THE ASTRONOMICAL JOURNAL, 118:2451–2459, 1999 November

RADIAL VELOCITY STUDIES OF CLOSE BINARY STARS. II.[1]

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Received 1999 June 22; accepted 1999 July 30

ABSTRACT

Radial velocity measurements and simple sine-curve fits to the orbital velocity variations are presented for the second set of 10 contact binary systems. Eight systems are of the A type: AH Aur, CK Boo, DK Cyg, UZ Leo, XZ Leo, V839 Oph, GR Vir, and NN Vir; V842 Her is the only W type, while SV Equ appears to be a semidetached system seen at a low orbital inclination rather than a contact binary. Several of the studied systems are prime candidates for complete light and radial velocity synthesis solutions.

Key words: binaries: close — binaries: eclipsing — stars: variables: general

1. INTRODUCTION

This paper is a continuation of the radial velocity studies of close binary stars started by Lu & Rucinski (1999, hereafter Paper I). The main motivation of this program has been the determination of mean (γ) velocities for *Hipparcos* stars to establish spatial velocity vectors, with an important by-product of preliminary values of mass ratios from simple sine-curve fits to the data. The program was started with contact binaries, mostly because of the evidence of their very high spatial frequency of occurrence relative to F–K dwarfs at the level of 1/100–1/80 (Rucinski 1998), but is slowly expanding to include other close binary systems accessible to the 1.8 m class telescopes at medium spectral resolution of about $R = 10{,}000$–$15{,}000$.

The paper is structured in the same way as Paper I in that it consists of two tables, one containing the radial velocity measurements (Table 1) and one containing their sine-curve solutions (Table 2), and of brief summaries of previous studies for individual systems. The reader is referred to Paper I for technical details of the program. In short, all observations described here were made with the 1.88 m telescope of the David Dunlap Observatory of the University of Toronto. The Cassegrain spectrograph, yielding a scale of 0.2 Å pixel^{-1}, or about 12 km s^{-1} pixel^{-1}, was used; the pixel size of the CCD was 19 μm. A relatively wide spectrograph slit of 300 μm corresponded to the angular size on the sky of 1″.8 and the projected width of 4 pixels. The spectra were centered at 5185 Å with the spectral coverage of 210 Å. The exposure times were typically 10 minutes long, with the longest exposures for fainter systems not exceeding 15 minutes.

The data in Table 1 are organized in the same manner as in Paper I. Table 2 is slightly different from that in Paper I, as it now provides information about the relation between the spectroscopically observed epoch of the primary eclipse T_0 and the recent photometric determinations in the form of the *O–C* deviations for the number of elapsed periods *E*. It also contains, in the first column after the star name, our new spectral classifications of the program objects. The classification spectra, typically two per object, were obtained using the same spectrograph but with a different grating, giving a dispersion of 0.62 Å pixel^{-1} in the range 3850–4450 Å. Several spectral classification standards were observed, and then the program-star spectra were "interpolated" between them in terms of relative strengths of lines known as reliable classification criteria.

In the radial velocity solutions of the orbits, the data have been assigned weights on the basis of our ability to resolve the components and to fit independent Gaussians to each of the broadening function peaks. Weight equal to zero in Table 1 means that an observation was not used in our orbital solutions; however, these observations may be utilized in detailed modeling of broadening functions, if such are undertaken for the available material. The full-weight points are marked in Figures 1, 2, and 3 by filled circles and triangles, while half-weight points are marked by open circles and triangles. Phases of the observations with zero weights are shown by marks in the lower part of the figures; they were usually obtained close to the phases of orbital conjunctions.

Because our data had been usually collected within one or two consecutive observing seasons, the orbital solutions were performed by fixing the values of the orbital period. The solutions for the four circular-orbit parameters γ, K_1, K_2, and T_0 were obtained in the following manner: First, two independent least-squares solutions for each star were made using the programs described in Paper I. They provided preliminary values of the amplitude, K_i, of the mean velocity, γ, and the initial (primary eclipse) epoch, T_0. Then, one combined solution for both amplitudes and the common γ was made with the fixed mean value of T_0. Next, differential corrections for γ, K_1, K_2, and T_0 were determined, providing best values of the four parameters. These values are given in Table 2. The corrections to γ, K_1, K_2, and T_0 were finally subjected to a "bootstrap" process (several thousand solutions with randomly drawn data with repetitions) to provide the median values and ranges of the parameters. As is common in the application of this method, the bootstrap 1 σ ranges were found to be systematically larger than the differential correction, linear least-squares estimates. Therefore, we have adopted them as measures of uncertainty of the parameters in Table 2.

Throughout the paper, unless the errors are written otherwise, we express standard mean errors in terms of the last quoted digits. For example, the number 0.349 (29) should be interpreted as 0.349 ± 0.029.

[1] Based on data obtained at the David Dunlap Observatory, University of Toronto.

TABLE 1

Observations of the Second Group of 10 Close Binary Systems

HJD (2,400,000+)	Phase	V_1	ΔV_1	V_2	ΔV_2
AH Aur:					
50,398.7976......	0.2271	−6.9	7.9	295.8	−12.9
50,398.8085......	0.2492	−14.2	1.1	309.9	−1.6
50,398.8205......	0.2734	−14.1	0.6	312.6	4.1
50,398.8313......	0.2953	−11.5	1.9	315.7	15.4
50,398.8449......	0.3228	−9.8	0.6	305.3	22.5
50,398.8560......	0.3453	−5.0	2.0	294.9	32.0
50,398.8679......	0.3693	2.1	4.7	274.6[a]	...
50,398.8792......	0.3922	−1.2	−3.6	248.0[a]	...
50,398.8908......	0.4157	4.6	−3.5	...	...
50,438.7659......	0.0917	−9.6	−15.8	182.2	−2.1
50,438.7765......	0.1132	−5.3	−6.4	202.5	−11.9
50,438.7883......	0.1370	−8.4	−4.5	234.2	−9.8
50,438.7991......	0.1589	−10.3	−2.6	265.4	−1.6
50,438.8122......	0.1854	−10.3	1.1	275.7	−13.1
50,438.8232......	0.2076	−13.8	−0.2	301.0	−0.7
50,469.7093......	0.6970	75.9	−0.6	−232.4	−0.1
50,469.7207......	0.7200	77.0	−1.3	−238.1	4.6
50,469.7333......	0.7455	77.8	−1.3	−240.8	6.8
50,469.7443......	0.7678	77.7	−1.1	−250.8	−4.9
50,469.7568......	0.7931	85.2	7.8	−226.8	10.7
50,469.7683......	0.8163	80.4	5.3	−217.0	6.7
50,477.5550......	0.5705	52.5	0.3	...	...
50,477.5671......	0.5950	48.5	−10.0	...	...
50,483.6318......	0.8652	72.2	4.9	−188.8	−11.3
50,520.5938......	0.6474	67.3	−2.4	−214.1	−22.5
50,520.6050......	0.6701	73.2	−0.1	−218.9	−5.7
50,524.5302......	0.6116	68.7	6.3	−165.5	−17.0
50,524.5491......	0.6499	76.7	6.6	−197.4	−3.3
50,524.6492......	0.8524	68.5	−1.2	−181.9	9.9
50,524.6550......	0.8641	53.5	−14.0	−172.5	6.3
50,535.5227......	0.8518	69.2	−0.6	−173.8	18.5
50,535.5334......	0.8735	57.1	−8.5	−160.8	6.8
CK Boo:					
50,535.9166......	0.7193	72.8	4.7	−238.7	4.3
50,539.8002......	0.6544	55.5	−7.7	−202.4	−4.0
50,539.8076......	0.6753	61.3	−4.0	−224.9	−7.5
50,539.8148......	0.6955	64.4	−2.5	−222.9	8.8
50,539.8241......	0.7217	67.6	−0.6	−237.7	6.1
50,539.8314......	0.7423	64.6	−4.1	−231.8	16.1
50,539.8388......	0.7631	71.3	2.7	−251.8	−4.5
50,539.8476......	0.7879	73.9	6.1	−246.6	−6.4
50,539.8553......	0.8096	65.4	−1.1	−232.1	−3.6
50,539.8630......	0.8313	58.1	−6.6	−212.3	−0.4
50,539.8712......	0.8543	57.2	−4.9	−184.3	4.8
50,539.8790......	0.8763	61.5	2.3	−160.0	3.0
50,540.8372......	0.5743	50.3	−1.0	−96.5	−5.1
50,540.8448......	0.5957	54.5	−0.5	−127.1	−2.7
50,541.7342......	0.1000	20.9	2.5	208.0	3.2
50,541.7414......	0.1203	12.6	−2.7	235.2	2.5
50,541.7487......	0.1408	5.6	−6.9	272.8	15.0
50,541.7580......	0.1670	7.7	−1.9	282.6	−1.9
50,541.7659......	0.1893	7.8	0.1	295.7	−6.1
50,541.7731......	0.2095	8.0	1.6	307.5	−5.7
50,541.7822......	0.2352	3.1	−2.4	321.3	0.2
50,541.7895......	0.2557	5.5	0.1	309.4	−12.8
50,556.7325......	0.3309	4.6	−4.8	294.9	8.6
50,556.7412......	0.3554	12.8	0.7	268.3	6.3
50,556.7498......	0.3796	16.3	1.0	246.0	13.2
50,609.6293......	0.2730	3.6	−2.1	318.8	−0.6
50,609.6380......	0.2975	8.8	2.0	310.5	0.8
50,609.6466......	0.3217	6.1	−2.4	294.7	0.9
DK Cyg:					
50,329.5606......	0.4148	−43.0	6.4	199.4[a]	...

TABLE 1—*Continued*

HJD (2,400,000+)	Phase	V_1	ΔV_1	V_2	ΔV_2
50,329.5720......	0.4390	−37.9	−0.5	...	...
50,330.5667......	0.5523	20.0	−3.8	...	...
50,330.5774......	0.5750	31.4	−4.0	−183.4[a]	...
50,330.6222......	0.6702	72.9	0.4	−243.2	−1.5
50,330.6553......	0.7405	74.2	−9.0	−271.4	3.1
50,330.6662......	0.7637	88.1	5.1	−276.9	−2.9
50,330.8288......	0.1091	−57.7[b]	2.5	...	...
50,330.8421......	0.1374	−85.5	−14.2	177.4	−23.6
50,363.5735......	0.6764	63.5	−10.6	−241.7	4.9
50,363.5853......	0.7015	80.8	1.5	−255.4	7.1
50,363.6136......	0.7616	72.4	−10.7	−257.7	16.6
50,363.6245......	0.7848	87.5	6.2	−251.8	16.8
50,363.6578......	0.8555	56.7	−8.0	−211.6	6.1
50,363.6686......	0.8785	65.5	9.3	−202.8	−11.2
50,398.4890......	0.8557	71.2	6.5	−232.0	−14.5
50.398.4998......	0.8786	69.3	13.1	−191.6	−0.2
50,415.5790......	0.1640	−84.3	−4.4	213.8	−13.6
50,415.5898......	0.1869	−88.2	−2.6	220.0	−25.0
50,415.6032......	0.2154	−92.8	−2.4	277.8	18.2
50,415.6140......	0.2384	−89.4	2.8	259.0	−6.2
50,415.6262......	0.2643	−95.2	−3.1	267.8	3.0
50,415.6368......	0.2868	−88.8	1.3	238.4	−20.3
50,597.8012......	0.3016	−90.7	−2.9	...	...
50,597.8120......	0.3246	−92.5	−9.6	252.4	15.6
50,608.7824......	0.6316	61.7	1.6	−222.9	−19.4
50,608.7933......	0.6548	59.9	−8.2	−234.4	−6.4
50,608.8060......	0.6817	85.3	9.9	−266.2	−15.7
50,631.6861......	0.2913	...	...	...	...
50,631.6977......	0.3160	−91.7[b]	−6.7	...	...
50,631.7110......	0.3442	...	...	...	...
50,631.7239......	0.3716	−70.7	−2.7	217.9	27.2
50,645.7171......	0.1007	−58.0	−1.5	193.0	37.6
50,645.7291......	0.1262	−61.1	6.0	203.4	15.3
50,645.7433......	0.1564	−74.6	3.0	239.8	19.3
50,645.7552......	0.1816	−77.4	7.0	242.3	0.9
50,645.7685......	0.2099	−84.6	5.0	253.2	−4.2
50,645.7811......	0.2367	−81.6	10.5	241.8	−23.2
SV Equ:					
50,312.6435......	0.0312	−38.0[a]	...	...	...
50,312.6921......	0.0863	−58.7	9.0	...	...
50,323.6003......	0.4683	−45.5	−15.8	...	...
50,323.6084......	0.4775	−47.9	−25.1	...	...
50,324.5581......	0.5555	21.4	−13.5	...	...
50,324.5689......	0.5678	27.5	−15.9	...	...
50324.5809	0.5814	39.0	−13.5	...	...
50,324.5920......	0.5940	49.4	−11.2	...	...
50,324.6836......	0.6980	101.1	−6.1	...	...
50,324.6947......	0.7106	105.8	−4.1	...	...
50,324.7514......	0.7750	119.5	7.4	...	...
50,324.7624......	0.7875	110.9	0.7	...	...
50,329.5890......	0.2662	−120.1	4.9	...	...
50,330.5496......	0.3566	−105.3	−5.5	...	...
50,330.5965......	0.4098	−79.5	−9.3	...	...
50,330.6395......	0.4586	−53.5	−16.7	...	...
50,363.5555......	0.8219	105.6	4.0	...	...
50,363.5994......	0.8717	95.9	15.6	...	...
50,363.6410......	0.9189	72.4	20.1	...	...
50,363.6846......	0.9684	35.4	17.9	...	...
50,595.8623......	0.5156	−6.5	−12.2	...	...
50,597.7810......	0.6935	91.9	−14.2	...	...
50,608.7333......	0.1256	−74.2	16.7	...	...
50,608.7457......	0.1397	−85.0	13.0	...	...
50,608.7593......	0.1551	−97.7	7.3	...	...
50,608.7709......	0.1683	−105.5	4.7	...	...
50,609.7865......	0.3211	−118.9	−5.0	...	...
50,615.7573......	0.0986	−69.8	5.7	...	...

TABLE 1—*Continued*

HJD (2,400,000+)	Phase	V_1	ΔV_1	V_2	ΔV_2
50,630.7042	0.0650	−57.5[a]	...	...	...
50,708.7452	0.6501	74.4	−16.4	...	...
50,709.5942	0.6138	57.0	−15.4	...	...
50,709.7350	0.7736	113.1	0.9	...	...
V842 Her (NSV 7457):					
50,540.8531	0.1473	−10.9	−7.5	−280.8	−9.8
50,540.8652	0.1762	−1.7	−4.9	−298.4	−2.0
50,540.8766	0.2034	9.9	2.4	−313.6	−0.4
50,540.8895	0.2342	1.9	−8.2	−317.7	5.6
50,540.9012	0.2621	8.4	−1.8	−324.9	−1.1
50,540.9115	0.2867	9.2	0.6	−321.9	−4.4
50,541.6279	0.9963	...	...	...	...
50,541.8929	0.6287	−113.9	−6.0	135.3	0.9
50,541.9047	0.6569	−114.4	1.1	168.1	4.3
50,541.9159	0.6836	−123.0	−1.9	185.3	0.1
50,556.7644	0.1189	−10.5	1.1	−263.4	−24.2
50,556.7768	0.1485	−5.8	−2.7	−273.4	−1.2
50,595.8045	0.2862	6.9	−1.7	−314.8	2.9
50,595.8132	0.3070	8.1	2.0	−307.2	0.5
50,595.8219	0.3277	6.2	3.8	−290.2	3.2
50,595.8323	0.3526	12.2	15.6	−272.1	−0.9
50,595.8410	0.3733	4.4	13.6	−242.4	6.2
50,595.8496	0.3938	−4.4	11.4	−228.5	−5.5
50,597.6319	0.6472	−122.8	−9.7	153.8	−0.6
50,597.6428	0.6732	−113.6	5.5	160.1	−17.6
50,597.6563	0.7054	−128.5	−4.2	194.6	−3.1
50,597.6671	0.7312	−111.5	15.0	192.8	−13.4
50,597.6774	0.7558	−126.4	0.5	217.8	9.9
50,597.7122	0.8388	−116.5	0.0	180.3	12.7
50,597.7209	0.8596	−109.8	1.5	145.1	−2.3
50,615.7316	0.8413	−126.4	−10.5	170.7	5.3
50,615.7403	0.8620	−101.1	9.5	151.7	7.0
50,631.6381	0.8014	−113.6	9.8	187.4	−6.9
UZ Leo:					
50,414.8420	0.1649	−84.8	−8.1	222.2	4.2
50,414.8561	0.1877	−83.6	−1.8	231.2	−3.6
50,469.9344	0.3049	−72.1	11.1	239.4	0.2
50,520.6242	0.3216	−79.0	1.0	235.3	6.7
50,520.6349	0.3389	−67.6	8.2	211.1	−3.7
50,520.6476	0.3594	−60.6	9.2	196.1	1.1
50,520.6583	0.3767	−66.3	−2.4	182.4	6.7
50,524.5702	0.7062	74.3	5.8	−256.0	5.2
50,524.5814	0.7243	70.0	−0.5	−259.7	7.9
50,524.5944	0.7454	72.3	0.8	−251.7	19.2
50,524.6051	0.7627	65.6	−5.7	−262.3	7.9
50,524.6171	0.7821	72.6	2.7	−257.6	8.1
50,524.6280	0.7997	74.1	6.4	−253.9	4.4
50,524.6422	0.8227	70.5	7.2	−266.7	−22.6
50,535.5927	0.5407	...	...	...	...
50,535.6051	0.5608	...	...	...	...
50,540.5729	0.5988	33.1	−5.1	−182.0[b]	−21.0
50,540.5842	0.6170	41.8	−3.5	−202.3	−17.8
50,540.5975	0.6386	50.8	−2.0	−218.7	−9.5
50,540.6086	0.6565	56.5	−1.7	−238.0	−11.0
50,540.6221	0.6784	66.4	2.8	−246.9	−2.0
50,540.7026	0.8086	59.3	−6.9	−251.0	2.4
50,540.7133	0.8259	67.9	5.3	−230.3	11.4
50,540.7252	0.8452	64.2	6.5	−240.9	−15.5
50,540.7366	0.8636	55.7	3.7	−216.0	−9.1
50,541.5380	0.1603	−81.3	−5.8	207.7	−6.3
50,541.5666	0.2066	−91.9	−7.0	238.8	−6.2
50,541.5776	0.2244	−84.6	2.2	244.0	−7.3
50,541.5898	0.2441	−77.1	10.7	262.1	7.6
50,541.6005	0.2614	−90.2	−2.5	242.5	−11.5
50,541.6124	0.2807	−83.6	2.8	258.5	8.7
50,596.5849	0.2268	−89.2	−2.2	241.7	−10.2

TABLE 1—*Continued*

HJD (2,400,000+)	Phase	V_1	ΔV_1	V_2	ΔV_2
50,596.5956	0.2441	−86.0	1.8	260.7	6.2
XZ Leo:					
50,469.8703	0.8115	89.3	6.6	−236.6	8.6
50,469.8813	0.8340	74.7	−2.3	−225.7	3.1
50,469.8944	0.8609	73.8	5.7	−210.8	−7.4
50,469.9052	0.8830	63.9	4.6	−181.7	−3.6
50,483.6791	0.1234	−74.2	−8.1	182.8	1.0
50,483.6899	0.1456	−62.1	12.4	205.1	−0.9
50,483.7027	0.1718	−80.5	2.2	239.4[b]	9.9
50,483.7134	0.1938	−87.2	0.7	218.9	−25.4
50,483.7283	0.2243	−77.9	14.4	255.4[b]	−1.7
50,520.5457	0.7105	91.8	5.1	−253.2	3.3
50,520.5564	0.7324	80.6	−8.3	−272.6	−9.6
50,520.5699	0.7601	92.1	2.8	−266.7	−2.6
50,520.5805	0.7818	95.4	7.8	−249.4	9.9
50,535.6229	0.6230	62.2	0.3	−194.7	−9.3
50,535.6337	0.6452	74.0	3.7	−210.3	−0.6
50,535.6457	0.6698	81.9	3.8	−236.3	−4.4
50,535.6567	0.6923	76.9	−6.6	−259.1	−11.6
50,541.5515	0.7784	90.1	2.1	−259.6	0.8
50,589.6459	0.3856	−58.1	4.2	197.6[b]	26.7
50,596.6109	0.6658	77.1	0.1	−234.0	−5.3
50,609.5872	0.2710	...	...	...	...
50,609.5980	0.2931	−97.7[b]	−7.5	...	...
50,609.6100	0.3177	...	...	...	...
50,610.5886	0.3241	−79.4	4.4	235.6	3.0
50,610.5994	0.3463	−80.1	−2.8	207.3	−6.7
50,610.6100	0.3680	−84.4[b]	−14.9	195.8[b]	4.2
V839 Oph:					
50,608.8269	0.0694	−113.5	−13.9	61.9	8.1
50,608.8359	0.0914	−119.8	−9.9	82.0	−5.4
50,608.8464	0.1170	−130.6	−9.9	121.5	−1.5
50,608.8551	0.1383	−134.2	−5.6	146.8	−2.1
50,609.6746	0.1420	−128.5	1.3	149.2	−3.7
50,609.6836	0.1640	−130.0	6.5	165.4	−9.6
50,609.6944	0.1904	−134.8	8.0	195.6	0.2
50,609.7031	0.2116	−141.8	4.4	207.6	1.0
50,609.7129	0.2356	−143.6	4.7	206.0	−7.6
50,609.7219	0.2576	−138.2	10.3	208.2	−6.2
50,609.7319	0.2820	−145.1	1.8	209.1	0.0
50,609.7420	0.3067	−145.1	−1.8	179.1	−18.1
50,609.7537	0.3353	−139.6	−2.9	182.5	6.9
50,609.7634	0.3591	−115.6	13.9	170.2	18.4
50,609.7735	0.3838	−117.2	3.2	136.1	14.1
50,610.6757	0.5896	−15.8	2.7	−239.1	−26.6
50,610.6846	0.6114	−7.6	1.6	−255.2	−12.0
50,610.6944	0.6353	6.3	6.4	−276.4	−3.3
50,610.7030	0.6563	8.0	1.3	−297.5	−2.0
50,610.7136	0.6823	16.5	3.1	−310.6	6.9
50,610.7223	0.7035	18.3	0.9	−322.7	7.8
50,610.7325	0.7285	18.1	−2.1	−338.3	1.5
50,610.7411	0.7495	17.3	−3.7	−339.6	2.7
50,610.7516	0.7752	18.9	−1.0	−335.1	3.8
50,610.7603	0.7964	17.5	0.1	−328.5	2.1
50,610.7712	0.8231	7.9	−4.3	−321.8	−8.3
50,610.7800	0.8446	13.7	7.2	−297.2	−2.6
50,610.7899	0.8688	6.6	8.2	−271.2	−2.9
50,610.7988	0.8906	3.7	13.7	−246.0	−5.4
GR Vir:					
50,469.9804	0.5585	...	...	...	...
50,469.9876	0.5792	−54.7[b]	−1.0	...	...
50,469.9942	0.5983	−51.5[b]	−1.6	...	...
50,535.7548	0.1215	−99.5	−1.7	162.2	20.4
50,535.7605	0.1380	−108.1	−7.6	163.9	0.2
50,535.7664	0.1550	−104.7	−1.7	178.0	−5.7
50,535.7723	0.1720	−103.5	1.5	197.1	−3.6

TABLE 1—*Continued*

HJD (2,400,000+)	Phase	V_1	ΔV_1	V_2	ΔV_2
50,535.7794......	0.1924	−105.4	1.7	215.3	−1.8
50,535.7853......	0.2094	−103.3	5.0	224.6	−2.5
50,535.7912......	0.2264	−109.3	−0.2	226.0	−7.7
50,535.7972......	0.2437	−110.5	−1.0	227.3	−9.5
50,535.8736......	0.4639	...	...	...	...
50,535.8809......	0.4850	...	...	...	...
50,535.8885......	0.5069	...	...	...	...
50,535.8969......	0.5311	...	...	...	...
50,535.9040......	0.5515	...	...	...	...
50,541.8365......	0.6491	−38.8	2.5	−338.1	−17.6
50,541.8409......	0.6618	−30.4	9.2	−335.1	−0.8
50,541.8453......	0.6745	−32.7	5.4	−351.3	−4.9
50,541.8497......	0.6872	−37.6	−0.7	−351.4	5.4
50,541.8543......	0.7004	−38.6	−2.8	−369.9	−4.2
50,541.8589......	0.7137	−36.5	−1.6	−376.0	−3.5
50,541.8650......	0.7313	−38.5	−4.3	−371.4	7.0
50,541.8696......	0.7445	−37.0	−3.0	−378.0	2.3
50,541.8741......	0.7575	−37.9	−3.9	−373.3	6.9
50,541.8785......	0.7702	−37.7	−3.5	−375.3	2.7
50,541.8830......	0.7831	−33.2	1.6	−364.9	9.0
50,555.7233......	0.6711	−37.2	1.3	−355.4	−12.0
50,555.7604......	0.7781	−38.2	−3.7	−382.6	−6.9
50,555.7655......	0.7928	−29.2	6.1	−366.1	3.3
50,555.7707......	0.8077	−39.1	−2.7	−358.5	1.9
50,555.7758......	0.8224	−33.2	4.6	−345.8	3.3
50,555.7821......	0.8406	−35.2	4.7	−338.9	−7.1
50,555.7873......	0.8556	−36.7	5.3	−328.1	−13.1
50,555.7927......	0.8711	−40.8	3.6	−303.4	−8.1
50,597.5720......	0.2799	−119.5	−10.7	216.6	−15.1
50,597.5778......	0.2966	−108.4	−0.5	229.3	5.4
50,597.5837......	0.3136	−99.2	7.3	207.7	−5.0
50,597.5912......	0.3352	−102.2	2.0	192.5	−1.4
50,597.5971......	0.3522	−89.6	12.4	192.1	16.6
50,597.6029......	0.3689	−95.3	4.1	166.5	11.7
50,597.6090......	0.3865	−84.3[b]	12.1	...	...
50,597.6166......	0.4084	−89.6[b]	2.7	...	...
NN Vir:					
50,595.5840......	0.4970	...	...	...	...
50,595.5891......	0.5076	...	...	...	...
50,595.5943......	0.5184	...	...	...	...
50,595.5995......	0.5292	...	...	...	...
50,595.6059......	0.5425	...	...	...	...
50,595.6111......	0.5534	...	...	...	...
50,595.6164......	0.5644	...	...	...	...
50,595.6215......	0.5750	38.1[b]	−6.8	−159.2[a]	...
50,595.6288......	0.5902	52.7[b]	−1.5	−169.4[a]	...
50,595.6343......	0.6016	54.3	−6.6	−183.1[a]	...
50,595.6395......	0.6124	61.2	−5.7	−180.6[a]	...
50,595.6447......	0.6233	70.1	−2.5	−187.6[b]	−21.0
50,595.6515......	0.6374	72.9	−6.5	−196.6[b]	−16.1
50,595.6567......	0.6482	83.8	−0.4	−201.5	−11.3
50,595.6618......	0.6588	91.3	2.8	−208.4	−9.5
50,595.6670......	0.6696	90.0	−2.4	−214.0	−7.1
50,595.6746......	0.6855	95.3	−2.0	−223.5	−6.6
50,595.6801......	0.6969	98.7	−1.5	−222.1	0.8
50,595.6856......	0.7083	103.4	0.8	−223.2	4.5
50,595.6910......	0.7196	105.2	0.8	−223.4	7.9
50,595.6984......	0.7350	94.2	−11.7	−242.6	−8.1
50,595.7057......	0.7502	106.7	0.3	−225.5	10.0
50,595.7119......	0.7631	104.9	−1.2	−220.4	14.3
50,595.7190......	0.7778	105.5	0.8	−222.0	10.0
50,595.7243......	0.7888	103.8	0.7	−220.6	8.1
50,595.7296......	0.7999	103.7	2.7	−208.4	16.0
50,595.7348......	0.8107	100.2	1.9	−223.2	−4.2
50,595.7413......	0.8242	100.8	6.4	−213.1	−2.1
50,595.7468......	0.8357	88.4	−2.1	−206.3	−3.2
50.595.7523......	0.8471	87.9	1.8	−202.8	−8.6
50,595.7575......	0.8579	79.1	−2.4	−194.1	−9.3
50,595.7652......	0.8739	86.8	12.8	−168.6	0.8
50,595.7709......	0.8858	78.0	10.1	−164.0	−7.0
50,595.7761......	0.8966	70.4	8.5	−141.4	3.5
50,615.5912......	0.1188	−90.9	−8.1	154.3	4.8
50,615.5966......	0.1300	−95.4	−7.0	162.6	1.7
50,615.6017......	0.1407	−99.2	−5.8	181.7	10.7
50,615.6069......	0.1515	−100.7	−2.7	181.9	1.4
50,615.6136......	0.1654	−97.9	5.5	188.4	−3.0
50,615.6191......	0.1769	−110.6	−3.4	198.8	−0.4
50,615.6243......	0.1877	−110.9	−0.5	205.1	−0.6
50,615.6295......	0.1985	−113.6	−0.5	207.4	−3.7
50,615.6364......	0.2128	−117.6	−1.7	214.5	−2.3
50,615.6419......	0.2243	−117.4	0.1	220.9	0.9
50,615.6474......	0.2357	−114.7	3.8	216.9	−5.2
50,615.6526......	0.2465	−113.5	5.4	214.2	−8.8
50,615.6588......	0.2594	−116.2	2.5	220.4	−2.2
50,615.6641......	0.2705	−114.7	3.3	220.6	−0.5
50,615.6693......	0.2813	−116.5	0.3	214.6	−4.0
50,615.6745......	0.2921	−115.4	−0.4	221.3	6.2
50,615.6817......	0.3071	−115.2	−3.4	208.7	0.3
50,615.6873......	0.3187	−108.7	−0.1	198.6	−3.4
50,615.6933......	0.3312	−106.2	−1.6	197.9	4.1
50,615.6991......	0.3433	−94.9	5.2	191.7	6.9
50,615.7052......	0.3560	−92.5	2.4	175.4	1.3
50,615.7104......	0.3668	−88.5	1.4	173.8[b]	9.8
50,615.7160......	0.3784	−83.1	1.1	169.3[b]	17.0
50,615.7218......	0.3905	−77.1	0.7	155.9[a]	...

[a] Not used in the orbital solution, because of strong influence of the proximity effects and large deviations from circular model; this is distinguished from the situation of the broadening- and correlation-function peaks being entirely inseparable, as marked by the ellipses.

[b] Half-weight given in the orbital solution.

2. RESULTS FOR INDIVIDUAL SYSTEMS

2.1. *AH Aur*

This binary was discovered by Tsesevich (1954), and early light curves were published by Hinderer (1960). The system was never observed for a study of radial velocity variations; even photometrically, it is one of the least observed contact binaries. It shows a light curve with an amplitude slightly larger than 0.5 mag and with indications of partial eclipses. Although it was included in the *Hipparcos* observing list, it has not been included in the analysis by Rucinski & Duerbeck (1997, hereafter RD97), because of the large error in its parallax, resulting in the absolute magnitude error of 0.72 mag. The $B-V$ color from the Tycho experiment, 0.55 (8), suggested a spectral type of late F to early G, which is in excellent agreement with our spectral type, F7 V; this is also consistent with the absolute magnitude calibration $M_V = M_V(\log P, B-V)$ of RD97, which yields $M_V = 3.1$.

The most recently available photometric timing of the primary eclipse was that by Agerer & Huebscher (1996); this timing was used as the first guess for our radial velocity solution. In our orbital solution, we assumed the orbital period following the 1985 edition of the General Catalogue of Variable Stars, $P = 0.4942624$ days. The *O–C* deviation for the primary eclipse epoch T_0 is relatively large and equals 0.0206 days, which is much larger than the error of determination of T_0. This shift may be partly due to an obvious asymmetry in the radial velocity curve of the less

TABLE 2

SPECTROSCOPIC ORBITAL ELEMENTS OF THE SECOND 10 CLOSE BINARY SYSTEMS

Name, Type	Type	Other Names	γ	K_1, K_2	ϵ_1, ϵ_2	$T_0-2{,}400{,}000$, $O-C$ and [E]	Assumed P (days)	$q = m_2/m_1$
AH Aur, F7 V	A	HD 256902	31.95 (1.45)	47.20 (1.16)	5.42	50469.8591 (16)	0.494262	0.169 (59)
		HIP 30618		279.61 (2.80)	15.15	+0.0206 [1478]		
CK Boo, F7/8 V	A	HD 128141	37.04 (0.75)	31.66 (0.78)	3.54	50539.9229 (5)	0.355150	0.111(52)
		HIP 71319		285.31 (1.63)	7.01	+0.0056 [787]		
DK Cyg, A8 V	A	BD +33 4304	−5.53 (1.48)	87.89 (1.48)	6.59	50331.2481 (20)	0.470691	0.325 (39)
		HIP 106574		270.46 (3.36)	16.74	+0.0049 [877]		
SV Equ, A7 V	EB	HIP 103431	−6.02 (0.88)	119.56 (1.11)	4.23	50324.0880 (15)	0.880972	
						−0.0281 [−38]		
V842 Her, F9 V	W	NSV 7457	−57.98 (1.55)	265.31 (1.58)	12.88	50595.6856 (8)	0.419032	3.852 (24)
		BD +50°2255		68.88 (1.60)	7.08	+0.0014 [189]		[=1/0.260]
UZ Leo, A9/F1 V......	A	BD +14°2280	−8.18 (1.12)	79.69 (1.12)	5.44	50595.6856 (16)	0.618043	0.303 (24)
		HIP 52249		262.87 (1.89)	9.93	−0.0006 [214]		
XZ Leo, A8/F0 V	A	BD +17°2165	−2.03 (1.43)	91.49 (1.80)	6.27	50520.6869 (9)	0.487737	0.348 (29)
		HIP 49204		262.55 (2.60)	10.05	−0.0037 [708]		
V839 Oph, F7 V	A	HIP 88946	−63.81 (1.09)	84.82 (1.33)	6.52	50610.8436 (9)	0.409005	0.305 (24)
				278.52 (2.01)	10.92	−0.0024 [−65]		
GR Vir, F7/8 V	A	HD 129903	−71.72 (0.89)	37.78 (1.00)	4.78	50541.9582 (8)	0.346979	0.122 (44)
		HIP 72138		308.81 (1.96)	12.10	+0.2208 [14053]		
NN Vir, F0/1 V	A	HD 125488	−6.24 (0.65)	112.68 (0.71)	4.40	50595.3452 (6)	0.480690	0.491 (11)
		HIP 70020		229.28 (1.24)	7.84	+0.0018 [145]		

NOTE.—The convention of naming the components is that the subscript 1 designates the component that is eclipsed at the deeper minimum and is therefore the hotter one. The standard errors of the circular solutions are expressed in units of last decimal places quoted; they are given in parentheses after each value. For example, the last table entry, 0.491 (11), should be interpreted as 0.491 ± 0.011. The average radial velocities γ, the velocity amplitudes K_i, and the standard unit-weight errors of the solutions ϵ are expressed in km s^{-1}. The calculated moments of primary minima are given by T_0, while their $O-C$ deviations (in days) have been calculated from the most recent available ephemerides as given in the text, using the assumed periods and the number of epochs, given by [E].

massive component in the first half of the orbital cycle (see Fig. 1). If we fix the T_0 at the epoch given by Agerer & Huebscher (1996), the asymmetry remains and the fit is only slightly modified. The values of the orbital parameters are then $(\gamma, K_1, K_2) = (30.96, 47.36, 279.68)$ km s^{-1}. The mass ratio remains at a relatively low value of $q = 0.17$, but values of velocity amplitudes, which determine the masses, are slightly changed. The system needs a modern photometric study.

2.2. *CK Boo*

Bond (1975) noted diffuse spectral lines and then obtained a fragmentary light curve indicating that the star is a W UMa–type binary. Since then, the binary has been the subject of several time-of-minima studies, the most recent one by Muyesseroglu, Gurol, & Selam (1996). We have taken the value of the period, $P = 0.3551501$ days, from the study of Aslan & Derman (1986).

The light curves of the system were presented by Krzesinski et al. (1991) and Jia, Liu, & Huang (1992). The light curves have small amplitudes, suggesting partial eclipses and, consequently, difficulties with light-curve synthesis solutions. Krzesinski et al. (1991) attempted a solution that included a determination of the photometric mass ratio. They derived $q_{ph} = 0.52$ or 0.59 (depending on the assumptions concerning spots) and found that the system is of the W type, i.e., with the primary, deeper minimum corresponding to eclipses of the smaller, less massive star in the system. The system was included in the *Hipparcos* study (RD97) with a relatively poor determination of the absolute magnitude, $M_V = 2.99$ (44), which is, however, consistent with $(B-V)_0 = 0.54$ and a spectral type of F6 V, as estimated by Krzesinski et al. (1991). Our estimate suggests a slightly later spectral type, F7/F8 V.

The only radial velocity study that we are aware of is by Hrivnak (1993). His preliminary spectroscopic determination of the mass ratio, $q_{sp} = 0.16$, was entirely different from the photometric solution of Krzesinski et al. (1991). Also, the type of the system was found to be A, not W; i.e., it is the more massive star that is eclipsed at the deeper minimum. Our data fully confirm that the system is of the A type, but our mass ratio is even smaller than that of Hrivnak (1993), $q_{sp} = 0.11$, although the error of the spectroscopic determination is relatively large for such small values of q.

2.3. *DK Cyg*

This contact system has not yet been studied spectroscopically, although it has been a subject of numerous photometric investigations since its discovery by Guthnick & Prager (1927). The most recent photometry and light curve have been given by Awadalla (1994); this study suggested a systematic period change. We adopted $P = 0.470691$ days for our data, a number based on the values given by Awadalla (1994) and Binnendijk (1964).

Because of the total eclipses at shallower minima (a clear A type), Mochnacki & Doughty (1972) recognized that the system would be convenient for their contact model light-curve synthesis solutions (one of the first such models); they used the light curve of Binnendijk (1964). Their photometric mass ratio determination was $q_{ph} = 0.33 \pm 0.02$. Our entirely independent spectroscopic result of $q_{sp} = 0.32 \pm 0.04$ agrees fully with this determination, confirming that systems with total eclipses can yield excellent photometric solutions, in contrast to systems with partial eclipses. Mochnacki and Doughty (1972) pointed out that the spectral type of the system, judged by its color, is probably F0–F2. This prediction did not agree with the direct esti-

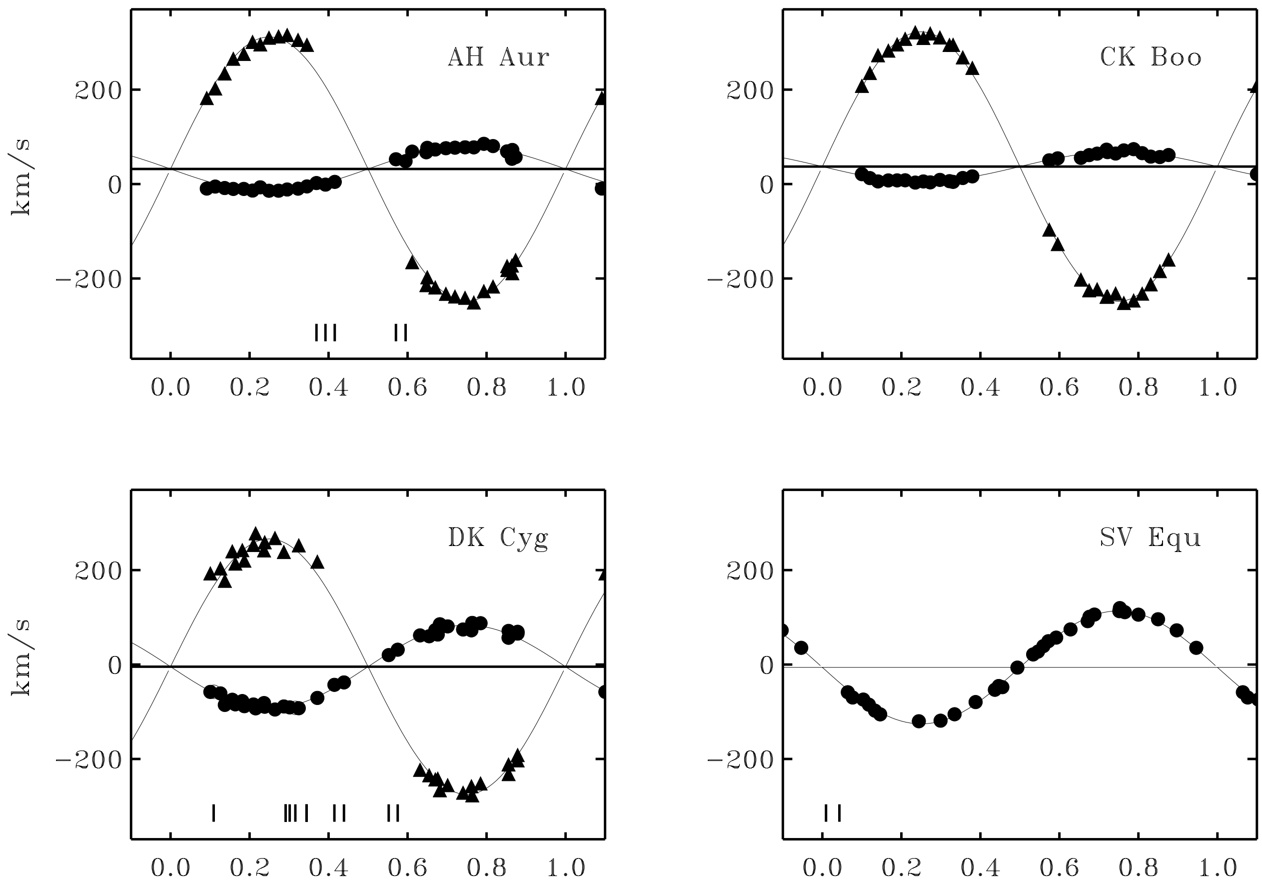

FIG. 1.—Radial velocities of the systems AH Aur, CK Boo, DK Cyg, and SV Equ plotted in individual panels vs. orbital phases. The thin lines give the respective circular-orbit (sine curve) fits to the radial velocities. SV Equ, previously considered a contact system, is apparently a semidetached (EB) binary. The remaining three systems are of the A type, i.e., with eclipses of larger, more massive components at primary (deeper) minima. Marks in the lower parts of the panels show phases of available observations that were not used in the solutions because of the blending of lines.

mate of the spectral type at A6–A8 V given by Hill et al. (1975). We also estimated the spectral type at A8 V. The Strömgren color $b-y=0.24$ (Hilditch & Hill 1975) suggests a spectral type of A8–F0. The *Hipparcos* parallax is small and has a large error ($\epsilon M_V = 0.9$), so that the system was not included in RD97.

The system was included in the list of near-contact binaries by Shaw (1994), but as far as we can establish, it is an excellent example of an A-type contact system without any particular complications, so there are no reasons to consider it " near-contact."

2.4. *SV Equ*

This relatively long period system (0.881 days) was discovered by Catalano & Rodono (1966) and then photometrically studied by Eggen (1978). Because of the color $b-y=0.145$, suggesting a spectral type of A5, and because of the shallow (0.15 mag) light curve, Eggen considered the system to be a contact binary of little interest in the context of genuine early-type systems. The system has been somewhat forgotten, except for its inclusion among near-contact binaries in the compilation by Shaw (1994). The *Hipparcos* parallax is poor in this case, resulting in $M_V = 3.7(9)$.

Recent photometric observations of SV Equ were reported by Cook (1997), who gave the new time-of-minimum prediction with the period $P = 0.88097307$ days. These observations were obtained very close in time to our observations, but they disagree in the time of minimum T_0. We do not see any obvious reasons why the *O–C* for contemporaneous observations should be as large as -0.028 days, but note that the graph of the data in Cook (1997) indicates rather large photometric errors.

In spite of attempts to isolate lines of the secondary component with different template spectra, our spectroscopic observations led to detection of only one component. Thus, the star is not a contact binary (EW), as it had been classified, but most probably a semidetached system (EB), seen at a low orbital inclination angle.

2.5. *V842 Her* (*NSV 7457*)

The variability was discovered by Geyer, Kippenhahn, & Stroheimer (1965), but the real nature of the star as a contact binary was identified relatively recently by Vandenbroere (1993) and, apparently independently, by Nomen-Torres & Garcia-Moreno (1996). We analyzed all the recent determinations of eclipse timings, as published by Vandenbroere (1993), Diethelm (1994), Nomen-Torres & Garcia-Melendo (1996), and Agerer & Huebscher (1997, 1998a) and found the following ephemeris: HJD = 2,447,643.1771 (29) + 0.41903201 (56)E. As for the other systems, only the period was used to determine the phases of the spectroscopic observations.

V842 Her has not yet been observed for radial velocity changes. There exist also no previous estimates of its spec-

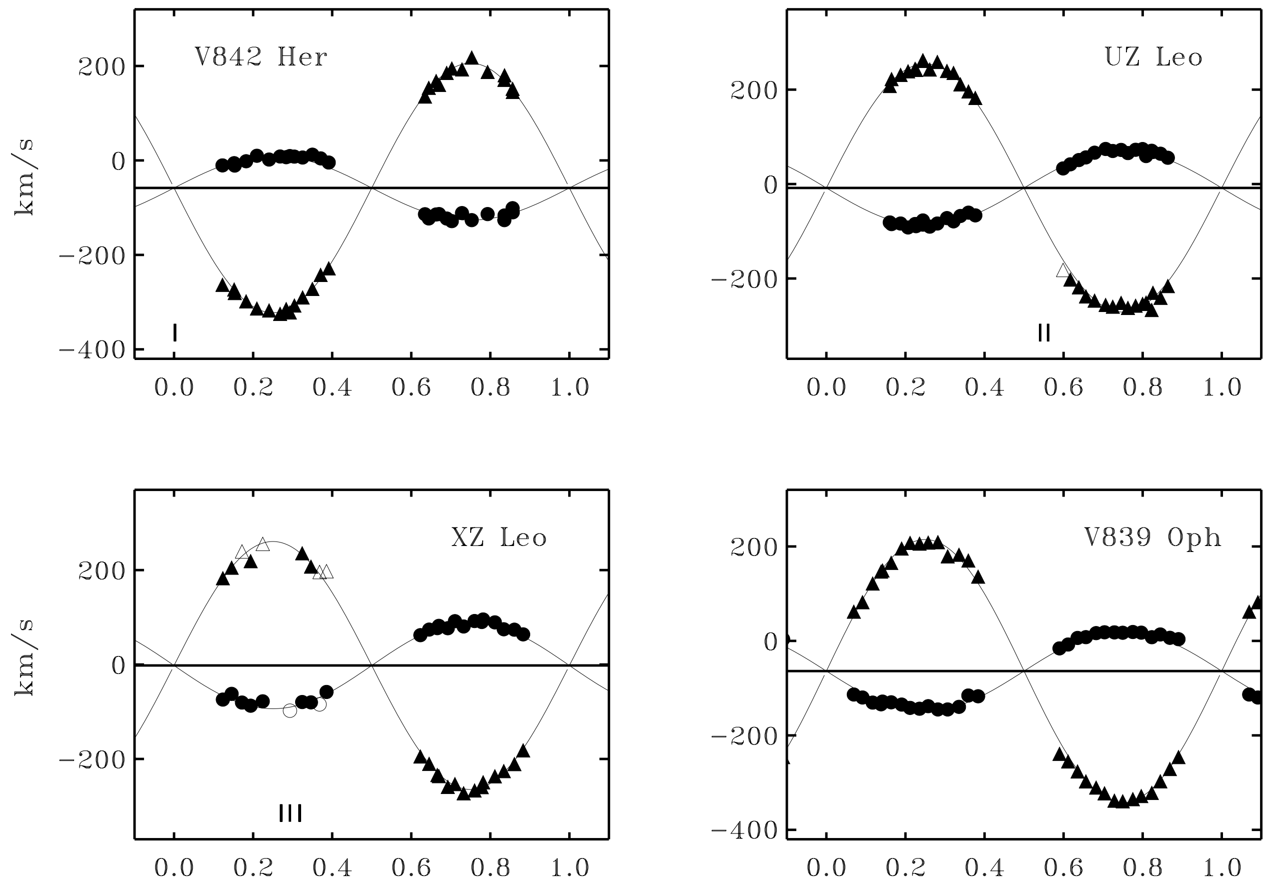

FIG. 2.—Same as Fig. 1, but for V842 Her, UZ Leo, XZ Leo, and V839 Oph. V842 Her is the only W-type system among the 10 WUMa–type systems described in this paper. Open circles and open triangles in this and the next figure indicate observations given half-weights in the solutions.

tral type or color. It is the only W-type system in the current study; coincidentally, it is also the only system without a *Hipparcos* parallax measurement in this group of 10 contact systems. The orbital period of 0.42 days is somewhat long for a typical W-type system, and the spectral type of F9 V is relatively early for a W-type system. The light curve has a moderately large amplitude of about 0.6 mag and the primary (deeper) eclipses appear to be total or very close to total, so that the system has the potential of an excellent combined light and radial velocity solution.

2.6. *UZ Leo*

The variability of this star was discovered by Kaho (1937), but its correct type was identified much later, by Smith (1954). Since then, there have been many photometric studies of the system, but no radial velocity studies. For guidance on the orbital phases, we used the recent determination of Agerer and Huebscher (1998a). To phase our observations, we used the value of the period from the study by Binnendijk (1972).

The modern light-curve synthesis solutions of Vinko, Hegedues, & Hendry (1996) arrived at two similar, possible values of the mass ratio: $q_{\rm ph} = 0.233$ and 0.227. They differ rather substantially from our spectroscopic value, $q_{\rm sp} = 0.303$ (24). The system is clearly of the A type with a large-amplitude light curve and total eclipses offering excellent prospects for a combined radial velocity–photometric solution. The *Hipparcos* parallax placed the system slightly outside the M_V error threshold of 0.5 mag used in RD97. The resulting relatively faint absolute magnitude of $M_V = 3.75$ (55) agrees better with the spectral type of F2–F3 V, implied by $B-V = 0.373$, than with the direct estimate of A7 V (Vinko et al. 1996). Our estimate of the spectral type is A9–F1 V.

2.7. *XZ Leo*

The system was discovered by Hoffmeister (1934). The recent time of minimum has been taken from Agerer & Huebscher (1997), while the period is that determined by Niarchos, Hoffman, & Duerbeck (1994). The system was never observed spectroscopically. Niarchos et al. (1994) made the plausible and apparently correct assumption that the system is of the A type and attempted to determine the mass ratio. Their value, $q_{\rm ph} = 0.726$, is very far from our spectroscopic determination, $q_{\rm sp} = 0.348(29)$, once again demonstrating the dangers of spectroscopically unconstrained light-curve solutions for partially eclipsing systems. They attempted to estimate the spectral type and preferred the range A7 to F0, rather than the previous estimates of A5 to A7. The Tycho's experiment color $(B-V)_{\rm T} = 0.45$ (7) indicates a mid-F spectral type. Our spectral type is A8–F0 V, so that there is a disagreement between the color and the spectral type.

2.8. *V839 Oph*

The variability of this star was discovered by Rigollet (1947). The system has not yet been observed for radial velocity variations. The recent timing of the minimum was

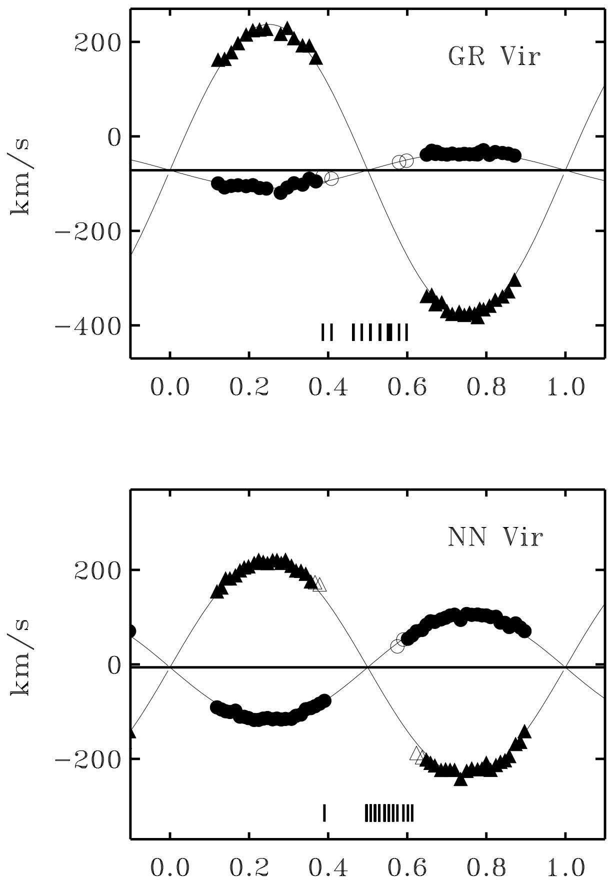

FIG. 3.—Same as Fig. 1, but for GR Vir and NN Vir. Because preliminary epochs of eclipses were not known for these systems, many unneeded observations were taken at conjunctions.

determined by Agerer & Huebscher (1998b), while the period used for phasing our observations was determined by Akalin & Derman (1997).

In spite of partial eclipses and light-curve instabilities, the system was subject to many photometric contact-model solutions. The most recent one, by Akalin & Derman (1997), arrived at the photometric mass ratio of $q_{ph} = 0.40$. This substantially differs from our spectroscopic determination of $q_{sp} = 0.305$ (24). The system is of the A type.

V839 Oph was included in the study of the *Hipparcos* data (RD97) with a moderately accurate determination of $M_V = 3.08$ (38). This absolute magnitude is consistent with the Tycho color $(B-V)_T = 0.62$, with $b-y = 0.41$ (Hilditch & Hill 1975) and the spectral type of F8 V (Akalin & Derman 1997), under the assumption that the reddening is relatively high, $E_{B-V} = 0.09$ (RD97). Our spectral type is F7 V.

2.9. *GR Vir*

Strohmeier, Knigge, & Ott (1965) noticed light variations of the star, but an independent discovery by Harris (1979) led to its identification as a close binary system. The assumed period, as well as the recent timing of the eclipse, comes from the photometric study by Cereda et al. (1988). Since the system was not recently observed, the accumulated uncertainty in the period, as well as a likely change in its length since the observations of Cereda et al. (1988), has led to a large difference between the spectroscopic and predicted values of T_0 of 0.2208 days. We handled the implied problem of relating our radial velocity to the photometric data of Cereda et al. (1988) by assuming that the system is of the A type, as indicated by the fact that the secondary (shallower) eclipses are apparently total.

The mass ratio of the system, $q = 0.12$, is one of the smallest known for contact systems. Because of the total eclipses and the availability of the spectroscopic mass ratio, the system is an ideal candidate for a new light-curve synthesis solution.

GR Vir is the third and last system in this series that was included in the *Hipparcos* analysis (RD97). The absolute magnitude $M_V = 4.17$ (14) was the best determined among the three determinations. Because of its brightness and the features mentioned above, the system deserves much attention. The colors $b-y = 0.37$ (Olsen 1983) and $B-V = 0.55$ (Cereda et al. 1988) suggest the spectral type F9–G0. Our spectral classification is F7/F8 V.

2.10. *NN Vir* (*HD 125488*)

This is one of the stars whose variability has been detected by the *Hipparcos* satellite. Gomez-Ferrellad & Garcia-Melendo (1997) correctly identified the type of variability and determined the period and the initial epoch, T_0. The radial velocity variations have been observed by us for the first time. The star is bright ($V = 7.6$), but it was excluded from the radial velocity survey of early F-type stars by Nordström et al. (1997) because of the strong broadening of the spectral lines indicating rapid rotation and/or close binary character of the star.

NN Vir has a relatively large mass ratio, $q_{sp} = 0.491$ (11), which is rather infrequent among the A-type contact systems. The light curve of Gomez-Ferrellad & Garcia-Melendo has a moderately large amplitude, so that the system should be subject of a combined radial velocity–photometric solution.

NN Vir was not included in RD97, but its parallax is moderately large, leading to a relatively secure determination of the absolute magnitude of $M_V = 2.52(26)$. The color $b-y = 0.25$ (Olsen 1983) suggests the spectral type F3. This is confirmed by our direct classification F0/F1 V.

3. SUMMARY

The paper presents radial velocity data for the second group of 10 close binary systems that we observed, this time all obtained at the David Dunlap Observatory. All but SV Equ, which is probably a short-period semidetached system, are contact binaries with both components clearly detected. We point out in § 2 which of the contact systems will be of greatest interest in the individual descriptions.

Although our observational selection for this group of 10 systems had been purely random, we found, after excluding SV Equ, that eight systems among nine W UMa–type systems are of the A type; only V842 Her is of the W type. A combination of factors could lead to this unusual preference over the W-type systems: (1) although it is generally more difficult to detect low-mass secondaries in A-type systems than in W-type systems because of the more extreme mass ratios, our instrumental setup is ideal for observations of the type presented here; (2) the A-type systems are, on the average, hotter and brighter, so that they would be preferentially selected close to the faint limit of a magnitude-limited survey like ours; and (3) it is possible that, in cases in which spectral lines of secondary components had not been detected during first attempts by previous observers, the A-type systems were preferentially discarded in favor of the W-type systems, since the latter would normally yield full, two-component orbital solutions.

To save space, we do not give the calculated values of $(M_1 + M_2) \sin^3 i = 1.0385 \times 10^{-7}(K_1 + K_2)^3 P$ (days) $M_\odot$; we note, however, that for all nine contact binaries these quantities are relatively large and range between 1.17 $M_\odot$ (CK Boo) and 2.25 $M_\odot$ (UZ Leo), indicating that the orbital inclination angles for all of them are not far from 90° and that the final, combined solutions of the light and radial velocity variations should yield reliable values for the masses. Three of our systems have very small mass ratios: 0.11, 0.12, and 0.17 for CK Boo, GR Vir, and AH Aur, respectively. Small values are common among the A-type systems, but the physical state of such extreme mass-ratio systems remains elusive. We note that the only W-type system, V842 Her, has a relatively small (for a W-type system) mass ratio of 0.26, while NN Vir has a relatively large (for an A-type system) mass ratio of 0.49.

This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France, and accessible through the Canadian Astronomy Data Centre, which is operated by the Herzberg Institute of Astrophysics, National Research Council of Canada.

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