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RADIAL VELOCITY STUDIES OF CLOSE BINARY STARS. I.

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ABSTRACT

Radial velocity data are presented for 10 W UMa–type systems—GZ And, V417 Aql, LS Del, EF Dra, V829 Her, FG Hya, AP Leo, UV Lyn, BB Peg, and AQ Psc—together with preliminary circular-orbit determinations of spectroscopic elements, with the main goal of obtaining mean radial velocities and mass ratios for these systems. This is the first part of a series that will contain radial velocity data for northern hemisphere, short-period eclipsing binaries, accessible to medium-resolution spectroscopic studies with 1.8 m–class telescopes.

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

1. INTRODUCTION

Contact binary stars consisting of solar-type components (also called W UMa–type binary stars) are very common: according to new, unbiased statistics (a by-product of the OGLE microlensing project) their *apparent* frequency of occurrence among main-sequence stars of spectral types F to K (intrinsic colors $0.4 < V - I_C < 1.4$) is about 1/130–1/100, which leads to the spatial frequency at the level 1/60–1/80 (Rucinski 1998). Most of them have orbital periods within 0.25 days $< P <$ 0.7 days. They apparently do not exist below the orbital period of 0.22 days, and they are rare at orbital periods longer than 0.7 days and spectral types earlier than about F0 to F2. The kinematic data for contact systems in the solar neighborhood (Guinan & Bradstreet 1988) and the spatial distribution in the Baade's window direction (Rucinski 1997a, 1997b) suggest an old disk population of interacting binaries formed primarily during the turnoff-point stage of evolution. This stage is conducive to rapid synchronization and formation of contact systems from close, but detached, binaries when component stars expand and are able to interact to the point of mutual contact.

While survey data such as that from the OGLE project can give statistical information on the relative numbers of stars in various stages of evolution and on the duration of the pre- and in-contact stages, only detailed studies of individual systems in the solar neighborhood can yield the absolute parameters of the systems and help establish correct kinematic properties of this contact binary population. Also, precise data for individual bright contact systems should lead to improvements in their luminosity calibration and use as distance indicators (Rucinski 1997a, 1997b). These aspects formed the main rationale of a program started by the current paper of the series.

The *Hipparcos* astrometric satellite provided the best and most consistent parallaxes and proper motions for a sample of contact binaries: Parallaxes giving error in absolute magnitude $\epsilon(M_V) < 0.5$ became available for 40 systems (Rucinski & Duerbeck 1997), with half that number having error $\epsilon(M_V) < 0.25$. Most of these systems have high-quality proper-motion determinations with errors at the level of 1–10 mas yr^{-1}. The proper-motion data can be combined with mean systemic radial velocities γ to provide spatial velocities of these stars. However, many systems with excellent parallax and tangential-velocity data from *Hipparcos* lack correspondingly accurate radial velocity data. The present paper describes observations of 10 systems collected over the recent years at the Dominion Astrophysical Observatory and at the David Dunlap Observatory (DDO), together with results of a new program that was initiated at the DDO to determine primarily the mean radial velocities γ.

Determinations of γ-velocities cannot be usually separated from determinations of the velocity amplitudes, K_1 and K_2. Thus, other important products of this program are the spectroscopic mass ratios, $q = K_2/K_1$, as well as the individual masses of the components. For determinations of stellar masses, orbital inclination angles are needed, and these can only come from light-curve solutions. In turn, light-curve solutions gain in quality when spectroscopic values of q are used. Although we did recognize that combined spectroscopic-photometric solutions would provide the most consistent approach, we decided not to perform full solutions of our program binaries through combination of the new velocity data with the light curves from the literature. The main reason for this decision was that light curves were simply not available for many of our systems or that in some cases they did exist, but were of disputable quality. Thus, the goal of these observations was simply to provide radial velocity data and the simplest possible circular solutions giving γ, q, K_1, and K_2. The selection of the objects was based on their brightness, visibility from the Northern Hemisphere, and availability of astrometric data from the *Hipparcos* satellite. It is hoped that this program will lead eventually to spectroscopic data for all short-period and contact binaries accessible to 2 m–class Northern Hemisphere telescopes equipped with spectrographs providing spectral resolutions of the order of 10,000–15,000.

2. OBSERVATIONS AND DATA REDUCTIONS

Observations were collected at the Dominion Astrophysical Observatory (DAO), Victoria, British Columbia, for three stars (LS Del, AP Leo, UV Lyn) and at the David Dunlap Observatory (DDO) near Toronto for the remaining seven stars. At DAO, the 1.8 m telescope and the "21121" spectrograph, giving dispersion of 15 Å mm^{-1}, were used. The CCD detectors, central wavelengths, and spectral windows were not the same, so they are described below in discussions of individual systems. Typically, about 240 Å were covered at 0.23 to 0.25 Å $pixel^{-1}$ at 4160 or 5020

TABLE 1

OBSERVATIONS OF 10 W URSAE MAJORIS TYPE SYSTEMS

HJD (2,400,000+)	Phase	V_1	ΔV_1	V_2	ΔV_2
GZ And (DDO):					
50,329.8571......	0.7752	−136.2	−8.1	236.8	−12.2
50,329.8680......	0.8109	−116.5	3.8	229.3	−4.6
50,329.8800......	0.8503	−98.9	5.9	212.5	8.8
50,329.8907......	0.8854	−88.4	−2.9	168.1	1.8
50,329.9017......	0.9214	−58.9	2.5	156.5[b]	37.0
50,330.8095......	0.8978	−74.5	3.2	162.4	11.4
50,330.8564......	0.0515	42.1[a]	0.8	−153.8[b]	−73.6[b]
50,330.8683......	0.0906	70.5	0.6	−179.4[b]	−43.6[b]
50,330.8804......	0.1302	99.4	4.7	−197.0	−13.0
50,363.8842......	0.3370	118.0	7.2	−199.3	16.0
50,363.8929......	0.3655	93.5	−3.5	−196.5	−8.0
50,398.6186......	0.2178	137.0	9.9	−235.7	11.3
50,398.6287......	0.2509	134.1	4.4	−279.1	−27.0
50,398.7193......	0.5480	...	...	...	...
50,398.7310......	0.5863	−80.4[a]	−13.5	135.3[a]	5.2
50,398.7437......	0.6280	−96.2	−2.8	165.0	−16.6
50,398.7700......	0.7142	−119.8	6.6	244.7	−1.1
50,398.7816......	0.7522	−132.1	−2.4	245.1	−7.0
50,407.8025......	0.3283	108.5	−5.8	−234.1	−11.9
50,415.6562......	0.0776	50.9[a]	−9.8	−152.9[b]	−34.9[b]
50,415.6671......	0.1133	76.0	−8.7	−187.0	−22.3
50,415.6797......	0.1546	112.6	5.5	−218.0	−9.8
50,415.6905......	0.1900	124.2	3.6	−221.4	13.0
50,415.7024......	0.2290	123.4	−5.2	−245.9	4.0
50,438.7185......	0.6900	−118.6	2.0	229.8	−4.6
50,438.7292......	0.7251	−123.5	4.6	235.0	−14.0
50,438.7418......	0.7664	−124.0	5.0	253.9	3.1
V417 Aql (DDO):					
50,321.6014......	0.1040	39.6	−5.2	−208.2[a]	−31.0
50,321.6135......	0.1366	63.3	4.1	−231.5	−14.3
50,321.6280......	0.1758	66.2	−6.2	−261.7	−7.9
50,321.6389......	0.2052	72.0	−7.0	−263.7	8.2
50,321.6526......	0.2422	80.7	−2.0	−285.3	−3.2
50,321.6639......	0.2727	90.4	8.6	−276.3	3.4
50,321.6768......	0.3076	86.4	9.9	−269.1	−4.0
50,321.6880......	0.3378	66.1	−2.3	−231.8	10.8
50,321.7031......	0.3786	57.2	4.4	−206.9	−7.4
50,321.7149......	0.4105	45.2	7.7	−156.9	0.4
50,323.6309......	0.5845	−65.2	−1.9	139.2[a]	17.6
50,323.6421......	0.6147	−89.6	−11.4	177.2	14.4
50,323.6559......	0.6520	−97.9	−4.5	194.7	−10.1
50,323.6666......	0.6809	−101.6	0.6	230.9	1.8
50,323.6790......	0.7144	−102.1	6.7	231.1	−16.2
50,329.6019......	0.7088	−98.8	9.2	240.0	−5.1
50,329.6128......	0.7382	−108.2	2.8	243.2	−10.1
50,329.6267......	0.7757	−111.3	−1.3	240.2	−10.3
50,329.6378......	0.8057	−103.0	2.3	241.7	3.9
50,329.6522......	0.8446	−98.5	−3.9	205.7	−2.3
50,329.6629......	0.8735	−73.2	10.3	189.8	12.5
50,329.6753......	0.9070	−73.2	−5.5	149.9[a]	16.1
LS Del (DAO):					
48,153.7319......	0.5334	...	...	...	...
48,153.7495......	0.5817	...	...	...	...
48,153.7608......	0.6128	−70.3[a]	0.5	94.0[a]	−0.3
48,153.7722......	0.6442	−76.5	3.7	123.5	4.0
48,153.7803......	0.6664	−80.3	5.3	130.4	−3.5
48,153.7908......	0.6953	−88.8	2.1	146.7	−1.3
48,153.7984......	0.7162	−94.8	−1.4	139.5	−15.2
48,153.8136......	0.7580	−84.6	10.3	149.2	−9.4
48,153.8216......	0.7799	−88.2	5.5	169.5	13.9
48,153.8427......	0.8379	−93.4	−8.7	141.8	10.4
48,155.6610......	0.8355	−87.0	−1.8	140.7	7.8
48,155.6741......	0.8715	−79.2	−3.4	117.6	10.0

TABLE 1—*Continued*

HJD (2,400,000+)	Phase	V_1	ΔV_1	V_2	ΔV_2
48,155.6825......	0.8946	−80.1	−11.7	73.3	−14.5
48,155.6886......	0.9113	−69.1	−6.7	74.7	2.9
48,155.6967......	0.9336	...	...	...	...
48,155.7028......	0.9504	...	...	...	...
48,155.7105......	0.9715	...	...	...	...
48,155.7164......	0.9876	...	...	...	...
48,155.7240......	0.0086	...	...	...	...
48,155.7300......	0.0251	...	...	...	...
48,155.7398......	0.0521	...	...	...	...
48,155.7420......	0.0581	...	...	...	...
48,155.7518......	0.0850	3.2[a]	−6.0	−123.6[a]	−3.6
48,155.7580......	0.1021	11.8[a]	−3.6	−145.1[a]	−8.7
48,155.7657......	0.1233	16.7	−5.7	−157.1	−2.0
48,155.7712......	0.1384	17.5	−9.3	−184.3	−17.3
48,155.7760......	0.1516	19.0	−11.3	−179.3	−2.9
48,155.7832......	0.1713	33.6	−1.3	−187.2	1.3
48,155.7900......	0.1900	46.8	8.5	−193.1	4.6
48,155.7989......	0.2145	43.0	1.6	−203.6	2.5
48,155.8050......	0.2313	45.9	3.3	−195.4	14.0
48,155.8126......	0.2522	40.5	−2.6	−223.0	−12.4
48,155.8203......	0.2733	52.7	10.3	−197.0	11.7
48,155.8263......	0.2898	35.2	−5.8	−207.4	−2.5
48,155.8354......	0.3148	33.9	−3.6	−195.7	−0.1
48,155.8416......	0.3319	39.9	5.7	−193.6	−6.8
48,155.8510......	0.3577	23.6	−4.3	−171.1	−1.1
48,155.8572......	0.3747	42.9	19.9	−146.6	10.2
48,155.8649......	0.3959	23.7	7.6	−123.1	15.3
48,155.8716......	0.4143	...	...	...	...
48,155.8807......	0.4393	...	...	...	...
48,155.8877......	0.4586	...	...	...	...
EF Dra (DDO):					
48,764.6756......	0.0994	−75.2	−4.4	164.0	27.2
48,764.6901......	0.1336	−86.0	−7.3	162.9	−22.7
48,764.7063......	0.1718	−91.8	−6.4	216.1	−11.6
48,764.7205......	0.2053	−83.0	6.2	274.2	22.3
48,764.7385......	0.2477	−85.8	5.4	252.5	−11.4
48,764.7528......	0.2814	−79.3	10.9	254.3	−3.6
48,764.7694......	0.3206	−74.3	12.1	238.1	3.8
48,764.7835......	0.3538	−75.9	5.2	206.4	5.4
48,788.6431......	0.6243	−3.7	4.1	−302.9	−45.1
48,788.6577......	0.6587	1.2	2.3	−287.9	11.5
48,788.6748......	0.6990	−7.6	−11.8	−311.9	20.9
48,788.6894......	0.7334	13.9	7.5	−366.5	−19.8
48,788.7064......	0.7736	−3.3	−9.4	−313.9	31.1
48,788.7208......	0.8075	7.2	3.7	−318.0	10.6
48,788.7390......	0.8504	−2.8	−0.1	−297.9	−8.5
48,788.7535......	0.8846	3.3	13.1	−285.0	−39.8
V829 Her (DDO):					
48,415.6430......	0.5188	...	...	...	...
48,415.6642......	0.5780	...	...	...	...
48,415.6839......	0.6330	−78.8	0.3	144.4	−3.1
48,415.7024......	0.6846	−106.3	−11.6	172.1	−13.4
48,415.7202......	0.7343	−99.0	2.6	202.3	−0.2
48,415.7372......	0.7818	−97.4	2.9	205.7	6.5
48,415.7545......	0.8301	−81.3	9.8	183.0	6.3
48,415.7941......	0.9407	...	...	...	...
48,415.8107......	0.9870	...	...	...	...
48,415.8269......	0.0322	...	...	...	...
48,416.6938......	0.4527	...	...	...	...
48,416.7110......	0.5008	...	...	...	...
48,416.7282......	0.5442	...	...	...	...
48,416.7461......	0.5988	−69.2	−4.2	109.0	−3.8
48,416.7626......	0.6448	−89.9	−6.5	145.4	−12.5
48,416.7791......	0.6909	−94.9	1.1	193.5	4.7
48,416.7960......	0.7381	−103.1	−1.3	208.9	5.9
48,417.6141......	0.0223	...	...	...	...

TABLE 1—*Continued*

HJD (2,400,000+)	Phase	V_1	ΔV_1	V_2	ΔV_2
48,417.6350	0.0807	...	...	...	...
48,417.6558	0.1388	55.5	1.1	−180.4	−0.9
48,417.6766	0.1968	76.8	6.5	−210.5	7.9
48,764.8378	0.5143	...	...	...	...
48,764.8523	0.5548	...	...	...	...
48,764.8666	0.5947	...	...	...	...
48,788.7822	0.3700	54.9	3.7	−188.6	−17.0
48,788.7939	0.4027	36.7	−0.7	−143.7	−5.7
50,489.9281	0.1819	64.0	−3.2	−213.5	−2.7
50,489.9389	0.2120	68.6	−4.1	−225.5	−1.2
50,489.9515	0.2472	68.3	−6.9	−227.6	2.8
50,489.9622	0.2771	74.2	0.3	−222.1	5.2
FG Hya (DDO):					
50,398.9056	0.4075	...	...	...	...
50,398.9167	0.4414	...	...	...	...
50,398.9287	0.4780	...	...	...	...
50,398.9396	0.5112	...	...	...	...
50,398.9526	0.5509	...	...	...	...
50,414.7690	0.7964	25.2	−3.6	−295.5	19.0
50,414.7798	0.8293	29.5	3.6	−293.5	−4.6
50,414.7928	0.8690	31.9	11.2	−236.9	5.3
50,414.8037	0.9022	16.7	1.6	−170.2[b]	21.4[b]
50,438.8378	0.2144	−36.5	4.3	317.6	8.9
50,438.8486	0.2474	−41.5	0.2	301.7	−14.9
50,438.8622	0.2889	−41.4	−0.8	316.8	9.7
50,438.8731	0.3221	−40.7	−2.6	281.5	−2.6
50,438.8855	0.3599	−36.4	−3.0	256.4	13.6
50,438.8954	0.3901	−25.8	2.8	212.0	12.4
50,469.6340	0.1534	−40.8	−5.5	270.8	11.7
50,469.6447	0.1860	−36.0	2.8	295.5	4.5
50,469.6582	0.2272	−55.1	−13.8	314.6	1.2
50,469.6691	0.2605	−45.4	−3.8	306.3	−9.7
50,469.6813	0.2977	−41.9	−1.8	295.9	−6.4
50,469.6920	0.3303	−33.2	4.0	276.1	−0.4
50,469.7989	0.6564	29.0	4.7	−274.7	−0.8
50,469.8097	0.6894	32.7	5.0	−304.4	0.6
50,469.8215	0.7254	27.5	−2.4	−312.0	12.2
50,469.8323	0.7583	15.7	−14.6	−325.2	2.4
50,469.8450	0.7970	28.3	−0.4	−318.5	−4.4
50,469.8558	0.8300	14.7	−11.2	−294.6	−6.4
50,477.7347	0.8633	12.1	−9.5	−255.9	−6.1
50,477.7451	0.8950	16.0	−0.4	−199.6[b]	3.6[b]
50,483.6474	0.8991	16.1	0.5	−177.1[b]	19.6[b]
AP Leo (DAO):[c]					
48,310.7545	0.2330	−102	1	224	−12
48,310.7701	0.2692	−103	0	220	−16
48,310.7925	0.3213	−98	−2	210	−2
48,311.7786	0.6126	30	4	−205	−8
48,311.7976	0.6568	53	13	−266	−21
48,311.8116	0.6893	37	−10	−248	21
48,311.8304	0.7330	63	10	−287	0
48,311.8439	0.7644	49	−4	−290	−2
48,311.8572	0.7953	48	−2	−251	26
48,311.8705	0.8262	38	−6	−263	−4
48,311.8839	0.8573	46	10	−244	−13
48,311.8975	0.8889	41	16	−186	8
48,312.8527	0.1085	−60	14	143	2
48,312.8664	0.1403	−94	−8	160	−18
48,312.8810	0.1742	−96	−1	207	−1
48,312.8953	0.2074	−92	10	216	−12
48,312.9106	0.2430	−98	5	235	−2
48,312.9262	0.2792	−90	12	242	8
48,312.9427	0.3176	−93	3	203	−11
48,312.9607	0.3595	−94	−8	175	−3
48,312.9792	0.4054	...	...	...	...

TABLE 1—*Continued*

HJD (2,400,000+)	Phase	V_1	ΔV_1	V_2	ΔV_2
UV Lyn (DAO):					
48,254.7929......	0.6929	−80.8	0.5	213.0	−7.2
48,254.8101......	0.7343	−83.4	3.0	237.1	3.0
48,254.8261......	0.7729	−95.2	−9.2	237.5	4.7
48,254.8530......	0.8377	−65.8	8.3	195.5	−4.9
48,254.8691......	0.8765	−58.8	2.2	175.5	10.7
48,254.9526......	0.0777	...	...	...	...
48,254.9699......	0.1194	61.0	2.4	−155.6	5.3
48,254.9846......	0.1548	67.9	−3.2	−206.0	−11.0
48,255.0010......	0.1943	84.1	3.2	−226.8	−5.2
48,255.0278......	0.2589	94.6	8.6	−248.2	−12.6
48,255.0446......	0.2994	77.8	−4.2	−211.5	13.2
48,255.0607......	0.3382	67.4	−5.8	−204.7	−4.0
48,255.0770......	0.3775	55.6	−4.3	−161.6	2.8
48,260.7996......	0.1675	76.0	1.2	−204.9	0.0
48,260.8124......	0.1984	84.9	3.3	−221.1	2.5
48,260.8234......	0.2249	75.7	−9.4	−229.1	3.9
48,260.8366......	0.2567	80.2	−5.9	−237.8	−2.1
48,260.8672......	0.3304	66.0	−9.4	−205.8	0.7
48,260.8798......	0.3608	64.5	−1.6	−172.5	8.7
48,260.8929......	0.3923	...	...	...	...
48,260.9855......	0.6155	−67.6	−9.9	165.3	0.4
48,260.9987......	0.6473	−82.2	−12.8	196.0	8.2
48,261.0091......	0.6724	−82.9	−6.2	195.9	−11.8
48,261.0211......	0.7013	−78.2	4.6	217.8	−6.5
48,261.0314......	0.7261	−70.0	15.9	224.1	−8.5
48,261.0438......	0.7560	−87.4	−0.6	253.9	18.8
48,261.0538......	0.7801	−95.8	−10.5	233.6	−2.5
48,261.0651......	0.8073	−76.5	4.8	210.5	−9.7
48,261.0814......	0.8466	−73.2	−1.8	214.9	21.7
48,261.0939......	0.8767	−53.8	7.1	169.2	4.7
48,261.1014......	0.8948	...	...	...	...
BB Peg (DDO):					
50,321.7422......	0.3230	54.1	−4.1	−263.6	7.6
50,321.7546......	0.3573	49.1	2.1	−241.7	−1.7
50,321.8049......	0.4964	...	...	...	...
50,321.8190......	0.5354	...	...	...	...
50,321.8356......	0.5813	−70.0[a]	6.4	140.2[a]	37.0
50,321.8503......	0.6220	−94.2	2.1	175.9	17.4
50,321.8675......	0.6696	−110.8	3.1	206.5	−1.0
50,324.6104......	0.2571	65.2	−3.0	−302.5	−3.7
50,324.6216......	0.2880	65.4	−0.1	−278.4	13.0
50,324.6336......	0.3212	53.2	−5.5	−270.3	2.2
50,324.6445......	0.3514	55.2	6.0	−251.9	−5.8
50,324.6569......	0.3857	40.3	5.3	−209.0	−2.3
50,324.6678......	0.4158	30.1[a]	10.0	−183.7[a]	−18.5
50,324.7196......	0.5591	...	...	...	...
50,324.7346......	0.6006	−103.0	−16.7	127.9	−2.9
50,324.7785......	0.7221	−123.4	1.2	223.4	−13.7
50,324.7868......	0.7450	−136.6	−10.6	236.0	−5.2
50,324.7974......	0.7743	−114.2	10.7	226.3	−11.8
50,324.8074......	0.8020	−119.4	1.5	238.1	11.1
50,324.8203......	0.8377	−120.0	−8.3	198.7	−2.6
50,324.8313......	0.8681	−92.0	8.5	177.8	7.6
50,324.8445......	0.9046	−98.6[a]	−14.9	147.4[a]	23.9
50,330.6851......	0.0611	...	...	...	...
50,330.6964......	0.0924	30.1[a]	5.7	−197.0[a]	−19.9
50,330.7140......	0.1411	47.7	1.3	−245.7	−7.5
50,330.7274......	0.1781	56.6	−1.9	−270.9	1.1
50,330.7418......	0.2180	62.3	−4.0	−288.2	5.4
50,330.7529......	0.2487	64.3	−4.0	−291.0	8.1
AQ Psc (DDO):					
50,312.7508......	0.4320	...	...	...	...
50,312.7636......	0.4589	...	...	...	...
50,312.7780......	0.4892	...	...	...	...
50,312.7889......	0.5121	...	...	...	...

TABLE 1—*Continued*

HJD (2,400,000+)	Phase	V_1	ΔV_1	V_2	ΔV_2
50,312.8039......	0.5436	...	...	...	...
50,312.8145......	0.5659	...	...	...	...
50,312.8294......	0.5972	23.8	2.5	−171.2[a]	−7.3
50,312.8394......	0.6183	27.0	−0.4	−202.8	−11.8
50,312.8506......	0.6418	38.6	5.2	−215.7	2.0
50,312.8565......	0.6542	38.8	2.6	−225.0	4.9
50,321.8836......	0.6344	32.3	0.7	−216.1	−6.3
50,321.8945......	0.6574	37.3	0.5	−228.2	4.6
50,321.9063......	0.6822	43.2	1.9	−249.5	3.1
50,324.8788......	0.9321	...	...	...	...
50,324.8898......	0.9552	...	...	...	...
50,324.9028......	0.9826	...	...	...	...
50,329.6924......	0.0531	...	...	...	...
50,329.7019......	0.0731	...	...	...	...
50,329.7239......	0.1193	−53.6	−0.1	173.8	7.3
50,329.7357......	0.1441	−60.3	−0.6	189.2	−5.0
50,329.7484......	0.1708	−64.1	1.1	206.3	−12.2
50,329.7593......	0.1937	−68.3	0.5	220.2	−13.9
50,329.7726......	0.2217	−72.2	−0.7	227.2	−19.0
50,329.7833......	0.2442	−70.7	1.7	236.2	−14.0
50,329.7958......	0.2705	−70.8	1.2	247.2	−1.0
50,329.8065......	0.2930	−70.0	0.3	244.8	4.0
50,329.8200......	0.3214	−68.1	−1.5	226.1	1.7
50,329.8309......	0.3443	−59.9	2.4	214.7	9.2
50,329.8432......	0.3701	−55.9	0.4	202.4	23.5
50,363.7596......	0.6822	39.5	−1.8	−250.3	2.3
50,363.7702......	0.7045	42.1	−2.1	−267.9	−2.4
50,363.7818......	0.7289	42.5	−3.6	−267.1	6.8
50,363.7927......	0.7518	46.9	0.3	−281.8	−5.6
50,363.8053......	0.7783	44.6	−1.1	−268.3	3.7
50,363.8162......	0.8012	46.7	3.1	−264.6	−1.9
50,363.8298......	0.8298	41.1	1.8	−266.3	−22.5
50,363.8473......	0.8666	28.5	−2.9	−217.8	−9.1

[a] Half-weight given in the orbital solution.
[b] Not used in the orbital solution, because of strong influence of the proximity effects and large deviations from circular model.
[c] Radial velocities of AP Leo were measured with the accuracy of 1 km s^{-1}.

Å. At DDO, the 1.9 m telescope and the Cassegrain spectrograph illuminating a CCD at a dispersion of 10.8 Å mm^{-1}, corresponding to about 0.2 Å pixel^{-1} or about 12 km s^{-1} pixel^{-1}, were used for most observations (see also the descriptions for individual systems below). All the spectra for stars observed at DDO were centered at 5185 Å, giving a spectrum coverage of 210 Å.

The velocity determinations of binary component stars were done using cross-correlation of spectra with standard stars (program VCROSS; Hill 1982) or broadening function (BF) algorithms (Rucinski 1992), which also use spectra of sharp-line standard stars. The former method was used for the systems observed at DAO, while the latter method was used for the systems observed at DDO. In both cases, the radial velocities of stars were determined by fitting Gaussians to the peaks. Tests showed that systematic differences between VCROSS and BF results were well below the level of formal errors, so that it was decided to disregard this minor inconsistency in the methodology.

Spectra of different stars were used as sharp-line templates for cross-correlation and broadening function determinations. They were, for systems observed at the DAO: HD 32963 (G2 V) for LS Del, HD 126053 (G1 V) for AP Leo, UV Lyn (HD 22484 [F8 V] and HD 32963 [G2 V]); at the DDO, HD 22484 (F8 V) was used for AQ Psc, V417 Aql, BB Peg, GZ And, and FG Hya, whereas HD 102870 (F9 V) was used for EF Dra, and HD 187691 (F8 V) for V829 Her.

The spectra of the program stars were reduced with IRAF.[1] The standard procedures were employed, which consist of de-biasing, cosmic-ray removal, flat-fielding, extraction of one-dimensional spectra, wavelength calibration, and rectification. The radial velocity orbits were solved using programs RVORBIT by G. Hill (1986, private communication) and SBCM by Morbey (1975). For each system, circular solutions of the form $V(t) = \gamma + K_i \sin \phi$, with ϕ being the phase, were made separately for each component and then for the whole system. No significant differences in γ-velocities for separate solutions were noted in any of the 10 systems. Normally, unit weights were given to individual observations, with the exception of those indicating blending at eclipses. The initial epoch T_0 was included among unknowns in all cases because of lack of recent photometric eclipse timings or possibilities of period changes. The values we give for T_0 correspond to moments of the deeper eclipses for each of the systems.

[1] IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

TABLE 2

SPECTROSCOPIC ORBITAL ELEMENTS OF 10 W URSAE MAJORIS SYSTEMS

Name, Type	γ	K_1, K_2	ϵ_1, ϵ_2	T_0 − 2,400,000, Assumed P	$a_1 \sin i$, $a_2 \sin i$	$m_1 \sin^3 i$, $m_2 \sin^3 i$	$q = m_2/m_1$
GZ And (W)	0.0 (12)	129.7 (13)	±5.9	50398.5521 (08)	0.782 (08)	1.164 (31)	0.514 (08)
		252.1 (28)	±12.3	0.3050067	1.519 (17)	0.599 (13)	
V417 Aql (W)	−14.2 (14)	97.0 (16)	±6.5	50321.5629 (10)	0.710 (12)	1.376 (36)	0.362 (07)
		268.2 (27)	±11.1	0.37031142	1.962 (20)	0.498 (15)	
LS Del (W).........	−25.9 (14)	69.0 (16)	±6.2	48154.9932 (08)	0.496 (12)	0.449 (11)	0.375 (10)
		184.8 (22)	±9.5	0.3638384	1.328 (16)	0.168 (05)	
EF Dra (A).........	−42.2 (35)	48.9 (43)	±7.9	48788.3784 (18)	0.410 (36)	1.699 (91)	0.160 (14)
		306.1 (54)	±24.4	0.4240331	2.564 (45)	0.271 (32)	
V829 Her (W)......	−13.4 (10)	88.6 (15)	±5.2	48417.6061 (09)	0.627 (11)	0.754 (19)	0.408 (08)
		217.0 (21)	±6.4	0.3581502	1.535 (15)	0.308 (09)	
FG Hya (A)........	−5.7 (12)	36.0 (13)	±6.3	50438.7675 (06)	0.233 (08)	1.410 (24)	0.112 (04)
		322.4 (18)	±8.9	0.327835	2.088 (12)	0.157 (07)	
AP Leo (A).........	−25.1 (21)	78.2 (23)	±8.5	48311.9453 (13)	0.665 (20)	1.368 (33)	0.297 (09)
		263.1 (29)	±12.4	0.4303546	2.237 (24)	0.406 (15)	
UV Lyn (W)	−0.3 (13)	86.5 (15)	±7.6	48254.9203 (08)	0.709 (12)	1.053 (18)	0.367 (07)
		235.7 (19)	±9.0	0.41498088	1.932 (15)	0.387 (09)	
BB Peg (W)	−28.9 (14)	97.2 (15)	±7.2	50324.5174 (09)	0.694 (11)	1.369 (33)	0.360 (06)
		270.2 (25)	±11.5	0.361501	1.930 (18)	0.493 (13)	
AQ Psc (A).........	−12.9 (04)	59.5 (04)	±2.0	50333.4720 (09)	0.559 (04)	1.355 (27)	0.226 (02)
		263.3 (19)	±10.2	0.4756056	2.474 (19)	0.307 (05)	

NOTE.—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 first entry 0.0(12) should be interpreted as 0.0 ± 1.2. The average radial velocities γ, the velocity amplitudes K_i, and the standard unit-weight errors of the solutions are expressed in km s^{-1}. The derived quantities of the orbit dimensions a_i and component masses m_i are in the solar radius and solar mass units $R_\odot$ and $M_\odot$.

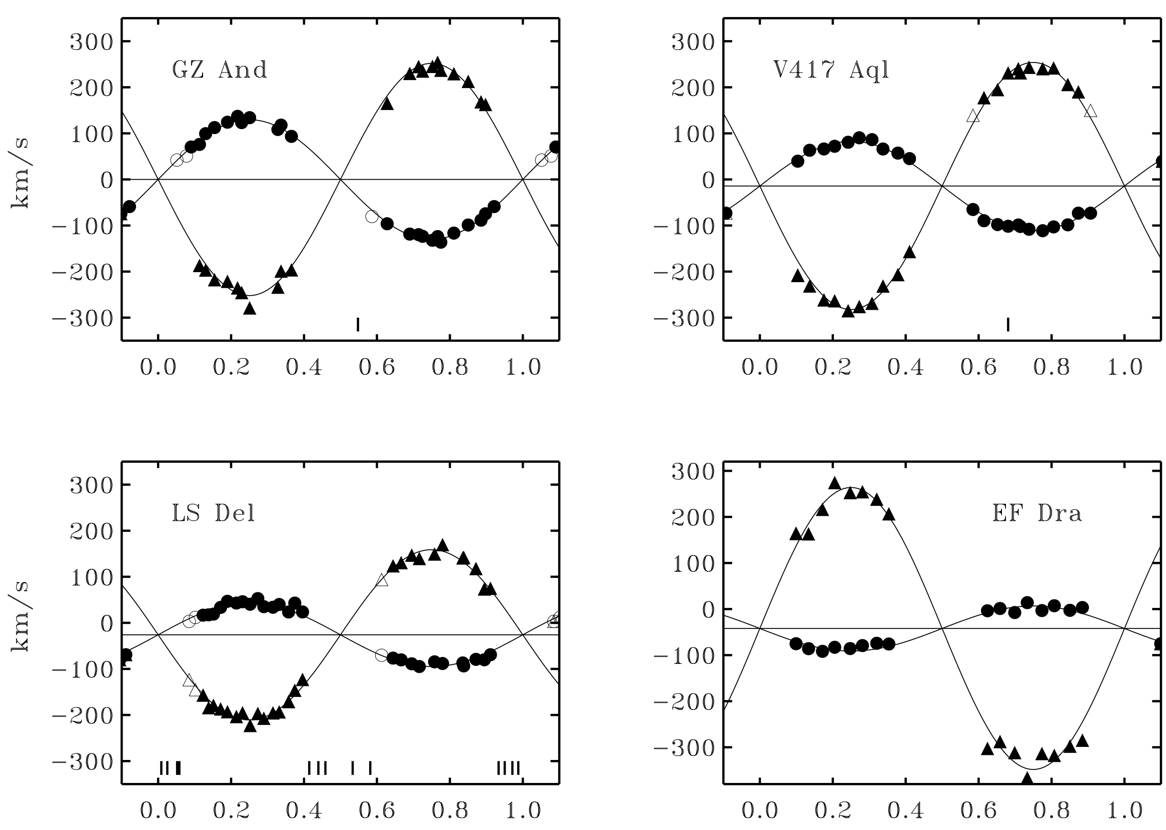

FIG. 1.—Radial velocities of the first four systems, GZ And, V417 Aql, LS Del, and EF Dra, plotted in individual panels versus orbital phases. The thin lines give the respective circular-orbit (sine curve) fits to the radial velocities. Open symbols indicate observations given half-weights in the solutions, while marks at the lower portions of the panels show phases of available observations which were not used in the solutions because of the blending of lines. EF Dra is the only A-type system among the four systems shown here; all other systems are of the W type, with slightly hotter, less massive components.

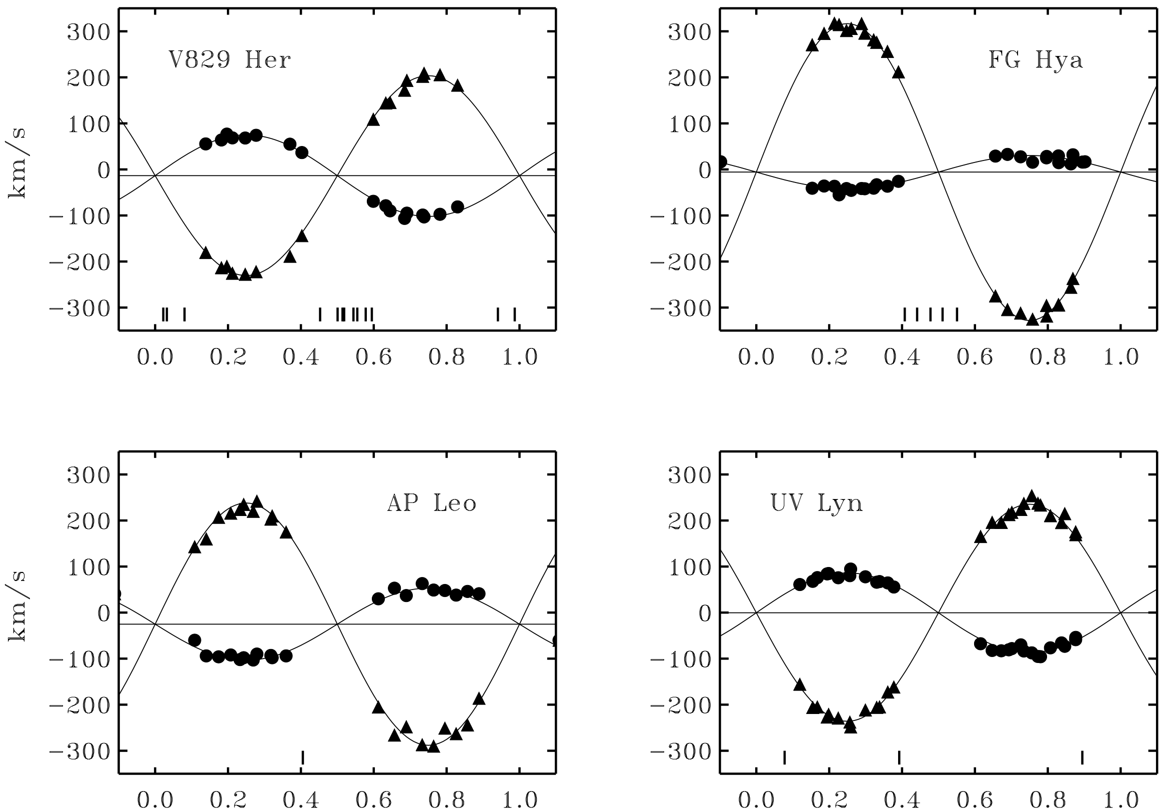

FIG. 2.—Radial velocities of the systems V829 Her, FG Hya, AP Leo, and UV Lyn, in the same format as in Fig. 1. Among the four systems, FG Hya and AP Leo belong to A type.

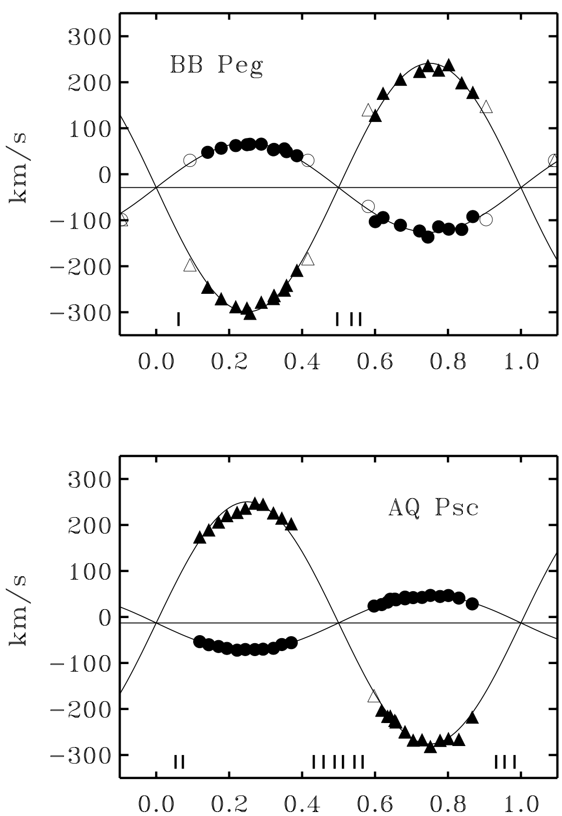

FIG. 3.—Radial velocities of the systems BB peg and AQ Psc, in the same format as in Figs. 1 and 2. AQ Psc is an A-type system.

Standard stars were observed on each night of observations of program stars. These observations were used to check zero points in velocity. For DAO and early DDO observations, zero points were accurate to 1.2 km s^{-1} on average, while for the 1996–1997 DDO observations, the accuracy (limited by the spectrograph flexure) was slightly lower and equaled 1.6 km s^{-1}.

From a series of over 60 observations of IAU standard stars, it was found that the velocity of the template star HD 22484, which was used for the radial velocity determinations of the DDO observations, had a measured value 1.8 km s^{-1} more negative than the IAU value. The effect may have been caused by a nightly instability of the Cassegrain spectrograph. Thus, the derived radial velocities for five systems, AQ Psc, V417 Aql, BB Peg, GZ And, and FG Hya, should be increased by 1.8 km s^{-1}, leading to a corresponding increase in the derived γ-velocity for each of these systems. This value of 1.8 km s^{-1} may be taken as an estimate of the external error of our observations.

The observations are listed in Table 1 listing the Heliocentric Julian Date (HJD)of the exposure, the adopted phase, and the two radial velocity determinations, together with the deviations from the circular solution. The stars are arranged in this table in the alphabetic order of constellations. The next section discusses individual systems. For each system, we first describe the observations and then summarize briefly how they relate to the previous existing data. For some quantities we quote determination uncertainties; they are given in parentheses, following the actual numbers. This convention is used in Table 2, which summarizes the results of the paper. Figures 1, 2, and 3 show individual observations for the program stars together with the respective sinusoidal fits.

3. RESULTS FOR INDIVIDUAL SYSTEMS

3.1. *GZ And*

The spectroscopic orbit presented here (based on the DDO observations) has been determined for the first time. A total of 27 spectra were obtained in the period of 1996 September–December. The exposure times were 15 minutes, corresponding to about 0.034 of the orbital period. This time resolution is somewhat lower than for the other systems because of the shortness of the period. The orbital period of 0.3050067 days has been adopted after Liu, Yang, & Tam (1987).

The system was discovered as a W UMa–type binary by Walker (1973), as a brightest component (A) of a visual multiple system ADS 1693. whose properties were studied later by Walker (1991, 1996). He claimed that, in addition, the W UMa binary belongs to a close triple system with a period of about 5.3 yr for the wide pair. Indeed, on the basis of the photometric properties it appears that all visual components of ADS 1693, except star D, are probably physical members of the multiple system. However, we have been unable to detect the third component in our spectroscopic observations of GZ And (ADS 1963A). Both Walker (1991, 1996) and Liu et al. (1987) signaled that they made photometric solutions, but their results are not available yet, so that this W-type system still awaits a combined photometric–radial velocity investigation.

3.2. *V417 Aql*

The spectroscopic orbit presented here has been determined for the first time. The system was observed at DDO in 1996 August–September. A total of 22 spectra were obtained, all of them at phases around the orbital quadratures. The exposure times were 15 minutes, corresponding to a phase resolution of 0.028. A period of 0.37031142 days was adopted in the spectroscopic orbit solution, following Faulkner (1986).

V417 Aql was discovered by Hoffmeister (1935). There were few investigations of this system other than those devoted to timing of eclipse minima. Recently, Samec, Pauley, & Carrigan (1997) obtained high-precision photometric light curves and made solutions of geometric elements. Their mass ratio of $q = 0.3684$ is almost the same as our spectroscopic value of 0.362. By combining the photometric solution of Samec et al. with our radial velocity solution, the following absolute parameters can be derived: $a = 2.68\ R_\odot$, side radii $R_1 = 1.29\ R_\odot$, and $R_2 = 0.80\ R_\odot$, and masses $M_1 = 1.40\ M_\odot$, $M_2 = 0.50\ M_\odot$. The degree of contact is 19%. This W-type system is very similar to BB Peg, which we discuss below.

3.3. *LS Del*

The spectroscopic orbit for this system is presented here for the first time. The star was observed at DAO with the "21121" spectrograph and the RCA2 CCD detector at a dispersion of 15 Å mm^{-1}, or the scale 0.25 Å pixel^{-1}. The binary was observed only on two nights, 1990 September 19 and 21. The spectra were centered at 4160 Å with a coverage of 250 Å. Forty-two observations were obtained, of which 29 were at orbital quadratures, and 13 at conjunctions. The conjunctions were observed unintentionally, purely because of the inaccurately known period. Typical exposure time was 8 minutes, corresponding to 0.015 in orbital phases. A single spectrum at low dispersion taken in the blue region showed that the spectral type of the star is G0 V, not G5 as given in Bond (1976). LS Del is a W-type W UMa system.

The LS Del system was discovered spectroscopically as a close binary by Bond (1976). Since then, the system has been analyzed several times. Derman, Demircan, & Selam (1991) gave a period of 0.3638384 days, which was used in our solutions of radial velocities for orbital elements. An attempt at a solution of the light curve (Wang, Lu, & Fan 1986), using the mass ratio from the present RV data by means of Wilson-Devinney method (Wilson 1979) led to the inclination $i = 48\overset{\circ}{.}5$, almost identical temperatures of components (with T_2 higher than T_1 by 40 K, implying a W-type system), and a shallow contact of $f = 7\%$. The absolute dimensions obtained were $a = 2.44\ R_\odot$, $M_1 = 1.07\ M_\odot$, and $M_2 = 0.40\ M_\odot$. Another photometric analysis of the system was carried out by Weaver (1990), who obtained a similar inclination of $i \simeq 45°$ and also weak contact; he suggested that light variations are probably due to ellipsoidal deformation of components instead of eclipses; the mass ratio was not given.

3.4. *EF Dra*

Two sets of spectra were obtained at DDO at two different dispersions, 10.8 and 30 Å mm^{-1}. Of the total of 43 spectra, only the 16 higher dispersion spectra (obtained in 1992 May–June) were used for the radial velocity determinations, which led to our first-time spectroscopic orbital orbit. The exposures were 20 minutes, corresponding to 0.033 in orbital phases. The spectra indicated that the system is a triple one (Lu 1993). This circumstance resulted in such a heavy blending of the low-dispersion spectra at 30 Å mm^{-1} that no reliable radial velocities could be measured; these spectra were not used in our orbital determinations. The third component is probably a physical companion, since its radial velocity of -38 km s^{-1} is very close to the systemic velocity of -42 km s^{-1} of the eclipsing pair.

The system EF Dra was discovered as an X-ray source by the *Einstein Observatory* Extended Medium Sensitivity Survey (Gioia, Maccacaro, & Wolter 1987). Fleming, Gioia, & Maccacaro (1989) suggested that it was a W UMa–type variable. Robb & Scarfe (1989) obtained the first light curves and confirmed the suggestion of Fleming et al., giving the orbital period of 0.42400 days. Later, Plewa et al. (1991) refined the period on the basis of their photometric observation. This period was used in our orbital solution. The photometric mass ratio derived by Plewa et al., $q \simeq 0.125$, is different from our spectroscopic result probably because they did not take the third light into account. Our analysis shows that EF Dra is an A-type W UMa system with the more massive primary component eclipsed at the deeper minimum.

3.5. *V829 Her*

The spectroscopic orbit of V829 Her has been determined for the first time. Thirty spectra were obtained at DDO, consisting of 26 observations during the first run in 1991 June and 1992 May–June and four observations during the second run on 1997 February 10. Of the spectra obtained during the first run, 13 (one-half of the total) were secured around the orbital conjunctions due to an inaccurately known period at the time of the observations. The four spectra of the second run were all around the first orbital quadrature. The exposure times were about 15 minutes long, corresponding to about 0.03 in orbital phases.

V829 Her was discovered serendipitously as an X-ray source during the *Einstein Observatory* Extended Medium Sensitivity Survey (Gioia et al. 1987). It was suspected of being a W UMa system by Fleming et al. (1989). Soon thereafter, Robb (1989) obtained photometric observations of the system and confirmed the W UMa variability type. He found a period of 0.35813 days, which was only approximate because of the short time span. Later, he obtained a time of light minimum of 2,448,505.7163 (R. M. Robb 1992, private communication), which was combined with two times of minima by Agerer & Hübscher (1995) to derive an ephemeris:

$$\text{Min I} = \text{HJD } 2{,}447{,}680.8910(11) + 0.3581502(4)E \ .$$

For this star, as for all our spectroscopic orbit solutions, the photometric values of periods were adopted and our radial velocities were used only to determine the zero epochs of the spectroscopic orbital solutions.

By combining the observed and synthesized light curves (R. M. Robb 1992, private communication) and BF fits, in the same way as in Rucinski, Lu, & Shi (1993), we derived the following geometric and absolute parameters for this W-type W UMa system: $i = 57(2)$ deg, $f = 15(9)\%$, $X = 0.030(6)$, $a = 2.697(13)\ R_\odot$, $R_1 = 1.266(6)\ R_\odot$, $R_2 = 0.849(4)\ R_\odot$, $M_1 = 1.458(21)\ M_\odot$, $M_2 = 0.596(10)\ M_\odot$, and $q = 0.409(5)$.

3.6. *FG Hya*

The spectroscopic orbit presented here has been determined for the first time with the modern instrumentation, although five prism spectra at a dispersion of 75 Å mm^{-1} at Hγ were used by Smith (1963), from which he derived a primary semiamplitude of 92 km s^{-1}, questioned as too large by Mauder (1972).

The current spectroscopic orbit has been based on data obtained at DDO in 1996 November–1997 February. Thirty spectra were secured with exposure times of 15 minutes, corresponding to 0.032 in orbital phases. The orbital solution assumed a period of 0.327835 days, following Yang et al. (1991).

After the discovery of its light variation by Hoffmeister (1934), FG Hya was the subject of many investigators. Three sets of photometric solutions exist in the literature: Mochnacki & Doughty (1972), Twigg (1979), and Yang et al. (1991). All these investigations found small mass ratios: 0.145, 0.142, 0.128; none, however, were as small as our spectroscopic value of 0.112. We admit that for such extreme values the spectroscopic mass ratio may be difficult to determine accurately and that photometric determinations utilizing eclipse contacts may give superior results. All three photometric solutions arrived at a very deep overcontact, the largest being 90% by Yang et al. (1991).

This A-type system deserves further investigation. Assuming the preliminary value of $i = 87^\circ\!.6$, following Yang et al. (1991) (simply because their mass ratio was the closest to ours from among several photometric determinations), we derive $a = 2.32\ R_\odot$, $M_1 = 1.41\ M_\odot$, and $M_2 = 0.16\ M_\odot$. These numbers are obviously approximate because the photometric solution was not for the same mass ratio; for the same reason, we have not evaluated the radii. The point worth noting is the very low mass of the secondary component.

3.7. *AP Leo*

The spectroscopic orbit described here has been determined for the first time. The template spectrum star for the cross-correlation function (CCF) determinations was HD 126053 (G1 V).

A total of 21 spectra, all around at quadratures, were obtained on three consecutive nights, 1991 February 23, 24, and 25, at DAO with the 1.8 m telescope and "21121" spectrograph with the RCA2 CCD detector at a dispersion of 15 Å mm^{-1}, or 0.23 Å pixel^{-1}. All the spectra were centered at 5020 Å with a coverage of 240 Å. The exposure times were 15–20 minutes, corresponding to a phase resolution about 0.024–0.032. The period of 0.4303546 days by Zhang, Zhang, & Zhai (1992) was used in the spectroscopic orbit solution. A spectrum taken in blue showed that the spectral type of the system is F7–F8 V.

Mauder (1967) obtained the first geometric elements solution, based on photometric data. He derived a mass ratio of 0.31 and inclination of 77°. A modern photometric solution was carried out by Zhang et al. (1992), who found a mass ratio of 0.301, almost identical to our spectroscopic value. We note that similarly excellent agreement exists for BB Peg, which was also analyzed photometrically by this group. However, their photometric solution of AP Leo leads to a hotter, less massive secondary being eclipsed at the deeper minimum, a configuration that is normally called the W-type subtype of the W UMa systems, whereas our radial velocity curves show that the primary minimum is a transit; i.e., it is the more massive star that is hotter and eclipsed at the deeper minima, suggesting an A-type W UMa system. This discrepancy should be clarified. There is a chance that the photometric solution of Zhang et al. was affected by incorrect placement of spots (parenthetically, we note that the spot locations were unbelievably accurately determined in this solution). Nevertheless, the inclination of $79^\circ\!.9$ and fractional radii of $r_1 = 0.502$ and $r_2 = 0.284$ (side values) derived by Zhang et al. could be used with some confidence to derive the absolute dimensions $a = 2.95\ R_\odot$, $M_1 = 1.43\ M_\odot$, $M_2 = 0.42\ M_\odot$, $R_1 = 1.48\ R_\odot$, $R_2 = 0.84\ R_\odot$. We note that we were not able to detect any spectroscopic signatures of a third body in the system, whose existence was suggested by Zhang et al.

3.8. *UV Lyn*

The spectroscopic orbit of UV Lyn has been determined by us for the first time. The system was observed on two nights, 1990 December 29 and 1991 January 4, at DAO with the 1.8 m telescope and the "21121" spectrograph. Unfortunately, the data were obtained with two different CCD detectors on each of the two nights. On the first night, RCA2 (1024 pixels) was used with a coverage of 240 Å, while on the second night, Ford (512 pixels) was used with a coverage of 160 Å. The dispersion was 0.23 Å pixel^{-1} for the former detector and 0.31 Å pixel^{-1} for the latter. All of the spectra were centered at 5020 Å. Two template stars were used during each night, HD 22484 (F8 V) and HD 32963 (G2 V). A total of 31 spectra were accumulated with the exposure times ranging between 15 and 20 minutes, with the corresponding phase resolution of 0.025 to 0.033. RV were first measured using VCROSS and then remeasured using

BFs. The velocities given in Table 1 are those obtained by the BF method. The spectroscopic elements were derived by adopting the period of 0.41498088 days from Markworth & Michaels (1982).

The variability of UV Lyn was discovered by Kippenhahn (Geyer, Kippenhahn, & Strohmeier 1955). There are three sets of photoelectric observations in the literature, with the most recent one by Zhang et al. (1995), who published complete light curves and listed two times of minima. Earlier photometric data sets were obtained by Bossen (1973) and by Markworth & Michaels (1982); photometric solutions were attempted in both of these papers, but the derived photometric mass ratios were very different from those presented here so that other parameters of these solutions are obviously highly questionable.

An attempt was made to produce a combined solution of geometric elements of UV Lyn, based on the light curve by Bossen (1973) and the BFs obtained here. The light curve by Bossen[2] was used because the Markworth & Michaels light curves were very perturbed. The approach consisted of fitting the theoretical BFs computed with the light-curve/line-profile synthesis program WUMA5 to the observed BFs, using the spectroscopic mass ratio q derived here as the initial value. A very brief information about WUMA5 and the approach can be found in Hill & Rucinski (1993) and in a short series of papers: Rucinski (1992), Lu & Rucinski (1993), and Rucinski et al. (1993). The mass ratio changed from the spectroscopic value insignificantly to $q = 0.371(8)$, with the remaining parameters $i = 67(2)$ deg, $f = 20\%$, $X = 0.018(4)$. The absolute parameters are $a = 2.914(17)\ R_\odot$, $M_1 = 1.412(31)\ M_\odot$, $M_2 = 0.523(15)\ M_\odot$, $R_1 = 1.403(8)\ R_\odot$, $R_2 = 0.905(5)\ R_\odot$.

3.9. *BB Peg*

The present spectroscopic orbit determination is the second one, after the solution by Hrivnak (1990). Our observations were obtained at DDO in 1996 August–September. Twenty-eight spectra were obtained with exposure times of 15 minutes, corresponding to 0.029 in orbital phases. The orbital period in our solution was fixed at the value of 0.361501 days determined by Leung, Zhai, & Zhang (1985).

The system was discovered by Hoffmeister (1931) and since then has been the topic of several investigations. The only spectroscopic orbit solution of Hrivnak (1990) was based on radial velocity data obtained from spectral cross-correlations. His mass ratio, $q = 0.34 \pm 0.02$, is in a good agreement with ours, which was derived from the BFs. The mass ratio derived from CCF method is not too significantly different from the one from BF method, but the cross-correlation method carries a potential of underestimating the amplitude of the more massive star, which would lead to a smaller value of q. The most consistent approach in the derivation of physical parameters is a combined solution of photometric and spectroscopic data, as in the case of AH Vir (Lu & Rucinski 1993) and also in the case of UV Lyn (this paper), which in both cases confirmed the BF result. As we understand Professor Hrivnak plans to obtain a combined photometric and spectroscopic solution on the basis of his CCF determination of q. This will provide an external check on our solutions, as the two data sets are both of good quality but also entirely independent of each other.

Several photometric solutions of light curves are available, among them solutions by Cerruti-Sola, Milano, & Scaltriti (1981). They derived a mass ratio 2.49, or, following our convention, $q = 0.40$, which is significantly different from ours. Moreover, they found a rather deep contact configuration of 37%, which is uncommon for W-type W UMa stars. Leung et al. (1985) solved their light curves of BB Peg and derived a mass ratio of 0.356, which is almost identical to our spectroscopic q. They also found a more likely fill-out factor of 12%. Using their geometric parameters (inclination and fractional radii), the following absolute dimensions of this W-type system have been derived: $a = 2.63\ R_\odot$, side radii $R_1 = 1.26\ R_\odot$ and $R_2 = 0.76\ R_\odot$, $M_1 = 1.38\ M_\odot$, $M_2 = 0.50\ M_\odot$.

3.10. *AQ Psc*

The spectroscopic orbit of this system is presented for the first time. It was observed at DDO, in 1996 August–October. Due to the inaccurately known period, from among our 37 spectra, 11 were secured around conjunctions rather than quadratures. The exposure times were 15 minutes, corresponding to about 0.022 in orbital phases.

This system has not been investigated extensively before. Pastori (1985) discovered it to be a W UMa variable and gave a period of 0.47564 days. Since then a few more times of minima have becomes available (Mūyesseroğlu, Gūrol, & Selam 1996; O. Demircan 1997, private communication). With these limited material available, we derived a new ephemeris:

$$\text{Min I} = \text{HJD } 2{,}449{,}283.3292(16) + 0.4756056(4)E ,$$

of which only the period was used in the spectroscopic orbit solution. Although the period was not precisely determined, it should be accurate enough for our spectroscopic solution since the time span of our observations was relatively short. With our well-determined spectroscopic orbit, this A-type system deserves a new photometric investigation.

4. SUMMARY

The paper presented the first installment of radial velocity determinations for 10 bright, close binary systems lacking adequate radial velocity data. The new results have been obtained using the modern techniques of template matching (cross-correlation and broadening function) on the basis of observations collected with the 1.8 m–class telescopes at the Dominion Astrophysical Observatory and David Dunlap Observatory. Preliminary, circular-orbit spectroscopic orbit solutions have been obtained for all 10 systems with the immediate goal of extracting the “gamma” velocities and mass ratios. The former will be used for a rediscussion of the kinematics of the contact systems, while the latter can serve as an important departure point in combined, precise photometric/spectroscopic synthesis solutions of individual systems.

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[2] The light curve was made available by the librarian P. D. Hingley at the Royal Astronomical Society, London, UK.

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