Time-Series Spectroscopy of ζ Ophiuchi

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Abstract

We have undertaken a multi-site, multi-wavelength observing campaign on the archetypal O stars ζ Puppis (O4 I(n)f) and ζ Ophiuchi (O9.5 V). Both stars are well known for the strength of their line profile variations (lpv's), and represent extremes of O spectral type and luminosity class. UV time-series spectroscopy of ζ Pup and ζ Oph is described by Prinja *et al.* (Ap.J. 1992, **390,** 266), and Howarth *et al.* (Ap.J. 1992, *submitted*) respectively. The optical spectroscopic results of ζ Oph are reported by Reid *et al.* (1992, ApJ *submitted*), of which some of the principal results are given here.

During late April, and early May, 1989, we obtained high-resolution, high signal-to-noise optical spectra of the late O-type, rapid rotator ζ Oph. Time-series analysis, using the CLEAN algorithm, has shown that the characteristic lpv seen in He I λ4471Å, Si III $\lambda\lambda$4552, 4567, 4575Å, and Mg II λ4481Å can be satisfactorily represented as a set of 4 sinusoids. No substantial variation is observed in He II λ4541, or N III λ4517Å. We attribute this behaviour to a combination of equatorial gravity-darkening and a latitudinally-confined origin for the lpv.

The phase changes over the line profiles indicate repetitive patterns of axial symmetry, rotating prograde in the co-rotating frame of the star. The periods are 3.339 hours ($-m = 4$), 2.435 hours ($-m = 5$ or $-m = 6$), 1.859 hours ($-m = 9 \pm 1$), and either 1.366 hours or 1.292 hours ($-m = 11 \pm 1$); $-m$ represents the spatial frequency around the stellar equator. The first three periods confirm those found at earlier epochs, and we conclude that some lpv characteristics are reproduced over at least a 2-year interval.

Since no commensurate superperiod ($|m|$P) exists, and since the superperiods are less than our estimated minimum rotation period for ζ Oph (> 18 hours), we reject a rotational modulation origin for the lpv and conclude that the star is undergoing multi-mode, sectorial, non-radial pulsations.

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