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The Spectroscopic Orbit of SAO 167450, Visual Companion of AA Ceti

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ABSTRACT. We have determined a spectroscopic orbit for SAO 167450, which is the visual secondary of the W UMa-type eclipsing binary AA Cet, and so the system is quadruple. Radial velocities from the coudé feed and 4 m telescopes at Kitt Peak National Observatory produce an orbit with a period of 25.68 days and an eccentricity of 0.50. We classify both the primary and secondary as G0 subgiant/dwarf stars and find that they are somewhat metal rich relative to the Sun. The high lithium abundances of both components argue that the stars are less than 1 Gyr old. If the components are dwarfs, they are pseudosynchronously rotating, while if they are subgiants, they are rotating more slowly than pseudosynchronous. We very roughly estimate a period of 5,000–15,000 yr for the visual pair. Although it has been suggested that in a multiple system, the combination of Kozai cycles and tidal friction may produce contact binaries, the separation between the visual components in this system appears to be much too large to accomplish that result.

1. INTRODUCTION

SAO 167450 (ADS 1581 B, $\alpha = 01^h59^m00.1^s$, $\delta = -22°55'0.6''$ [2000]) is the fainter star of the visual pair first identified by Herschel (Mason et al. 2001) and given the discoverer identification H 2 58 in the Washington Double Star Catalog (Mason et al. 2001). The visual pair is currently separated by 8.6″ and has a V magnitude difference of 0.44 (Lampens et al. 2001). Comparing the observations in Aitken (1932) and Lampens et al. (2001), over roughly the past 200 yr there has been only a slight change of 4° in the position angle of the pair, while the separation has also remained essentially constant.

The brighter star of the visual binary, HD 12180 (AA Cet = ADS 1581 A = SAO 167451), rose from obscurity when Bloomer (1971a, 1971b) examined Bamburg Observatory patrol plates of the southern sky and discovered that its light varies with an amplitude of 0.5 mag. Shortly thereafter, Kukarkin et al. (1972) assigned the star the variable star name AA Cet. Additional observations enabled Bloomer (1972) to determine that AA Cet has continuous variability between eclipses and a very short period of 0.53617 days. Recently, Duerbeck & Rucinski (2007) obtained a spectroscopic orbit and concluded that AA Cet is a rather typical contact binary with a mass ratio of 0.35. They also reported a mean spectral type of F3 V, deduced from its color, while Pribulla et al. (2009) determined a type of F4 V from classification spectra.

The fainter star of the visual pair, SAO 167450 (ADS 1581 B), has engendered much less interest even though Chambliss (1981) found that it also is a double-lined binary, making the wide visual binary a quadruple system. In a spectroscopic survey of F-type dwarfs, Nordström et al. (1997) obtained three spectrograms when the components were at double-lined phases. Their velocities clearly show orbital motion. Chambliss (1981) gave a mean spectral class of F5 for this binary. Some basic properties of the visual components are given in Table 1.

In this article we have determined the short-period spectroscopic orbit of SAO 167450 and estimated the spectral types, iron and lithium abundances, and projected rotational velocities of its components. We have also discussed the relationship between the visual secondary and AA Cet.

2. RADIAL VELOCITY OBSERVATIONS

From 1985 through 2008 we obtained 53 observations at Kitt Peak National Observatory (KPNO). One was acquired with the 4 m telescope, Cassegrain echelle spectrograph, and a CCD detector, while all the rest were made with the coudé feed telescope, coudé spectrograph, and various CCD detectors. The latter telescope is comprised of a 1.5 altitude-azimuth mounted flat mirror that sends light to a 0.9 m off-axis paraboloid. Table 2 provides a summary of the various telescope, spectrograph, and detector combinations.

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TABLE 1

Basic Properties of the Visual Pair

HD	SAO	ADS	Spectral Type	V[a] (mag)	$B-V$[a] (mag)	Parallax[b] (mas)
12180	167451	1581 A	F4 V[c]	7.26	0.43	8.99
…	167450	1581 B	G0 subgiant/dwarf[d]	7.59	0.59	…

[a] Perryman et al. 1997.

[b] van Leeuwen 2007.

[c] Pribulla et al. 2009.

[d] This article.

We determined velocities for our KPNO observations with the IRAF cross-correlation program FXCOR (Fitzpatrick 1993). We used the IAU radial velocity standard stars HR 33,10 Tau, and ι Psc, which have spectral types similar to SAO 167450, as reference stars for the correlations. Their velocities were adopted from Scarfe et al. (1990). In cases where the lines of the components were partially blended, we determined the velocities with a double Gaussian fit to the cross-correlation function. Table 3 lists the dates of observation, radial velocities of the components, and the appropriate source code, taken from Table 2, for each observation.

As noted in § 1, there are a small number of additional observations in the literature that were obtained at double-lined phases, specifically, the single observation of Chambliss (1981) and the three of Nordström et al. (1997). The usefulness of those velocities will be examined after our observations are analyzed.

3. SPECTROSCOPIC ORBIT

We determined a preliminary period for the primary with the program PDFND, which uses the least string method, implemented by T. J. Deeming (Bopp et al. 1970). Next, with our KPNO velocities we computed a preliminary orbit for each of the two components with the program BISP (Wolfe et al. 1967), which employs a slightly modified version of the Wilsing-Russell method. We then refined those orbits with SB1 (Barker et al. 1967), a program that uses differential corrections. The orbital elements in common from those two single-lined solutions were in excellent agreement. From the ratio of the variances of the two solutions, we adopted weights of 1.0 for all the primary and secondary velocities, except for two observations that were given zero weight because the lines were extensively blended. With SB2, a program that is a slightly modified version of SB1, we then obtained a simultaneous solution of our velocities of the two components, which we call the KPNO solution.

Having determined an orbit with our KPNO velocities, we next looked at the literature velocities for possible inclusion in a final orbital solution. Because those observations are so few, we examined the two velocities of Chambliss (1981) and the six of Nordström et al. (1997) in the context of our double-lined orbit. When added with unit weights to our KPNO velocity data set, the eight velocities from the literature had significantly larger average residuals than the KPNO velocities.

TABLE 2

Telescope, Spectrograph, and Detector Combinations

Telescope	Camera/Grating	CCD Detector[a]	Central Wavelength (Å)	Wavelength Range (Å)	Dispersion (Å pixel^{-1})	Source Code
Coudé feed	5/D	TI5	6428	6382–6473	0.114	1
Coudé feed	5/31.6 echelle	STIS2048	5205	4820–5590	0.036	2
Coudé feed	5/A	TI5	6428	6386–6470	0.106	3
4 m	Long Red/58-63 echelle	T2KB	4679	4177–5181	0.057	4
Coudé feed	5/A	T2KB	4536	4366–4707	0.17	5
Coudé feed	5/31.6 echelle	F3KB	4338	4126–4549	0.019	6
Coudé feed	5/31.6 echelle	F3KB	5842	5417–6267	0.025	7
Coudé feed	5/A	TI5	6700	6658–6742	0.106	8
Coudé feed	5/31.6 echelle	F3KB	4283	3976–4590	0.018	9
Coudé feed	5/A	F3KB	4537	4377–4697	0.107	10
Coudé feed	5/31.6 echelle	T2KB	6087	5690–6484	0.042	11
Coudé feed	5/31.6 echelle	T2KB	4955	4430–5480	0.034	12
Coudé feed	5/A	T1KA	6400	6314–6486	0.168	13

[a] TI5 = Texas Instruments 800×800, 15μ pixel. STIS2048 = Tektronix 2048×2048, 24μ pixel. T2KB = Tektronix 2048×2048, 24μ pixel. F3KB = Ford/Loral 3072×1024, 15μ pixel. T1KA = Tektronix 1024×1024, 24μ pixel.

Comparing this new all-data solution with the KPNO solution, all of the orbital elements were changed by just 1–1.5σ and there was a slight improvement in the uncertainties. Despite the fact that the observation of Chambliss (1981) was obtained 3 yr before our first KPNO observation, the uncertainty in the period was not substantially improved. Given their larger average residuals, the appropriate weights for the literature velocities should be less than the initially adopted values of unity, resulting in smaller revisions to the orbital elements than the 1–1.5σ changes in the all-data solution. Therefore, we have chosen not to include the small number of observations from the literature in our adopted final solution but have retained the KPNO solution. However, the literature radial velocities are listed in Table 3 along with their residuals to our final orbit.

Table 4 lists the orbital elements of this final solution. The period is 25.68 days and the orbit is rather eccentric with $e = 0.50$. The minimum masses are large and nearly equal. Figure 1 compares the radial velocities and computed orbit, where zero phase is a time of periastron.

4. SPECTRAL TYPES AND MAGNITUDE DIFFERENCE

Strassmeier & Fekel (1990) identified several luminosity-sensitive and temperature-sensitive line ratios in the 6430–6465 Å region. They employed those critical line ratios and the general appearance of the spectrum as spectral-type criteria. However, for stars that are hotter than about G2 spectral class, the line ratios in that wavelength region have little sensitivity to luminosity. Thus, we have used the entire 84 Å spectral region of our KPNO TI CCD observations to estimate just the spectral classes of the components. The luminosity class may be determined by computing the absolute visual magnitude with the *Hipparcos* parallax and comparing that magnitude to evolutionary tracks or a table of canonical values for giants and dwarfs.

Chambliss (1981) gave a spectral class of F5 for the combined spectrum but the Tycho $B - V$ of 0.59 (Perryman et al. 1997) suggests a later spectral type. Thus, spectra of SAO 167450 were compared with the spectra of several late-F and early-G stars primarily from the lists of Fekel (1997) and Keenan & McNeil (1989). The reference-star spectra were obtained at KPNO with the same telescope, spectrograph, and detector as our TI CCD binary-star spectra. To facilitate a comparison, various combinations of the reference-star spectra were rotationally broadened, shifted in radial velocity, appropriately weighted, and added together with a computer program developed by Huenemoerder & Barden (1984) and Barden (1985) in an attempt to reproduce the binary spectra.

The components have spectra that are very similar to each other, so the same reference star was used to represent both the primary and secondary. Various late-F and early-G stars with solar iron abundances did not produce good matches to the spectra of the components of SAO 167450. Instead, we found that the reference star ι Per (G0 V, Johnson & Morgan 1953, Keenan & McNeil 1989; with mean $[\mathrm{Fe/H}] = 0.07$, Taylor 2005) was an excellent fit to the spectrum of both the primary and secondary. Valenti & Fischer (2005) found an even higher [Fe/H] value of 0.16 for ι Per, so we conclude that the components of SAO 167450 are clearly somewhat metal rich, when compared to the Sun. As discussed in § 7, because the revised *Hipparcos* parallax has a large uncertainty, the stars may be subgiants or dwarfs. Thus, we classify each star as a G0 subgiant/dwarf.

The two stars have essentially identical spectral types. Therefore, the continuum intensity ratio is also the luminosity ratio and can be converted directly into a magnitude difference. The continuum intensity ratio of the secondary/primary is 0.887, which results in a magnitude difference of 0.13 at 6430 Å. We adopt this value as the V mag difference of the components.

5. PROJECTED ROTATIONAL VELOCITIES

We have determined $v \sin i$ values from our red-wavelength KPNO spectra with the procedure of Fekel (1997). For each component, the full width at half-maximum of several metal lines in the 6430 Å region was measured and the results averaged. An instrumental broadening of 0.21 Å was removed from the measured broadening by taking the square root of the difference between the squares of measurements of the stellar and comparison lines, resulting in the intrinsic broadening. The calibration polynomial of Fekel (1997) was used to convert this broadening in angstroms into a total line broadening in kilometers per second. Following Fekel (1997), for early-G stars we adopted a macroturbulent broadening value of 3 $\mathrm{km\,s^{-1}}$. For SAO 167450 our $v \sin i$ values, averaged from 11 spectra, are 6.0 ± 1.0 and 5.9 ± 1.0 $\mathrm{km\,s^{-1}}$ for the primary and secondary, respectively.

6. LITHIUM ABUNDANCE

With the coudé feed and TI CCD detector we acquired one spectrum of the region that includes the Li I line at 6707.8 Å. That spectrum shows that the lithium lines of both components are nearly as strong as the corresponding nearby Ca I line at 6717.7 Å. We measured equivalent widths of 74 and 57 mÅ for the lithium lines of the primary and secondary, respectively. Adopting our continuum intensity ratio of 0.887, we determined actual equivalent width values of 140 for the primary and 121 mÅ for the secondary. To convert those equivalent widths into lithium abundances requires the effective temperatures of the components. Using the mean $B - V$ color of 0.56, adopted in § 7, and Table 3 of Flower (1996), we assumed an effective temperature of 6000 K for both components. From Table 2 of Soderblom et al. (1993) we then obtained lithium log abundances of 3.1 and 3.0 for the primary and secondary, respectively. The two values are very similar to those of the solar-type stars in the Pleiades cluster, which has an age of 100 Myr (Meynet et al. 1993). By the age of the Hyades cluster, ~600 Myr, lithium has begun to be depleted in stars that have temperatures of 6000 K (Soderblom et al.

TABLE 3

Radial Velocities of SAO 167450

HJD (2,400,000)	Phase	V_1 ($\mathrm{km\,s^{-1}}$)	$(O-C)_1$ ($\mathrm{km\,s^{-1}}$)	V_2 ($\mathrm{km\,s^{-1}}$)	$(O-C)_2$ ($\mathrm{km\,s^{-1}}$)	Source[a]
44,887.838	0.151	68.0[b]	0.1	−12.0[b]	−2.0	C81
46,076.595	0.448	15.9	0.3	41.7	−1.5	1
46,077.668	0.490	11.5	0.0	46.9	−0.5	1
47,407.877	0.295	37.5[b]	2.1	21.6[b]	−1.4	N97
47,835.570	0.952	41.2[b]	1.7	17.1[b]	−1.8	N97
48,159.739	0.577	4.4[b]	0.4	55.2[b]	0.3	N97
48,209.747	0.525	8.5	0.2	50.8	0.2	2
48,210.759	0.564	5.0	0.0	54.0	0.1	2
48,913.826	0.946	34.0	0.0	23.5	−1.0	3
48,915.866	0.025	99.7	0.1	−43.0	−0.8	3
49,245.908	0.879	3.1	−0.1	56.1	0.3	3
49,248.903	0.995	81.2	−0.3	−23.4	0.4	3
49,249.892	0.034	101.5	0.3	−43.4	0.4	3
49,250.950	0.075	93.3	−0.8	−36.5	0.1	3
49,251.817	0.109	81.8	−0.3	−23.9	0.5	3
49,256.849	0.305	28.7[b]	−5.2	28.7[b]	4.2	4
49,293.783	0.743	−4.7	0.3	63.6	−0.5	5
49,294.781	0.782	−5.0	0.4	63.9	−0.6	5
49,301.818	0.056	100.3	0.9	−41.8	0.2	3
49,302.806	0.095	88.2	1.0	−28.9	0.7	3
49,307.929	0.294	36.4	0.7	22.6	−0.2	3
49,674.705	0.578	3.8	−0.1	54.7	−0.3	3
49,971.832	0.150	68.0	−0.2	−9.4	0.8	3
50,318.970	0.670	−1.9	0.1	61.0	−0.1	6
50,351.828	0.949	37.4	0.3	21.2	−0.1	7
50,364.804	0.455	15.1	0.2	43.0	−0.9	3
50,365.839	0.495	11.0	0.0	47.6	−0.3	3
50,366.801	0.533	8.2	0.6	51.5	0.2	3
50,400.719	0.853	−1.3	0.0	60.9	0.6	8
50,401.704	0.892	6.8	0.2	52.2	−0.1	3
50,753.783	0.604	2.5	0.4	57.1	0.2	3
50,754.778	0.642	−0.2	0.3	59.7	0.2	3
50,755.788	0.682	−2.5	0.2	61.7	0.0	3
50,758.861	0.802	−4.7	0.3	64.2	0.1	3
51,091.846	0.770	−5.4	0.0	64.3	−0.2	3
51,092.865	0.809	−4.4	0.4	64.0	0.1	3
51,093.852	0.848	−1.7	0.3	61.2	0.2	3
51,094.823	0.886	4.3	−0.6	53.8	−0.3	3
51,176.621	0.071	95.5	0.2	-38.0	−0.2	9
51,177.599	0.110	82.5	0.7	-25.3	−1.2	10
51,208.586	0.316	33.8[b]	1.7	25.0[b]	−1.4	10
51,411.847	0.232	47.0	−0.1	10.4	−0.7	10
51,470.817	0.529	7.5	−0.4	51.4	0.4	10
51,475.830	0.724	−5.0	−0.5	63.3	−0.2	3
51,805.896	0.579	3.2	−0.7	54.8	−0.2	3
52,180.850	0.182	58.6	−0.5	−1.5	−0.4	3
52,539.907	0.165	63.5	−0.1	−5.8	−0.2	3
52,540.908	0.204	53.0	−0.4	4.3	−0.4	3
52,941.854	0.819	−3.7	0.6	63.6	0.2	3
53,274.805	0.786	−5.0	0.3	64.9	0.5	3
53,639.860	0.004	88.3	−0.2	−31.1	−0.2	3
53,682.745	0.674	−2.5	−0.2	61.7	0.4	11
53,753.577	0.432	17.6	0.3	41.7	0.2	12
54,003.875	0.180	59.7	0.2	−1.4	0.0	3
54,407.806	0.912	13.4	−0.4	44.4	−0.6	3
54,408.806	0.951	38.6	0.4	20.4	0.2	3
54,733.938	0.613	2.0	0.6	57.3	−0.2	13

[a] C81–Chambliss 1981, N97–Nordström et al. 1997; other source numbers are from Table 2.

[b] Velocity given zero weight in the solution.

TABLE 4

Orbital Elements and Derived Parameters of SAO 167450

Parameter	Value
P (days)	25.676855 ± 0.000038
T (HJD)	$2{,}449{,}300.3770 \pm 0.0089$
e	0.5000 ± 0.0010
ω_1 (deg)	314.61 ± 0.16
K_1 (km s^{-1})	53.43 ± 0.10
K_2 (km s^{-1})	54.28 ± 0.10
γ (km s^{-1})	29.274 ± 0.043
$m_1 \sin^3 i$ ($M_\odot$)	1.0907 ± 0.0044
$m_2 \sin^3 i$ ($M_\odot$)	1.0736 ± 0.0044
$a_1 \sin i$ (10^6 km)	16.337 ± 0.031
$a_2 \sin i$ (10^6 km)	16.598 ± 0.031
Standard error of an observation of unit weight (km s^{-1})	0.4

1990). This comparison indicates that SAO 167450 is rather young, certainly younger than 1 Gyr, and perhaps as young as 100 Myr. Such an age suggests that the components of SAO 167450 are more likely to be dwarfs rather than subgiants.

7. CIRCULARIZATION AND SYNCHRONIZATION

The two main theories of orbital circularization and rotational synchronization (e.g., Zahn 1977; Tassoul & Tassoul 1992) disagree significantly on absolute time scales but do agree that synchronization should occur first. Observationally, Duquennoy & Mayor (1991) examined the multiplicity of solar-type stars in the solar neighborhood. They determined that while systems with periods ≤10 days had circular orbits, longer period orbits are generally eccentric. Thus, with an orbital period of 25.68 days it is not particularly surprising that SAO 167450 has an eccentric orbit.

Obviously, if the orbit is not circular, true synchronization can not occur. However, in an eccentric orbit, Hut (1981) has shown that the rotational angular velocity of a star will tend to synchronize with the velocity of orbital motion at periastron, a condition called pseudosynchronization. With equation (42) of Hut (1981), we compute a pseudosynchronous period of 9.15 days for SAO 167450.

To determine if the components of SAO 167450 are pseudosynchronously rotating, we must estimate their radii, which we obtain using the Stefan-Boltzmann law. From the Double and Multiple Systems Annex section of the *Hipparcos* catalog (Perryman et al. 1997) the combined Tycho V magnitude of SAO 167450 is 7.59 and its $B-V$ color is 0.59. We presume that interstellar extinction is negligible, a reasonable assumption given the distance estimates of the system that are computed below. With a magnitude difference of 0.13 we obtain $m_v =$ 8.28 and 8.41 for the primary and secondary components, respectively. According to the Double and Multiple Systems Annex, the parallax for SAO 167450 was assumed to be the same as that of its brighter visual companion, AA Cet. Recently, van Leeuwen (2007) has revised the *Hipparcos* parallax of 4.63 ± 2.36 mas to 8.99 ± 3.63 mas, a value that is nearly twice as large. His result corresponds to a distance of 111 ± 54 pc. The parallax, the V magnitude, and the adopted V magnitude difference were combined to obtain absolute magnitudes $M_V = 3.05 \pm 0.88$ mag and $M_V = 3.18 \pm 0.88$ mag for the primary and secondary, respectively. The adopted $B-V$ color of 0.59 for both stars was corrected for the increased metallicity of the system with equation (3) of Gray (1994), resulting in a revised value of 0.56 for both the primary and secondary. Then we used Table 3 of Flower (1996) to obtain the bolometric corrections and effective temperatures of the two components. The resulting luminosities of the primary and secondary are $L_1 = 5.0 \pm 4.0 L_\odot$ and $L_2 = 4.4 \pm 3.6 L_\odot$, respectively, while the radii are $R_1 = 2.0 \pm 0.8 R_\odot$ and $R_2 = 1.9 \pm 0.8 R_\odot$, respectively.

Given the large uncertainty of the revised *Hipparcos* parallax, we also estimated the distance to the system by using the relationship between the orbital period and color of a contact binary and its absolute magnitude, as determined by Rucinski & Duerbeck (1997). With their equation (5a) we obtain a distance of 85 pc to the visual primary, AA Cet. Assuming that the visual binary is a physical pair, as discussed in § 8, if we adopt this distance for the visual secondary, it reduces the luminosities and radii of the components to 2.9 and 2.5 $L_\odot$ and 1.6 and 1.4 $R_\odot$ for the primary and secondary, respectively.

Because of the large distance uncertainty, the luminosity and radius of each star ranges over values that are consistent with both a dwarf and a subgiant. Thus, we adopt typical values for the two possibilities and examine the results.

For the case in which the components are dwarfs, we adopt a radius of 1.2 $R_\odot$, which is a low-end value for our computed radius. This value and the pseudosynchronous period of 9.15 days result in a pseudosynchronous rotational velocity of 6.6 km s^{-1}.

To convert the $v \sin i$ values to equatorial rotation velocities we need to know the rotational inclination. If the components

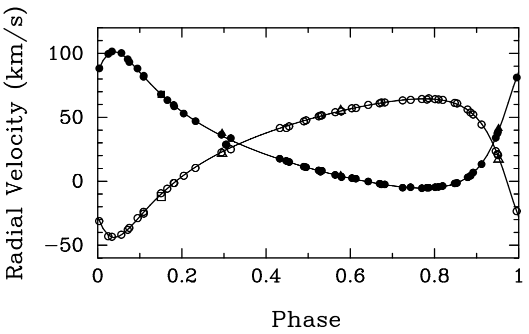

FIG. 1.—Radial velocities of SAO 167450 compared with the computed velocity curves. *Filled* and *open* symbols represent the primary and secondary, respectively. *Squares* represent Chambliss (1981) velocities, *triangles* represent Nordström et al. (1997) velocities, *circles* represent KPNO velocities. Zero phase is a time of periastron passage.

are dwarfs near the main sequence, then the miminum masses of the two components, 1.09 and 1.07 $M_{\odot}$, are quite large. From Gray (1992) the canonical mass of a G0 V star is 1.12 $M_{\odot}$, which for the average minimum mass of the pair produces an orbital inclination of 81°. We then assume, as is generally done, that the axes of the orbital and rotational planes are parallel, so the inclinations are equal. Adopting this inclination increases the $v \sin i$ values by just $0.1\ \mathrm{km\,s^{-1}}$, making the values 6.1 and 6.0 $\mathrm{km\,s^{-1}}$. Thus, if the components are dwarfs, the predicted pseudosynchronous rotational velocity and the observed rotational velocity of both components are in agreement, and we conclude that the primary and secondary are rotating pseudosynchronously.

For the case in which the components are subgiants, from the Stefan-Boltzmann law we adopt a radius of 2 $R_{\odot}$, which produces a pseudosynchronous velocity of 11 $\mathrm{km\,s^{-1}}$. Of course, an even larger adopted radius would produce an even larger pseudosynchronous velocity.

Assuming a mass of 1.4 $M_{\odot}$ for the primary results in an inclination of 66° and an equatorial rotational velocity of 6.6 $\mathrm{km\,s^{-1}}$. So if the stars are subgiants, they are rotating more slowly than pseudosynchronous rotation.

8. DISCUSSION

Despite the relatively wide angular separation between the visual components, 8.6″ (Lampens et al. 2001), which with the parallax of van Leeuwen (2007) translates into a projected linear separation of 956 AU, the visual pair appears to be a physical system. As noted in § 1, there has been only slight angular motion in the system over the past 200 yr. In addition, the center-of-mass velocities of the visual pair are in reasonable agreement. That of the brighter component, AA Cet, is $32.7 \pm 2.1\ \mathrm{km\,s^{-1}}$ (Duerbeck & Rucinski 2007), while our systemic velocity of the fainter component, SAO 167450, is $29.3 \pm 0.05\ \mathrm{km\,s^{-1}}$ (Table 4). An estimate of the visual period comes from Kepler's third law. If we assume masses of 1.54 $M_{\odot}$ (Pourbaix et al. 2004) and 2.14 $M_{\odot}$ (Table 4) for the visual components and adopt the projected linear separation of 956 AU as the semimajor axis, we obtain an orbital period of 15,400 yr. If that separation is instead taken to be the major axis, the period is reduced to 5450 yr.

As noted previously, the brighter visual companion of SAO 167450 is an eclipsing contact binary. Such W UMa-type variables are often part of multiple systems. Pribulla & Rucinski (2006) used a variety of techniques to estimate a lower limit to the frequency of W UMa systems that are triple. From their northern sky sample, they concluded that 59% of contact binaries are part of triple systems. In addition to AA Cet, several contact binaries such as ET Boo, VW LMi, and TV UMi (Pribulla et al. 2006) have been previously identified as being members of quadruple systems.

In a triple system, Kozai (1962) found that under certain conditions the eccentricity of the inner binary and the mutual inclination of the inner and outer orbits have periodic oscillations, which have been given the appellation, Kozai cycles. Eggleton & Kisseleva-Eggleton (2006) explored the parameter space for triple systems, searching for those conditions where Kozai cycles plus tidal friction would lead to interactions that would result in orbital shrinkage of the inner pair of stars and produce close or contact binaries. They crudely estimated the outer period needed to cause Kozai cycles to operate on a given inner orbit. An inner period of 25.68 days requires an outer period less than 65 yr. So, we conclude that with a period in the range of 5000 to 15,000 yr, neither visual binary component has had an effect on the short-period binary of the other component. If the W UMa component AA Cet has been created by Kozai cycles and tidal friction, another component, much closer to it than SAO 167450, is needed to produce the contact system.

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