Post-AGB stars in the AKARI survey

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Abstract. Obscured by their circumstellar dusty envelopes post-AGB stars emit a large fraction of their energy in the infrared and thus, infrared sky surveys like IRAS were essential for discoveries of post-AGBs in the past. Now, with the AKARI infrared sky survey we can extend our knowledge about the late stages of stellar evolution. The long-term goal of our work is to define new photometric criteria to distinguish new post-AGB candidates from the AKARI data.

We have cross-correlated the Toruń catalogue of Galactic post-AGB and related objects with the AKARI/FIS All-Sky Survey Bright Source Catalogue (for simplicity, hereafter AKARI). The scientific and technical aspects of our work are presented here as well as our plans for the future. In particular, we found that only 9 post-AGB sources were detected in all four AKARI bands. The most famous objects like: Red Rectangle, Egg Nebula, Minkowski’s Footprint belong to this group. From the technical point of view we discuss positional accuracy by comparing (mostly) 2MASS coordinates of post-AGB objects with those given by AKARI; flux reliability by comparing IRAS 60 and 100 \( \mu m \) fluxes with those from AKARI-N65 and AKARI-90 bands, respectively; as well as completeness of the sample as a function of the IRAS fluxes.

1. Post-AGB sample

Post-Asymptotic Giant Branch (post-AGB) objects are rapidly evolving stars of low and intermediate initial mass (0.8–8 \( M_\odot \)) in the transition phase between AGB and planetary nebulae (PN). This phase is very short (of the order of 1000 yrs) but yet very important and still poorly understood. The departure from spherical symmetry or changes in surface chemical composition during AGB are still studied using post-AGBs in order to understand the late stages of stellar evolution.

Analyzed post-AGBs were taken from the very likely part (346 objects) of the Toruń catalogue of Galactic post-AGB and related objects [Szczerba et al. (2009) – http://www.ncac.torun.pl/postagb2/]. Sources were cross-correlated with the AKARI catalogue. We found matches for 144 objects within 30″ radius from the reference coordinates of post-AGB objects (usually 2MASS coordinates), and all of them with good photometry at 90\( \mu m \).

2. Statistics

There are 256 sources with IRAS counterparts in Toruń catalogue. Among 144 post-AGB objects found in AKARI, 143 have IRAS counterparts. This
implicates that 56% of post-AGBs with IRAS counterparts have AKARI counterparts. There is a lack of AKARI sources with F65<5Jy when comparing to IRAS sources. The completeness of our sample as a function of fluxes is shown in Figure 1.

Figure 1. IRAS and AKARI sources in Toruń post-AGB catalogue.

The positional accuracy is in most cases in agreement with 2MASS coordinates. For 139 out of 144 objects the AKARI-2MASS separation is below 15″ and for 127 of them below 10″ (Figure 2). Since the IRAS coordinates differ from 2MASS ones, the AKARI-IRAS separation is slightly different and resulting in 126/143 objects with the separation below 15″ and 107/143 below 10″.

Figure 2. Separation of AKARI and 2MASS counterparts of post-AGB objects.

The comparison of AKARI and IRAS fluxes F60 vs. F65 and F90 vs. F100 is shown in Figure 3. The correlations are roughly linear (restriction to objects with cirrus emission less than 100 MJy/sr does not improve shown relation). In
general, post-AGB objects show maximum of their infrared emission between 25 and 60\(\mu\)m and thus their flux is smaller toward longer wavelengths, e.g. sources show less flux at 65\(\mu\)m than at 60\(\mu\)m and, consequently, less flux at 100\(\mu\)m than at 90\(\mu\)m.

According to Ueta, Meixner & Bobrowsky (2000) and Siódmiak et al. (2008) we can divide post-AGB sources into 3 groups depending on their morphology and spectral energy distribution (SED): DUPLEX with SEDs of class II and III (classes by van der Veen, Habing & Geballe (1989)), SOLE with SEDs of class IV and stellar objects with SEDs of class I or 0. Figure 4 shows color-color diagram for post-AGB objects with different SED classes. Stellar objects (crosses) have small values of \([12]-[25]\) characteristic for sources with no envelope. DUPLEX objects (circles) have in general larger values of \([65]-[90]\) than SOLEs (black dots) as a consequence of more (cold) dust in their envelopes.

![Color-color diagram for post-AGB objects with different SED classes.](image1)

Figure 4. AKARI \([65]-[90]\) vs IRAS \([12]-[25]\) for post-AGBs. Different symbols code types of SEDs (morphology class).

3. **Detections at 140 & 160\(\mu\)m**

At longer wavelengths there are 9 objects from our sample detected at both 140 and 160\(\mu\)m and additionally 25 sources detected only at 140\(\mu\)m. SEDs of 9 post-AGBs are displayed in Figure 5. In general, objects detected at 140 and/or 160\(\mu\)m are the brightest ones in our sample and very dusty at the same time (e.g. Red Rectangle, AFGL 618, Egg Nebula).

4. **Future work**

\([65]-[90]\) and/or \([140]-[160]\) AKARI colors in combination with other infrared measurements will be used to select new post-AGB candidates. Newly discovered sources will be included in the Toruń catalogue of post-AGB objects, together with all the available astrometric, photometric and spectroscopic data.
Having AKARI fluxes we will be able to (better) constrain the dust temperature of post-AGB objects. We also hope to obtain AKARI images of analyzed sources and thus get closer to understanding the late stages of stellar evolution.

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