AN IMPROVED MODEL OF THE B0.5e + Be BINARY SYSTEM φ Per

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1. Current knowledge

φ Per (HD 10516) is a spectroscopic binary with a 126.699-day period (Ludendorff 1910, Cannon 1910, Harmanec 1985). However, most of the published RV curves of the primary are based on H I shell lines and exhibit a typical distortion with a sharp maximum, shallow minimum and a bump at $0.^P4$ after the RV maximum (c.f., e.g., Harmanec 1985). There has been controversy on the nature of the secondary. Hynek (1940) and Hendry (1976) concluded that the binary was composed of two B stars. Peters (1976) suggested that the secondary of φ Per is a Roche-lobe filling K giant. Poeckert (1981) reported the discovery of a weak He II 4686 emission which moved in antiphase to the Be primary and suggested that it originated in the disk around the secondary. In his interpretation, the secondary is a helium star, a remnant of an originally more massive star which in the past transferred its mass to the present Be star. There is now no mass tranfer in the system according to Poeckert. Using RVs of the broad absorptions for primary, and of the He II 4686 emission for the secondary, Poeckert obtained two roughly sinusoidal RV curves and

$$M_1\sin^3 i = 21.1\ m_\odot \text{ and } M_2\sin^3 i = 3.4\ m_\odot.$$

The primary mass seems too high for a B0.5III-V star.

Harmanec (1985) advocated a model in which the secondary is evolutionary shrinking towards the helium main sequence *and loses mass* towards the Be primary due to the rotational instability at its equator. Recently, Gies et al. (1993) discovered two He I 6678 emissions moving in antiphase to the primary and argued in favour of Poeckert's (1981) orbital elements but Harmanec's interpretation of the system dynamics.

L. A. Balona et al. (eds.), Pulsation, Rotation and Mass Loss in Early-Type Stars, 327–328.

2. New preliminary orbital elements

To obtain better orbital elements, we adopted *emission-wing velocities for both components* of φ Per.

The finding that the hydrogen emission lines move in orbit with the primary of φ Per is not new. It was first established by Jordan (1913). We have verified that the Balmer emission-wing RVs published by various authors and our own lead to virtually identical sinusoidal RV curves - in spite of secular changes in the emission strength of Balmer emission.

We concluded that what Gies et al. (1993) describe as the main and secondary peaks of the emission (seen in both elongations) may in fact be **a double emission** from the disk around the secondary. We measured RVs of these emission wings of He I 6678 line on all Ondřejov Reticon and OHP ISIS and Aurelie CCD spectra we secured. Separate solutions for these data led to a sinusoidal RV curve in an exact antiphase to that of the Balmer emission, with a semiamplitude of 98 $\pm$ 5 km s^{-1}, i.e. *lower* than that obtained by Poeckert (1981) and Gies et al. (1993) but higher than that found by Hendry (1976). Solution for both components leads to

$$\text{Period} = 126.699 \text{ days} \quad T_{\text{prim.ecl.}} = \text{HJD } 2448226.8 \pm 1.3$$
$$e = 0 \text{ (assumed)} \quad K_1 = 10.12 \pm 0.54 \text{ km s}^{-1} \quad K_2 = 98 \pm 5 \text{ km s}^{-1}$$
$$M_1 \sin^3 i = 15.0\ m_\odot \quad M_2 \sin^3 i = 1.55\ m_\odot \quad A \sin i = 270.7\ R_\odot.$$

Since the orbit is very nearly circular, our orbital elements define – for the first time – the true phases of elongations and conjunctions of the binary. There is a hint of possible phase-locked light minima around phases 0.6 and possibly 0.05 in our Hvar and published UBV photometry. If real, they must be associated with projection effects of some circumstellar material within the system.

Dereddening of our standard mean UBV values of φ Per from Hvar V = $4^m.019$, B-V = $-0^m.081$, U-B = $-0^m.909$ leads to values which correspond to a spectral type B0.5V or slightly earlier, in a very good agreement with the primary mass of 15 $m_\odot$ which follows from our orbital solution. The mass of the secondary, 1.5 $m_\odot$, seems reasonable for a helium star.

References

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