An AKARI-FIS survey of post-AGB stars and (proto) planetary nebulae: an analysis of extended emission and the spectral energy distribution.

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Abstract. We present first preliminary results from AKARI/FIS pointed observations of post-AGB stars and planetary nebulae (PNe). A first analysis of the radial (azimuthally averaged) profile of the observed sources shows no evidence for excess emission due to the presence of circumstellar dust. No (detached) circumstellar faint dust-shells are seen in the image maps. Also, we present here first results of aperture flux photometry at wavelengths of 65, 90, 140 and 160 $\mu$m. Results are compared with IRAS flux densities as well as the $\beta$ release of the FIS Bright Source Catalog. Finally, spectral energy distributions are given, by way of an example, for two individual targets in our sample.

1. Introduction

The stellar evolution from the asymptotic giant branch (AGB) phase into planetary nebulae (PNe) is still shrouded in mystery. In particular, the mass loss mechanisms during the AGB and post-AGB phases are essential ingredients for stellar evolution models. It is therefore important to recover the mass loss history experienced by stars in their transition from AGB to PNe stage.

AGB stars have high mass loss rates of up to $10^{-5} \, M_\odot$/year, but the mechanism and evolution of mass loss rates are poorly understood. The mass loss drops to $10^{-7} \, M_\odot$/year when the star evolves to the post-AGB / proto-PN phases. Spherical circumstellar (CS) shells continue to drift away, pushed by the post-AGB wind and, somehow, transformed into aspherical PNe with fast outflows. For young PNe and proto-PNe the outer shells are not yet disrupted by fast post-AGB winds and therefore a fossil record of the original AGB mass loss may still be preserved. The distribution of cool dust in the extended envelopes of post-AGBs and PNe can be studied by measuring their infrared properties (e.g. size and flux). The structure of extended dust emission depends on the mass-loss mechanism (e.g. constant rate or fluctuations). The details are still uncertain; earlier ISOPHOT observations of two post-AGBs suggested episodic mass loss (Speck et al. 2000), while recent Spitzer observation revealed no CS shells in one of these sources (Do et al. 2007).
2. Observations

During the AKARI (Murakami et al. 2007) cold phase we obtained with the Far Infrared Surveyor (FIS; Kawada et al. 2007) instrument images of 13 post-AGB stars and PNe in the four far-infrared (FIR) filter bands at 60, 90, 140 and 160 µm.

The FIS Slow Scan Toolkit (ver. 20070914; Verdugo et al. 2007), implemented in IDL, was used to perform the FIS data reduction and to produce the maps. We applied the usual bad-pixel correction, stray-light removal, median & boxcar filtering. For bright point sources there is appreciable cross-talk, up to 10%, (only in the SW detector) as well as ghosts (at fixed positions in both SW and LW detectors). The final calibrated maps are in units of MJy/sr.

![Figure 1](image-url)

Figure 1. The azimuthally averaged radial profiles normalized to peak flux (for the 90 µm SW band) are shown for four targets in our sample. In the left panel the symbols show the radial profiles of our FIS targets and the solid thin line gives the Gaussian fit. The departure from Gaussianity can be clearly seen around 60” from the peak. The instrumental PSF for the the 90 µm SW band (extracted from the FIS Data User Manual) is over plotted in grey. The latter is traced closely by the observed radial profiles. In the right panel we show this in more detail (solid lines are targets and symbols indicate the Gaussian fit) of the point source PSF.

3. Results I: Radial Profiles & Extended Emission

We derived the radial (azimuthally averaged) profile for thirteen post-AGB stars and (P)PNe, which we subsequently compare to each other and to the point-spread function (PSF; Figure 1). The PSF of Ceres has a reported FWHM of 37” (65 µm), 39” (90 µm), 58” (140 µm) and 61” (160 µm) for the four bands, respectively. At low flux levels the instrumental PSF deviates from a Gaussian profile.
For the SW bands at 65 and 90 $\mu$m there is no evidence for the presence of circumstellar dust-shells connected directly to the (P)PN. In other words, all derived radial profiles are consistent with the PSF derived from know point sources (such as Ceres). The long wavelength images at 140 and 160 $\mu$m show structured emission - due to cirrus - at and near the target positions; only in a few cases are the point sources detected at these far IR wavelengths. CS dust shells, if present, are very faint or wide and disappeared in the background. For illustration, image maps of two targets, GLMP 1052 and HD 56126, are shown for each of the four filter bands (Figure 2).

![Image Maps](image.png)

Figure 2. Photometric image maps (10 x 40 arcmin; in MJy/sr) are shown for GLMP 1052 (top) and HD 56126 (bottom) at 65, 90, 140 and 160 $\mu$m. Logarithmic brightness levels are adjusted for each of the individual panels to provide optimal contrast.
4. Results II: Aperture Flux Photometry

We performed standard aperture flux photometry on the calibrated maps. When applicable we apply an aperture correction and a point-to-diffuse correction factor (for details we refer to the FIS Slow Scan Toolkit). We did not apply a colour correction at this point. PNe are strong IR emitters and the nearby extended envelope - if present - contributes negligible (within error bars) to the overall flux.
Figure 5. Spectral energy distribution of GLMP 1052 (IRAS 22036+5306)

We compare the 65 and 90 \( \mu \)m fluxes of the pointed observations both with the IRAS 60 and 100 \( \mu \)m and FIS-BSC 65 and 90 \( \mu \)m fluxes in Figure 3 (left and right panel respectively). The flux densities reported in the current \( \beta \)-1 release of the FIS BSC are under-estimated with respect to both the IRAS and FIS pointed observations (this work). Note that IRAS fluxes at 60 \( \mu \)m are indeed slightly lower than AKARI fluxes at 65 \( \mu \)m, as is indeed expected for dust temperatures between 20-70 K. In Figure 4 we compare the pointed observations with the reported fluxes (140 and 160 \( \mu \)m) in the all-sky FIS survey. Coordinates of IRAS and AKARI sources (both pointed and survey) agree all within 15". Note that one source in our sample (IRAS 19500-1709) is not in the BSC.

5. Results III: Spectral Energy Distribution

We use the new results of the aperture flux photometry to construct spectral energy distributions (SEDs). Previous data, from 2MASS, MSX, IRAS and ISO, were obtained via the Toruń catalogue of Galactic post-AGB and related objects (Szczerba et al. 2009).

In Figures 5 and 6 we show the SEDs for two sources, GLMP 1052 and HD 56126, in our sample. The AKARI data extend the SED into the FIR (>100 \( \mu \)m) improving the constraints necessary to fit dust emission models.
6. Summary and Outlook

Additional analysis of the radial profiles in 3D (e.g. differences in cross-scan and in-scan profiles) are in progress to elucidate the possible presence of very compact CS dust close to the star. Future observations, with for example Herschel, may shed more light on these elusive dust shells.

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