FIRST RESULTS WITH AN ELECTRONOGRAPHIC CAMERA USED AT THE PRIME FOCUS OF THE C.F.H. TELESCOPE IN HAWAII

J.P. Picat and Groupe Caméra*
Groupe Caméra (Groupe de Recherche n° 24 du C.N.R.S.)
Observatoire de Meudon, France.

ABSTRACT: First results have been obtained with an electronographic camera used at the prime focus of the C.F.H. Telescope in Hawaii. The camera is briefly described. It is an electronic camera with a new technological design and a tight valve allowing the recovery of the nuclear plates without destroying the photocathode. Some preliminary results are given.

INTRODUCTION

Up to now, the only two-dimensional detector which preserves spatial resolution and photometric accuracy over a large field of view is the electronic camera. Using magnetically focused optics it is possible to obtain resolution as high as 80 lp/mm on a field of 80mm (or more). Dr. Wlérick has reported on the magnificent camera developed at the Paris Observatory in the Lallemand Laboratory (see the paper by Wlerick et al. in these Proceedings).

Although electrostatically focused cameras may not give such good image quality they can be handled more easily for prime focus observations. Our group has specially designed such an electronic camera (CEV) for use at a prime focus. The camera is normally used head-down but small changes can be made to it to work head-up, for example at a Cassegrain focus.

DESCRIPTION OF CAMERA

The scheme of the camera is given in Fig. 1. It is a Lallemand Camera, with photocathode, optics, and nuclear plates in the same vacuum chamber. It differs from previous models in the technology used

*Groupe Caméra: J. Baudrand, R. Bellenger, M. Cailloux, A. Chevillot, F. Crifo, J.P. Dupin, P. Felenbok, J. Guérin, C. Jouan, J.P. Picat, I. Raulet, G. Rousset.

C. M. Humphries (ed.), Instrumentation for Astronomy with Large Optical Telescopes, 305–310.

https://doi.org/10.1017/S0252921100083688 Published online by Cambridge University Press

for its construction and by the presence of a valve between the optics chamber and the plate-holder.

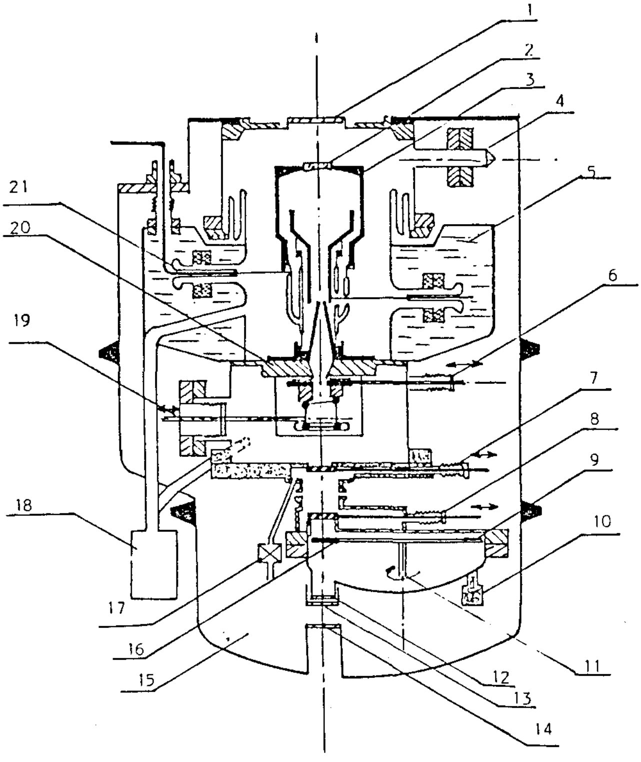

Figure 1

The photocathode (labelled 2 in Fig. 1) is prepared outside the tube in small glass ampules by the "Service des Cellules" of the Paris Observatory and then transferred in vacuum conditions into the camera. At the present time, the photocathodes are 30mm in diameter but their size will be increased to 34 x 40mm in the near future. The electrostatic optics were designed by M. Duchesne and are used at a magnification of about one.

The tight valve (20) allows recovery of the nuclear plates without destroying the photocathode. In its standby mode, the photocathode is kept at room temperature in the camera and the ion pumping system (18) prevents the photocathode from being poisoned by outgassing from the optics chamber. The quantum efficiency of the photocathode can be maintained for several months without noticeable degradation. The camera is cooled only for observations. A liquid nitrogen vessel (5) surrounds

https://doi.org/10.1017/S0252921100083688 Published online by Cambridge University Press

the optics compartment and cools the photocathode, the walls and the nuclear emulsion plates. The high voltage connections (21) are insulated by the liquid nitrogen and allow the camera to be used at high altitude without problems due to electric discharges.

The plate-holder (11) can be removed from the camera when the valve (20) is closed. Two additional valves (7 and 8) allow the plate-holder to be changed in bright light and preserve the cleanliness of the valve chamber. Fourteen plates can be used on each plate-holder. A clear fifteenth position allows the electronic image to be formed on a phosphor screen (16) which can be viewed through windows (13) and (14). It is then possible to determine precisely the best focusing conditions of both the telescope and the electronic camera by observing a stellar image.

The tight valve acts fairly well. The same copper gasket -pressed against a knife edge by the wedge system (19)- can be used for many closing and opening operations. If necessary, it can be replaced under vacuum conditions without destroying the photocathode. Usually this operation is not necessary during an observing run.

OPERATION AT PRIME FOCUS

The camera is remotely controlled from the observation room by a Motorola microprocessor Z80. Since the field acquisition, focusing operations and guiding are also performed remotely, an operator is not required in the prime focus cage during observations. Function status displays are presented on a video screen. Available functions are:

- adjustment of the accelerating and focusing high voltages from 0 to 30kV with a 10^{-4} accuracy,
- positioning of the plate-holder,
- control of the exposure time,
- positioning of a filter wheel in front of the camera.

The recovery and change of the plate-holder are done on the telescope. Changing the plate-holder takes four hours so that the camera is ready to be used, after cooling, at the end of the afternoon. The plates taken during the night may be scrutinized by the astronomer at the beginning of the afternoon so that the following night can be used in the best conditions.

CAMERA PERFORMANCE

The field curvature of the electronic optics is compensated by curving the entrant optical image by means of a single divergent lens on which is deposited the photoemissive coating. At a resolution of 30 lp/mm the measured modulation transfer is 50% over a field of 10mm. The change in radial magnification due to distortion both by the divergent lens and by the electron optics is 1.5% at 10mm from the optical axis.

https://doi.org/10.1017/S0252921100083688 Published online by Cambridge University Press

At that distance, magnitudes of extended objects must be corrected by 0.07 mag.

The background level on a resolved element of $1000 \mu m^2$ for a 1 hour exposure is always below 50 electrons, which means a r.m.s. fluctuation less than 7 electrons. In very good conditions this figure can be reduced to less than 3 electrons. The measurable dynamic range of the camera is about 300 but it is always possible to measure very faint signals close to bright objects since there is no electron scattering in the nuclear plate.

A useful way of defining the photometric quality of detectors is to determine the limiting magnitude obtainable in a given exposure time, for a given seeing, on a given telescope. For a 1 hr exposure we measure -in the field of Mrk 478- in the V spectral band a limiting magnitude of 25.2 with seeing of 1.4" (FWHM of a star profile). The sky magnitude was measured as 21.2 per square arc second.

FIRST OBSERVATIONS AT THE C.F.H.T.

Several observations with the camera have been performed in the UBV photometric system or in narrow spectral bands using interference filters. Up to now only S11 photocathodes have been used. In the near future S20 photocathodes will also be available.

Observational data obtained with this camera are now in the process of being reduced by the various astronomers responsible for the scientific programs. We give here some examples of the most recent results:

Observations of gravitational lens effects have been made on the double quasar (Q 0957 + 501) and on the triple quasar (Q 1115 + 080). These observations have been performed in the U, B and V bands for spectrophotometric studies of each component and to determine the position and magnitude of the deflecting galaxy.

Figure 2 shows the decomposition of the double quasar into two star-like components and one extended galactic component. The photometry has been done around the year with a periodicity of about 2 months and has allowed the brightness variations of each component to be studied (Vanderriest et al., 1982)

Figure 3 is a picture of the triple quasar. The exposure-time is 1 minute in the V band. The three components are very well resolved and the A component is asymmetric, as expected from theory (Young et al., 1981).

Figure 4 is a picture of the Orion Nebula observed in the line 5007 Å (OIII) through an interference filter 12 Å wide. The exposure time is 2 minutes and the image quality measured at mid-height of a star profile is 1 arc second. On this picture, it is worth noting that the

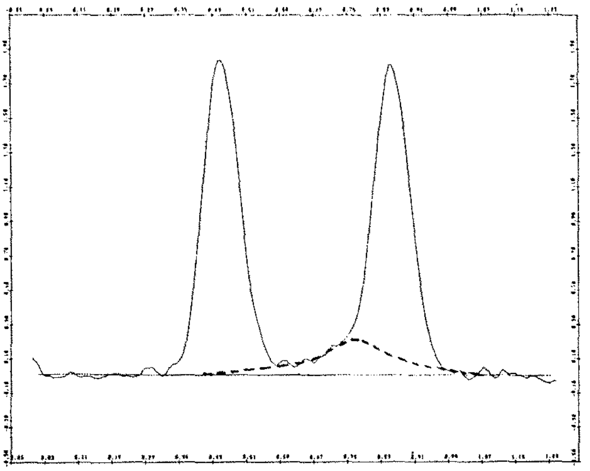

Figure 2

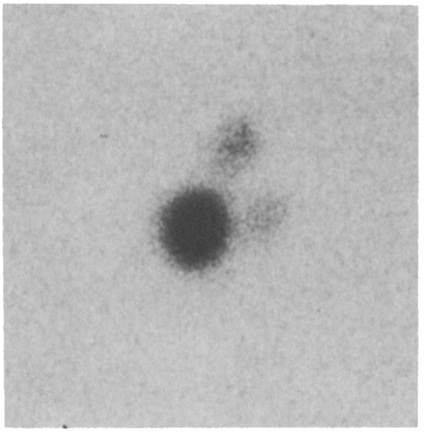

Figure 3

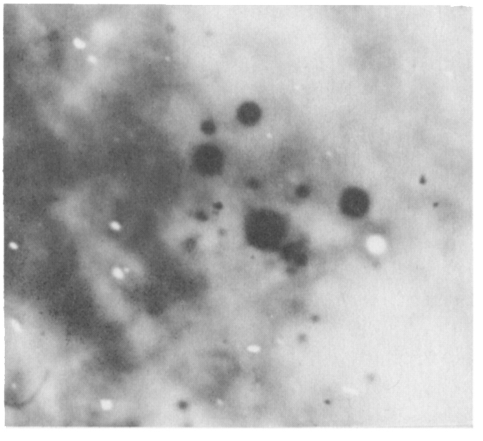

Figure 4

bright star A is of magnitude 4.6 and that it is possible to measure nearby regions even if it is not possible to measure the A star itself. A set of exposures have been taken in OII (3728 Å), OIII, Hβ and HeI (5876 Å) to study the small nebular condensations (Laques and Vidal, 1979).

Figure 5 is a 1 hr exposure of Mrk 478 in V. A limiting magnitude of 25.2 has been measured on this picture. Note that the nebulosity extends very far from the core (the nebulosity will be measurable even farther than shown because of the low contrast of the nuclear plate).

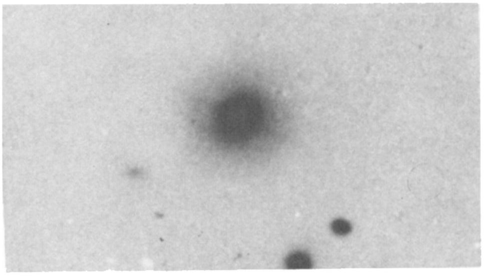

Figure 5

CONCLUSIONS

The camera has been shown to work well under remote control at the prime focus of C.F.H.T. The resolution is sufficiently high over a relatively large field (7 arc minute) to preserve the high quality of the telescope and of the seeing, and the field is generally large enough to include stars of the required magnitude for calibration. A particular advantage of electronography is the ability to measure faint brightness levels very close to bright objects, as illustrated in Fig. 4 and 5. The camera can be used for short and long exposures as there is no read-out noise, a very low noise background and very few cosmic ray traces.

Plate reduction is not a real problem now with fast measuring machines like the PDS. If such an instrument was available at the telescope, pictures could be digitized within a few hours of the observations. We think that electronography will be required for many more years for two-dimensional imaging in the visible range with good photometric accuracy over a large field. These qualities are well suited for use of the camera at the prime focus of the Russian 6m Telescope using a focal reducer.

REFERENCES

Laques, P. and Vidal, J.L. 1979, Astron. & Astrophys. 73, p.97.

Young, P., Deverill, R.S., Gunn, J.E. and Westphael, J.A. 1981, Ap. J. 244, p.723.

Vanderriest et al. 1982, Submitted to Astron. & Astrophys.

https://doi.org/10.1017/S0252921100083688 Published online by Cambridge University Press