SEVEN Be STARS RESOLVED BY OPTICAL LONG-BASELINE INTERFEROMETRY

A. QUIRRENBACH
NRL/USNO Optical Interferometer Project and USRA

1. Introduction

The recent progress in optical interferometry has made the direct study of the circumstellar matter around Be stars possible. The Hα emission region around γ Cas has been resolved with the I2T (Thom et al. 1986), GI2T (Mourard et al. 1989) and MkIII (Quirrenbach et al. 1993) instruments; the results support the basic picture of a rotating disk-shaped envelope (e.g. Poeckert and Marlborough 1978). Nearly spherical geometries can be ruled out. In this paper, first results from MkIII observations of a small sample of Be stars (see Table I) will be presented.

2. MkIII Observations of Be Stars

The observations were carried out on 13 nights between September 27 and November 27, 1992, using the variable north-south baseline of the MkIII interferometer, operated by the Remote Sensing Division of the Naval Research Laboratory (NRL). The instrument has been described by Shao et al. (1988); details of the data reduction and calibration procedures are given by Mozurkewich et al. (1991). For the Be star observations, baseline lengths ranging from 4.0 to 31.5 m were used. Two filters, 1 and 10 nm wide, were centered on the Hα emission line, while a 25 nm wide filter centered at 550 nm was used to measure the continuum for comparison.

None of the observed stars was strongly resolved at 550 nm, as expected from estimates of the photospheric diameters (0.35 to 0.75 mas). In the Hα line, however, all objects were clearly resolved, and deviations from circular symmetry are evident for some stars even in the raw data (e.g. γ Cas, see Quirrenbach et al. 1993). Model fits to the data in the narrow Hα channel with an elliptical Gaussian are presented in Table I; for β CMi the amount of data was insufficient to constrain the fitting parameters well, so a circular Gaussian was used. It should be noted that the contribution of photospheric emission to the flux in the Hα channel will systematically bias the fitted major axis a towards smaller values. This bias decreases with increasing E_α. The values of r derived for ϕ Per, ψ Per, and ζ Tau may actually be upper limits, since the resolution is not sufficient along the minor axes.

3. Discussion

The disk diameters (FWHM of the Gaussians) a correspond to 2 – 10 photospheric diameters; they increase to 3 – 12 photospheric diameters, if the bias to a mentioned above is taken into account. The two stars with the smallest values of E_α, which also have the latest spectral types, have the smallest disks.

The sky brightness distributions for γ Cas, ϕ Per, ψ Per, and ζ Tau are clearly not circularly symmetric; this proves that near-spherical models for the geometry

L. A. Balona et al. (eds.), Pulsation, Rotation and Mass Loss in Early-Type Stars, 450–451.

https://doi.org/10.1017/S0074180900215623 Published online by Cambridge University Press

TABLE I

The MkIII observing list. The Hα excesses E_α are from Coté and Waters (1987), $v \cdot \sin i$ from Uesugi and Fukuda (1982), and polarization position angles χ from Clarke (1990) and Poeckert et al. (1979). The right part of the table gives Gaussian model fits to the interferometer data, with formal uncertainties. The models have three free parameters: major axis a, axial ratio r, and position angle of the major axis ϕ.

Star	HR No.	V	E_α [Å]	$v \cdot \sin i$ [km s^{-1}]	χ [°]	a [mas]	r	ϕ [°]
γ Cas	264	2.47	22.7	260	-68	2.89 ± 0.02	0.77 ± 0.02	24±2
ϕ Per	496	4.07	57.6	505	26	2.36 ± 0.17	0.47 ± 0.05	-64±5
ψ Per	1087	4.23	43.2	375	44	2.78 ± 0.21	0.54 ± 0.07	-37±11
η Tau	1165	2.87	11.9	210		1.57 ± 0.05	0.98 ± 0.06	(48)
48 Per	1273	4.04	24.2	230	-43	2.40 ± 0.52	0.86 ± 0.18	81±43
ζ Tau	1910	3.00	26.9	320	33	3.55 ± 0.33	0.30 ± 0.02	-59±4
β CMi	2845	2.85	11.5	285		1.54 ± 0.03	–	–

of Be star shells are not adequate. Under the assumption of axial symmetry, lower limits for the inclinations i can be derived from $i \geq \arccos r$. The values obtained for ϕ Per, ψ Per, and ζ Tau suggest that these stars are seen almost edge-on, while γ Cas has an intermediate inclination $i \approx 45°$. η Tau and 48 Per are either intrinsically more spherical, or viewed more face-on; the latter possibility seems more plausible and is consistent with the relatively low values of $v \cdot \sin i$.

The polarization of Be stars is generally attributed to Thomson scattering in the circumstellar disk; this explanation predicts that the polarization position angle χ is perpendicular to the equatorial plane. In agreement with this expectation, we find that for the four stars which are significantly elongated the position angle ϕ of the major axis is indeed perpendicular to χ. For ψ Per, our value of ϕ agrees with the one found by Dougherty and Taylor (1992) in the radio regime on a ~ 40 times larger scale.

Acknowledgements

This work has been done in collaboration with Drs. J.T. Armstrong, D.F. Buscher, N.M. Elias, C.A. Hummel, and D. Mozurkewich. I thank the Alexander von Humboldt foundation for support through a Feodor Lynen fellowship.

References

Clarke, D.: 1990, *A&A* **227**, 151
Coté, J., and Waters, L.B.F.M.: 1987, *A&A* **176**, 93
Dougherty, S.M., and Taylor, A.R.: 1992, *Nature* **359**, 808
Mourard, D., Bosc, I., Labeyrie, A., Koechlin, L., and Saha, S.: 1989, *Nature* **342**, 520
Mozurkewich, D., et al.: 1991, *AJ* **101**, 2207
Poeckert, R., Bastien, P., and Landstreet, J.D.: 1979, *AJ* **84**, 812
Poeckert, R., and Marlborough, J.M.: 1978, *ApJ* **220**, 940
Quirrenbach, A., et al.: 1993, *ApJ*, in press
Thom, C., Granes, P., and Vakili, F.: 1986, *A&A* **165**, L13
Uesugi, A., and Fukuda, I.: 1982, *Revised Catalogue of Stellar Rotational Velocities*, Kyoto