Connection Between Morphology of Post-AGB Objects and Their Infrared Colors

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Summary. We present results of our ACS HST snapshot survey of post-AGB objects. 19 new HST images of post-AGB sources have been obtained to date. In addition, we include 14 ACS HST images of post-AGB objects which are still unpublished but available via the HST archive. This sample is supplemented by 33 already published images (23 from [1] and 10 from other works) obtained using instruments on board of HST.

Among the objects having detected nebulosities there is a clear morphological bifurcation of their shapes and properties into two groups: SOLE and DUPLEX objects, as introduced by [1]. Plots of combined 2MASS-IRAS color-color diagrams have allowed us to demonstrate that these two groups are well separated in the J-K versus K-25 diagram. Hence, this diagram can be used to indicate which of the not yet imaged post-AGB objects will have DUPLEX or SOLE morphology or will appear as stellar sources without nebulosities.

The correlations between morphology and physical and/or chemical properties are discussed.

Key words: planetary nebulae: general — stars: AGB and post-AGB — stars: circumstellar matter — stars: mass loss — reflection nebulae

1 Observation

Objects for our snapshot surveys (Siódmiak et al., in preparation) were selected from the Toruń catalogue of Galactic post-AGB and related objects available at

http://www.ncac.torun.pl/postagb/ ([2]). Chosen sources were not observed previously with HST and, because the exposure time for an object from a snapshot survey cannot be too long, our sample was biased towards rather bright stars. 19 post-AGB objects (program ID 10627, PI M. Meixner) were observed with the High Resolution Channel (HRC) of the Advanced Camera for Surveys (ACS) on-board HST. We also included in our reduction and analysis of the images already observed but unpublished to date 14 post-AGB sources imaged with ACS (programs ID 9463 & 10185, PI R. Sahai and 9430, PI S. Trammell). Together we had 33 PPNe observed in broad B (F435W), V (F606W) and I (F814W) filters, that differed in central star masses, optical and infrared colors and effective temperatures [3].

2 Analysis of HST Images

Obtained HST images (see examples in Figure 1) confirmed the clear morphological bifurcation among objects with detected nebulosities, as introduced by [1]: SOLEs with star-dominated emission and faint extended nebulae and dust dominated DUPLEXes with faint or completely obscured central stars.

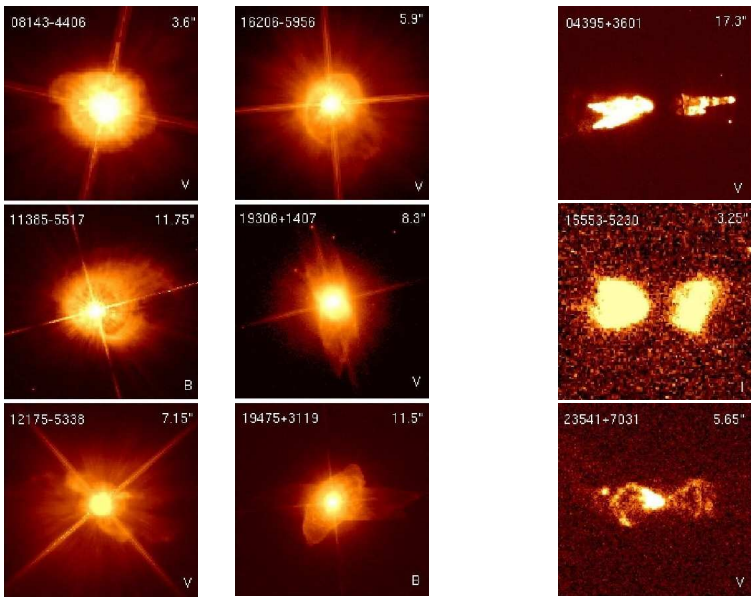

Fig. 1. Images of SOLE (left) and DUPLEX (right) post-AGBs

Our observations revealed also objects without nebulosities and we classified them as stellar post-AGB objects.

To get a wider view we included in our analysis other proto-planetary nebulae already observed with HST and analyzed by other authors. Together there are 66 post-AGB objects (21 SOLEs, 23 DUPLEXes and 22 stellar) with HST images published in the literature.

3 Infrared Color-color Diagrams

Infrared data from IRAS and 2MASS catalogues allowed us to construct and analyze infrared color-color diagrams for post-AGB objects already observed by HST (see Figure 2).

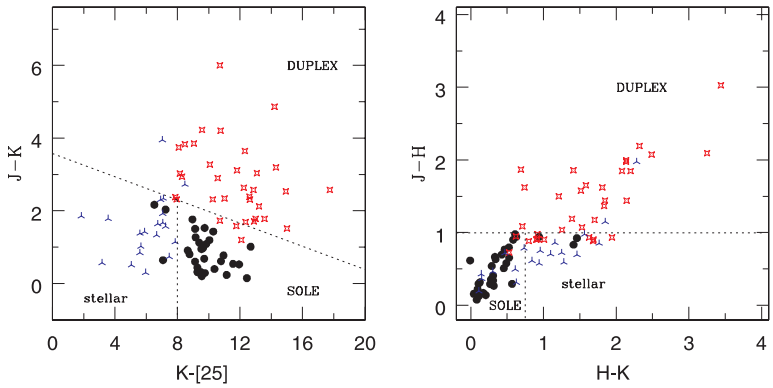

Fig. 2. 2MASS-IRAS color-color diagrams for post-AGB objects observed by HST

The three identified groups of objects are located in different parts of the diagrams (as already presented by [1]). Our bigger sample allowed us to draw more specific division lines between SOLE, DUPLEX and stellar objects. The location of each group is determined by the physical properties of objects and mostly by the thickness of the dust shell.

Differences between SOLE, DUPLEX and stellar objects result also in different spectral energy distribution (SED) shapes (examples are shown in Figure 3). According to the classification scheme of [4] SEDs of SOLEs are of class IV (with optical peak corresponding to the central star and infrared one due to dust emission), DUPLEXes are classified as class II and III (with very prominent dust maximum) and stellar objects are of class I or cannot be classified in this way.

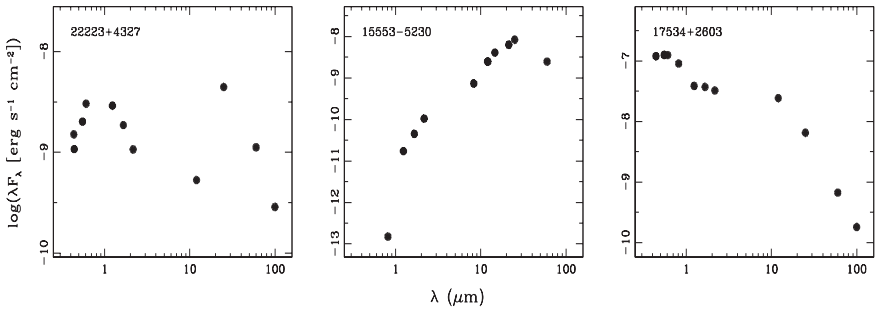

Fig. 3. SEDs of SOLE (left), DUPLEX (middle) and stellar (right) objects

Hence, looking at the infrared colors and having further support in SED shape we can indicate the type of morphology of a post-AGB object even without detailed images, what we did for sources still not observed with HST (Figure 4).

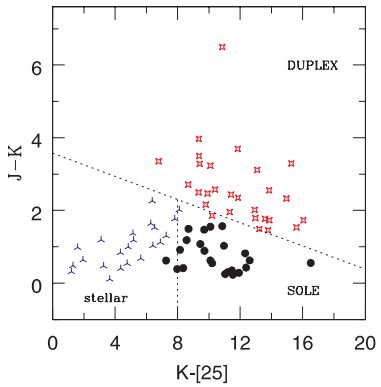

Fig. 4. Color-color diagram for objects not yet observed with HST

4 Do SOLE and DUPLEX Sources Have Different Progenitors?

It was already suggested by [1] that SOLEs and DUPLEXes may have different progenitors, with low and high masses, respectively. More massive object will have more material in the circumstellar shell and the star will be quite obscured - DUPLEXes are indeed fainter in optical but brighter in the infrared. On the contrary, less material in the envelope will result in clearly visible central star - SOLE objects have very prominent optical counterpart. Indeed, masses of SOLE post-AGB objects ([3]) are rather low (with the mean value of $0.6\ M_{\odot}$), but masses of DUPLEXes are not

know in general. Above-mentioned hypothesis can also be supported by the galactic distribution of analyzed post-AGB objects ([1], Siódmiak et al., in preparation) showing that DUPLEX sources are closer to the galactic plane, while SOLEs are usually further from the galactic plane. Those findings could suggest that DUPLEX objects have more massive progenitors than SOLE ones and will probably evolve into bipolar PNe, while SOLEs might form elliptical PNe. Stellar post-AGB objects that have usually low masses and lie far from galactic plane most likely originate from low mass progenitors and may not become PNe.

Acknowledgement. This work has been supported by NASA NAG5-12595, by STScI-G0-10627-01 and by grant N203 0661 33 of the Science and High Education Ministry of Poland.

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