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THE *AKARI* PROJECT: LEGACY AND DATA PROCESSING STATUS

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ABSTRACT

This paper provides an overview of the *AKARI* mission, which was the first Japanese satellite dedicated to infrared astronomy. The *AKARI* satellite was launched in 2006, and performed both an all-sky survey and pointed observations during its 550 days in the He-cooled mission phases (Phases 1 and 2). After the He ran out, we continued near-infrared observations with mechanical cryocoolers (Phase 3). Due to a failure of its power supply, *AKARI* was turned off in 2011.

The *AKARI* data are unique in terms of the observed wavelengths as well as the sky coverage, and provide a unique legacy resource for many astronomical studies. Since April 2013, a dedicated new team has been working to refine the *AKARI* data processing. The goal of this activity is to provide processed datasets for most of the AKARI observations in a Science Ready form, so that more users can utilize the *AKARI* data in their astronomical research. The data to be released will include revised All-Sky Point Source Catalogues, All-Sky Image Maps, as well as high-sensitivity images and spectra obtained by pointed observations. We expect that the data will be made public by in the Spring of 2016.

Key words: Space vehicles — Space vehicles: instruments — Astronomical databases: miscellaneous — Atlases — Catalogs — Surveys

1. INTRODUCTION

AKARI (Murakami et al., 2007), also known as ASTRO-F, was the first Japanese satellite dedicated to infrared astronomy. *AKARI* was launched in 2006 and carried out the second-generation all-sky survey in the infrared. *AKARI* also carried out many pointed observations. Two dedicated instruments, the Infrared Camera (IRC; Onaka et al., 2007) and the Far-Infrared Surveyor (FIS; Kawada et al., 2007) continuously covered the broad wavelength ranges between 2–26 μm and 50–180 μm, respectively, providing unique information on the astronomical source.

This paper gives an overview of the mission including its operation history and also presents the current status of the post-flight data processing activity.

2. THE *AKARI* MISSION

2.1. Mission Overview

Figure 1 shows the *AKARI* satellite during the final checkout before its launch. *AKARI* consisted of two parts: the bus module (the lower part) and the payload module (the upper part).

The payload module was mainly composed of a cryostat, which contained the telescope and focal-plane instruments. Both the telescope and the focal-plane instruments were cryogenically cooled to allow sensitive observations in the infrared. Table 1 describes main specifications of *AKARI*.

The *AKARI* telescope was a Ritchey-Chretian type with a effective aperture size of 68.5 cm. The mirrors of the telescope were made of SiC, and its high stiffness enabled us to reduce the mass of the telescope. The *AKARI* telescope achieved a diffraction-limited performance at wavelengths longer than 7 μm in orbit

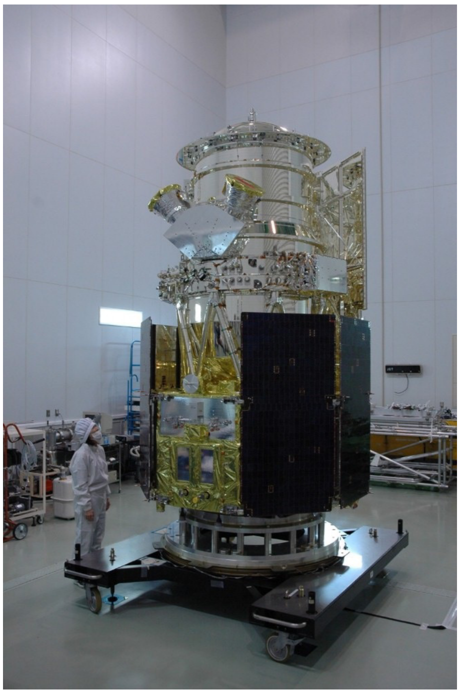

Figure 1. The *AKARI* satellite during the final checkout before the launch.

Table 1
Main specifications of *AKARI*.

Parameter	Specifications
Telescope	Aperture size: 68.5cm
	Temperature: 6 K
	(Phases 1 and 2)
Modes of Obs.	All-Sky Survey
	Pointing
	Slow-scan
	Fixed Pointing
Focal Plane Instruments	Infrared Camera (IRC)
	Far-Infrared Surveyor (FIS)

(Kaneda et al., 2007).

Figure 2 shows the wavelength coverage and resolution of the two instruments. The IRC covered the wavelength of 1.8–26.5 μm with three channels. It was designed for imaging and spectroscopic observations with large-format array detectors. The IRC was also used for the All-Sky Survey at 9 and 18 μm. The FIS was designed to carry out the All-Sky Survey in the far-infrared (65, 90, 140, and 160 μm). It also had a spectroscopic capability with a Fourier-transform spectrometer (FTS).

All of the above science instruments were cooled with a unique cryogenic system, which consisted of cryogen (liquid He) and mechanical coolers (2-stage Stirling coolers; Nakagawa et al., 2007). With the help of cryocoolers, the instruments remained cooled in orbit for 550 days with relatively small amount (179 L) of liquid He. After the He ran out, we continued observations in the near-infrared using the cyorcoolers alone.

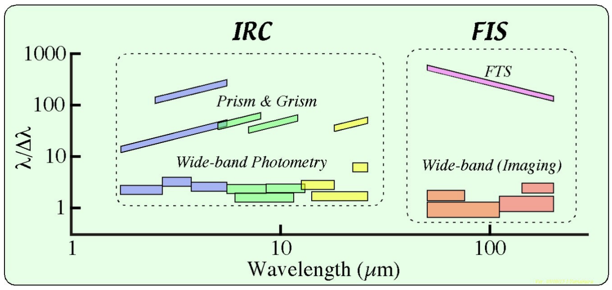

Figure 2. Wavelength coverage and resolution of the *AKARI* focal-plane instruments: IRC and FIS.

Table 2
AKARI Operation History

Events	Date (UT)
Launch	21 Feb 2006
Aperture-Lid Jettison	14 Apr 2006
Phase-1 Observations	7 May - 10 Nov 2006
Phase-2 Observations	10 Nov 2006 - 26 Aug 2007
Liq. He ran out	26 Aug 2007
Phase-3 Observations	1 June 2008 - 15 Feb 2010
End of Operations	24 Nov 2011

2.2. *Operation History*

Table 2 shows the operation history of *AKARI*. It was launched in February 2006 and was turned off in November 2011. The He cooled, most sensitive astronomical observations were carried out between May 2006 and August 2007, during which the first six months were mostly dedicated to the All-Sky Survey (Phase 1) and the remaining 10 months (Phase 2) were shared between many pointed observations and the supplemental All-Sky Survey. Phase 2 was terminated by the exhaustion of liquid helium. Observations in the near-infrared wavelength region with cooling only by the cryocoolers were started from June 2008 and lasted until February 2010 (Phase 3), when the detector temperature became so high due to degradation of the coolers that the data quality was degraded significantly We terminated the operation of *AKARI* in 2011 following trouble in its power supply system.

2.3. *Orbit and Observation Modes*

AKARI was launched into a Sun-synchronous orbit along the day-night border at an altitude of 700 km and an inclination of 98.2 degree. This orbit is suitable for the All-Sky Survey with the telescope pointing away

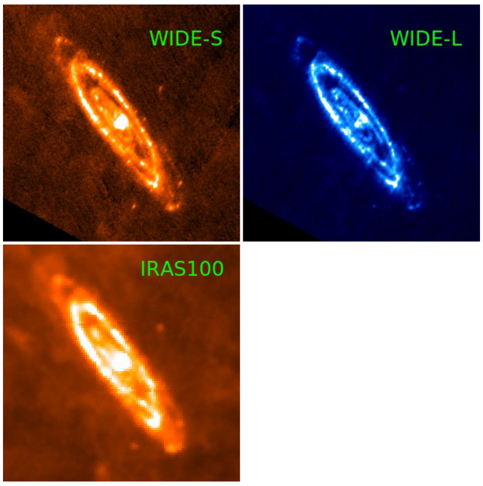

Figure 3. Comparison of the image quality between the *AKARI* and *IRAS* surveys. Upper panels show the *AKARI* data (upper left in 90 μm and upper right in 140 μm, while the lower panel shows the image by *IRAS* at 100 μm.

from the sun and the earth; during the All-Sky Survey mode, the telescope rotated around the axis toward the sun once in one orbital motion being kept away from the earth. Ideally, the whole sky could be covered in half a year.

AKARI also performed pointed observations, in which the telescope was pointed to a certain sky position for approximately 10 minutes.

3. OBSERVATIONAL RESULTS

AKARI made an all-sky survey covering more than 96 per cent of the entire sky in six wavelength bands (9, 18, 65, 90, 140, and 160 μm). This is the second-generation infrared all-sky survey, which had advantages over the first-generation survey by *IRAS* in both spatial resolution and sensitivity. Figure 3 shows an example of All-Sky Survey by *AKARI*. The image quality of the *AKARI* All-Sky Survey is improved significantly compared to that of *IRAS*

AKARI also carried out thousands of high-sensitivity imaging and spectroscopic observations in the pointed observation mode. Table 3 summarizes approximate number of observations made by *AKARI*.

Table 3
Approximate number of pointed observations made by *AKARI*

Obs. Mode	Phase 1 & 2 (Liquid He+cooler)	Phase 3 (Cooler only)
IRC imaging	3000	3800
IRC spectroscopy	900	8800
FIS imaging	1100	—
FIS spectroscopy	550	—

4. POST-FLIGHT DATA PROCESSING ACTIVITY

The *AKARI* data are unique in terms of the observed wavelengths as well as sky coverage, and will be invaluable for many studies in various astronomical topics. However, efficient use of the AKARI data by the general community requires mastering special software packages, and having detailed knowledge of the characteristics of the instruments hence our approach to provide processed Legacy products will make the data widely accessible.

In order to achieve this, a dedicated data processing team was formed. This team has been working since April 2013 to produce "Science Ready" processed data for as many *AKARI* observations as possible. The team consists of one faculty staff member (IY), four post-docs, and two engineers at ISAS, collaborating with other members in ISAS and universities, especially at the University of Tokyo and Nagoya University. The planned period of the activity is five years; with three years for data processing and two years for follow-up user support. The status and technical details of the data processing activities are given in separate papers in these proceedings (e.g., Egusa et al., Makiuti et al., Usui et al., Kondo et al., Amatsutsu et al., Nakamichi et al., Sano et al.).

Table 4 presents *AKARI* data products so far published. The Point Source Catalogues from *AKARI*s Large Area Surveys (the All-Sky Survey, the Large Magellanic Cloud Survey, and the North Ecliptic Pole Survey) have each become public already. We would like to stress that in addition to these project-lead data products, there are data sets created as results of scientific research based on *AKARI* observations. Such data are also listed in Table 4. Table 5 shows those products currently under processing. They are to be released to the public mostly by March 2016. ISAS offers the data as the primary data distributor via the project web[1] and DARTS[2]. Some data are also available from mirror sites (e.g., at IPAC and CDS).

5. STATUS OF THE FIS POINT SOURCE CATALOGUES

Since the release of the FIS Bright Source Catalogue Version 1 in March 2010, efforts to improve the cat-

[1] *URL:* `http://www.ir.isas.jaxa.jp/AKARI/Observation/`.
[2] *URL:* `http://darts.isas.jaxa.jp/ir/akari/`.

Table 4
Published *AKARI* Data Products

Product name	Description	Number of sources	Public Release
AKARI/FIS All-Sky Bright Source Catalogue Ver. 1	Position and flux densities of the sources detected by the *AKARI*/FIS All-Sky Survey at 65, 90, 140, 160 μm.	427,071	30 Mar 2010
AKARI/IRC All-Sky Bright Source Catalogue Ver. 1	Position and flux densities of the sources detected by the *AKARI*/IRC All-Sky Survey at 9 & 18 μm.	870,973	30 Mar 2010
Asteroid Catalogue Ver. 1	Radius and albedo of asteroids identified in the IRC All-Sky Survey data.	5,120	14 Oct 2011
LMC Point Source Catalogue Ver. 1	Flux and position of sources located in the LMC region ($\sim$10 deg^2).	660,286	13 Nov 2012
LMC Near-IR Spectral Catalogue Ver. 1	Low-resolution spectra taken with the objective prism on the IRC/NIR camera.	1757	7 Jan 2013
NEP-Wide Field Point Source Catalogue Ver. 1	NEP-Deep Field Point Source Catalogue Ver. 1.	114,794	15 Mar 2013
NEP-Deep Field Point Source Catalogue Ver. 2	Fluxes and positions of the infrared sources observed at 9 wavelengths (2, 3, 4, 7, 9, 11, 15, 18, 24 μm) in the NEP-deep region (0.67 deg^2).	27,770	16 Oct 2013
Users' contribution data			
Near-IR Diffuse Spectral Catalogue Ver. 1	Low-resolution ($R \sim 20$) near-IR spectra (1.8–5.3 μm) of diffuse radiation at various positions in the sky.	278	27 Jun 2013
AKARI Near-infrared Spectral Atlas of Galactic H II regions	Spectra of Galactic H II regions observed with the IRC/NIR prism and grism modes covering (2.5–5.4 μm).	464	10 Mar 2014
The Asteroid Catalog Using *AKARI* IRC Slow-Scan Observation	An asteroid catalogue produced based on the *AKARI* IRC Slow-Scan Observations.	88	20 May 2014

alogue efficacy have continued. However, the delivery schedule has been delayed significantly for various reasons. Currently, processing of the catalogue and production of the Faint Source Catalogue are being carried out by the new AKARI team. Both catalogues will be published in late 2015 (Table 5). We have achieved an improvement in detection completeness as well as better accuracy of source positions. More details on the data processing of the FIS Bright/Faint Source Catalogue is presented by Makiuti et al. (this volume).

6. SUMMARY

The *AKARI* legacy data products are unique and valuable for a wide range of future astronomical research studies. We are responsible for making these data available to the astronomical community in an easy-access format and having Science Ready quality. Most of the data will become public by spring 2016. We expect to see a number of new scientific research topics based on the *AKARI* data, and for its easy accessibility to spawn new ideas. The *AKARI* team welcomes supports from data users, reports and comments on the data products, suggestions to improve data reduction and calibration techniques, and new scientific research based on the improved data products.

ACKNOWLEDGMENTS

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Table 5
Planned *AKARI* Processed Data Products

Product name	Description	Public Release
FIS Bright Source Catalogue Ver.2	Revision of the FIS BSC. Accuracy and reliability will be improved. Single-scan photometric database and scan density data will also be available.	Oct. 2015
FIS Faint Source Catalogue Ver.1	The catalogue will improve detection limit in the high-visibility regions.	Jan. 2016
FIS All-Sky Image Maps	All-Sky image maps in the four FIS bands (65, 90, 140, 160 μm).	Dec. 2014
IRC Faint Source Catalogue	The catalogue will improve detection limit in the high-visibility regions.	Mar. 2016
IRC All-Sky Image Maps	All-Sky image maps in the two IRC bands (9 & 18 μm) at spatial resolution of $\sim$ 10 arcsec.	Mar. 2016
FIS FTS data	Processed imaging-spectroscopic data-set observed with the Fourier Transform Spectrometer (FTS) on the FIS.	Oct. 2015
IRC Slit spectroscopy Data	Spectra taken with the IRC spectroscopic mode with a slit (and a point source aperture mask).	Mar. 2016
IRC Pointed Observation Images	Processed Near- and mid-IR images from the IRC. Individual observation data will be processed separately. No mosaicing will be applied.	Mar. 2015 Mar. 2016
FIS Slow-scan Data	Processed image data of individual FIS Slow-scan mapping observations.	Mar. 2016
IRC Slow-scan Atlas	Processed image data of individual IRC Slow-scan mapping observations.	Dec. 2016

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