ple of a custom designed CCD wafer is shown in Figure 1.

What is the major drawback of custom designed CCDs? With all their interesting advantages, they remain front illuminated devices with no sensitivity in the astronomically very important UV-blue spectral region. In his second talk at the workshop, J. Geary discussed the problem of CCD thinning and the companies/laboratories who have acquired experience in this field. Various mechanical/chemical processes of whole wafer or single cut CCD thinning have been used with different degrees of success. RCA more than ten years ago, Tektronix, EG&G Reticon, Thomson and EEV in the recent past have all successfully produced thinned devices with enhanced UV-blue sensitivity. Tektronix seems at present to be the only one who regularly masters the process on devices as large as 50×50 mm. Thinning experiments are also carried out at the CCD Lab of Mike Lesser at Steward Observatory, at the lab of Danbury Optical Systems and at the David Sarnoff Research Center. These are potential addresses for CCD customers with a batch of printed wafers to thin, but the rate of success and the cost of the process are still not well defined.

The final session was dedicated to the PRESENTATIONS FROM INDUSTRY. The participants had the opportunity to hear reports on the latest products from most of the major manufacturers of scientific CCDs, as shown in the list of talks on page 43. On the size of CCDs, the trend is clearly dominated by the need to maximize the number of devices which can be fitted on 10 cm wafers to reduce the costs. This explains the success of the 2048^2, 15-μm-pixel format which allows to squeeze 4 devices on one wafer as shown in Figure 1. Improved performance was also reported due to the progress in microchannel technology for a high CTE at very low light levels and the Lightly Doped Drain (LDD) on-chip preamplifier for lower noise and higher gain.

On the performance of CCDs that a potential customer can get now off-the-shelves of industry, we suggest to contact the commercial agents of the companies. As a provisional guideline, we give below a summary of the situation as obtained from our notes on the presentations and the data sheets distributed at the workshop.

EG & G has obtained good results with 1200 × 400, 27-μm-pixel thinned devices and is currently redesigning the chip support for improved flatness.

Thomson CSF has produced thinned devices in the 512^2 format and has made plans to develop a 2048^2, 17-μm-pixel, 3-edge-buttable, thinned device.

Tektronix announced the availability of their 2048^2, 24-μm-pixel, thinned, CCD for July 1991. The device is offered with a guaranteed performance and it appears the only one of this size available on short term. The price was not named at the workshop, but Tektronix is now willing to quote it.

Richard Bredthauer of the CCD laboratory of Loral presented their results on CCDs of different formats, like the 2048^2, 15-μm-pixel and the 4096^2, 7.5-μm devices.

EEV now delivers front-illuminated devices with up to 1242 × 1152 pixels (22-μm size) and has announced a 2186 × 1152 pixel CCD, buttable on two sides. They also obtained good results in thinning smaller devices.

Beside the presentations, the workshop offered many opportunities – including a nice dinner in Munich – to discuss the various topics, and to share know-how and expertise. We have the feeling that the meeting fully met its main goals, providing an updating view of the subject and favouring the collaboration between the different groups and with the industrial suppliers.

The Use of Photography in Astronomy:

Some Thoughts about Schmidt Telescope Wide-Field Work

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1. Introduction

During the past decade, a revolution has taken place in the field of astronomical detector techniques, and astronomers all over the world are profiting from new digital devices like CCDs and photon-counting detectors. Indeed, it might appear that photography, previously so widely used in astronomy, will soon be a thing of the past in professional work, no longer of any value in front-line investigations.

Among the various types of ground-based astronomical instruments now in use, none has been more intimately connected to the development of improved photographic methods over the past decades than the large Schmidt telescopes. The future of the photographic detector in astronomy is therefore largely dependent on its useful application at Schmidt telescopes. In this article I shall explore a question that is now being posed at many observatories: is it reasonable to continue to use photographic plates in Schmidt telescopes or has the time come to aim at a rapid implementation of CCD techniques, also here?

In this connection, it should be remembered that *"an astronomical instrument is only as good as the scientific results it produces"*. This maxim is not always kept in mind and around the world there are quite a few examples of "senior" telescopes with associated methodology which for sentimental or traditional reasons continue to be in use, long after it has been shown (in other places) that their ability to produce good science of current relevance has begun to decline. Moreover, it is not always fully appreciated that it is the *science* resulting from an instrument that defines its current value in a global context, not the *technology* it employs.

In addition to the fundamental limitations imposed by the funds available in any one place, there may of course be other, perfectly valid reasons, for instance long-term continuity of observational programmes and the availability of well-established calibration systems, which makes it advantageous to keep using certain telescopes, auxiliary instruments and associated methods, also well beyond their prime years. However, in the ideal case, and certainly for most front-line research programmes, it is clear that failure to adopt new and improved technology and observational methods will eventually result in slower scientific progress and ultimately, in falling behind the rest of the world. It is also a question of the real cost of the observational data – if from a certain moment a new method allows the same astronomical information to be gathered at significantly lower expense in time and manpower, then a change-over ought to be seriously considered.

The question above can then be reformulated: would the introduction of CCD techniques in Schmidt telescopes enhance their ability to produce good science?

The most important, intrinsic properties of the photographic and CCD techniques are compared in Table 1.

Both types of detector demand very careful handling. To ensure the best use of CCDs, it is necessary to obtain bias, flat-field and dark frames, and the elimination of artificial and natural blemishes, e.g. cosmic-ray events, implies time-consuming work which is not necessarily "easier", but perhaps better controllable than the delicate hypersensitization and processing of photographic plates. In this connection, it is an interesting fact that only the photographic emulsion is at the same time detector and storage medium and that therefore the important question of complete archiving of the raw observational data for the benefit of future users is *a priori* taken care of in photography.

On the other hand, the digital output from CCDs is perfectly suited for direct input to computers, thereby streamlining the reduction procedures and, above all, eliminating the need for a preceding transfer from analogue density to digital numbers via more or less noisy registration devices.

It is therefore clear that the main advantages of the photographic plate over the CCD are *its larger size and the ease with which the observed data can be archived.* Within the foreseeable future, no CCDs, not even mosaics, can be expected to approach the field size and thereby also the total information storage capacity of large photographic plates.

But are these advantages important enough to warrant further use of the photographic method in existing large Schmidt telescopes? Would it not, with the shorter exposure times needed, be possible to cover the same total sky field in the same time with multiple CCD exposures? And why should we continue to use photographic methods at large Schmidt telescopes, when the digital detectors are so much more accurate and "clean"?

As we shall see below, a more detailed analysis indicates that *the photographic technique is still superior for wide-field, high angular resolution Schmidt work.*

TABLE 1.

	Photography	CCD
Quantum efficiency	max. 4 %	70–80 % at peak sensitivity
Size (pixels)	$> 20{,}000^2$	max. $2{,}048^2$
Response	non-linear	basically linear
Dynamic range	$\sim 10^3$	$> 10^4$

Comparison of the most important, intrinsic properties of the photographic and CCD techniques (optical region; status 1991; a 15-μm "pixel" size is assumed for the photographic plate, corresponding to 1 arcsec in telescopes of the F = 3-metre class).

2. Current Use of Schmidt Telescopes

All of the world's large Schmidt telescopes (e.g. with aperture above 50 cm) currently rely on the use of large photographic plates, which permit the simultaneous registration of direct images or slitless (objective prism) spectra of objects in sky fields of the order of $5° \times 5°$ or larger, with angular resolutions that in most cases are equal to the instantaneous local seeing.

Schmidt plates are used for a great variety of astronomical programmes. Some of these do not fully take advantage of the large field which is the main virtue of Schmidt telescopes, and could well be carried out with other instruments. There are in the literature many examples of research programmes with photographic Schmidt telescopes which are concerned with individual objects whose small angular dimensions would make them fit into a normal CCD frame. In these cases, it would clearly have been more efficient to use the CCD technique at another telescope, although such an instrument may not have been accessible to the astronomers concerned.

"Narrow"-field Schmidt work will not be further considered here and in what follows, I shall restrict myself to *sky surveys* (coverage of a major part of the sky, often in several colours) and *sky patrols* (repeated coverage of the same part of the sky).

Schmidt plates, whether obtained for large sky surveys or for less comprehensive programmes, and whether originals or high-fidelity copies, serve several scientific purposes, of which the following are particularly important:

- Record for later research (e.g. to check the previous behaviour of an object of current interest)
- Inventory of objects in a particular sky area (e.g. to produce catalogues of all objects with particular characteristics)
- (Optical) identification of objects (radio, X-ray, gamma-ray . . .)
- Serendipitous discoveries (e.g. of minor planets, comets and variable objects)

Astronomical observations, including those made with Schmidt telescopes, provide different types of information (data) which may be classified into a number of natural areas (not necessarily in order of perceived significance):

1. Discovery of new objects
2. Astrometric positions (α, δ) of individual objects
3. Photometric intensities of the radiation I (λ, $\vec{p}$) received from individual objects
4. Detection and characterization of temporal variations in position (μ_α, μ_δ) and intensity (light curves) of individual objects
5. Identification of larger structures and their surface characteristics, including higher-order clustering of individual objects

How well is the wide-field Schmidt photographic technique doing in these areas?

1. Discoveries. There is little doubt that Schmidt surveys in different colours, direct or through an objective prism, as well as Schmidt patrols, constitute one of the most successful techniques of identifying (i.e. discovering) particularly "interesting" new objects, due to the ability to cover large sky fields at high angular resolution and at regular time intervals. A well-known example is the Palomar 48-in Schmidt (Oschin) telescope with which large quantities of peculiar objects have been identified for subsequent, detailed studies with the 5-m Hale telescope. Most new minor planets and a large fraction of the new comets are still found on Schmidt plates and all major surveys of particular objects, e.g. emission-line stars, planetary nebulae, galaxies and galaxy clusters, continue to be based on Schmidt plates. Some discoveries also include the archival use of Schmidt plates; a recent example is the identification of the progenitor of the bright supernova 1987A in the LMC with a surprisingly blue colour and early-type spectrum; this "observation" had a direct impact on model calculations of late evolutionary stages of heavy stars.

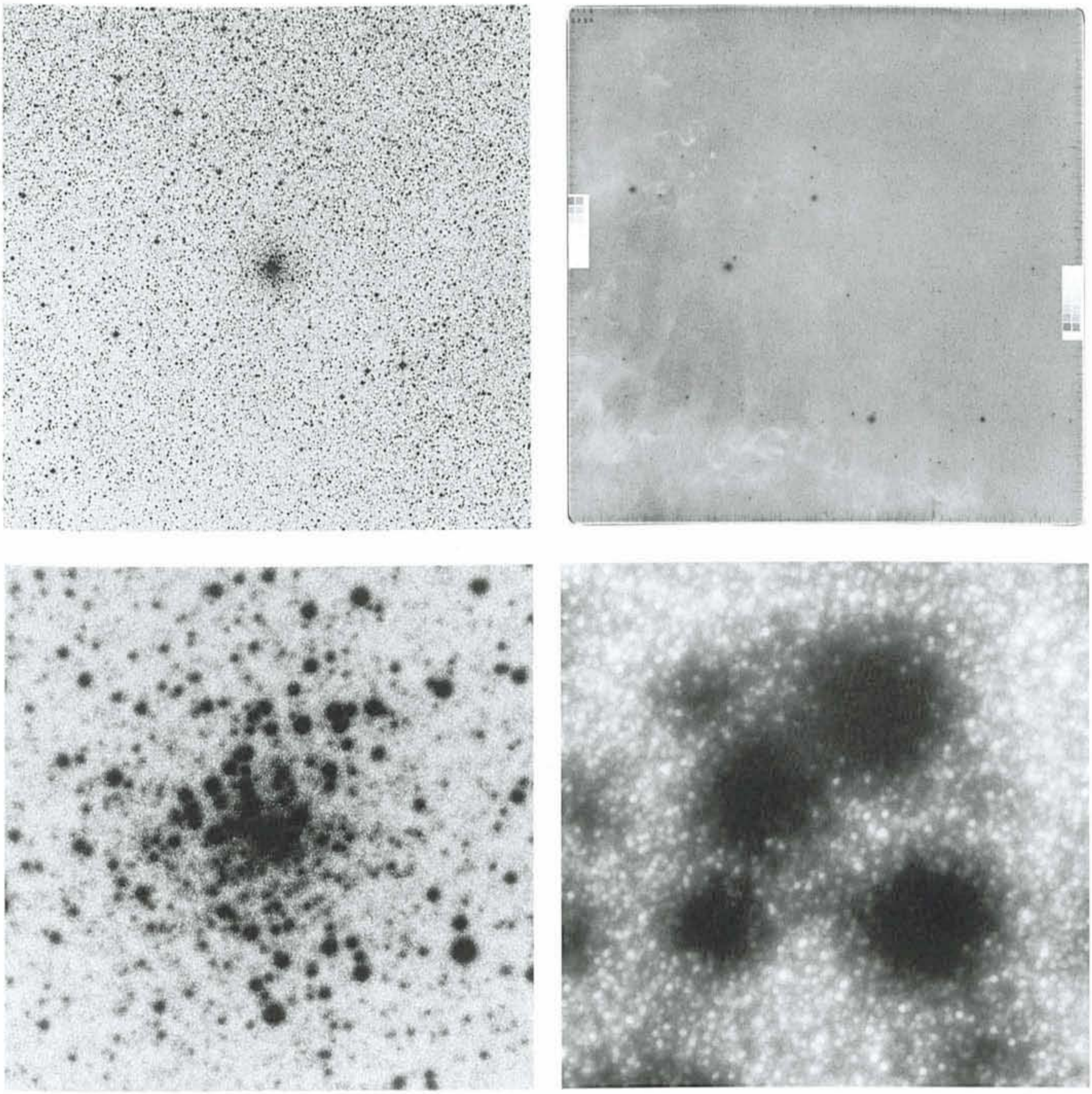

Figure 1: *The enormous amount of information contained on a single Schmidt plate is illustrated by these four images, which were reproduced from an exposure of a sky field in the Milky Way band, obtained with the 1-metre ESO Schmidt telescope on a red-sensitive emulsion (Plate 5714; ESO/SRC field 519; 120 min; 25 July 1984; seeing ~ 1 arcsec). The full plate measures 30×30 cm (upper right) and covers a sky area of 5.6×5.6 degrees. The other three images (counterclockwise) are 3.6×, 36× and 360× enlargements of an area near the globular cluster NGC 6325, seen above the centre of the plate. The field edges measure 1600, 160 and 16 arcsec, respectively; and the total plate area corresponds to 160, 16,000 and 1,600,000 such fields. The limiting magnitude of this ESO(R) plate is about 22. Observer: O. Pizarro. Photographic work: H. Zodet.*

2. Astrometry. Due to the absence of an all-sky, accurate astrometric net with sufficient density for CCD work (~ 1 star per square arcmin) – the HST Guide Star Catalogue may be well suited for guiding purposes, but not for astrometry at the sub-arcsecond level – the only existing method for the determination of accurate astrometric positions of objects too faint to be observed with meridian circles is to use Schmidt plates on which a sufficient number of bright astrometric standards are visible. The absolute position of a faint object (e.g. in the FK5 system) must either be measured directly on a Schmidt plate or, if it is only visible in a narrow-field, deep CCD frame, by transfer of local secondary standards from a Schmidt plate to the CCD field.

3. Photometry. Absolute photometric accuracies of the order of ± 0.07 mag can normally be achieved on well-exposed photographic plates for point-like objects which are at least 3 mag above the plate limit. It is possible to improve this value somewhat by having many photometric standards in the immediate area, but the intrinsic non-linearity of photography and the need to establish a unique intensity calibration for each plate restrict the ultimate level of precision. This compares to ± 0.01–0.02 mag in good CCD frames (total counts per object > 10,000) and illustrates an important limitation of the photographic method. However, the possibility to measure on the same plate a very large number of objects makes Schmidt photometry ideal for statistical investigations which do not demand the highest accuracy.

4. Variability. Photographic Schmidt exposures are a rich source of discovery of variable objects and a base for many long-term variability studies. They include photometric variability of quasars over many decades, the large-scale investigation of variable stars in selected Milky Way fields and, in particular, the identification of faint, high proper-motion objects, e.g. white dwarfs. So far the variability has most often been established by the use of blink comparators, but more recently automatic methods (computer-"blinking") have begun to produce important results.

5. Large Structures. The identification and study of large structures, like Milky Way cirrus and clusters of galaxies at intermediate distances, is obviously facilitated by the availability of wide-field exposures. The importance of all-sky work is amply illustrated by the scientific impact of satellite observatories like IRAS and ROSAT; it has a direct bearing on the study of the largest structures in the Universe and its evolution. While the CCD technique lets us study the finest details in individual objects, the establishment of large samples with clean definition criteria is only possible with wide-field instruments. When combined with the high angular resolution and comparatively faint limiting magnitude of present, large Schmidt telescopes, it is also possible to observe at the same time smaller details within larger structures; some examples are the overall structure of the Gum Nebula, the intricate network of thread-like nebulae in the area of η Carinae, and the complex of interstellar reflection nebulae, near the south celestial pole. In this connection must also be mentioned the objective prism technique, which makes it possible to obtain large numbers of spectra of stars and small nebulae simultaneously and which is unsurpassed for deep studies of the overall stellar distribution in the Galaxy.

In summary, it is obvious that photographic wide-field observations with Schmidt telescopes play an important role in current front-line observational astronomy and would also continue to do so in the near future.

3. Limitations of the Methods

It is now of interest to look more closely at the critical limitations which are inherent in the two types of detectors in order to better judge how the introduction of a CCD into one of the existing large Schmidt telescopes may influence its observational potential.

It is important to emphasize that here it is not the question of installing a small CCD chip into a large Schmidt telescope; this would immediately rob it of its unique wide-field capability, the importance of which has been demonstrated above. Nor is it likely that it would be technically feasible to have a dual system, with the possibility to change between large plates and the CCD camera and its cooling system. The mechanical adjustment of a large Schmidt telescope is extremely critical and frequent exchanges would most certainly lead to inferior performances. Present Schmidt telescopes are obviously optimized for photography, but it would of course be interesting to construct smaller, intermediate-field instruments which are optimized for the largest available CCDs.

3.1 Photography

Regular users of Schmidt telescopes are well aware that in wide-field work, the quality and the astronomical value of the photographic plates depend on a very large number of factors, not all of which can be fully controlled. In the case of sky surveys, of which those in the northern (Palomar) and the southern sky (ESO and UKST) constitute the most comprehensive observing programmes presently undertaken with photographic Schmidt telescopes, the quality of the final product, i.e. the Atlas copies, is among others influenced by the seeing, the mechanical performance of the telescope, the processing and copying of the plates and the archival conditions.

Lack of technological progress. Perhaps the most serious problem in present-day astronomical photography is that for quite a few years, no new, improved emulsions have become available; the latest major advance in the photographic field was the introduction of the IIIa emulsion in 1970, followed some years later by the TP-2415 emulsion. Likewise, most of the photographic techniques which are now in use were already fully developed more than 10 years ago. Thus the field of astronomical photography, in the technical sense, is in a period of stagnation, with correspondingly little incentive to new investments in photographic techniques by the observatories. This is also reflected in the decision not to include any photographic equipment in the new generation of super telescopes, for instance in the ESO 16-m Very Large Telescope, even though the large focal fields could only be fully covered by a photographic plate. The use of multiple-slit techniques, e.g. in the planned fibre optics spectrographs, will only permit the simultaneous registration of a minuscule fraction of the light that is collected and focussed by the telescope.

Extraction of information. Next, the extraction of information from photographic plates has always been a bottleneck in Schmidt work. However, there are positive developments. During the past years, it has been increasingly realized that photographic plates contain a greater wealth of information than thought before, and that their potential has not been exhaustively exploited in the past. This is demonstrated by the impressive results obtained with the photographic amplification, masking and stacking techniques which now make it possible to recognize and measure extremely faint objects which cannot be perceived by direct, visual inspection or even by microphotometric measurement of the plate. At the same time, much effort has been put into improving the extraction of data from photographic plates by means of fast scanning microphotometers, but there are only a few devices in the world in the technological front-line which are also in regular use. Main areas of future improvement are increased speed and extension of the dynamical range by means of better sources of illumination and faster A/D converters.

Archival storage of photographic plates. Photographic plates are stored under very different conditions at the world's observatories. While some plate vaults have advanced climatic control, in other places plate libraries form part of book libraries and the plates are therefore subject to variable temperature and humidity. Old envelopes are often dangerous to plates, since they contain traces of bleaching and/or colouring agents. It is unfortunately also true that not all plate archives profit from an associated efficient retrieval system and at some observatories there is no access to the plates for outside researchers.

In this connection, there are interesting developments which aim at the digitization of existing photographic sky surveys, although it is not yet technically possible to store the complete information of a major sky survey in digital form at an affordable cost. However, the availability of computer-readable digital copies with less resolution and smaller dynamical range than the original survey plates will be very useful for many purposes, e.g. the preparation of finding charts for observations.

3.2 CCDs

When compared to photography, the main drawbacks of the CCD technique are the smaller frame size and the archival problems, while the total cost may play a smaller role.

Field size. The currently largest CCDs in common use in astronomy have 2000 × 2000 pix^2 fields. 4000 × 4000 pix^2 arrays have been experimentally tested but it will still be some time before a reasonable number become available. It seems realistic that mosaics of up to four 2000 × 2000 pix^2 CCDs may be available to observers in five years time. Such a device would cover about 1/25 (~ 1° × 1°) of the Schmidt field. With the present sensitivity ratio (e.g. 75 : 3), the total CCD exposure time necessary to cover the same field to the same limiting magnitude as one photographic plate would be similar; this however, does not take into account the non-negligible read-out time (probably 25 × 2 to 3 min) of the enormous data quantities. The curved focal field in present Schmidt telescopes may be another obstacle. In the ESO f/3 Schmidt, the focal position is critical to within ~ 10 μm, compared to a curvature of ~ 25 μm from the centre to the corner of a 3 × 3 cm^2, 2000 × 2000 pix^2 CCD chip; this may necessitate the insertion of a field flattening lens. The proper recombination of the individual frames into a larger unity, when needed, may also constitute an added difficulty.

Archiving. Probably the most serious problem is that there is still no cheap, universally available storage medium for CCD data. Magnetic tapes are still used in most places to provide a temporary record of raw CCD data and the rapid accumulation of these tapes, in particular because most CCD exposures are comparatively short, is of major concern in many places, including the European Southern Observatory. Unless the tapes are transcribed to a more stable medium, e.g. optical disks, it must be feared that a significant fraction of the valuable data will become unreadable and therefore lost within a few decades. Also the long-term stability of optical disks is still relatively unknown. The problem of organizing and retrieving information in a data base of several Tbytes should not be underestimated either.

Cost. A complete, top-quality CCD system for use in astronomy implies a capital expense that may exceed US$ 100,000, and therefore be beyond the financial reach of most smaller observatories. A CCD can of course be used to obtain an unlimited number of frames, and when the total costs are calculated, the need for archiving of the CCD data must also be taken into account. This involves the time-consuming transfer to the final storage medium and the cumulative cost of magnetic tapes and/or optical disks as well as the associated computer hard- and software. Although in photography the capital investment at the telescope and in the plate processing laboratory may be smaller than the above figure, the total costs are not necessarily so. The 1991 price of one 14 × 14 inch spectroscopic plate is below 100 US$, but in recent years Kodak has repeatedly increased its prices for astronomical emulsions. For a qualified astronomical exploitation of the plates, it is furthermore necessary to acquire (or have access to) a fast measuring machine and a photographical laboratory equipped for advanced plate manipulations.

Conclusions

In summary, it appears that *the photographic technique has virtues which make it better suited than CCDs for wide-field, high-angular resolution Schmidt telescope work, at least until further notice.* Notwithstanding the shortcomings of the photographic plate, its large size and archival properties make it indispensable for the permanent recording of large sky areas during optical sky surveys and patrols. As mentioned above, there is a great current interest in all-sky work and the intimate collaboration between such instruments working in different wavebands, on the ground and from orbiting satellites, is absolutely necessary for the study of the largest structures in the Universe and therefore of its evolution.

For more than 100 years, the photographic technique has guaranteed a continuous record of the visible sky, of

Figure 2: *An astronomical plate archive. Each cupboard in the ESO plate vault at the Headquarters in Garching contains up to 1,500 Schmidt plates. The plates have been processed to the strict ANSI archival standards with a minimum content of residual active silver in the emulsion. The temperature and the humidity in the vault are strictly controlled, and accelerated aging tests indicate that the images on these plates will remain virtually unchanged during many centuries. It is, however, likely that they will be digitized some time in the (not very near) future, once sufficiently compact and equally stable storage media for digital data have been developed. Photograph: H.-H. Heyer*

immense and lasting value for astronomical research, now and in the future. Sky surveys and patrols must continue, lest future generations of astronomers will blame us for not having done our historical duty. When carefully processed and properly stored, photographic plates can last for centuries, while there is at the present no guarantee that even a fraction of the many CCD frames obtained during the past ten years will also be accessible, say, 100 years from now.

It must be stressed that the present conclusion does not apply to work at lower angular resolution and with smaller instruments; there are several examples of the great utility of wide-angle CCD work, for instance the extensive monitoring of Comet Halley's CO^+ tail with a 640 × 1024 pix^2 camera at La Silla in 1986. *It would be highly desirable in the future to complement large Schmidt surveys with very-wide field patrol exposures by specialized low-resolution CCD cameras.*

There is little doubt that CCDs and other digital detectors will ultimately replace the photographic plates in all instruments, and also in the large Schmidt telescopes. But this step should only be taken when these detectors have become big enough not to compromise the efficient and exhaustive exploitation of the unique scientific capabilities of wide-field Schmidt work and when the CCD archiving problem has been satisfactorily resolved.

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CASPEC's New Look

L. PASQUINI and A. GILLIOTTE, ESO, La Silla

1. Introduction

CASPEC, the 3.6-m Cassegrain Echelle Spectrograph, is one of the 4 high-resolution (HR) spectrographs presently available at La Silla. Together with the EMMI high-resolution mode, CASPEC is the only HR spectrograph capable of reaching relatively faint objects and, thanks to the crossdispersed orders, to record large wavelength ranges (up to 1400 Å in the present configuration) in only one frame. Since the high-resolution mode of EMMI is available in the RED arm only (i.e. for wavelengths redder than 4000 Å) CASPEC will probably remain for the next years the only HR spectrograph available at La Silla capable of reaching faint objects in the BLUE and in the near UV. Recently it has been successfully used at wavelengths as blue as 3130 Å (Baade and Crane, 1991).

ESO has started a programme to upgrade the instrument in order to increase the performance of CASPEC; we report here the recent improvements and we anticipate some of the changes foreseen before the end of the year. For a general description of the instrument the reader is referred to the ESO CASPEC Operating Manual (Pasquini and D'Odorico, 1989).

2. The New Detector

Since September 1990 a new detector is available for CASPEC: it is a 512 × 512 Tektronix chip (ESO CCD 16), with a pixel size of 27 × 27 μm. Its characteristics and response curve are given in Figure 1 (Sinclaire, 1991).

This chip is in several aspects much better than the old RCA 8, previously mounted on CASPEC; in particular:

- It has a larger format, which allows a wavelength coverage up to ~ 1400 Å in one frame.
- It has a lower Read-Out Noise (RON) (~ 10 e^- compared to ~ 28 e^-). This greatly increases the instrumental performance for low S/N observations, where the RON is the dominant source of noise.
- It has a very good cosmetic, no offset columns and no interference fringes; all these characteristics are essential for the correct reduction of Echelle data.

The efficiency of CASPEC with the 31.6 lines/mm echelle plus short camera and CCD 16 was measured through wide slit (4 × 4 arcsec) observations of the standard star Feige 56 (Stone, 1977); results are presented in Figure 2. We note that, in order to compute the data points of Figure 2, the echelle orders were not merged: electrons at wavelengths appearing in more than one order were measured separately and then added up.

The CCD response curve shown in Figure 1 was obtained after UV flooding, a procedure which enhances the detector sensitivity at wavelengths below ~ 4300 Å. When the efficiency tests were performed, the UV-flooding was not properly working; as a consequence, the points of Figure 2 in the Blue and UV ranges must be considered only as lower limits to the real instrumental efficiency.

The points of Figure 2 must be taken as indicative only, because when considering a real science exposure, possible slit losses must be taken into account. With this configuration, however, these losses are not expected to be very important; in fact, a good spectral sampling (2 pixels FWHM) is obtained with a slit width of ~ 300 μm, which corresponds to 2.12 arcsec on the sky. This aperture is much wider than the typical seeing registered at the 3.6-m telescope.

In Figure 3, the expected S/N per pixel as a function of the integration time and the stellar magnitude is shown (continuous lines). In our calculations the stellar light was considered to spread over 3 pixels in the direction perpendicular to the dispersion (one Tektronix pixel corresponding to 0.648 arcsec in the sky with the short camera) and an airmass equal to 1. We fixed the CCD RON to 10 e^-/pixel (instead of the nominal 8.8) because this value seems to be the most common at the telescope.

In Figure 3 are also plotted similar curves computed for the RCA (dashed lines, Pasquini and D'Odorico 1989); despite the lower quantum efficiency of the Tektronix with respect to the RCA, its bigger pixel size and lower RON allows to reach fainter objects.

The new chip, on the other hand, suffers some limitations, the knowledge of which is important for the users:

- The 27 μ pixel size limits the maximum achievable resolving power to R ~ 18,000 with the Short Camera.
- With the Long Camera a resolving power almost two times higher can be obtained, but with no order overlap. In such a configuration, in fact, the portion of the spectrum covered by each order is only 46 % of the wavelength ranges reported in the Thorium-Argon reference spectrum (D'Odorico et al., 1987). By tilting the crossdisperser it is possible to observe any portion of the orders (i.e. not necessarily the central part), but this adjustment can be made only in the afternoon, during the set-up procedure and it cannot be changed by the observer during the night.