V379 Cep: a System of Two Binaries

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Abstract. We obtained new series of electronic spectra and *UBV* photometry of V379 Cep
and analyzed them in an effort to check whether the conclusion about its anomalous masses
is not premature. We found that the second system of spectral lines seen in the spectra of
V379 Cep does not belong to the secondary but to the primary of another binary Ba+Bb
(orbital period of $159^{\rm d}\!.0$) which constitutes a quadruple system with the narrow-lined $99^{\rm d}\!.76$
eclipsing binary Aa+Ab (for which we report probable detection of the secondary and derive
improved period and orbital elements). The mutual motion of the two binaries A+B around the
common centre of gravity is also observable and the probable orbital period is some 7878 days.
Our result shows that the components Aa and Ba are somewhat evolved but removes the re-
ported discrepancy of anomalously small masses. We find that V379 Cep is an astrophysically
interesting quadruple system for which a future combination of interferometry, spectroscopy and
photometry can provide *individual masses of all four bodies.*

Keywords. binaries: eclipsing, stars: early-type, stars: individual (V379 Cep)

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1. Introduction

As found by Jerzykiewicz (1993) and confirmed by Clayton (1996), the variable star
V379 Cep (also HD 197770, HR 7940) is an eclipsing binary; the spectral type is B2 IV,
magnitude $V = 6.3$ mag, the period is 99.76 day. The minima are only about 0.05 mag
deep, the secondary minimum comes at phase 0.5. Variability of radial velocity of this
object has been known for a long time. Gordon *et al.* (1998) obtained modern spectra
of this object and found two sets of lines: sharp lines and broad lines, both of identical
spectral type. Gordon *et al.* interpreted them as lines of the primary and secondary
components of the eclipsing binary; however, the resulting masses came out as rather
strange, being only about a third of the values expected for the given spectral type.

2. New spectroscopy and the second binary

We obtained more spectra with the Ondřejov Observatory 2-m telescope (partly using
HEROS, an echelle fiber spectrograph loaned by Landessternwarte Heidelberg) and the
Dominion Observatory 1.2-m telescope. These data showed that the original interpreta-
tion was not true: the broad lines vary in RV but not with the $99^{\rm d}\!.76$ eclipsing-binary

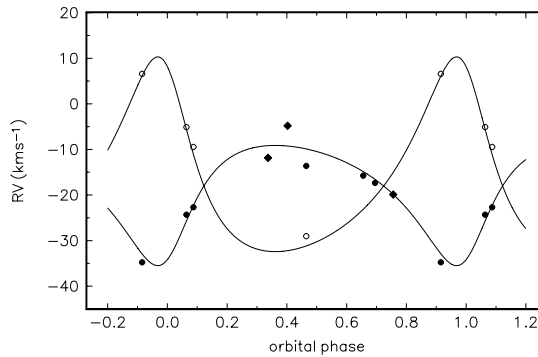† E-mail address: `mayer@mbox.cesnet.cz`

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Figure 1. A phase diagram for the wide orbit with a period of 7878 days, as defined by the locally derived systemic velocities for the $99^\text{d}.76$ and $159^\text{d}.0$ binaries. The values from the old data are shown by diamonds, those for the new ones by circles (black ones for the $99^\text{d}.76$ binary and empty ones for the 159^d binary).

Table 1. Orbital parameters

Element	Binary A	Binary B	Mutual orbit
Peroid (days)	99.7634	159.0	7878 (?)
T(periastron)	24 41905.52	24 53004.5	24 53090
Eccentricity	0.120	0.50	0.36
ω (°)	268.1	58	206
K_1 (km s^{-1})	43.2	18	12.8
K_2 (km s^{-1})	75 (?)	–	–
$A_3 \sin i$ (AU)	0.39	0.23	19

period. Therefore, they belong to another binary. After collecting enough spectra, we were able to find a period for this binary of 159 days. It also became clear that the systemic velocities of both binaries vary in antiphase, i.e., both binaries revolve around the common mass centre. A possible period for this orbit is 7878 days, however this period and velocity amplitudes are not yet known with certainty, since the period depends upon velocities obtained early in the last century at Mount Wilson and DAO observatories (which we interpret as velocities of the sharp lines).

3. Parameters of three orbits

The orbital parameters of all three orbits are listed in Table 1, and the radial velocity curves are shown in Figures 1 and 2. Phases calculated relative to the periastron are used (also in Figure 3); note that then the phase of the primary minimum is close to 0.5 and of the secondary minimum to 0.0.

4. Light curve solution

We obtained also additional photometry at the Hvar Observatory, San Pedro Martir Observatory and with APT Villanova. We found that the periastron longitude of the orbit of A is very close to 270°, which explains why the secondary minimum is so close to phase 0.5 (if the phase of the primary minimum is assumed zero). The photometry has not yet defined both minima with the accuracy needed for a reliable solution of the light
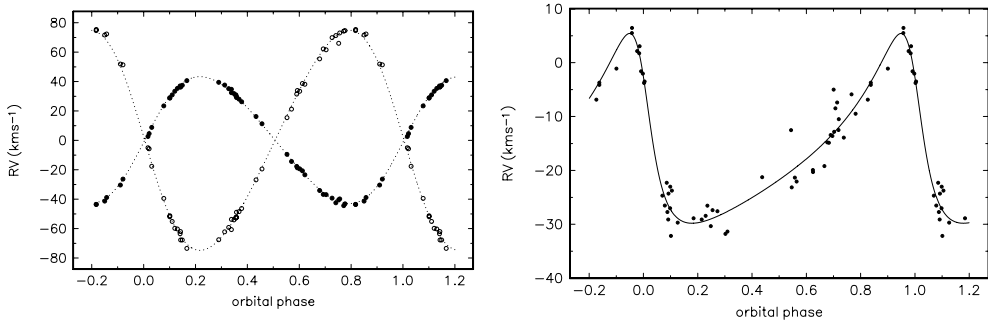
Figure 2. A phase diagram for the $99^{\rm d}.762$ (left) and $159^{\rm d}$ orbits (right) and all new RVs based on a FOTEL triple-star solution, i.e., prewhitened for the $7878^{\rm d}$ period.
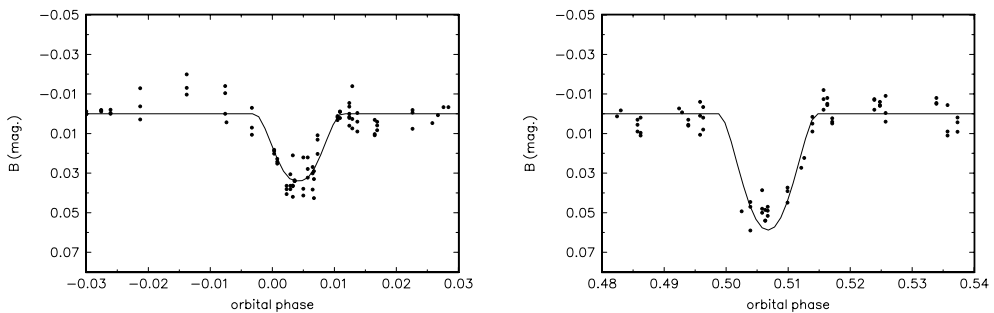

Figure 3. The *B* light curves of the eclipsing system Aa+Ab with the solution for a 64% contribution of the light from B binary shown in the neighbourhood of both minima.

curve, but some preliminary results are possible. The best solution was obtained when the contribution of the binary B was assumed as 64%; the observations are compared with theoretical light curve in vicinity of both minima in Figure 3. The secondary star in the eclipsing binary (Ab) is of low luminosity (less than $1/10$ of L_1), therefore its lines are invisible. Attempts to disentangle the spectrum around the line H_α using KOREL (Hadrava 1995, 1997, 2004) gave some results, but — due to the low luminosity of Ab — only of low weight.

5. Masses

Very probably, all components of both binaries are normal stars, albeit the discussion of their masses is not yet quite unambiguous. Masses of the components of the eclipsing binary depend on the KOREL solution; with the present values, the mass of the primary component Aa well corresponds to its spectral type B2 IV. For the orbit of B, the mass function is 0.056 $M_\odot$, which means that the minimum mass of the secondary (Bb) is less than 2 $M_\odot$. The total mass of the B binary follows from the mutual orbit; the mass of the primary (Ba) is then about 9 $M_\odot$, again not too far from the value expected for the given spectral type (identical to Aa).

Table 2. Binary A: FOTEL light curve solution and absolute parameters

	System	
	Primary	Secondary
P [days]	99.7638	
a [R$_\odot$]	231	
i [$^\circ$]	88.2	
M [M$_\odot$]	10.6	6.1
R [R$_\odot$]	9.9	3.2
$\log g$ [cgs]	3.47	4.21

6. Conclusion: interferometry needed

The distance of the system was estimated as 440 pc by Gordon *et al.* (1998). Due to the multiplicity, the distance is larger, and may be about 500 pc. The semimajor axis of the binary A is then 2.1 mas, of B is $2.5/\sin i_B$ mas. It will take several years until a better coverage of the mutual orbit is obtained. This orbit is so large that interferometry should separate both binaries — the advantage is that their magnitudes are comparable. The semimajor axis might be about 40 mas; at present however the binaries are close to conjunction, i.e., the separation depends mostly on the inclination of the orbit. Since integral masses of both binaries are known, this inclination can be calculated as 73°, and the separation should be under 20 mas for several next years. Both individual binaries might be separated by an advanced interferometer; the luminosity ratio is high in both cases, however.

Acknowledgements

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