THE ASTROPHYSICAL JOURNAL, **198**:551–553, 1975 June 15

HELIUM λ10830 IN ALPHA VIRGINIS A AND B

DAVID D. MEISEL*
Department of Physics and Astronomy, State University of New York College at Geneseo
AND
RICHARD A. BERG
Department of Physics and Astronomy and the C. E. K. Mees Observatory, University of Rochester
Received 1974 October 29; revised 1974 December 23

ABSTRACT

Line profiles and velocities of He I λ10830 obtained at maximum velocity separation of the spectroscopic binary Spica (α Vir) are presented. We derive a mass ratio, M_A/M_B, of 1.4 and an equatorial velocity of 88 km s^{-1} for α Vir A. A meaningful discussion of observed equivalent widths of the He I λ10830 line awaits a more certain determination of the spectral classification of α Vir B.

Subject headings: binaries — early-type stars — stars, individual

Spica has been the subject of two recent studies of its spectroscopic orbit and β Cephei nature (Shobbrook, Lomb, and Herbison-Evans 1972; Dukes 1974). During initial tests of the Vaughan pressure-scanned Fabry-Perot interferometer (modified to restrict the bandpass to a single order), we obtained a scan of Spica at He I λ10830. Although this scan is not of maximum possible quality, it was obtained within hours of the maximum velocity separation of the line components. The interferometer was attached to the 24-inch (61 cm) reflector of the C. E. K. Mees Observatory at South Bristol, New York. The scan consisted of 13 separate 30 s integrations at 1.5 Å intervals. The scan epoch was 1973 April 15 between 0600 and 0650 UT. The half-power full width of the interferometer was 1.2 Å and the scanning gas was N_2 between 2 and 120 pounds per square inch (i.e., between 1.4 and 83 × 10^4 Nt m^{-2}) above ambient atmospheric pressure. The wavelength stability of the instrument is better than ±0.1 Å (±3 km s^{-1}) during a given night. The zero point of the wavelength scale is established using dome-diffused, He I emission-lamp radiation. Contributions to each point due to finite instrumental bandwidth have been removed using an iterative deconvolution procedure. Corrections for blocking filter transmission have also been applied where necessary. The wavelengths, radial velocities, and normalized intensities are given in Table 1 and Figure 1.

Taking the γ velocity to be zero, the following line velocities (±5 km s^{-1}) and total absorptions were derived.

α Virginis A.—$V \sin i$ = 80 km s^{-1}. He I λ10830 equivalent width = 0.45 ± 0.04 Å. Radial velocity: (*a*) line depth weighted average = +115 km s^{-1}; (*b*) minimum line intensity = +84 km s^{-1}.

α Virginis B.—$V \sin i$ = 100 km s^{-1}. He I λ10830 equivalent width = 0.61 ± 0.04 Å. Radial velocity: (*a*) line depth weighted average = −164 km s^{-1}; (*b*) minimum line intensity = −210 km s^{-1}.

* Associate at the C. E. K. Mees Observatory.

TABLE 1

SPICA, 1973 APRIL 15, 0600–0650 UT, EPOCH JD 2,441,787.75

Rest Wavelength	Radial Velocity (km s^{-1})	Normalized Intensity
10819.5.......	−294	1.00
10821.0.......	−252	0.88
10822.5.......	−210	0.72
10824.0.......	−168	0.79
10825.5.......	−126	0.86
10827.0.......	−84	0.86
10828.5.......	−42	0.93
10830.0.......	0	1.00
10831.5.......	+42	0.94
10833.0.......	+84	0.73
10834.5.......	+126	0.79
10836.0.......	+168	0.80
10837.5.......	+210	1.00
±0.1 Å*	±3 km s^{-1}*	±0.02*

* rms deviation.

Using the line-depth weighted velocities, we obtain M_A/M_B = 1.4 for the mass ratio for α Vir. Both line profiles are asymmetrical, with the secondary showing the greatest line distortion. The orbital elements of Dukes (1974) for the primary predict a velocity of +114 km s^{-1}, in good accord with that obtained using line-depth weighting. Neither of the weighted velocities agree with the predictions of the orbit given by Shobbrook *et al.* (1972), but the maximum depth velocity of the secondary (−210 km s^{-1}) agrees acceptably with the predicted −208 km s^{-1}. Shobbrook *et al.* (1972) state that their measurements refer to the line cores. However, the core of the λ10830 line of the primary is displaced −36 km s^{-1} away from the point predicted by the Shobbrook *et al.* elements. Such an amplitude is large for the 4-hour periodicity, but is within the range of the velocity amplitude (31 ± 5 km s^{-1}) found from Baker's (1909) data with a 6-hour period (Shobbrook *et al.* 1972). If a systematic correction of 31 km s^{-1} is applied to the line core

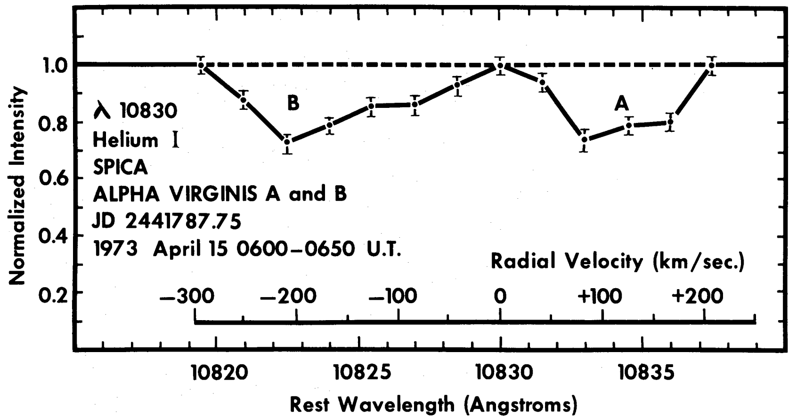

FIG. 1.—Helium line λ10830 profile in Spica. The error bars indicate uncertainty due to counting statistics.

velocity, we obtain a value of $+116$ km s^{-1} for the A component, which agrees quite well with the Dukes prediction and the line-depth weighted average. With this correction, the line cores predict $M_A/M_B = 1.8$. Without the correction, the line cores would give an unusually high M_A/M_B value. It is not clear which M_A/M_B value is the better estimate, but we note that $\langle M_A/M_B \rangle = 1.6 \pm 0.2$ (m.e.) is in excellent agreement with that found by Shobbrook *et al.* and adopted by Dukes, but with a much larger uncertainty ($\pm 12\%$ versus $\pm 2\%$). Considering the pronounced B component line asymmetry in the λ10830 profile and the possibility that the β Cepheid variation can be ± 30 km s^{-1} when the 6-hour pulsation is present, an uncertainty in the mass for B of ± 12 percent does not seem unreasonable ($M_A = 10.3 \pm 0.8\ M_\odot$ [Dukes] and $M_B = 6.4 \pm 0.8\ M_\odot$).

If the line core displacement of the A component is due entirely to the β Cephei pulsation, then the 6-hour fundamental (?) may have been present in mid-1973. This interesting possibility should be examined in any available photometric data.

The rotational velocities implied by the half-intensity full widths are only somewhat less than would be expected from synchronous rotation. Our rotational velocities cannot be easily reconciled with the 155 km s^{-1} quoted by Watson (1972), unless his value was obtained at a phase where blending was significant. The rotational frequency estimate made by Dukes (1974) based on Watson's value is therefore too high. Our results imply that the equatorial velocity is 88 km s^{-1} and $\Omega = 0.22$ c/d for α Vir A. Arguments concerning the rotational splitting of the β Cephei pulsation modes should be revised accordingly. For Spica, it seems that models such as those considered by Denis (1972) assuming synchronous rotation would be applicable if extended to higher polytropic indices.

No quantitative discussion of the observed equivalent widths of He I λ10830 has been attempted because of the uncertainty of the spectral classification of α Vir B. It seems well established that B1 V is reasonable for α Vir A (Jaschek, Conde, and de Sierra 1964). A mean spectral type for α Vir A+B of B1.5 V in a spatial configuration similar to the maximum velocity phase was derived by a careful intercomparison of microphotometer tracings of 40 Å mm^{-1} plates taken with the 72-inch (1.8 m) Perkins telescope of the Ohio State and Ohio Wesleyan Universities at Lowell Observatory in the years 1965–1966. The exposure of Spica was made on baked Kodak IIa-O plates by Philip Ianna. A total spectral range of 3400–4900 Å is available. The epoch of the Perkins plate was 1965 June 25.12 UT, a time when the velocity separation between A and B lines was 90 km s^{-1} and the phase was such that the "back side" of α Vir A and "front side" of α Vir B were toward the Earth in a configuration $+0.1$ orbital phase away from that of the λ10830 profile. Our classification is based on the relative strengths of the He I lines shortward of the Balmer limit, the relative strengths of the H I and He I lines at the Balmer limit, the O II and N II lines, and the relative strengths of the He I lines longward of Hγ. The MK standard star tracings available included ω^1 Sco (B1 V), ζ Cas (B2 V), o Per (B1 III), and σ Sco (B1 III). Comparison was also made to a tracing of 23 Ori A (B1 IV). We are in the process of studying near-infrared spectra of Spica taken with the 24-inch Mees telescope at maximum velocity phases in an effort to improve the spectral classification, especially of the B component. Preliminary inspection indicates B2$^+$ V for B, but this is somewhat uncertain, and more plates must be taken to improve the result. The above classification of the composite spectrum (with the A component assumed predominant) is slightly cooler than the usual estimates (Jaschek *et al.* 1964) for this star, but the microphotometric tracings indicate quite clearly that Spica A+B is intermediate to the standards with regard to temperature and not intermediate with regard to luminosity.

This work is supported by NASA grant NGR 33-219-002 and a Research Grant from the State University College at Geneseo. We thank Dr. Arne Slettebak of the Perkins Observatory, Delaware, Ohio for extended loan to one of us (D. D. M.) of Perkins plates used to derive the spectral type of α Vir A.

REFERENCES

Baker, R. H. 1909, *Pub. Allegheny Obs.*, **1**, 65.
Denis, J. 1972, *Astr. and Ap.*, **20**, 151.
Dukes, R. J. 1974, *Ap. J.*, **192**, 81.
Jaschek, C., Conde, H., and de Sierra, A. C. 1964, *Obs. Astr. Univ. Nac. de La Plata*, Serie Astronomica, **28**, No. 2.
Shobbrook, R. R., Lomb, N. R., and Herbison-Evans, D. 1972, *M.N.R.A.S.*, **156**, 165.
Watson, R. D. 1972, *Ap. J. Suppl.*, **24**, 167.

RICHARD A. BERG: Department of Physics and Astronomy, University of Rochester, Rochester, NY 14627

DAVID D. MEISEL: State University of New York, College at Geneseo, Geneseo, NY 14454