The Future Utilisation of Schmidt Telescopes
ASP Conference Series, Vol. 84, 1995
J. M. Chapman, R. D. Cannon, S. J. Harrison and B. Hidayat (eds)

CCD Cameras for the Kiso 105 cm Schmidt Telescope

S. Yoshida, T. Aoki, T. Soyano, and K. Tarusawa

Kiso Observatory, Institute of Astronomy, University of Tokyo, Mitake, Kiso, Nagano 397-01, Japan

M. Sekiguchi

National Astronomical Observatory of Japan, Mitaka, Tokyo 181, Japan

M. Doi, N. Kashikawa, S. Okamura, K. Shimasaku, M. Yagi, and N. Yasuda

Department of Astronomy, School of Science, University of Tokyo, Tokyo 113, Japan

Abstract. We report on the status of the CCD cameras for the Kiso 105-cm Schmidt telescope. We have two types of cameras – single-chip and mosaic. The single-chip camera is available for common use. At present about 90 % of the telescope time is allocated to observations with CCD cameras.

1. Introduction

Equipping a large Schmidt telescope with a CCD brings us two important advantages over a CCD with a conventional reflector, that is, a wide field of view and a short exposure time to obtain deep sky-limited images due to the bright focal ratio of the Schmidt telescope. The wide field is a strong advantage for most kinds of survey observations, and it is also critical to the determination of an accurate sky level for extended objects such as galaxies. The short exposure time allows us a much more effective use of the telescope time.

The above remarkable advantages were recognized in 1987, when we attached a rented CCD camera to the Kiso Schmidt and made pilot observations (Iye et al. 1988). Since then the construction of a single-chip CCD camera and a more ambitious mosaic CCD camera for the Kiso Schmidt have been carried out. The single-chip CCD camera was made available in April 1993 as a common use facility to outside users, including those from abroad. The mosaic camera is still in an experimental stage. At present, a model with 16 1k $\times$ 1k chips is operational.

In this report, we describe the CCD cameras now being operated at the Kiso Observatory.

https://doi.org/10.1017/S0252921100021643 Published online by Cambridge University Press

2. Single-chip CCD camera

The single-chip CCD camera is placed at the prime focus of the Kiso 105 cm Schmidt telescope. It comprises a virtual-phase, front-illuminated CCD chip TC-215, manufactured by Texas Instruments of Japan. The chip has 1024 by 1024 pixels with a pixel size of 12 μm square; the effective imaging area is limited to 1000 by 1018 pixels. The camera covers a sky area of 12.5 arcmin square with a resolution of 0.75 arcsec/pixel.

For the CCD control and data acquisition, we use a system called MESSIA (Modularized Expandable SyStem for Image Acquisition) developed by Sekiguchi et al. (1992), which is a general-purpose CCD controller. The MESSIA system is based on VMEbus which is connected to the SBus of a Sun SPARCstation via a dedicated interface. The system reads out data as 16 bit integers, so one frame amounts to about 2 Mbytes. The CCD control software installed on a SPARCstation has automated procedure functions which enable us to make efficient observations.

The performance characteristics of the camera, which were measured in laboratory tests and actual observations, are summarized below:

read-out noise	$\sim 10e^-$ (dark room value)
	$\sim 13e^-$ (at telescope prime focus)
quantum efficiency	$\sim 30\%$ (from 4000 to 5000 Å)
	$> 40\%$ (from 5000 to 8500 Å)
	maximum $\sim 60\%$ (around 7000 Å)
dark current	$< 1e^-\text{hour}^{-1}$ (at -100°C)
linearity	deviation from linear is < 0.5 %
	when the count value is < 25000
charge transfer efficiency	> 0.99995 at > -120°C

In the R band, we can obtain a reasonably deep frame within 5 minutes, and a 20 minutes exposure makes the frame sky-limited. The limiting magnitude for a 20 minutes exposure is about 22.5 mag in the R band, which is about 2.5 mag fainter than that for photographic plates.

Since the single-chip camera was made available as a common use facility, a variety of research programs have been carried out with it. They include the determination of the rotation period of the comet P/Swift-Tuttle (1992t) (Yoshida et al. 1993), photometry of the supernova SN1993J (van Driel et al. 1993), imaging observations of nearby galaxies (van Driel & Buta 1993; Sofue et al. 1993; van Driel 1994). Several other programs are also in progress; e.g., light variation of asteroids, survey observations of carbon stars, investigation of color distributions in reflection nebulae. The use of a grism with the CCD camera has also been tested. A special project of this year will be the monitoring of the comet Shoemaker-Levy 9 before and during its collision with Jupiter.

As a project of the Kiso observatory staff, we are now collecting images of nearby bright galaxies in the $BVRI$ color bands to study the structure and color distribution. We plan to compare these data with those obtained with the near-infrared camera now under construction at Kiso observatory (Ichikawa et al. 1994).

3. Mosaic CCD camera

The mosaic CCD technology is indispensable for the exploitation of the wide field of view of Schmidt telescopes. The present mosaic CCD camera uses 16 TC-215 chips, the same chip used in the single-chip camera. The chips are arranged in an 8-by-2 array with a space between the chips. This camera was designed for exclusive use with the Kiso Schmidt telescope, with the CCD chips placed on the spherical focal surface of the telescope. This difficult alignment was achieved successfully. The MESSIA system is used for the camera control. The details of the design and performance of the camera are reported by Sekiguchi et al. (1992).

We can scan an area of $1^\circ\!.67 \times 3^\circ\!.33$, which corresponds to 8000×16000 pixels, with 15 exposures centered on grid points, which are chosen in such a way that the 15 exposures cover the scanning area with ample overlaps. The objects exposed in the overlapped region are used to define the zero point of the flux and a common coordinate system for the entire area.

The amount of data produced in one exposure is 32 Mbytes, and 480 Mbytes for a full scanning area. The total amount obtained in one night can reach 1 Gbyte, including calibration frames. We have developed a software system to handle these data quickly and effectively. With our software we can now perform the mosaicing of different exposures, detection and surface photometry of objects, star/galaxy separation, and rudimentary morphological classification of galaxies (e.g. Doi et al. 1993, Okamura et al. 1994).

The mosaic CCD camera is not fully available yet as a common use facility of the Observatory because its operation requires some guidance by the development group. The areas observed so far with the mosaic CCD camera include the Coma, A1367, and Perseus clusters of galaxies, and the north Galactic pole region. A study of the velocity distribution and the luminosity function of Coma and A1367 was made with the mosaic CCD data by Shimasaku (1994).

A second version of the mosaic CCD camera is now under construction, which can be used with any conventional reflector because the chips are placed on a flat plane. When it is used with the Kiso Schmidt, a field flattener will be installed in the camera. The CCD package for the new camera is more compact, and the gap between the chips is much smaller than in the present model, so only four exposures will be needed to map a complete area. The new model with 4×8 array will be completed in May 1994.

At present, about 90 % of the telescope time at the Kiso observatory is allocated to observations with these CCD cameras. Though the demand for observations with glass plates is not likely to diminish in the next several years, the construction and use of a new near-infrared camera will make the trend toward digital data acquisition with Kiso Schmidt even more pronounced.

References

Doi M., Fukugita M. & Okamura S., 1993, MNRAS, 264, 832

Ichikawa T., Tarusawa K., Yanagisawa K. & Itoh N.,1994, these proceedings

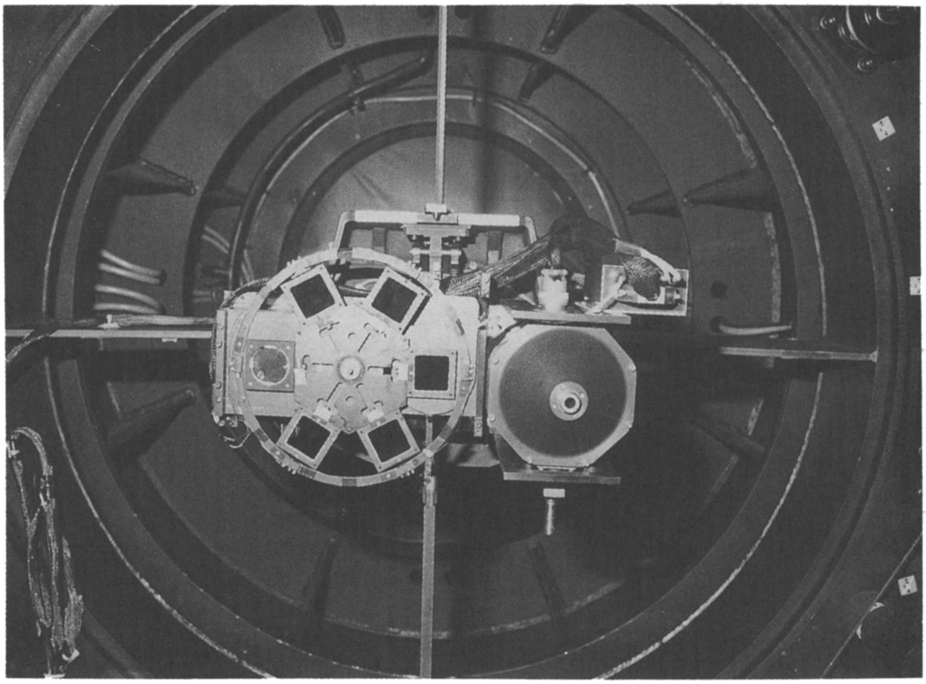

Figure 1. Single-chip camera attached to the Kiso Schmidt telescope

Iye M., Ichikawa S., Okamura S. & Takato N., 1988, *Big Bang, Active Galactic Nuclei and Supernovae*, S. Hayakawa & K. Sato, eds, (Universal Academy Press, Tokyo), p.187

Okamura S., Doi M., Fukugita M., Kashikawa N., Sekiguchi M., Shimasaku K. & Yasuda N., 1994, *Astronomy from Wide Field Imaging*, Proc. IAU Symp. 161, H.T. MacGillivray & E.B. Thompson, eds, in press

Sekiguchi M., Iwashita H., Doi M., Kashikawa N. & Okamura S., 1992, PASP, 104, 744

Shimasaku K., 1994, Ph.D thesis, University of Tokyo

Sofue Y., Yoshida S., Aoki T., Soyano T., Tarusawa K. Wakamatsu K., 1994, PASJ, 46, 1

van Driel W. & Buta R., 1993, PASJ, 45, L47

van Driel W., Yoshida S., Aoki T., Soyano T., Tarusawa K., Ichikawa T., Kakehashi T., Nomoto K. & Wakamatsu K., 1993, PASJ, 45, L59

van Driel W., 1994, these proceedings

Yoshida S., Aoki T., Soyano T., Tarusawa K., van Driel W., Hamabe M., Ichikawa T., Watanabe J. & Wakamatsu K., 1993, PASJ, 45, L33

https://doi.org/10.1017/S0252921100021643 Published online by Cambridge University Press

Discussion

Armandroff: Please comment on the amount of light obscuration by the mosaic CCD camera.

Yoshida: The main body of the camera is nearly completely hidden behind the plate holder support of the telescope. The electronics boxes and cryogen tanks protrude from the support, making additional light obscuration of 2%.

Florentin Nielsen: (i) Is the Texas Instrument of Japan 1k × 1k CCD commercially available? (ii) Can it be obtained in a thinned version?

Yoshida: (i) Yes, the price is about $3000. (ii) You have to make a special order, but I do not know if TI Japan accept it.