WAVELENGTH-DEPENDENT STELLAR DIAMETERS USING MAPPIT

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1. Introduction

Interferometry with 4m-class telescopes can be used to measure angular diameters of M giants (including Mira variables) and M supergiants. It has been clear for several years, however, that these stars are not always spherical (Tuthill et al. 1994) and that their shapes, limb darkening characteristics and diameters are wavelength dependent. Several authors have called for wavelength-dependent measurements to improve our understanding of the internal structure and atmospheres of these types of stars (Scholz & Takeda 1987; Bessell et al. 1989; Bessell et al. 1996).

To prevent decorrelation of the interference signals, interferometric angular diameter measurements are generally made in narrow wavelength channels selected by dielectric filters. Here we describe wavelength-dispersed observations which allow us to measure angular diameters simultaneously over a wide range of wavelengths or, with a higher duty cycle, within a tunable narrow-band wavelength region.

2. MAPPIT

MAPPIT (Masked Aperture-Plane Interference Telescope) is an aperture-masked interferometer located in the west coudé room of the 3.9-m Anglo-Australian Telescope. A mask with either a linear array of five holes or a long thin slit is placed at the re-imaged pupil of the telescope. The interference fringes are dispersed in wavelength by a prism and recorded by a CCD camera, giving a wavelength resolution of about 3 nm in the blue and 10 nm in the red.

The observations reported here were made using a setup similar to that described by Bedding et al. (1994), with the following differences: (i) no atmospheric dispersion corrector was used; (ii) a Thomson 1024x1024 CCD was used in place of the IPCS detector; and (iii) an adjustable slit, placed in front of the detector, was used to set the bandpass. With this slit opened wide (Mode 1), we were able to record fringes over a wide bandwidth, allowing simultaneous measurements at several wavelengths. For this mode, the CCD was operated as a conventional two-dimensional detector. In a second configuration (Mode 2), the adjustable slit was narrowed to transmit a narrow range of wavelengths. The central wavelength was selected by tilting a flat mirror. The interference fringes were aligned along columns of the CCD, which was fully binned onto one dimension. More details are given in the following table:

	Mode 1	**Mode 2**
Central wavelength	820 nm	820 & 850 nm (alternating)
Bandpass	320 nm	20 nm
Exposure time	10 ms (at 650 ms intervals)	11 ms (continuous readout)
CCD window —		
spatial direction:	600 pixels	328 pixels
wavelength direction:	220 pixels binned by 5 to 44	about 30 pixels, fully binned

3. Observations of R Doradus

We observed R Doradus (HR 1492; $V = 5.4$; spectral type M8 III) in 1996 December. We have recently shown this star to have a large angular diameter and Mira-like properties (Bedding et al. 1997). Figure 1 shows a single raw exposure using Mode 1 and Fig. 2 shows the stellar spectrum. The wavelength resolution, set by the CCD binning factor, is approximately 7 nm at the central wavelength. This frame shows the wide bandwidth possible with MAPPIT (320 nm in this case), which should allow simultaneous measurements in and out of several TiO bands.

We also observed R Dor using Mode 2 and a five-hole mask. Fig. 3 shows the calibrated visibility curves. The data consisted of 10,000 11-ms frames in each of two wavebands: 850/20 nm (a TiO absorption band) and 820/18 nm (a neighbouring pseudo-continuum region). Despite the large scatter on short baselines, it is clear that the visibilities at longer baselines are lower at 850 nm than at 820 nm, showing that R Dor has a diameter about 20% greater in the TiO band than in the pseudo-continuum. The

Figure 1. A single raw exposure of R Dor using Mode 1. The mask was a thin slit, having an effective width of 10 cm, placed diametrically across the pupil. Fringes are visible in the spatial direction (a result of the telescope's central obstruction) and TiO absorption bands are prominent in the wavelength direction. The structure in the spatial direction provides information about the source structure at a range of spatial frequencies. The central wavelength is 820 nm and the bandwidth is 320 nm.

data at 850 nm are in excellent agreement with earlier observations using a slit mask at 855/40 nm (Fig. 4 of Bedding et al. 1997).

These preliminary results show the flexibility of MAPPIT for measuring wavelength-dependent structure. Observations of R Dor and α Ori, taken using both observing modes, are currently being analysed.

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Figure 2. A spectrum of R Dor made by combining many frames similar to Fig. 1 and collapsing them in the spatial direction. The TiO band and pseudo-continuum region observed with Mode 2 are marked (see Fig. 3).

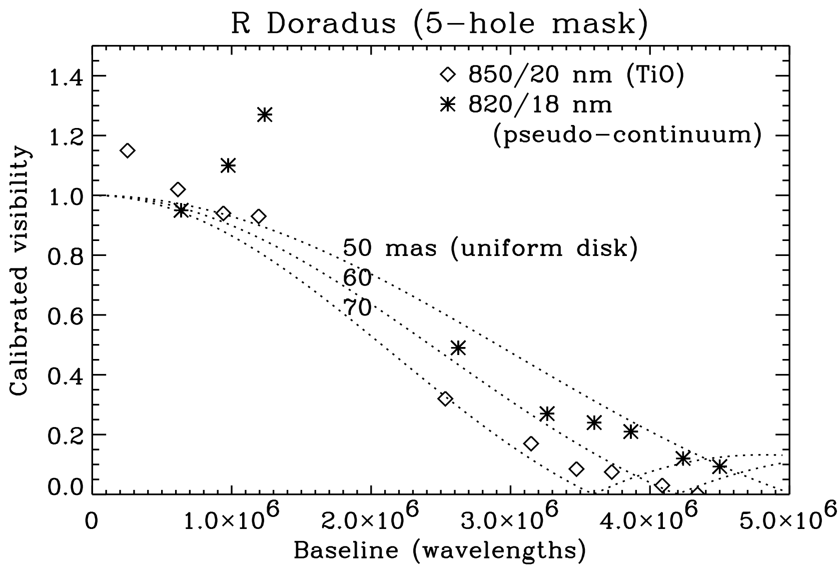

Figure 3. Visibility curves for R Dor using Mode 1. The aperture mask had five holes, each with an effective diameter of 10 cm, and the longest baseline was 3.69 m. The points are measured visibilities at two wavelengths: a TiO band and the neighbouring pseudo-continuum (see Fig. 2). The three dotted curves show visibilities expected from uniform circular disks of diameters 50, 60 and 70 mas. They clearly do not provide a good fit to our data — a Gaussian model or a more detailed approach, as suggested by Haniff et al. (1995), may do better.