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ABSOLUTE PROPERTIES OF ZZ URSAE MAJORIS

CLAUD H. SANDBERG LACY AND JEFFREY A. SABBY

Department of Physics, University of Arkansas, Fayetteville, AR 72701 USA

Radial velocities have been measured on 27 spectrograms obtained with the Kitt Peak National Observatory coude-feed CCD spectrometer between May 1989 and May 1999. A typical spectrogram is shown in Fig. 1. Radial velocities were obtained by cross-correlation with suitably broadened spectra of the radial velocity standard β Vir (RV = 4.3 km/s, Mayor & Maurice 1985). The radial velocities are listed in Table 1.

We have adopted an eclipse ephemeris based on the dates of minima of Mallama (1980) and Hanzl (1991):

$$\text{Min I} = 2\overset{\text{d}}{.}2992599n + \text{JD } 2447967.4134$$
$$\pm 0.0000005 \qquad\qquad \pm 0.0004$$

We have fitted a circular spectroscopic orbit, given in Table 2. The fitted orbit is displayed in Fig. 2. The residuals from both the primary and secondary orbits were 1.1 km/s. We have combined our spectroscopic orbits with the photometric orbit of Clement et al. (1997); the results are shown in Table 2.

Table 1: Heliocentric radial velocities of ZZ UMa.

HJD − 2400000	RV (km/s)		HJD − 2400000	RV (km/s)	
	Primary	Secondary		Primary	Secondary
47651.6661	18.7	−165.2	51246.8659	−154.6	38.0
47652.7547	−144.8	24.7	51246.9082	−149.5	33.8
47655.6915	−109.7	−14.4	51247.9057	28.8	−176.7
47656.7073	5.3	−149.0	51248.9040	−154.2	40.1
48013.6395	−124.1	3.8	51249.9436	9.2	−153.4
48017.7156	2.8	−141.0	51309.7210	9.1	−151.3
48018.7101	−154.2	39.4	51309.8099	21.6	−165.0
49485.7416	−140.7	23.3	51312.6475	−18.6	−120.2
49486.7165	27.6	−175.0	51313.6480	−140.6	25.1
49488.7593	17.3	−162.1	51313.6900	−133.3	16.7
50938.7165	−157.9	44.0	51313.7331	−124.9	8.0
50939.6885	26.4	−172.4	51314.7072	22.7	−169.3
50940.7404	−147.1	31.4	51315.7079	−160.5	47.2
50944.7106	−7.4	−133.0			

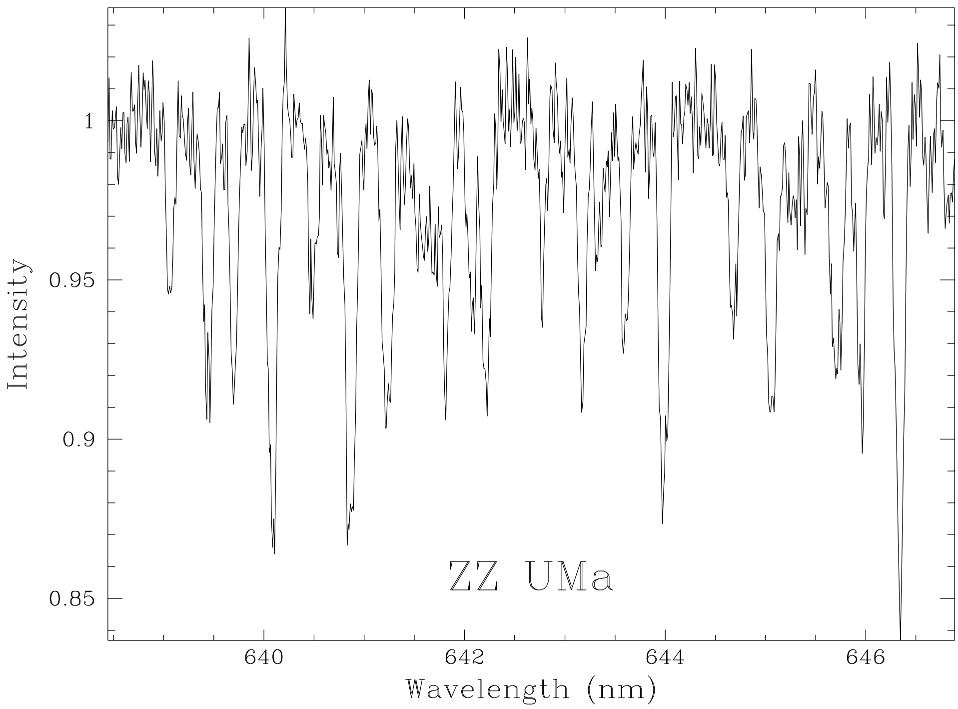

Figure 1. Typical spectrogram of ZZ UMa near 643 nm. Lines of the secondary component are displaced to the left (blueward) at the phase shown.

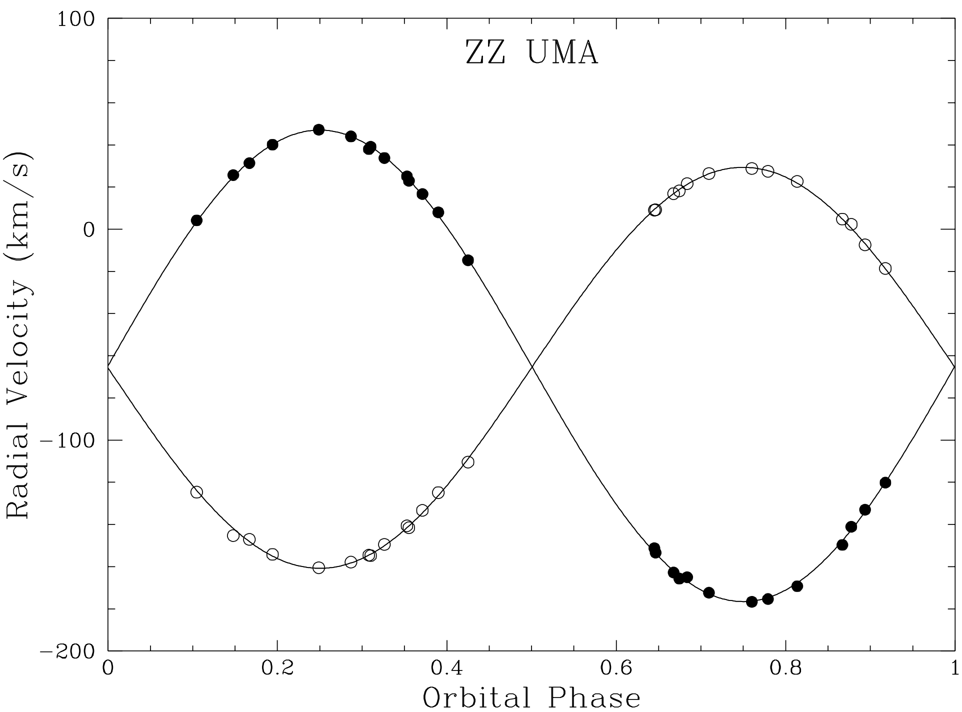

Figure 2. Spectroscopic orbits of the components of ZZ UMa. The primary (hotter and more massive) component is represented by open circles, the secondary by filled circles.

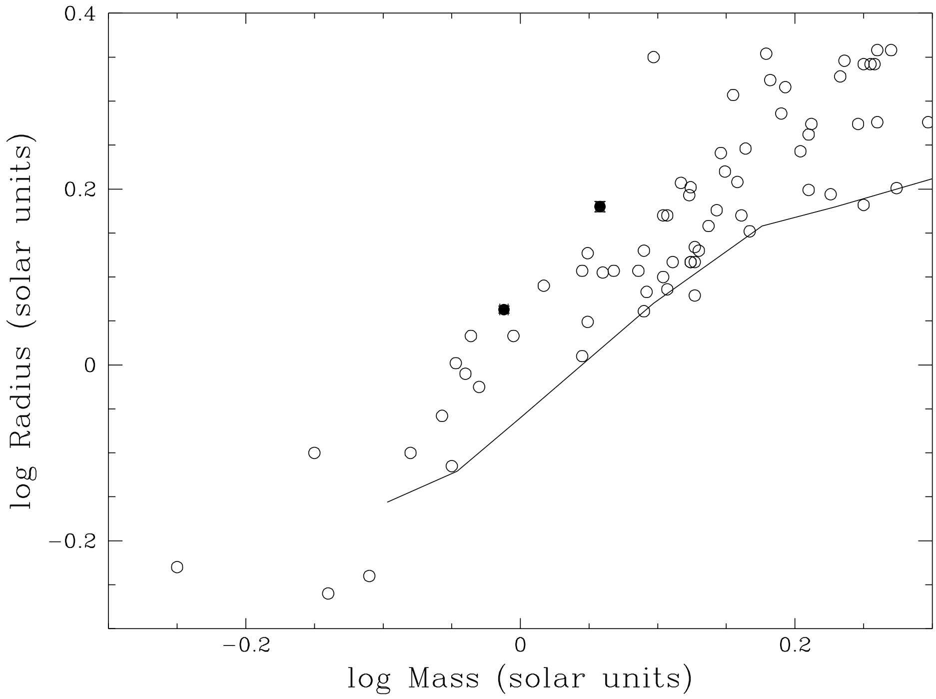

Figure 3. The components of ZZ UMa (solid circles with error bars) in the mass-radius plane. Open circles correspond to accurately-known components of eclipsing binaries. The curve is the theoretical ZAMS of Schaller et al. (1992).

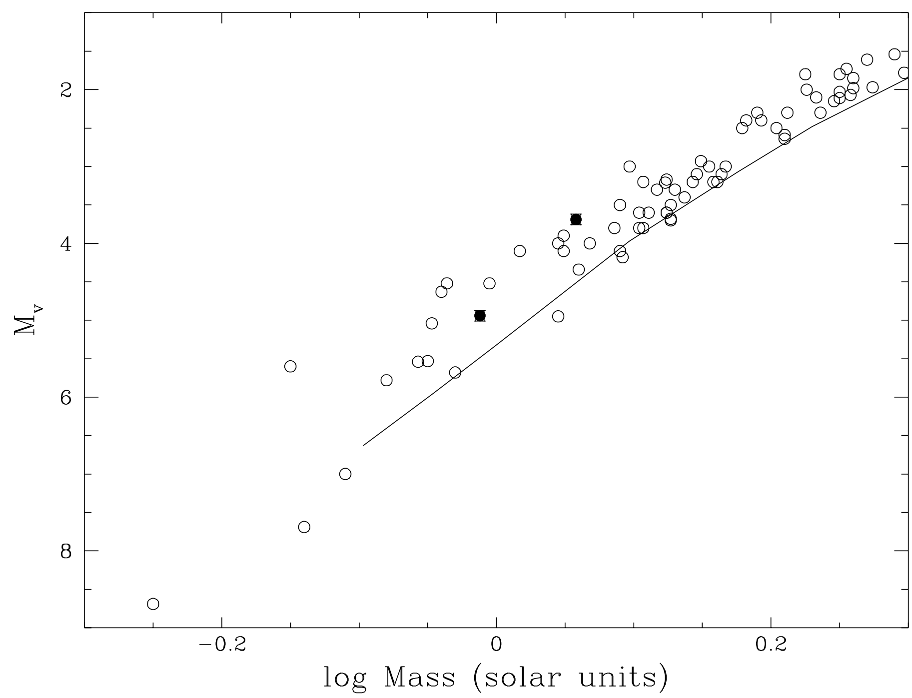

Figure 4. The components of ZZ UMa in the mass-luminosity plane. The symbols are the same as in Fig. 3.

Table 2: Absolute properties of ZZ UMa.

Parameter	Symbol	Primary	Secondary
Relative radius	r	0.161 ± 0.002	0.123 ± 0.001
Orbital inclination (degrees)	i	88.01 ± 0.07	
Visual central surface brightness	$J_{\rm v}$	1.0	0.556 ± 0.006
Intrinsic color index (mag.)	$(b-y)_0$	0.374 ± 0.012	0.479 ± 0.012
Temperature (K)	T	5960 ± 70	5270 ± 90
Radial velocity semi-amp. (km/s)	K	95.1 ± 0.3	111.8 ± 0.3
Center-of-mass radial vel (km/s)	γ	-65.7 ± 0.2	-64.8 ± 0.2
Observed rotational vel (km/s)	$v \sin i$	32 ± 2	26 ± 2
Mass (solar units)	M	1.142 ± 0.007	0.972 ± 0.007
Radius (solar units)	R	1.51 ± 0.02	1.16 ± 0.01
Surface gravity (cm/s^2)	$\log g$	4.135 ± 0.011	4.299 ± 0.007
Synchronous rotational vel (km/s)	$v \sin i$	33.3 ± 0.4	25.5 ± 0.2
Luminosity (solar units)	$\log L$	0.42 ± 0.02	-0.03 ± 0.03
Absolute visual mag.	$M_{\rm v}$	3.69 ± 0.07	4.94 ± 0.07
Distance (pc)		195 ± 10	

The results are displayed in Figs. 3 & 4. Our results differ from those of Clement et al. (1997) due to improved accuracy of the spectroscopic orbits, and due to a significantly redder adopted color index for the secondary component. Our color index is based on the visual central surface brightness of the secondary, which is a parameter of the photometric orbit, through the equation in Lacy et al. (1987): $\delta F_{\rm v} = 1/4 \log J_{\rm c}$. Popper's (1980) calibration (his Table 1) was used to convert from surface brightness parameters into effective temperatures. The primary component parameters are well fitted by theoretical models such as those of Schaller et al. (1992) or Claret & Gimenez (1992) for solar composition at an age of about 5–6 $\times$ 10^9 yr, but the secondary component can not be well fitted by any of the current models because it is cooler than predicted by the models. The origin of this discrepancy is unknown.

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