Latest Surprises from Mira the Wonderful

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Abstract We report the latest results from our long-term study of Mira A and its companion Mira B. These include a study of the dust environment in mid-IR wavelengths (Marengo *et al.* 2001), and of the accretion processes in the Mira AB interacting system (Wood, Karovska, and Raymond 2002).

1. Introduction

Mira (o Cet, Mira A) is one of the most extensively observed variable stars, representing the prototype of the "Mira variable" class of pulsating stars. These stars are red giants on the asymptotic giant branch (AGB), with high mass loss rates and extended circumstellar envelopes. Mira A has been observed by the American Association of Variable Star Observers (AAVSO) for more then 100 years; The first measurement of this star in the AAVSO International Database was made by Joao de Moraes Pereira in 1902 (AAVSO 1998).

Mira A pulsation properties are typical for long period Mira variables, with large visual brightness changes of about 7 magnitudes during its 332-day pulsation cycle. Mira A has a hot companion star, Mira B (VZ Cet). The emission from Mira B is generally assumed to be from a white dwarf surrounded by an accretion disk fed by the Mira A massive wind. Mira B dominates the UV emission from the Mira AB system.

2. Discussion

We resolved the dusty circumstellar envelope of Mira AB at 9.8, 11.7, and 18 microns and measured the size of the extended emission. The high-angular resolution mid-IR imaging of the Mira AB circumbinary environment was carried out in 1999 using the MIRAC3 camera at the NASA Infrared Telescope Facility (IRTF). The measured mid-IR apparent sizes of the dust envelope are 10–20 times larger then the apparent size of the Mira A photosphere. We estimate the apparent spatial scale of the Mira A dust envelope from 50 AU (at 10 μm) to 100 AU at 18 μm (assuming a distance of ≈130 pc).

We also detected strong deviations from spherical symmetry in the dust envelope of Mira A in the direction of the accreting companion. Figure 1 shows the deconvolved images at 9.8 and 11.7 µm. These observations suggest that Mira B plays an active role in shaping the morphology of the circumstellar environment of Mira A as it evolves toward the Planetary Nebula phase.

In addition to the images, the spectra of Mira B also show significant changes in the past few years. The most recent Hubble Space Telescope (HST) Space Telescope Infrared Sprctrometer (STIS) observations of Mira B (1999 August) showed that the UV spectrum is dominated by numerous narrow H_2 lines. These lines were not detected in the previous HST observations from 1995 (Karovska *et al.* 1997), or in any of the numerous observations of Mira B by the International Ultraviolet Explorer (IUE) from more then 10 years ago. In addition, the continuum fluxes of our HST/STIS spectra are well below those detected by IUE and previous HST observations, as shown in Figure 2.

This emission may be due to H_2 that is heated in a photodissociation front within Mira A's wind a few AU from Mira B, or to interaction between the winds of Mira A and B. The latest HST observations also show that the accretion rate onto Mira B was much lower then before, indicating possible disruption of the accretion disk. This change may have altered the character of Mira B's UV spectrum. However, the cause of this change is not yet well understood.

Future multiwavelength observations of Mira AB, especially continuing AAVSO monitoring, are critical for determining the origin of this significant variability and for understanding the accretion processes in this fascinating system.

3. Acknowledgements

The predicted and observed dates of maxima of Mira issued by the AAVSO are essential to this ongoing research; they would not be possible without the thousands of observations of Mira contributed to the AAVSO by variable star observers around the world over many decades. I am very grateful to the AAVSO observers and to Janet Mattei for continuous support and inspiration. Support for this work was provided through grant GO-08298-99A from the Space Telescope Science Institute, which is operated by AURA, Inc., under NASA contract NAS-26555. I am a member of the Chandra Science Center, which is operated under contract NAS8-39073, and is partially supported by NASA.

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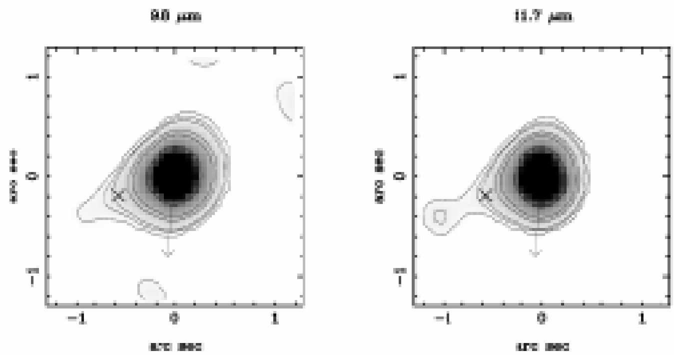

Figure 1. Deconvolved images of Mira AB at 9.8 and 11.7 μm. North is up and West is right. The location of Mira B, as observed by the HST in 1995, is marked by a cross; the arrow indicates the orientation of the dominant asymmetry in the 1995 HST image of Mira A (from Marengo, Karovska, *et al.* 2001).

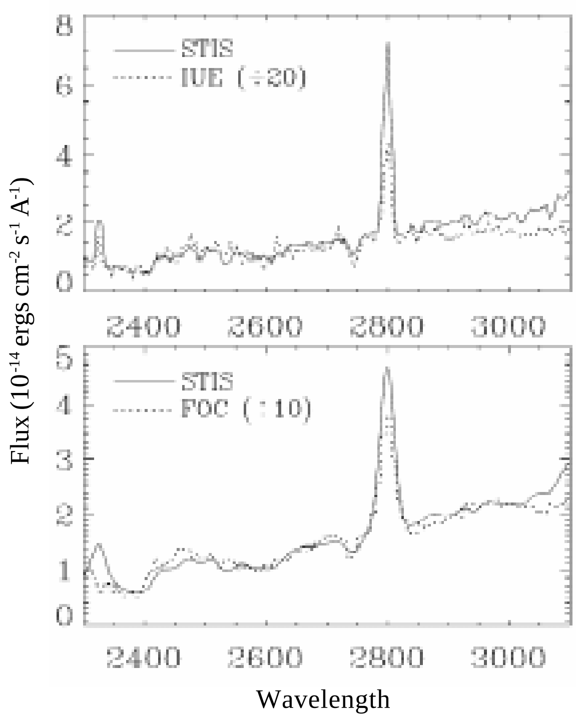

Figure 2. Comparison of the HST/STIS 1999 spectrum of Mira B with previous observations: from IUE almost ten years before (top panel), and from HST/FOC (Faint Object Camera) four years before (bottom panel). In both panels, the STIS spectrum is rebinned, and the IUE and HST/FOC fluxes had to be reduced by factors of 20 and 10, respectively, to match the HST/STIS data (from Wood, Karovska, and Hack 2001).