STScI), Doug Tody (NOAO) and Diana Worrall (SAO), the conference presented an overview of the worldwide developments in the area of astronomical data analysis.

“Rolling your own” data analysis

Since a detailed account of the conference presentations and posters will be contained in the proceedings (Hanisch et al. 1993), I will confine myself to some selected highlights and comment on a few topics that were not included (or escaped my notice).

Hardware development

Given the long timescales of software development, an important question any software developer must ask themselves is “What will the hardware look like in five to ten years from now?”

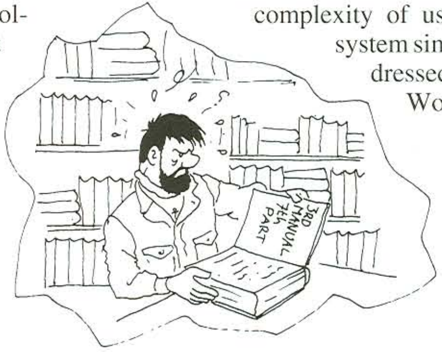
It was the principal developer of the X-window system, *Jim Gettys*, who addressed this question. He gave a sneak preview of the near future of scientific computing—seen from the perspective of a DEC-employee. Gettys’ important message was: computer hardware capabilities currently grow exponentially. However, different components have different capability doubling-times: the fastest growing sector is compute-power, the slowest is input-output, with memory and permanent storage falling in-between. Strict limits of growth are not yet in sight but will ultimately be constrained by physical principles such as the speed of light. These different growth rates are difficult to follow by the architecture designers and even more so by the software developers.

These days it is often cheaper to recompute a result from scratch rather than to save it for potential later retrieval. Thus Gettys would presumably answer the question whether to generally store processed (eg, calibrated) data with: Don’t! But *do* store the algorithm(s) along with the raw data and all other auxiliary information required for a (re-)computation should it be desired.

Object-oriented design

There is no doubt that the object-oriented software development paradigm is currently spreading in the software engineering world and it is attracting followers in the astronomical community.

It seems that NRAO with the development of AIPS++, a second generation data analysis system for radio astronomy and designated successor of AIPS, has taken the lead in applying the object-oriented methodology to the construction of data analysis software. While first discussions about the future of AIPS (now frequently called ‘AIPS-1’) took place three years ago, the decision to start afresh with a revolutionary rather than an evolutionary software development methodology, dates back about two years. The NRAO-team is now leading an international academic consortium in a novel, world-wide distributed, yet tightly coordinated software development effort.



*How do they want me to do it?!**!*

The AIPS++ team presently expends a major effort on the design of an abstract ‘class-library’, which includes a generic model of a radio telescope, and which will be made publicly available prior to the release of AIPS++ itself.

R.M. Hjellming (NRAO) addressed the question of AIPS^{++} programmability, a topic met with considerable interest from the audience. The AIPS++ team includes people with a multi-lingual background, so one can hope that the system will be equipped with at least one functional programming language ‘user interface’, which should make the high-level coding of algorithms in AIPS++ comparatively easy.

Exchangeability of data

The future of IRAF, of immediate interest to the HST-community, was outlined by its principal architect, *Doug Tody* (NOAO). He explicitly acknowledged the existence of other data analysis systems for optical astronomy, such as MIDAS or IDL, with which IRAF has to peacefully coexist. Steps to achieve the conviviality include a true FITS-reader (something different from a FITS-converter) that will allow the use of DiskFITS files and native IRAF image data files interchangeably.

As an aside, the FITS file format standard has caught on within the astronomical community to the extent that other more recent, more general (and supposedly more efficient) data formats, currently being developed outside astronomy and being adopted by a much wider science community, are being neglected. With all due respect to the FITS-designers, the history of Fortran should be a warning regarding the potential pitfalls of an early, too successful standardization.

Superstructures and graphical user interfaces

The problem of how to overcome the complexity of using more than one system simultaneously was addressed by several groups. Work is being concentrated on graphical user interfaces (GUIs) on top of one or more data analysis systems.

I have some reservations about this approach. First of all, it moves the analyst further away from data and algorithms. Secondly it adds complexity. Also, there is additional software to be installed and maintained. I cannot suppress the feeling that these later, high-level developments have to make up for earlier, low-level design flaws.

Anything missing?

In my view, the most important omitted question is: “Where is the astronomer in the data analysis process?” Obviously, software providers are guided by *some* assumptions concerning the expectations of their users and their level of experience. But what exactly are these assumptions and how do the software people arrive at their user model? Is the software aiming at a single ‘median user’ or at a few different types? I should like to see user models explicitly discussed and the design of software centred on real needs.

The second question is: “Where is the

algorithm in the data analysis system?" Data analysis systems are, in some sense, simply a form of 'glue' holding the parts together. But their real value is associated with the core data analysis algorithms. It is therefore crucial, in my view, to develop and publicize algorithms and corresponding libraries with sample implementations of the algorithms.

The third question is: "Where is the language in which one can most conveniently express an algorithm?" Many programmers still view code as a collection of imperatives for a computer to obey, rather than as a means for expressing ideas about problem solution (cf. Abelson, Sussman & Sussman 1985, p. xv).

The fourth question is: "What granularity should an astronomical data analysis system offer?" In other words, should a system consist of general, comprehensive tasks with many control parameters and a complex internal logic? Or should it be a toolbox of small functions that can be effortlessly assembled to solve the specific data analysis problem at hand?

Another item largely neglected at the conference is the cost of software development which, compared to the cost of hardware, is high these days.

Conclusion

We see there are many topics, some of which hopefully will be discussed at the next "Data Analysis Software and Systems Conference" to be held at the Dominion Astrophysical Observatory, Canada, in autumn 1993.

References

Abelson, H., Sussman, G. J., & Sussman, J.: 1985, "Structure and Interpretation of Computer Programs", The MIT Press, Cambridge, MA; McGraw-Hill Book Company, New York.

Hanisch, R.J., Brissenden, R.J.V., Barnes, J. (eds.): 1993, *Proc. 2nd Annual Conf. on Astronomical Data Analysis Software and Systems* (ADASS II), Boston, MA, 2—4 Nov 1992, Astronomical Society of the Pacific Conference Series, (in preparation).

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Contents

Archive user registration

Obtaining authorisation to dearchive HST data

If you wish to have an account set up to dearchive HST data, please complete the form below and return it to us, on paper or via electronic mail. You will be assigned a unique username and password, which will be sent to you at the e-mail address specified on the form. You will be registered for one year. One month before expiration, you will be warned, so that you can renew the registration if you wish to do so. Any changes to the information given in the form should be communicated promptly so that we can take appropriate actions.

ST–ECF Archive Registration Form

☐ new registration ☐ renewal

First name: _
Middle initial(s): _
Last name: _
Title [Dr., Prof., Mr., Mrs.]: _
Institute: _
Address: _

Phone: _
Fax: _
Preferred E-mail address: _

User category:
- ☐ HST PI
- ☐ HST Co-I
- ☐ scientist
- ☐ post-graduate
- ☐ student
- ☐ other (specify): _

Preferred distribution medium:
- ☐ magnetic tape 1600 bpi
- ☐ magnetic tape 6250 bpi
- ☐ Exabyte cartridge
- ☐ DAT cartridge (not supported yet)
- ☐ Local Area Network (ESO users only)

FITS blocking factor (1–10): _

STScI NEWSLETTER

The Space Telescope Science Institute publishes a Newsletter at regular intervals (3–4 times per year). The STScI Newsletter contains information of interest to proposers, including updates on the status of the HST and its instruments. Subscriptions are available at no cost to all interested scientists; requests to be added to the mailing list should be sent (by regular or electronic mail) to the User Support Branch at the following address:

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3700 San Martin Drive
Baltimore, MD 21218
USA

E-mail: scivax::usb (SPAN)
usb@stsci.edu (Internet)
usb@stsci (Bitnet/Earn)

Requests should also specify whether the subscriber wishes to receive future Calls for Proposals.

News

Staff movements

In January we welcomed the new Director General of ESO, Riccardo Giacconi, who obviously does not need to be introduced to our readers! He has already reviewed the VLT project with great energy and he will, I am sure, move on to the ST–ECF and HST related activities. We will not be able to hide much from him there and his knowledge of HST and of the ST Science Institute will be a great asset in further improving our service to the community of HST users.

At the ECF we also had some staff movement: Bo Frese Rasmussen (Danish) joined the Archive Group last August; Wolfram Freudling (German), previously an ESO Fellow, joined the Science Data and Software Group in January, replacing Gustaaf van Moorsel who moved to NRAO last August. Almudena Prieto, an ex-ESA Fellow, moved to the nearby Max Plank Institute for Astrophysics after having spent over three years with us. Werner Zeilinger was awarded an Austrian Schrödinger Fellowship and joined the ECF in January.

The M & R mission

The preparation for the first Maintenance and Refurbishment Mission proceeds on schedule for a shuttle launch in early December 1993. Both COSTAR and WFPC 2 should be ready in time. What is becoming increasingly complicated is the schedule of EVAs (Extra Vehicular Activities) for the Astronauts, particularly after the failure of a third gyro. Last December we received a visit from Claude Nicollier, the ESA Astronaut who will be member of the shuttle crew on the M & R Mission. Claude, who is also a professional astronomer, was very interested in discussing with us the details of the spherical aberration problem. He has great enthusiasm to see that everything goes right with the installation of COSTAR and WFPC 2. Claude has promised to write an article for us—watch out in the next issue.

Advanced call for Cycle 4

Although the shuttle manifest for the M&R Mission has been rather stable during the last year, there is always the possibility of a last minute slip. For this reason the STScI must have an observing programme which can adapt to different scenarios. If the M & R is on schedule and the necessary verification activities proceed as expected, the GO and GTO observations for Cycle 4 will begin in March 94. Therefore the complex scheduling system of HST requires that Phase II information for Cycle 4 be at the STScI by mid-July 93. Hence the advanced issue of the Call for Proposal next March and the deadline for Proposal submission by May 14th, 1993. The STScI is considering some simplification of the submission procedures and it will also streamline the time allocation process, which should take place in July.

If everything goes smoothly, we should expect to see a Cycle 5 Call for Proposal in early 94 when most of the verification should have taken place.

In the event of a substantial delay in the launch of the M & R Mission, the STScI will gradually fill the schedule with medium priority and supplemental proposals which have been approved for Cycle 3.

Piero Benvenuti

We should like this Newsletter to reach as wide an audience of interested astronomers as possible. If you are not on the mailing list but would like to receive future issues, please write to the editor stating your affiliation.

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