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MITSuME—Multicolor Imaging Telescopes for Survey and Monstrous Explosions(*)

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Summary. — Development of MITSuME is reported. Two 50-cm optical telescopes have been built at Akeno in Yamanashi prefecture and at Okayama Astrophysical Observatory (OAO) in Okayama prefecture. Three CCD cameras for simultaneous $g'R_CI_C$ photometry are to be mounted on each focal plane, covering a wide FOV of about $30'' \times 30''$. The limiting magnitude at V is fainter than 18. In addition to these two optical telescopes, a 91-cm IR telescope with a $1^\circ \times 1^\circ$ field of view is being built at OAO, which performs photometry in $YJHK$ bands. These robotic telescopes can start the observation of counterparts of a GRB within a minute from an alert. We aim to obtain photometric redshifts exceeding 10 with these telescopes. The performance and the current construction status of the telescopes are presented.

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1. – The MITSuME Project

Three IR/optical robotic telescopes for prompt observation of GRBs and afterglows are under development. The project, *MITSuME,* is promoted by Tokyo Tech, National Astronomical Observatory of Japan (NAOJ), the Institute of Cosmic-Ray Research (ICCR), Kyoto University, and Aoyama Gakuin University. *MITSuME* stands for *Multicolor Imaging Telescopes for Survey and Monstrous Explosions,* and also means *three eyes* in Japanese. The objective of the project is multi-band photometry from K_s to g' of GRBs and afterglows within tens of seconds and detection/determination of cosmological events with redshifts exceeding 10. Two optical telescopes, *Akeno 50 cm* and *OAO 50 cm*, have been constructed at Akeno Observatory of the ICCR, Akeno in Yamanashi prefecture, and at Okayama Astrophysical Observatory (OAO) of NAOJ, Kamogata in Okayama prefecture. Each telescope has a *Tricolor Camera* capable of $g'R_CI_C$-bands photometry. An existing 91- cm telescope at OAO is being converted to an IR telescope, *OAOWFC* (OAO Wide Field Camera). It is designed to have a wide field of view of $56' \times 56'$ and perform $YJHK_S$ photometry [1]. These three telescopes are to promptly respond to GRB alerts without a human operator.

2. – Telescopes

The specification of each telescope is shown in table I. *OAO 50 cm* can be maneuvered at a speed of 4 deg s^{-1}, or within 45 s to any direction, and *Akeno 50 cm* at a speed of 9 deg s^{-1}, within 20 s to any direction. *OAO 50 cm* and *Akeno 50 cm* have large field of views of $30' \times 30'$ and are suitable for a source with a position uncertainty up to $15'$, which is typical for an on-board localization by GRB monitoring missions. *OAOWFC* has an even larger field of view of $1^\circ \times 1^\circ$, and will be used for a survey of Mira variables when it is not occupied in a follow-up observation. A mixture system of g', R_C, and I_C is adopted for *Akeno 50 cm* and *OAO 50 cm* instead of the standard Johnson-Cousins system [2, 3] or the SDSS system [4]. We have chosen g' rather than V, because the broader bandwidth of the former would give a better sensitivity [4]. We have chosen I_C rather than i' for the same reason. By selecting R_C instead of r' we can avoid artificial lights in the night sky. For *OAOWFC*, a $YJHK_S$ system is adopted [1, 5].

A *Tricolor Camera* is to be mounted on each focal plane of *OAO 50 cm* and *Akeno 50*

TABLE I. – *Specification.*

	OAOWFC	*OAO 50 cm*	*Akeno 50 cm*
Maneuverability	1.5 deg s^{-1}	4 deg s^{-1}	9 deg s^{-1}
Mirror Diameter	910 mm	500 mm	500 mm
Focal Length	2260 mm	3250 mm	3000 mm
F Number	2.5	6.5	6.0
FOV	$56' \times 56'$	$26' \times 26'$	$28' \times 28'$
Bands	$YJHK_S$	$g'R_CI_C$	$g'R_CI_C$
Limiting Mag.	$J = 16.6$	$V = 18.4$	$V = 18.2$
(10 min, S/N=10)	$H = 15.8$	$R = 18.5$	$R = 18.2$
	$K = 15.4$	$I = 17.7$	$I = 17.5$
Location	OAO/NAOJ		Akeno Observatory/ICRR
	Kamogata, Okayama, Japan		Akeno, Yamanashi, Japan
	133°35′E, 34°34′N, 372 m A. S. L.		138°30′E, 35°47′N, 900m A. S. L.

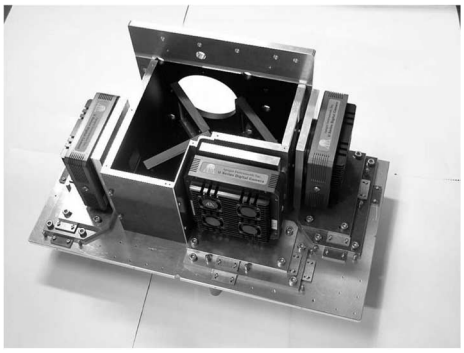

Fig. 1. – Top View of *Tricolor Camera*. A top panel is removed. The light led in the camera from above is divided into three bands with two dichroic mirrors and a gold-coated mirror and distributed to three *Alta U6* CCDs.

cm. A prototype of *Tricolor Camera* is shown in fig. 1. The *Tricolor Camera* employs three *Alta U-6* cameras (Apogee Instruments Inc.), and each *Alta U-6* has a *KAF-1001E* CCD (Kodak) with 1024×1024 pixels. The pixel size is 24μm $\times 24\mu$m, or $1.6'' \times 1.6''$ at the focal planes. Three images of different bands are simultaneously taken.

As for *OAOWFC*, an array of *HAWAII-2 RG PACE* (Rockwell Science) is employed as a focal plane detector, and its housing is being developed.

3. – Robotic system

The robotic system to control *Akeno 50 cm* is shown in fig. 2. When the mastering PC receives an alert, it points the telescope to the GRB location or waits until the target becomes observable. CCD images are transfered to Tokyo Tech. An automated search for an optical counterpart is to be performed. The system is designed to function without on-site maintenance for weeks.

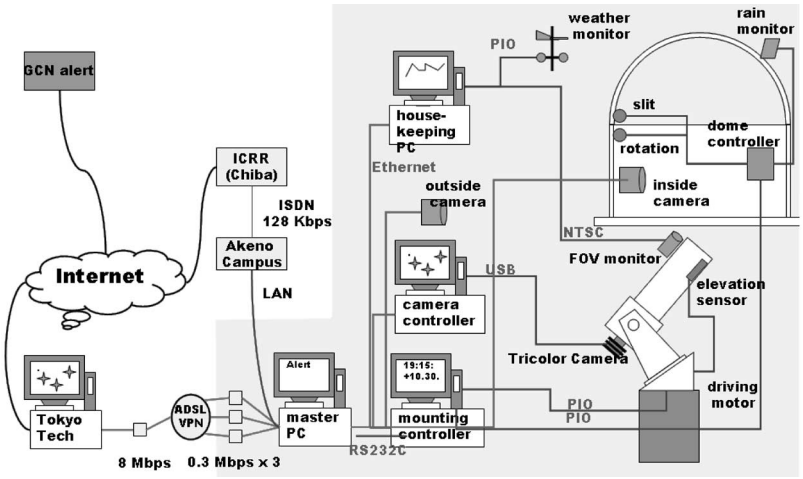

Fig. 2. – Robotic System to control *Akeno 50 cm*. The system resides in a 4- m dome at Akeno (shaded area). It is connected with Tokyo Tech via ADSLs.

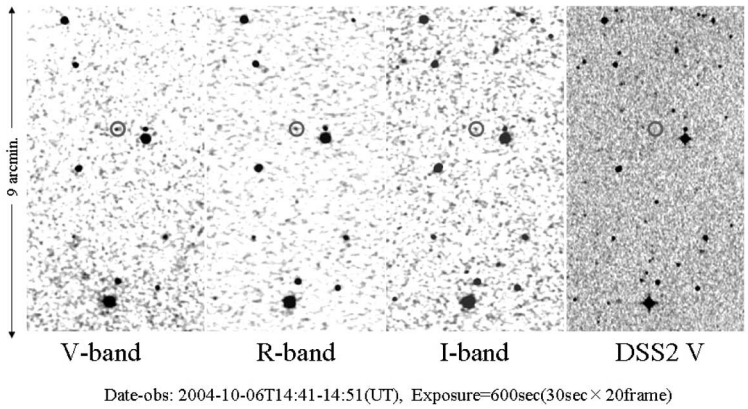

Fig. 3. – GRB041016. V, R, and I images of GRB041016 taken with *OAO 50 cm* and the DSS image of the same field of view. The position of GRB041016 is indicated with a circle.

4. – Current Status

OAOWFC. Conversion from an existing telescope is in progress. The designing of a new optics, detector, and cooling system has been done. A first light is scheduled in 2005.

OAO 50 cm. The construction of the telescope and a 4-m dome has been done. Calibration and performance verification are almost done. It is currently operated by a human operator. The images of GRB041016 taken with the prototype *Tricolor Camera* is shown in fig. 3 [6]. The afterglow is successfully detected, which is not recognized in the DSS image.

Akeno 50 cm. The construction has been done. Calibration and performance verification are almost done. A robotic program is being developed based on RIBOTS' program [7,8]. It is operated by a human operator at a remote site. GRB050124 and GRB050209 were observed [9, 10].

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