Temporal Variation of the Warm Molecular Layers around the Mira Variable RR Sco Detected with the VLTI/MIDI Instrument

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1 Introduction

Infrared spectroscopic observations of asymptotic giant branch (AGB) stars with the Infrared Space Observatory (ISO) have revealed the existence of a quasi-static, warm, dense molecular envelope close to the star (e.g., Tsuji et al. [4], Yamamura et al. [5], Cami et al. [1], Matsuura et al. [2]). Although this warm molecular envelope is most likely to play an important role in mass loss, its formation mechanism is not yet understood. The first mid-infrared spectro-interferometric observations of the Mira variable RR Sco (period 281 days, distance 320 pc) using MIDI have revealed that optically thick emission from dense, warm molecular layers (H_2O and SiO) as well as dust thermal emission can make the N-band angular size more than twice as large as that in the K band (Ohnaka et al. [3]). The physical properties of the warm molecular layers derived from the MIDI observations ($T_{\rm mol} \sim 1400$ K, $R_{\rm mol} \sim 2.3\ R_{\star}$, H_2O column density $\simeq 3 \times 10^{21}$ cm^{-2}, SiO column density $\simeq 10^{20}$ cm^{-2}) have turned out to be consistent with those derived for other Mira variables from ISO observations. Here we present the results of MIDI observations of RR Sco at the second epoch.

2 MIDI observations

RR Sco was observed with MIDI (prism mode, $\lambda/\Delta\lambda \simeq 30$) in 2004 July as part of the Open Time proposal (P.I.: K. Ohnaka, 073.D-0347(A)). We used two different MIDI data reduction packages, MIA developed in the Max-Planck-Institute für Astronomie and EWS developed at the Leiden Observatory, and took the average of the visibilities obtained with both reduction packages.

Figure 1 shows the results of MIDI observations at the second epoch (phase 0.0). The wavelength dependence of the uniform-disk diameter observed at phase 0.0 reveals a marked difference compared to the observation at phase 0.6 presented by Ohnaka et al. ([3]). The uniform-disk diameters at phase 0.0 are ~40% larger than that observed at phase 0.6. The wavelength dependence of the uniform-disk diameter observed at phase 0.0 shows a monotonic increase from 8 to 13 μm, while that observed at phase 0.6 is characterized by the constant part between 8 and 10 μm and a gradual increase longward of 10 μm. However, it should be noted that the visibilities at the second epoch were obtained with baseline lengths ranging from 42 to 47 m, while the data at the first epoch were obtained with baseline lengths of 74–100 m. This large difference in the baseline lengths makes the intepretation of the data less straightfoward, and it is necessary to carry out model calculations in order to derive physical properties of the warm H_2O +SiO layers and their temporal variation between maximum and minimum light.

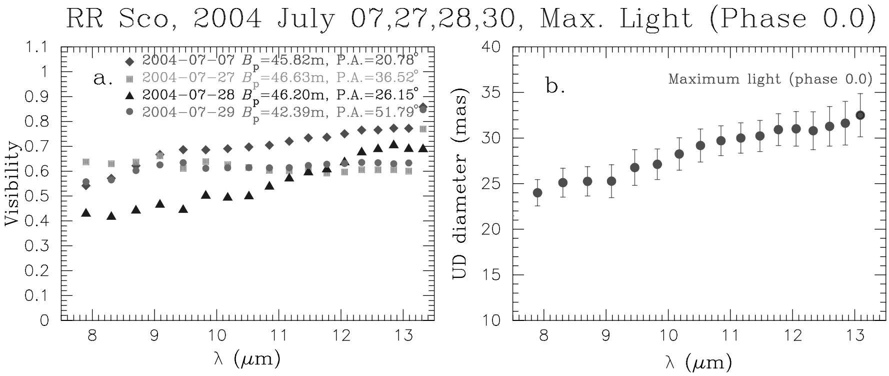

Fig. 1. a: Visibilities measured at four different projected baseline lengths are plotted as a function of wavelength. The errors of the observed visibilities are typically ±10–20%, but the error bars are omitted in this panel for the sake of visual clarity. **b:** Uniform-disk diameter as a function of wavelength. The diameters are derived from uniform-disk fits using all four visibility data points at each wavelength.

References

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