

NICMOS Imaging of HD 179821 and AFGL 4106

M. Bobrowsky¹, T. Ueta² and M. Meixner³

¹CSC/Space Telescope Science Institute, Baltimore, MD, USA
email: mattb@stsci.edu

²NASA Ames Research Center/SOFIA, Moffett Field, CA, USA

³Space Telescope Science Institute, Baltimore, MD, USA

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 $\sim 12''$. Until 1600 years ago, it was losing mass at a rate of $3 \times 10^{-4} M_{\odot} \text{ yr}^{-1}$. 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 $\sim 3''$. Here we present the first image that shows not only the nebula but also the binary companion. It appears at a position angle of $\sim 270^{\circ}$ 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 $34 \pm 2 \text{ km s}^{-1}$ (Zuckerman & Dyck 1986) — larger than the $10\text{--}20 \text{ km s}^{-1}$ 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 $17 \pm 2 \text{ km s}^{-1}$. 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

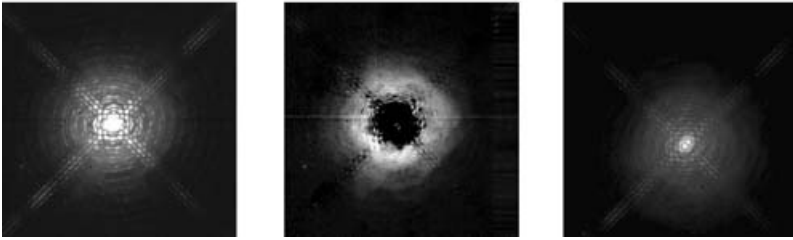


Figure 1. The left image shows HD 179821 imaged in the NICMOS F164N filter. The center image shows the F164N image of HD179821 with the PSF subtracted. The image on the right shows AFGL 4106 imaged in the NICMOS F164N filter. Note the binary star system.

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 2×10^{12} km and an expansion age of 3.7×10^3 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 $2 \times 10^{-6} M_\odot \text{ yr}^{-1}$, 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

- García-Lario, P., Manchado, A., Parthasarathy, M., & Pottasch, S.R. 1994, *A&A* 285, 179
 Gledhill, T.M. *et al.* 2001, *MNRAS* 322, 321
 Hawkins *et al.* 1995, *ApJ*, 452, 314
 Hrivnak, B.J., Kwok, S., & Volk, K.M. 1989, *ApJ* 346, 265
 Le Coroller, H., Lebre, A., Gillet, D., & Chapellier, E. *A&A* 400, 613
 Molster, F.J. *et al.* 1999, *A&A* 350, 163
 Molster, F.J. *et al.* 2002, *A&A* 382, 184
 Reddy, B.E. & Hrivnak, B.J. 1999, *AJ*, 117, 1834
 Parthasarathy, M., Jain, S.K., & Sarkar, G. 2005, *AJ* 129, 2451
 Trammell, S.R., Dinerstein, H.L., & Goodrich, R.W. 1994, *AJ* 108, 984
 Zuckerman, B. & Dyck, H.M. *ApJ* 311, 345