AKARI/IRC Near-Infrared Point Source Spectral Catalogue

Fumihiko Usui,[1] Takashi Onaka,[2] and The *AKARI*/IRC team

[1]*Center for Planetary Science, Graduate School of Science, Kobe University, 7-1-48, Minatojima-Minamimachi, Chuo-Ku, Kobe 650-0047, Japan*
[2]*Department of Astronomy, Graduate School of Science, The University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo 113-0033, Japan*

ABSTRACT

AKARI performed about 10,000 spectroscopic observations with the Infrared Camera (IRC). These IRC observations provide unique spectral data at near- and mid-infrared wavelengths. These data enable astronomical research in the various fields throughout the next few decades, empowered by its high sensitivity and unique wavelength coverage. Near-infrared spectral data taken with the point source aperture mask ($1'\times1'$ aperture, called the "Np" window) are provided. The spectral coverage is 2.5–5.0 μm in the grism mode, and 1.8–5.5 μm in the prism mode. Subpixel stacking of spectral images, cosmic ray removal, revised distortion correction, revised estimation of uncertainty of the flux density, and wavelength calibration considering the refractive index of the grism are taken into account in the data processing, producing the first version of the spectral catalogue released in April 2016. Remaining issues, including revised spectral calibration by subtracting the second-order light and re-examination of the flux uncertainty, are now implemented in the latest data reduction process. The revised catalogue based on the data reduction with the latest version toolkit will be delivered soon.

Keywords: infrared: general — methods: data analysis — techniques: spectroscopic

1. INTRODUCTION

The Infrared Camera (IRC; Onaka et al. 2007) is one of the two instruments on board the *AKARI* satellite (Murakami et al. 2007), which was operated at near- to mid-infrared wavelengths. IRC has capability of spectroscopy as well as wide-field deep imaging (Egusa et al. 2016), in addition to the All-Sky Survey observations (Ishihara et al. 2010). Spectroscopic observations (Ohyama et al. 2007) were carried out with the specified position parameters (see Figure 3 in Onaka et al. 2007) as Ns (common to NIR and MIR-S), Nh (high resolution of NIR), or Ls (MIR-L) for the slit mode, Np (NIR) for the point source aperture, and Nc (NIR, MIR-S) or Lc (MIR-L) for the slitless mode (Yamagishi et al., in this volume). The sensitivities and resolution powers of spectroscopic observations for point source are shown in Figure 1.

The IRC spectroscopic observations were performed 872 times with NIR, MIR-S, and MIR-L before the liquid helium cryogen was exhausted (Phase 1 & 2), and 8941 times only with NIR at the detector temperature below 50 K during the warm mission phase (Phase 3) until the performance of the on-board cyro-cooler seriously degraded in February 2010 (Phase 3; Onaka et al. 2012).

The Np mode was designed for spectroscopic observations of single point sources. The slit mode (Ns, Nh) is not good for point sources due to the stability and/or pointing accuracy of the satellite of a few to ten arcsecond. The small aperture window of the Np mode ensures that contamination of the spectra by background source overlap is minimal. Note that the Np mode was used for intended targets, which were given by observers in the target lists in advance of observations. Figure 2 shows the fraction of the position parameters specified for the Np mode observations. More than 64% of observations were done for galaxies and active galactic nuclei. Figure 2 also shows the spatial distribution of the targets for the spectroscopic observations. It is found that the Np observations were performed over the all-sky including the Large and Small Magellanic Clouds.

2. UPDATED IRC SPECTROSCOPY TOOLKIT

There are updates available for the official data reduction toolkit (`irc_specred`) written in the IDL as follows:

- Subpixel stacking of spectral images
- Cosmic ray removal before image stacking
- Revised distortion correction of 2-D spectral images

Corresponding author: Fumihiko Usui
usui@cps-jp.org

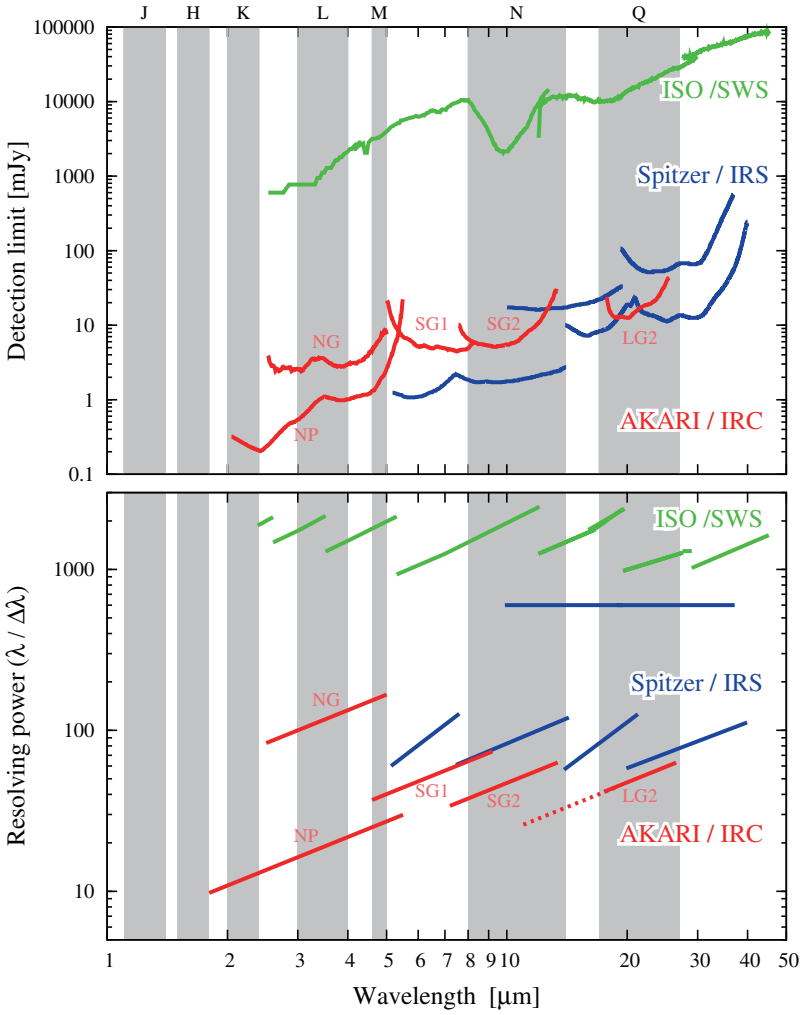

Figure 1. Sensitivities (upper panel) and resolution powers (lower panel) of spectroscopic observations for point source with space telescopes (ISO:Leech et al. 2003, Spitzer:http://irsa.ipac.caltech.edu/data/SPITZER/docs/irs/irsinstrumenthandbook/, and AKARI:http://www.ir.isas.jaxa.jp/AKARI/Observation/support/IRC/). The gray shadows indicate the atmospheric windows for ground-based observations.

- Revised estimation of uncertainty in the flux density
- Wavelength calibration considering the spectral dependence of the refractive index of the grism (Baba et al. 2016)
- Revised calibration of the spectral response by considering the second-order light contamination (> 4.9 μm) (Baba et al. 2016)
- Correction of the instrument sensitivity drift due to the detector temperature change

There are caveats and limitations with this version of toolkit as: ghosts (small- and large-scale, see Egusa et al. 2016), telescope drift during the exposure cycle, detector saturation, and contamination from nearby sources (e.g., Noble et al. 2013) are not fully taken into account. Stacking of multi-pointing spectroscopic data is not provided in the toolkit.

3. EXAMPLE OF SPECTRAL DATA

Figures 3 and 4 show examples of the reduced spectra. The following options were applied for `plot_spec_with_image` in the data reduction: `nsum=7, median=1, /no_slit_flat`. In these data reductions, two toolkits were used for comparison: the toolkit v150331 (the publicly released version) and v170225RC (the latest one, a release candidate). In the toolkit v170225RC, the new features described in Section 2 are implemented. In these figures, it is found that leakage of the second-order light in 4.9–5.0 μm was corrected (Figure 3 a, c), the wavelength calibration was revised (Figure 4 a, b, c), and the cosmic ray removal and the instrument sensitivity correction were improved (Figure 3 d and Figure 4 d).

4. POINT SOURCE SPECTRAL CATALOGUE

The Point Source Spectral Catalogue was constructed from 5712 spectroscopic observations with NIR at the Np position. Observations in Phase 1 & 2 are 217 times(grism only), and those in Phase 3 are 5495 times (510 prism and 4985 grism).

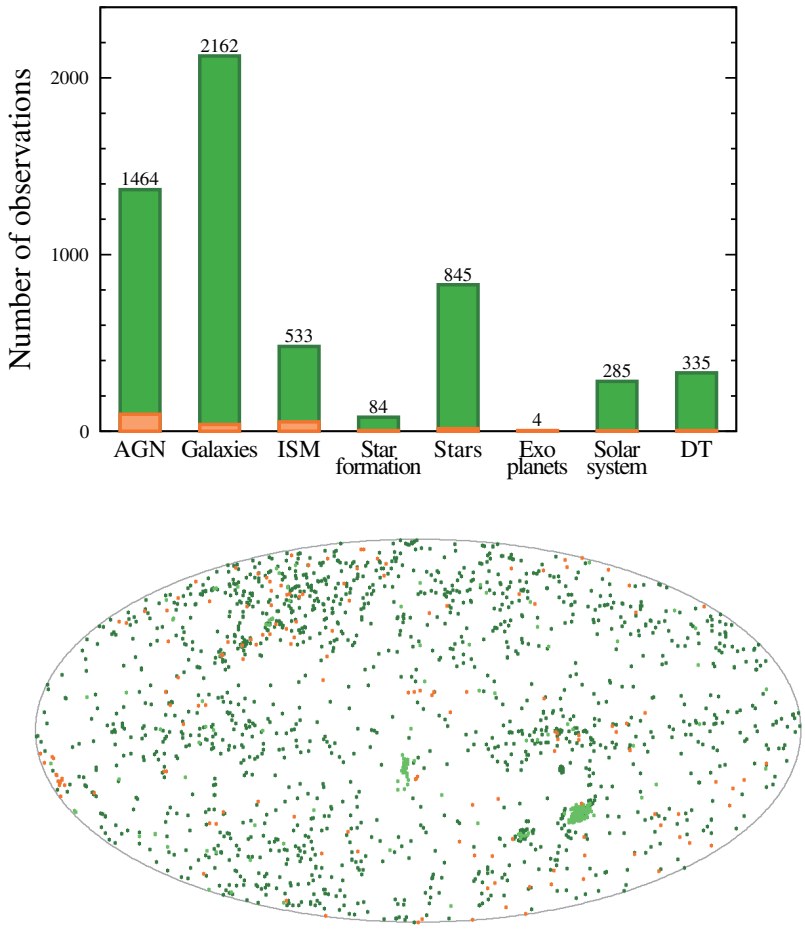

Figure 2. Number of observations of each science category in the catalogue (upper panel). Distribution of targets in the catalogue in the galactic coordinate (lower panel). Orange and green denotes the observations in Phase 1 & 2, and Phase 3, respectively.

The archived data consist of the spectral data (ASCII table), the 2-D spectral images, and the object list. The data set was open to the public on the web [1]. The catalogue based on the data reduction with the latest version toolkit described in Section 2 will be delivered soon.

ACKNOWLEDGMENTS

This research is based on observations with *AKARI*, a JAXA project with the participation of ESA. We are grateful to Youichi Ohyama (Institute of Astronomy and Astrophysics, Academia Sinica), Takashi Shimonishi (Tohoku University), Shunsuke Baba (The University of Tokyo, ISAS/JAXA), Kenichi Yano (The University of Tokyo, ISAS/JAXA), Kazumi Murata, Mitsuyoshi Yamagishi, Takafumi Ootsubo, and Takao Nakagawa (ISAS/JAXA) for their contributions.

REFERENCES

Baba, S., Nakagawa, T., Shirahata, M., et al. 2016, PASJ, 68, 27
Egusa, F., Usui, F., Murata, K., et al. 2016, PASJ, 68, 19
Ishihara, D. Onaka, T., Kataza, H., et al. 2010, A&A, 514, A1
Leech, K., Kester, D., Shipman, R., et al. 2003, in The ISO Handbook, Vol. V. SWS — The Short Wavelength Spectrometer Version 2.0.1 (2003 June), series, ed. T.G. Mueller, J. A. D. L. Blommaert, & P. Garcia-Lario (ESA SP-1262; Noordwijk: ESA
Murakami, H., Baba, H., Barthel, P., et al. 2007, PASJ, 59, S369
Noble, J. A., Fraser, H. J., Aikawa, Y., Pontoppidan, K. M., & Sakon, I. 2013, ApJ, 775, 85
Ohyama, Y., Onaka, T., Matsuhara, H., et al. 2007, PASJ, 59, S411
Onaka, T., Matsuhara, H., Wada, T., et al. 2007, PASJ, 59, S401
Onaka, T., Matsuhara, H., Wada, T., et al. 2012, in Proceedings of the SPIE, 8442, 844213

[1] http://www.ir.isas.jaxa.jp/AKARI/Archive/Catalogues/IRC_PointSource_spec/

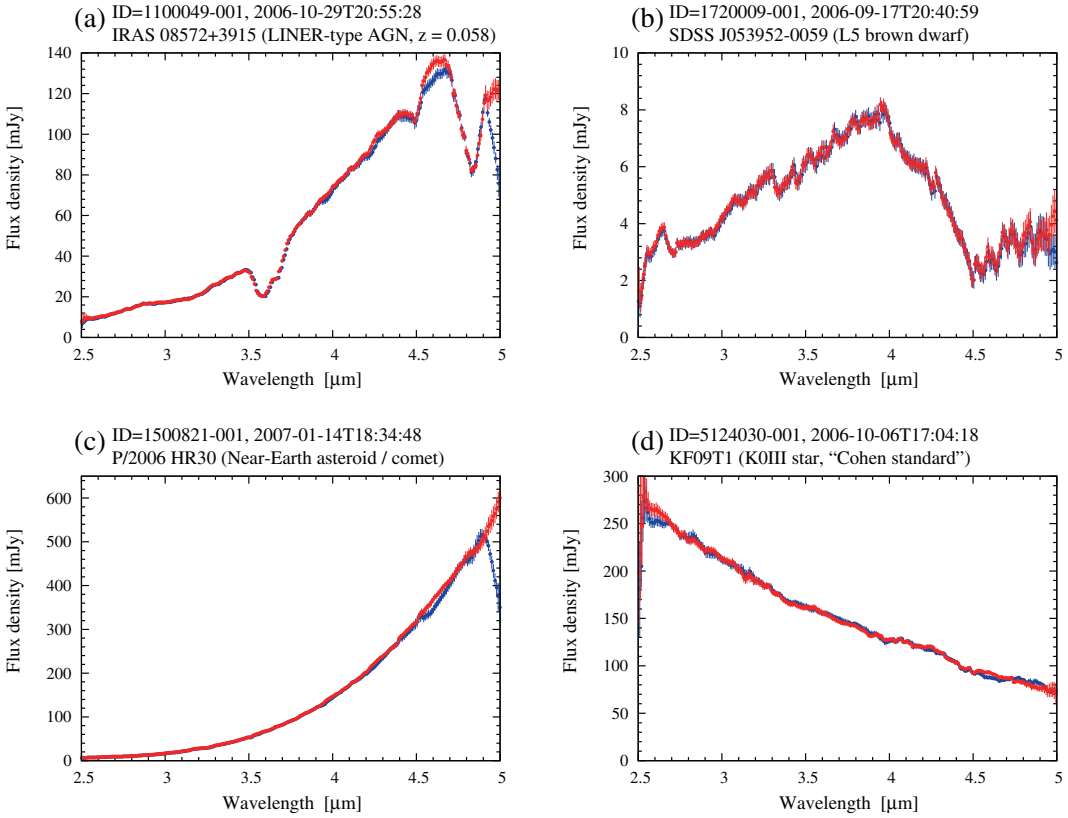

Figure 3. Example of reduced spectra for the data in Phase 1 & 2 observations. The red and blue curves denote the spectra reduced with the toolkit v150331 and v170225RC, respectively.

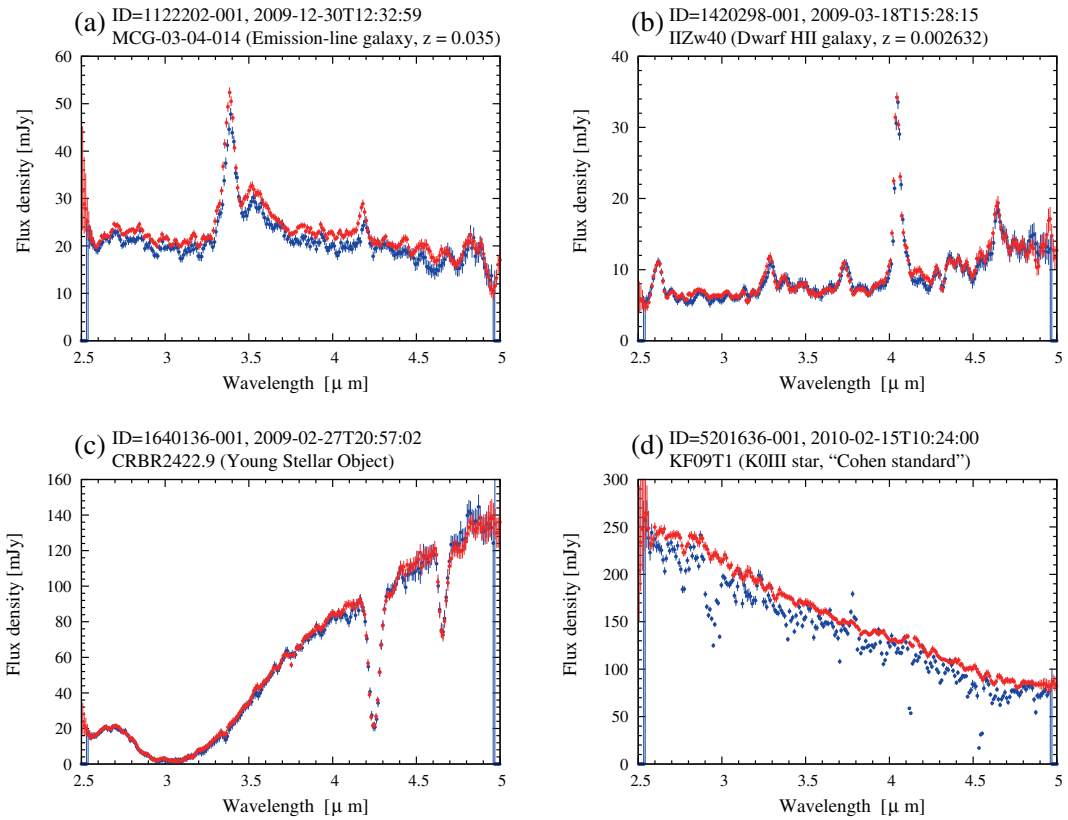

Figure 4. Same as Figure 3 but for the data in Phase 3.