AKARI near- and mid-infrared point source catalogue using reference images of IRC spectroscopy

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ABSTRACT

We present details of a point source catalogue using all the reference images for spectroscopic observations of *AKARI*/IRC-*S9W* (Yamagishi et al. in this volume). The catalogue includes about 42,000 sources, for which we performed PSF fitting with two-dimensional Gaussian and cross-identifications with 2MASS and *WISE* PSCs. About 80% of the sources in the catalogue are found in the other PSCs. Thanks to the deeper sensitivity and higher spatial resolution than *WISE*, we find 8400 sources and provide 9 μm flux for 8500 objects not detected in *WISE* $W3$. The procedure of this work can be applied to all the pointed imaging data of IRC, which shall detect a few tens thousands MIR sources and be helpful to understand the SED of many objects such as YSO.

Keywords: Catalogs, Infrared: general

1. INTRODUCTION

Mid to far-infrared observations are essential for understanding objects concerned with significant dust emission: young stellar objects, asymptotic giant branch stars, and star-forming galaxies for instance. *AKARI* conducted an all-sky survey as well as a lot of deep pointed observations in 3–200 μm (Murakami et al. 2007). The InfraRed Camera (IRC; Onaka et al. 2007) onboard *AKARI* has the capability of spectroscopy in near and mid infrared wavelength with the spectral resolution of 20–120. The spectroscopic observations had also provided reference images to understand positions of sources on the detector, which is a few times deeper and has slightly higher spatial resolution at the some wavelength than those of *WISE* all-sky survey. We made a mid-infrared point source catalogue (PSC) using reference images of *AKARI*/IRC-*S9W*. The details the PSC: point source detection, PSF fitting, cross-identifications with other infrared all-sky surveys, and contents of the PSC are here represented.

2. POINT SOURCES IN THE REFERENCE IMAGES

2.1. Point source detection

For point source detections on the reference images, we employed "find" procedure[1] written in IDL, which is one of procedures in astronomical library, and found about 58,000 sources. The data reduction for those images are very similar to an approach constructed by Egusa et al. (2016). Each observation was used as independent datasets; duplicated FoVs were not combined to a single image. The catalogue contains about 42,000 unique sources in essence. We estimated their flux with two approaches; aperture photometry with 5 pix radius corresponding to 5.″8 and PSF photometry defined by $flux = 2\pi\sigma^2 H$. The PSF width, σ was referred to Egusa et al. (2016), and the PSF amplitude H was obtained by the detection procedure. In order to understand photometric uncertainty, we estimated flux scatters for sources detected in more than four different observations. Consequently, the scatters were proportional to fluxes, implying backgrounds and/or calibration errors were more dominant for bright sources. The detection limit: a peak of source counts for all the sources is 0.3–0.4 mJy.

2.2. PSF fitting for source size estimation

We performed PSF fitting with a two-dimensional Gaussian function for sources described in the previous section, in which rotation angle of sources was fixed to zero, nearly along the Ecliptic meridian. Although many sources were reproduced by the Gaussian, 25.4% of them could not be fitted well due to their faintness and background structures.

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[1] https://idlastro.gsfc.nasa.gov/ftp/pro/idlphot/find.pro

Figure 1 shows histograms for FWHMs of *AKARI*/IRC-*S9W* PSF, and a typical size of FWHM is averagely obtained as 5.26 ± 1.33 arcsec. Sources whose FWHMs are 3σ larger (smaller) than the typical sizes are marked with "EXTended (SMaLl)" flags in our catalogue.

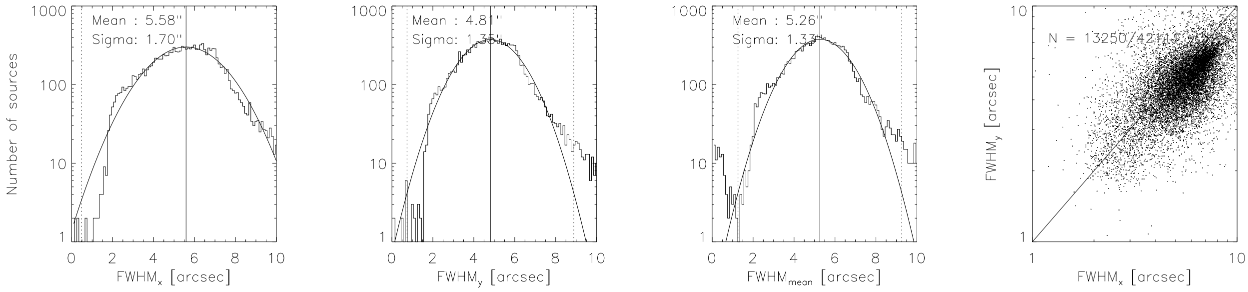

Figure 1. The left three panels show PSF widths with best-fitted Gaussian function in x, y direction on the detector, and averages of them, respectively. The right panel represents FWHMs of x and y directions, indicating the PSF of *AKARI*/IRC-*S9W* is slightly elongated to x direction on the detector. In these panels, sources in Large Magellanic Cloud and the galactic plane ($|b| \leq 20°$) are excluded.

2.3. Cross-identification with 2MASS and *WISE*

We performed cross-identifications to other infrared all-sky surveys of 2MASS (Skrutskie et al. 2006) and *WISE* (Wright et al. 2010), resulting 67.6% and 77.6% of sources to be found in them, respectively. Although many sources are also in the *WISE* PSC, their flux in competitive wavelength to IRC-*S9W* ($W3$, 12 μm) were poorly determined for 26.7% of them; only 56.9% of sources in our PSC have reliable $W3$ photometry in *WISE* PSC. Figure 2 represents position difference (dr) between *AKARI*/IRC and others. We found that the dr has σ of 0.33 arcsec for both 2MASS and *WISE*, which may reflect the astrometric positional accuracy of *AKARI*/IRC-*S9W*.

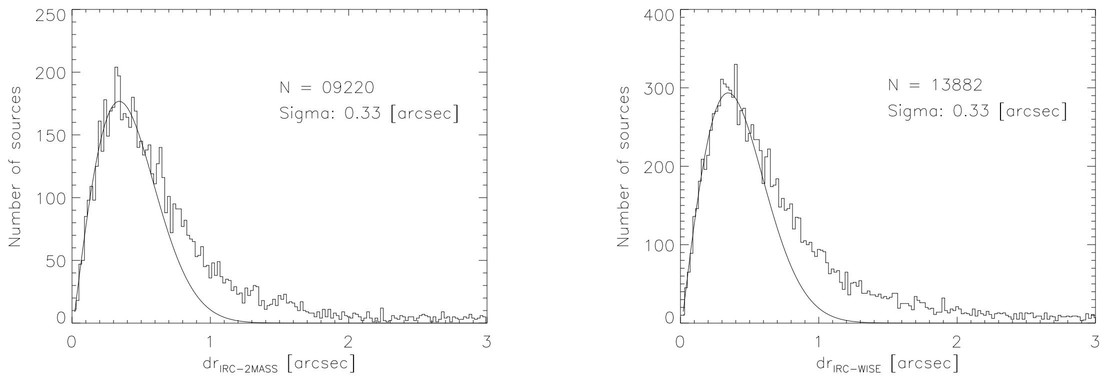

Figure 2. The left panel shows position difference (dr) between *AKARI*/IRC and 2MASS as a histogram with best-fitted area-weighted Gaussian function. The right panel also presents for *AKARI*/IRC vs *WISE* with a same manner to the left. In these panels, sources in Large Magellanic Cloud and the galactic plane ($|b| \leq 20°$) are excluded.

3. CONTENTS OF THE CATALOGUE

We investigated contents of the catalogue. Koenig et al. (2014) developed a source classification based on *WISE* (partly 2MASS) photometries, in which objects are roughly classified as YSO, SFG, AGB and others (possibly nearby dwarfs). In order to understand the contents, we applied the classification to sources in our catalogue. Consequently, among 17256 reliable sources considering several flags, 503 (2.9%), 2031 (11.8%), 274 (1.6%), and 14483 (83.9%) of them were classified as SFG, AGB, YSO, and others, respectively. Stellar objects classified by that approach were indeed concentrated on the galactic plane, and external galactic objects were flatly distributed in the galactic latitude.

4. IRC-*S9W* VS *WISE*-*W3*

The IRC-*S9W* photometries may be used as an alternative of *WISE*-*W3*, which is helpful to understand more objects, and the color of the competitive broad-bands should be understood. The color excess of these competitive broad-bands, IRC-*S9W* and *WISE*-*W3*, may suggest the presence of circumstellar medium and interstellar medium in star-forming galaxies. In the mid-infrared wavelength around 10 μm, dust emissions with a few to several hundred Kelvins are significant. We collect sources classified as "Star" and "Galaxy" including several subgroups in the SIMBAD[2] online database (Wenger et al. 2000). Many of dwarfs do not indeed show excesses. In contrast, systematic excess for galaxies is found, $S9W - W3 = 0.94 \pm 0.32$, which may indicate that those star-forming galaxies have colder ISM. However, it should be noted SEDs of galaxies in mid-infrared wavelength are complicated due to such as PAH emissions.

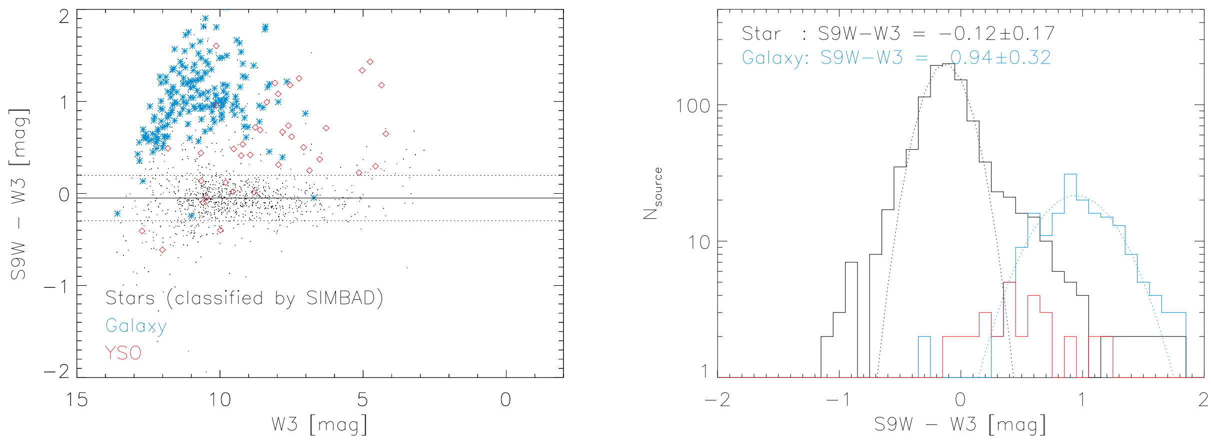

Figure 3. Fluxes of IRC-*S9W* and *WISE*-*W3* are compared. In the panels, sources are classified as star, galaxy, and yso by SIMBAD database, and presented with different colors.

5. SUMMARY

We present details of a point source catalogue using all the reference images for spectroscopic observations of *AKARI*/IRC. Due to the deeper sensitivity and higher resolution than *WISE*, we found 8400 sources and provided 9 μm flux for 8500 objects not detected in *WISE*-*W3*. Many of sources are also in other infrared all-sky catalogues, 2MASS and *WISE*, suggesting the sources in our catalogue probably are objects. The procedure of this work may be applied to all the pointed imaging data of *AKARI*/IRC, some of which should provide the most reliable mid-infrared photometry for a few tens of thousands of objects.

This work is strongly related with the slitless-spectroscopic catalogue of *AKARI*/IRC (Yamagishi et al. in this volume). The spectroscopic catalogue may provide spectrum for the limited number of objects with a conservative processing. However, all the object in our PSC are dispersed, some of which can be potentially obtained as spectra by more dedicated analyses. For advanced studies with next-generation facilities, *AKARI* archives including this work will provide mid to far-infrared information of a lot of targets.

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