NICMOS Imaging of HD 179821 and AFGL 4106

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Abstract. Near-infrared images from a NICMOS survey revealed the circumstellar matter around several proto-planetary nebulae (PPNe), including IRAS 18184–1623, AFGL 4106, and HD 179821 (=IRAS 19114+0002). The IRAS 18184 data was previously analyzed by O’Hara et al. (2003). Here we present the data on the other two objects.

The true nature of HD 179821 is still a subject of some debate. It could be a yellow hypergiant or a post-AGB star. Regardless, the NICMOS images show that it is surrounded by a nebula with a diameter of ∼ 12″. Until 1600 years ago, it was losing mass at a rate of 3 \times 10^{-4} M_\odot yr^{-1}. It now exhibits multiple concentric shells with small bipolar outer protuberances.

AFGL 4106 was known previously as a spectroscopic binary, consisting of a luminous F-type post-red-supergiant and an M-type red supergiant. It is surrounded by a faint nebula with a diameter of ∼ 3″. Here we present the first image that shows not only the nebula but also the binary companion. It appears at a position angle of ∼ 270° and a separation of 0.′′3.

Keywords. planetary nebulae: individual (HD 179821, AFGL 4106), circumstellar matter

1. Introduction

HD 179821 (= IRAS 19114+0002 = SAO 124414) is an oxygen-rich evolved star surrounded by an extended envelope of gas and dust (Le Coroller et al. 2003). The outflow velocity of HD 179821 is 34 ± 2 km s^{-1} (Zuckerman & Dyck 1986) — larger than the 10–20 km s^{-1} that is typical of post-AGB stars. Polarization measurements made by Trammell et al. (1994), Gledhill et al. (2001), and Parthasarathy et al. (2005) have indicated that the circumstellar dust is bipolar or ring-shaped.

AFGL 4106 (= IRAS 10215–5916) was classified as a transition object by Hrivnak et al. (1989) based on its IRAS colors. García-Lario et al. (1994) classified the central star as a G2 supergiant, and found a nebular expansion velocity of 17 ± 2 km s^{-1}. Molster et al. (1999) concluded, based on its near-infrared spectrum, that AFGL 4106 is a binary system, consisting of an M and A-F-type star of almost equal luminosity. The relatively small luminosity difference between both stars suggests that both components are evolved, i.e., the M star is a giant or supergiant.

2. Results

HD 179821 (see Fig. 1) is approximately 8″ across, roughly symmetrical, but with small-scale protuberances and multiple shells indicating several episodes of mass loss. When the central star and the PSF is subtracted out (see Fig. 1), we see that the nebula is actually ring shaped, with an elliptical hole in the middle. The minor axis of the hole
measures $\sim 1.''72$ in a north-south direction and the major axis measures $\sim 2.''24$ in the east-west direction. At an estimated distance of 6 kpc, the size of the cavity indicates that the stellar wind has been at a low intensity for $\sim 1.7 \times 10^3$ yr. Figure 1 also shows the F164N image of AFGL 4106. The $\sim 8''$ size of the nebula, combined with a distance of 3.3 kpc (Molster et al. 1999), indicates that the nebula has a radius of $2 \times 10^{12}$ km and an expansion age of $3.7 \times 10^3$ yr. The emission in these images is mainly dust-scattered continuum, which is consistent with the fact that the emission has the same spatial distribution in the F164N, F166N, and the F222M images (not shown). The figure also clearly reveals the binarity of the central star(s). The secondary star has a position angle of $\sim 270^\circ$ and a separation of $0.''3$.

3. Conclusions

Recent studies of HD 179821 have suggested that it may be low-mass post-AGB star or a massive (30 M$_\odot$) yellow supergiant caught between the red giant branch and Wolf-Rayet phases (Reddy & Hrivnak 1999). Our NICMOS images show a circumstellar dusty nebula, which is hollow in the center, consistent with observations by Gledhill et al. (2001) and Hawkins et al. (1995), with the latter estimating a change in mass loss rate from $10^{-2}$ to $2 \times 10^{-6}$ M$_\odot$ yr$^{-1}$, accounting for the observed hole in the nebula.

We also presented the first images that directly show the binary nature of the central object in AFGL 4106. The nebulae surrounding AFGL 4106 and HD 179821 are similar, both morphologically and chemically (Le Coroller et al. 2003, Molster et al. 2002).

References