Bull. Astr. Soc. India (2002) 30, 661–664

High angular resolution structures in the dust shell surrounding WR 104 from lunar occultation observations at 2.2 μm

Soumen Mondal* and T. Chandrasekhar*

Physical Research Laboratory, Ahmedabad 380009, India

Abstract. A rare event of lunar occultation of a Wolf-Rayet star (WR104) in the near IR K-band (2.2 micron) is reported. Analysis of the occultation light curve shows a fully resolved dust envelope departing significantly from a uniform disk profile. We report three major peaks in the derived brightness profile. Our results of the dust structure are in good agreement with contemporaneous aperture masking interferometry carried out at the Keck I 10m telescope which shows a pinwheel dust structure around WR104.

Keywords : lunar occultation, Wolf-Rayet star, WR104, dust structure

1. Introduction

A small fraction of Wolf-Rayet (WR) stars belonging to the latest WC evolutionary stage show strong infrared emission signifying the presence of a heated dust shell mainly made up of hot carbon grains (Williams, van der Hucht & Thé 1987). The existence and survival of the dust shells in the intense radiation field encountered in the vicinity of the Wolf-Rayet stars has however been difficult to explain by the conventional spherically symmetric outflow scheme. The brightest infrared WR stars like WR104 and WR98a are nonvariable and are classified as persistent dust makers. The nature of the dust formation in these systems is still not fully understood. It has been suggested that short period binaries lie buried in these systems with wind-wind collisions again catalyzing dust formation (Usov 1991).

The lunar occultation (LO) technique provides elucidation of one-dimensional high spatial resolution structures of typically 2 milliarcseconds (mas) of these types, of extended dusty sources, along the direction of occultation. This paper presents the first lunar occultation study of the Wolf-Royet star WR104 at 2.2 μm. We compare our results with recently observed high angular resolution K-band images by aperture masking interferometry method on Keck I 10m telescope.

*soumen@prl.ernet.in ; chandra@prl.ernet.in

2. Observations and data analysis

The lunar occultation (LO) of the Wolf-Rayet star WR104 was observed on 10 May 2001 at the 1.2m Infrared Telescope of Gurushikhar Observatory, Mt. Abu, India. The event was recorded in only one channel using the high-speed photometer with a sampling rate of 1 ms in the standard K filter (λ = 2.2 μm, $\Delta\lambda$ = 0.4 μm). Details of the instrument can be found in Mondal et al. 1999.

As the conventional least square modeling of the light curve of WR104 shows clear departures from a uniform disk, a model-independent algorithm (MIA), used earlier to study dust structures in IRC+10216 (Chandrasekhar & Mondal 2001), is used. To compare our results with the Keck data we have downloaded six-epoch high-resolution K-band images observed by aperture masking interferometry on 10m Keck I telescope (Tuthill, Monnier & Danchi 1999; 2002). Keck images are properly rotated to match the position angle of our LO observations. For a proper comparison of Keck images with our derived LO brightness profile (BP) we have further reduced the Keck images to one dimension along the direction of our occultation.

Table 1. Relative position of features observed by LO and Keck profiles.

Features	Relative positions in mas	
	LO Profile (May 2001)	Keck 1D Profile (June 2000)
A	0	0
B	26	41
C	43	–
F	–70	–63

3. Results and discussion

The LO profile shown in Fig. 1 exhibits a lot of fine structure consistent with its higher angular resolution but not seen in the Keck profiles as their spatial resolution is 50 mas. We find that our smoothed profile averaged over 90 mas corresponds well with the 1-D Keck profiles. The relative positions of the structures in the dust shell of WR104 as derived by the two techniques of lunar occultation and aperture interferometry at Keck are shown in Table 1.

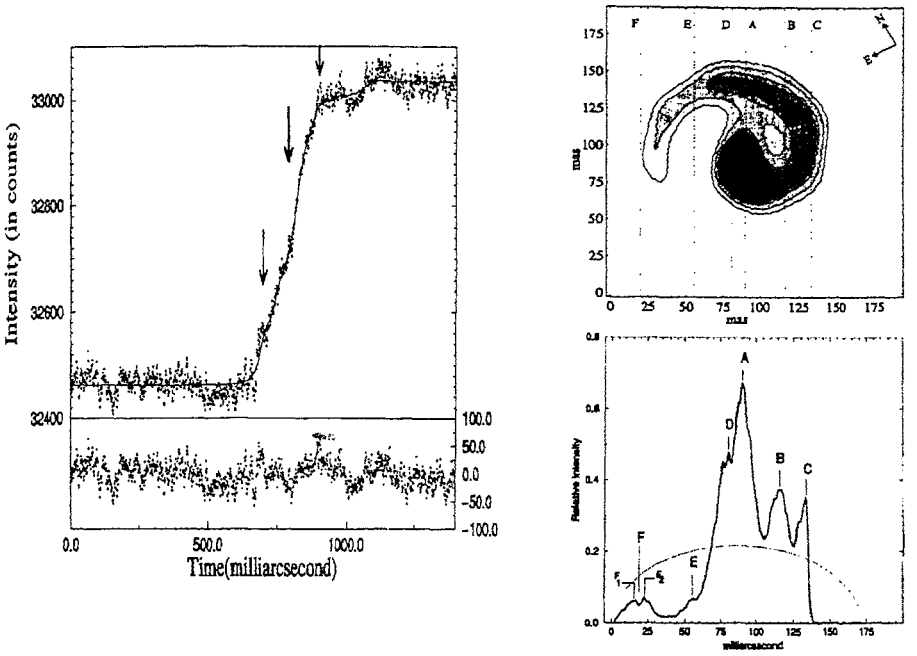

Figure 1. Left : The *dotted line* is the observed Lunar Occulation light curve of WR104 in K-band and the *solid line* is best fit obtained by the MIA analysis. The velocity component of the Moon in the direction of the occultation is 0.553 km/s. The arrows indicate the position of the light curve which result in the departures from the uniform disk profiles and give the source structure. The residual (Data - Model) of the best fit is shown expanded at the bottom. **Right :** *Lower Panel :* The *solid line* is the brightness profile of WR104 derived from the Lunar Occultation light curve and the *dotted line* is the uniform disc (UD) profile. *Upper Panel :* Keck I image of WR104 was taken in April 1998. The direction of occultation is along X-axis.

In addition to main features listed above occultation data also reveal smaller features D and E located from the main peak A at −10 mas and −35 mas respectively. Comparing our observations with the Keck observations, taken one to three years earlier, we conclude that the overall structure is not greatly altered over timescales of a few years. Small temporal changes could however be taking place in the dust structure as evidenced by smaller features, D and E in our observations.

Acknowledgements

We thank Dr. P.G. Tuthill for kind permission to download his high resolution Keck images of WR104.

References

Chandrasekhar T., Mondal S., 2001, MNRAS, **322**, 356
Mondal S., Chandrasekhar T., Ashok N.M., Kikani P.K., 1999, BASI, **27**, 335
Ragland S., Richichi A., 1999, MNRAS **302**, L13

Tuthill P.G., Monnier J.D., Danchi W.C., 1999, Nature, **398**, 487

Tuthill P.G., Monnier J.D., Danchi W.C., 2002, in Moffat A.F.J. and St-Louis N., eds, ASP conf. Ser., Vol. 260, Interacting Winds from Massive Stars, Astron. Soc. Pac., p.321

Usov V.V., 1991, MNRAS, **252**, 49

Williams P.M., van der Hucht K.A., Thé P.S., 1987, A&A, **182**, 91