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)

Near-Infrared Imaging with the 105 cm Kiso Schmidt

T. Ichikawa, K. Tarusawa

Kiso Observatory, The University of Tokyo, Mitake-mura, Kiso-gun, Nagano 397-01, Japan

K. Yanagisawa, N. Itoh

Department of Astronomy, The University of Tokyo, Yayoi, Bunkyo-ku, Tokyo 113, Japan

Abstract. We have carried out imaging observations in the near-infrared (J, H and K' band) with a large format array camera attached to the prime focus of the 105 cm Schmidt telescope at Kiso Observatory. The image resolution, limiting magnitudes and effect of thermal radiation are presented, based on observations of nearby galaxies. Considering the results, we are constructing a new larger near-infrared camera optimized for use with the Kiso Schmidt.

1. Introduction

CCD cameras with a large format array and mosaic CCDs have replaced photographic plates as powerful detectors for observations at optical wavelengths. For example, a 1024 × 1024 single chip CCD camera and a 1024 × 1024 × 16 mosaic CCD camera have been used for many studies with the Kiso Schmidt telescope (Yoshida et al. 1994; van Driel 1994). Wide field imaging in the near-infrared, important for studies of nearby galaxies and star forming regions in our Galaxy, has not been performed yet, however, since neither plates nor large format arrays sensitive at wavelength longer than 1 μm were available. The 256 × 256 HgCdTe array is currently the most widely used and largest array readily available in the near-infrared. Such arrays may be too small for wide field imaging, however. The variable OH emission sky background makes mosaicing observations with a small field of view difficult. Also the alignment of adjacent images is limited if there are only a few stars in the overlapping area. Therefore, large format arrays for infrared observations have been long awaited.

2. Test Observations with a 512 × 512 PtSi Camera

We have tested a combination of an infrared camera with a large format array (Ueno et al. 1992) and the 105 cm Schmidt telescope at Kiso Observatory. The fast f-ratio of the Schmidt telescope (f/3.1) is also advantageous for the observation of nebulous objects like galaxies against a bright sky background. The camera uses a Platinum Silicide (PtSi) Schottky barrier diode array (Kimata et al. 1987) supplied by Mitsubishi Electric Co. The array size is 512 × 512 pixels, and the pixel size is 26 μm × 20 μm, giving a field of view of 14 arcmin × 11 arcmin and a pixel resolution of 1.6 arcsec × 1.3 arcsec when attached to the prime focus of the Kiso Schmidt.

Since the Kiso Schmidt was constructed for optical observations, three points should be taken into account for near-infrared observations: (i) the transparency of the corrector plate made of UBK7; (ii) spherical aberration; (iii) the thermal emission of the telescope. The transparency of UBK7 is about 0.99 at the wavelengths shorter than 1.7 μm, so there is no light loss in the *J* and *H* bands. But it decreases to 0.70 in the K′ band, which means that the emissivity of the correcting plates is 30 %, giving the largest contribution to the thermal emission entering the detector from the telescope. A cold baffle with a length appropriate to the Kiso Schmidt, however, reduced the thermal emission to a negligible level in the *H* and *J* bands. Since the corrector plate was designed to have a minimum aberration at 0.45 μm, the spherical aberration makes the image size worse in the near-infrared. The Hartmann constant theoretically estimated is ~ 1 arcsec – 1.3 arcsec in the *J*, *H*, and *K′* bands, which was confirmed through Hartmann tests. Considering the typically ~ 3 arcsec near-infrared seeing size at Kiso, we can still take seeing limited images.

Observations were made of M82, NGC 891, and some other nearby galaxies in*J*, *H* and *K′* (Ichikawa et al. 1994a; Yanagisawa et al. 1994). Fig, 1 shows the *H*-band image of M82 and the *J*-band image of NGC 891. The amorphous features of M82 caused by the irregular dust distribution seen in the optical (Ichikawa et al. 1994b) are not clear in the near-infrared images. Instead, it rather resembles an S0 galaxy with a large bulge and no dust lane in the disk. A bar structure is also evident in the central part. Though the quantum efficiency of the array is low, the excellent uniformity and stability of the PtSi chip, and the low readout noise of the camera controller, combined with the fast f-ratio, led to a calibration accuracy of 0.1 % of the sky background in 70 min. exposure *H*-band images of Coma and Pisces cluster members. The observationally confirmed detection limits are summarized in Table 1.

Table 1. Detection limit of the 512 × 512 PtSi camera at S/N=1.0 (20 min exposure, 4 arcsec seeing)

Band	for Diffuse Objects	for Point Objects
$J(1.25\mu m)$	21.5 mag arcsec^{-2}	20.5 mag
$H(1.65\mu m)$	19.6 mag arcsec^{-2}	18.6 mag
$K'(2.15\mu m)$	17.6 mag arcsec^{-2}	16.5 mag

3. A New Near-Infrared Camera for the Kiso 105 cm Schmidt

Thus, finding that near-infrared imaging can successfully be performed with the Kiso Schmidt, we determined to construct a new near-infrared camera optimized for use at the prime focus of the Kiso Schmidt. The camera head attached to the

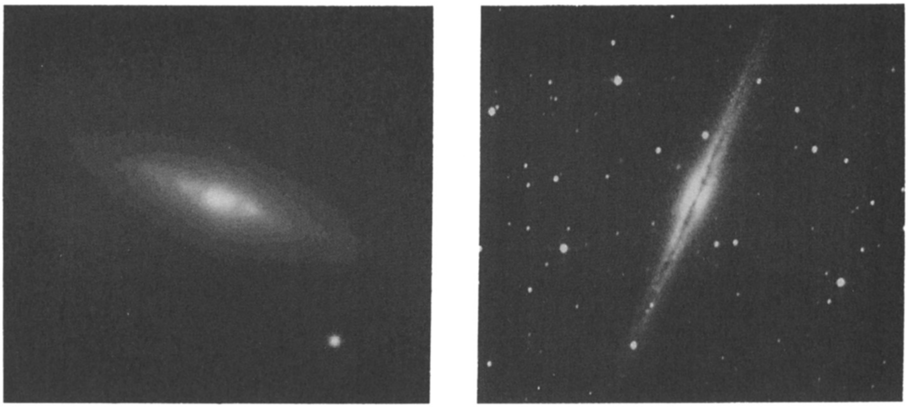

Figure 1. H-band image of M82 (left) and J-band image of NGC 891 (right), taken with the Kiso Schmidt and the 512 × 512 PtSi camera

prime focus is shown in Fig. 2. Since the small space of the prime focus limits the size of the camera, an optical system for a cold stop, with which infrared cameras are generally equipped, cannot be installed in our camera. Instead, we designed an optimum–size cold baffle, which reduces the thermal emission entering the detector from the telescope. As far as the J and H bands are concerned, the thermal emission does not affect the observations. In the K' band it is still about three and half times as much as sky brightness; nevertheless, this may be tolerable for the observation of bright objects.

A small refrigerator cools the radiation shield to 80 K with its first-stage cold finger, and the work surface, on which a PtSi chip is located, to 50 K with its second stage. The vibration of the refrigerator is so small ($<5\,\mu$m) that absorbers were found to be unnecessary. The filter turret can hold six filters of 30 mm diameter. A shutter, kept at the temperature of the radiation shield, is built in in front of the filter turret. This will be useful for sweeping latent images before exposing objects or for taking dark images.

The camera is controlled by the MESSIA II (Modulated Expandable SyStem for Image Acquisition II) system designed by Dr. M. Sekiguchi and modified specially for near-infrared detectors by Dr. H. Kataza. The data acquisition and storage are performed with a dedicated SUN workstation.

In general, the quantum efficiency of the PtSi chip is lower than those made of HgCdTe or InSb. Nevertheless, PtSi arrays still have the advantage of a large format and uniformity. Recently, PtSi arrays as large as optical CCDs have been developed by Mitsubishi Electric Co. (Yutani et al. 1991). This chip has 1040 × 1040 pixels and a pixel size of $17\,\mu$m × 17μm. Such small pixel size is also advantageous for observations at high spatial resolution. If such a chip is installed in our new camera, the pixel size would correspond to 1.06 arcsec, which is very favorable compared to the 2 arcsec image size. The field of view is 18.4 arcmin x 18.4 arcmin, which is as large as that of the Kiso CCD camera. Therefore, it will be a powerful tool for imaging objects of large apparent size, and for survey work. Another merit is that near-infrared observations can

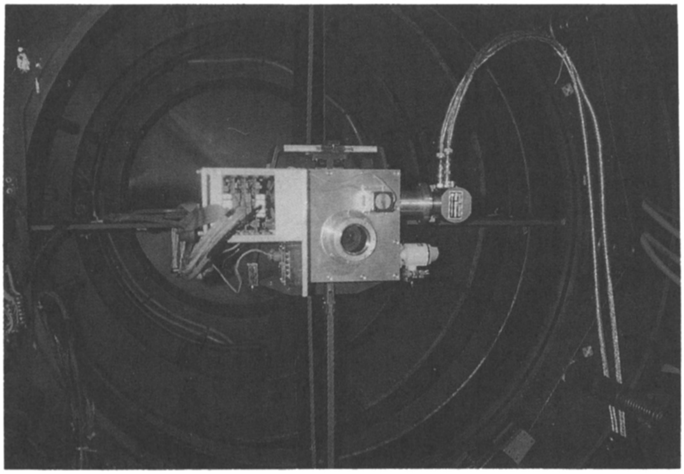

Figure 2. The new infrared camera attached to the prime focus of the Kiso Schmidt.

be made even with bright moon light when the Kiso Schmidt is generally not allocated for optical observations.

The Kiso CCD camera provides *B*, *V*, *R*, *I* images, while *J*, *H*, K' images can be obtained with the near-infrared camera at a spatial resolution similar to the optical. Thus combined studies in both near-infrared and optical bands will be very interesting.

References

Ichikawa T., Tarusawa K., Yanagisawa K., Itoh N. & Ueno M., 1994a, in Proc. IAU Symp. 161, in press

Ichikawa T., van Driel W., Aoki T., Soyano T., Tarusawa K. & Yoshida S., 1994b, ApJ, in press

Kimata M., Denda M., Yutani N., Iwade S. & Tsubouchi N., 1987, Solid-State Circuit, IEEE J., 22, 92

Ueno M., Ito M., Kasaba Y. & Sato S., 1992, SPIE, 1762, 423

van Driel M., 1994, these proceedings

Yanagisawa K., Itoh N., Ichikawa T., Tarusawa K. & Ueno M., 1994, in Proc. IAU Symp. 161, in press

Yatani N., Yagi H., Kimata M., Nakanishi J., Nagayoshi S. & Tubouchi N., 1991, IEEE IEDM, 91,175

Yoshida S., Aoki T., Soyano T. & Tarusawa K., 1994, these proceedings

https://doi.org/10.1017/S0252921100021679 Published online by Cambridge University Press