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The CHARA Catalog of Orbital Elements of Spectroscopic Binary Stars

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ABSTRACT. Optical interferometry is entering a new age, with several ground-based long-baseline observatories now making observations of unprecedented resolution. Interferometers bring a new level of resolution to bear on spectroscopic binaries, enabling the full extraction of the physical parameters for the component stars with high accuracy. In the case of double-lined systems, a geometrically determined orbital parallax becomes available as well. The first step in preparing to observe spectroscopic binaries is to list them, which has not been done since the 1989 publication of the Eighth Catalogue of the Orbital Elements of Spectroscopic Binaries by Batten et al. We present a new catalog with roughly half again as many listings as the Eighth Catalogue. Angular separation predictions are made for each catalog entry. The numbers of spectroscopic binaries available for study as a function of several important observational parameters are explored, and in particular, the number of spectroscopic binaries as a function of expected separation is discussed.

1. INTRODUCTION

It has often been remarked how sparse the data are regarding well-determined stellar masses in spite of the thousands of known binary star systems. It is equally often remarked that the reason for this paucity is the fact that no single technique, other than the limited case of a resolved astrometric binary, for determining orbital motions in binaries can, of itself, provide all the information required to extract the masses. Furthermore, the selection effects of the various techniques have traditionally created nonoverlapping sets of binary stars. The selection effects surrounding various approaches to binary star study have been discussed at length elsewhere (McAlister 1992; Pourbaix 2000) and will not be repeated here. Observations with long-baseline stellar interferometers are improving on the success of speckle interferometry in bridging the selection-effect gap between visual and spectroscopic binaries (McAlister 1992) and, in the case of double-lined spectroscopic binary systems (SB2s), can even provide an independent and geometrically determined distance: the orbital parallax. Orbital parallax not only can provide an independent check on *Hipparcos* distances, they will in many cases yield parallaxes for stars beyond the *Hipparcos* limit.

Several ground-based interferometers are particularly well suited to the study of binary stars as a result of the length of their longest baselines, the number of available baselines, and the large number of spectroscopic binaries awaiting direct resolution. These include the Navy Prototype Optical Interferometer (NPOI; Armstrong et al. 1998), the Palomar Testbed Interferometer (PTI; Colavita et al. 1999), the Sydney University Stellar Interferometer (SUSI; Davis et al. 1999), and our own instrument, the Center for High Angular Resolution Astronomy (CHARA) array (ten Brummelaar et al. 2003). In many instances, these instruments are capable of measuring the angular diameters of the component stars in addition to defining orbital motions.

There now exists a very large collection of spectroscopic binary orbits well suited for observation by optical interferometers. Since the orbits of these stars are already determined in the radial dimension, the remaining two dimensions of these orbits are waiting to be filled in by astrometric observations of these stars using interferometers. What has been an unfortunately small range of overlap between spectroscopic and astrometric observations is now an opportunity for interferometrists to fill in the missing orbital data for these objects. The question we seek to find general answers for is the following: "As a function of an interferometer's limiting observational parameters, for how many binary stars does this opportunity exist?"

In order to evaluate these observational opportunities, we need a more current compilation of binary stars than has been available. We have therefore produced a new compilation of spectroscopic binaries, since the most recent published compilation of spectroscopic binaries was the catalog published by A. H. Batten and coworkers in 1989, which is comprehensive through 1986 and includes some but not all systems published between 1987 and 1989 (Batten, Fletcher, & MacCarthy 1989).

This paper describes our new compilation of orbital elements of spectroscopic binaries and the current availability of spectroscopic binaries for different capabilities of high-resolution observation. We choose to call it a "catalog" as defined by the Centre de Données astronomiques de Strasbourg (CDS), but recognize that it is not, however, the type of graded and care-

fully commented catalog that Batten et al. produced. This catalog[1] allows one to survey the general availability of measurements that can be made but does not grade the value that better measurements of each binary system would have. McAlister (1992) noted that the number of stars with accurately known mass varies considerably by spectral type, with the number of measurements being concentrated around solar-like stars. Hence, measurements of higher or lower mass stars, evolved stars, or metal-poor stars will aid exploring less well studied stellar parameter space (Andersen 2003 and references therein). Mass studies such as the surveys of low-mass stars by Henry et al. (1999) and high-mass stars by Gies (2003) illustrate that much remains to be learned about non–solar-like stars. Our new catalog currently would more accurately qualify as a bibliographic compilation with specific parameters estimated so that it can serve as an input catalog for an interferometric campaign on spectroscopic binaries. Its purpose is to give a wide overview of available opportunity of spectroscopic binary stars, and we defer to these other papers and to users of the catalog the important subject of which stars are most worthy of measuring. This compilation will be submitted to the CDS as a new catalog.

2. COMPILATION OF THE AVAILABLE DATA

Roughly two-thirds of the orbits in this catalog are from the Eighth Batten Catalogue (Batten et al. 1989). The NASA Astrophysical Data Service (ADS) was used to find papers with new spectroscopic binary star orbits from 1987 to the present. The new orbital element entries were found by searching ADS for strings including "spectroscopic binaries" and "orbital elements," plus other combinations of these four words, also including the other word forms, "binary" and "orbit." These results were still found to be incomplete, and follow-up searches were performed on some of the more prolific authors, including, for example, Griffin, Mayor, Latham, Stickland, and Duquennoy.

For CHARA's purpose of finding an input target list of spectroscopic binaries to observe, absolute completeness of the catalog was not essential, but because making this catalog available to the general community would be of value to others, it is important to seek out missed orbital elements papers. It is therefore requested that references to sets of orbital elements that we have overlooked be sent to S. F. Taylor. Efforts will continue to make the catalog as complete as possible, in addition to annually updating the catalog with newly published orbital elements.[2]

The CHARA catalog will also be submitted to the IAU Commission 30 on Radial Velocities to be included in its Ninth Catalogue of the Orbital Elements of Spectroscopic Binary Stars Web site (Pourbaix & Tokovinin 2001).[3] A. Tokovinin and D. Pourbaix of the Commission are currently leading work on a more ambitious catalog that also includes the radial velocity data with a plot of the orbit for each binary (A. Tokovinin & D. Pourbaix 2002, private communication). They plan to compute a "grade" for the quality of each orbit similar to that done by Batten et al. (1989), except they will be able to compute their grades more automatically than did their predecessors (A. Tokovinin & D. Pourbaix 2002, private communication).

3. COLLECTED DATA

Once the orbital elements were entered, further data were obtained from SIMBAD, and other important parameters were calculated. This catalog contains the following parameters (see Tables 1A and 1B).

The first three parameter fields give the HD number, the HIP number, and a common name of the stellar system or an alternative catalog designation. Some stars without HD, HIP, common name, or alternative catalog designations use designations from the paper referenced. Many papers gave only one name, so many of these data are from SIMBAD.

The next two parameter fields give the right ascension and declination in J2000.0 coordinates from SIMBAD. Giving the position in degrees rather than the more common sexagesimal format was done to facilitate computer sorting. Other data added from SIMBAD are the V magnitude, spectral type, parallax, and proper motion.

Estimated K magnitudes and absolute magnitudes are provided only as a rough guide. Estimated K magnitudes are adjustments of the V magnitudes based on spectral type and standard $V-K$ differences for main-sequence stars (Drilling & Landolt 2000). Providing the correct calculation for evolved stars is planned. For systems without *Hipparcos* parallaxes, a spectroscopic parallax is presented. Absolute magnitude estimates are adjustments of the V magnitudes according to the system's parallax. The K magnitude and absolute magnitude estimates are uncorrected for reddening or other factors such as color difference between the primary and secondary star.

The orbital elements (and errors, if given by authors) are also given: the period P in days, the epoch of periastron T, the eccentricity e, the longitude of periastron ω, the semiamplitudes of the primary and (if given) secondary K_1 and K_2, and the systemic velocity γ.

4. METHODOLOGY FOR PREDICTING ANGULAR SEPARATION

To aid in selecting candidate stars for observations by interferometry, we have included estimates of the predicted

[1] See the "References" column of the full catalog for the parameters used as data herein.

[2] This CHARA catalog will be made available on-line at http://www.chara.gsu.edu/CHARA.

[3] http://sb9.astro.ulb.ac.be.

TABLE 1A

SAMPLE PAGE OF CATALOG (NOT ALL DERIVED QUANTITIES SHOWN)

HD	HIP	Other Name	R.A.[a]	Decl.[a]	P (days)	T (HJD −2,400,000)	e	ω (deg)	K_1 (km s^{-1})	K_2 (km s^{-1})	γ (km s^{-1})	π[b] (mas)
106516	59750		183.79	−10.31	853.2 ± 8.2	46749 ± 70	0.046	201 ± 30	7.87 ± 0.24		4.69 ± 0.14	44.34 ± 1.01
106760	59856		184.13	33.06	1314.3	41468.5	0.43	303.6	6.5		−40.4	10.65 ± 0.93
107259	60129	η Vir	184.98	−0.67	71.9	17644.41	0.34	191.6	30.5	43.7	5.3	13.06 ± 0.84
108754	60956		185.17	19.98	25.937 ± 0.02	45022.6 ± 1.6	0.158 ± 0.027	58.4 ± 6.2	7.64 ± 0.18		0.67 ± 0.15	19.2 ± 1.13
107401			185.20	13.31	896.9 ± 2.3	47183.5 ± 38	0.14 ± 0.04	98 ± 16	3.29 ± 0.12		−0.19 ± 0.08	
107760	60331	AS Dra	185.55	73.25	5.4125 ± 0.02	44600.62	0		66.2 ± 0.2	74.5 ± 0.2	−98.9	23.16 ± 0.67
107700	60351	12 Com	185.63	25.85	396.567 ± 0.047	48472.4 ± 2.8	0.61 ± 0.01	101.3 ± 1.7	25.1		0.3 ± 0.2	11.93 ± 0.72
107742	60364		185.66	27.13	875	44777.5	0.1	293	6.2		−12.7	1.5 ± 1.11
107935	60490		186.01	25.85	176.08 ± 0.44	48405.4 ± 4.9	0.19 ± 0.04	260 ± 9	19.4 ± 0.8		−13.3 ± 0.5	11.57 ± 0.74
		CD −27°8661	186.14	−28.32	763.63 ± 5.89	49280.49 ± 5.04	0		10.54 ± 0.51		10.54 ± 0.51	
108078	60555		186.2	31.03	61.411	43318.74	0.4	329.2	11.3		−10	5.6 ± 0.97
108248		α^1 Cru	186.65	−63.1	75.7794	17642.3	0.46	21	41.7		11.9	
108642	60880		187.16	26.23	11.7843 ± 0.0004	48306.5 ± 0.01	0 ± 0.001		41.14 ± 0.05		−0.7 ± 0.04	9.76 ± 0.79
108651	60891	17 Com B	187.19	25.9	68.29 ± 0.012	48313.4 ± 0.4	0.296 ± 0.008	260.7 ± 2.2	14 ± 0.2		−1.8 ± 0.1	12.66 ± 0.93
108907	60998	4 Dra	187.53	69.2	1703 ± 3	42868.5 ± 40	0.3 ± 0.05	244 ± 9	3.67 ± 0.19		−14.35 ± 0.12	5.61 ± 0.51
108945	61071		187.75	24.57	18.813 ± 0.01	49089.6 ± 1.5	0.19 ± 0.06	255 ± 30	30.5 ± 3.6	6.7 ± 0.19	1 ± 1.8	10.49 ± 0.83
	61243	RW Com	188.25	26.72	0.2373	40022.42	0		78	226	−53	11.45
		CSS 798	188.47	−42.59	1983	51068	0.17	226	6		6	
109510	61415	24 Com	188.78	18.38	7.3361 ± 0.005	44593.29 ± 0.04	0.26 ± 0.01	300.0 ± 3.0	68.7 ± 1.0	80.6 ± 1.3	4.9 ± 0.5	1.24 ± 9.91

[a] Degrees, FK5 J2000.0, from CDS (SIMBAD).
[b] Parallax from CDS (SIMBAD).

TABLE 1B

SAMPLE PAGE OF CATALOG (*Continued*)

HD	HIP	Other Name	V Magnitude[a]	Spectral Type[a]	μ_α[b] (mas yr^{-1})	μ_β[b] (mas yr^{-1})	$(a_1 \sin i)''$[c] (mas)	$(a_2 \sin i)''$[c] (mas)	$(a_{sum} \sin i)''$[d] (mas)	Separation[e] (mas)	GNS (mas)	Reference
106516	59750		6.1	F5 V	31.97	−1012.43	27.3			74.9		1992, AJ, 104, 774
106760	59856		5	K0.5 IIIb	−54.87	−111.87	7.6			20.7		1984, J. Astrophys. Astron., 5, 181
107259	60129	η Vir	3.9	A2 IV	−59.14	−23.13	2.5	3.5	6.0		8.0	1935, Publ. Dominion Astrophys. Obs., 6, 207
108754	60956		9	G7 V	−328.02	−562.64	0.35			0.95		1988, AJ, 96, 567
107401			9.9	K2	−7.2	3.9						1993, Obs., 113, 193
107760	60331	AS Dra	8	G7 V	−455.39	184.34	0.76	0.85	1.6		1.6	1987, A&A, 171, 157
107700	60351	12 Com	4.8	F2	−10.75	−8.85	8.6			23.7		1999, ApJ, 521, 682
107742	60364		8.6	K2 III	−0.16	−8.68	0.74			2.0		1983, J. Astrophys. Astron., 4, 19
107935	60490		6.7	Am	−12.87	−9.1	3.6			9.8		1999, ApJ, 521, 682
		CD −27°8661	S									2000, A&AS, 145, 51
108078	60555		7.6	K2 IIICN	−44.02	0.61	0.33			0.90		1980, Obs., 100, 1
108248		α^1 Cru	1.3	B0.5 IV								1980, MNRAS, 191, 217
108642	60880		6.5	A2m	−17.67	−5.66	0.43			1.2		1999, ApJ, 521, 682
108651	60891	17 Com B	6.7	A0p	−18.5	−15.76	1.1			2.9		1999, ApJ, 521, 682
108907	60998	4 Dra	5	M4 III	−63.12	−56.48	3.1			8.4		1988, A&A, 193, 180
108945	61071		5.4	A2pvar	−12.02	−8.94	0.54	0.12	0.66		0.72	1999, ApJ, 521, 682
	61243	RW Com	11	G2	−125.45	2.45	0.019	0.056	0.076		0.076	1985, AJ, 90, 109
		CSS 798										2000, A&AS, 145, 51
109510	61415	24 Com	5	A9 Vm	24.82	12.78	0.056	0.066	0.12		0.14	1987, A&A, 171, 157

[a] V magnitude and spectral type from CDS (SIMBAD).
[b] Proper motion vector from CDS (SIMBAD).
[c] Angular semimajor axis (SB1) or axes (SB2).
[d] Sum of angular semimajor axes $[(a_1 + a_2) \sin i]''$.
[e] Separation for SB1 high-resolution studies using $2.74(a_{sum} \sin i)''$.

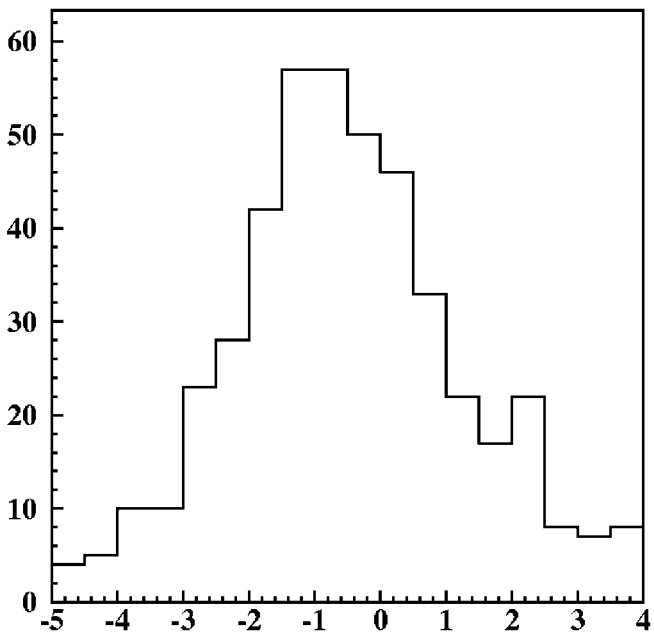

FIG. 1.—Histogram of expected separations of the 505 SB2s binned as logarithm of greater nodal separation (GNS) in milliarcseconds.

angular separation (PAS). For both SB2s and SB1s, we present estimated PAS values with adjustments to the standard angular separation of the orbit.

The semimajor axis of the absolute orbit of a spectroscopic component is given by

$$(a \sin i)'' = (9.191 \times 10^{-5}) KP\pi(1 - e^2)^{1/2},$$

where the parallax π is incorporated to convert to angular measure, the velocity amplitude K is in km s^{-1}, and the period P is in days.

For SB1s, a rough estimate of the separation of systems with known parallax at first glance would be made by multiplying $2a\pi$, but since the secondary is generally less massive than the primary, from a statistical point of view we can follow McAlister (1976) and tally the separation using $2.74a\pi$. The value of 2.74 is calculated as in McAlister (1976) where we adopt $\Delta m \sim 4$, following the expectation similar to McAlister (1976) that for $\Delta m \leq 3$ the system would probably be double-lined and for $\Delta m \geq 5$ the effect of the secondary on the visibility/baseline curve would be too small too detect.

For SB2s, because the inclination i, although generally large, is unknown, $(a \sin i)''$ is not the best indication of resolvability. Alden (1946) suggested for SB2s that a lower limit to the value of separation that is unaffected by projection is given by the sum of the radius vectors obtained when the polar equation of the ellipse is evaluated at the nodes, i.e., when the true anomaly equals $-\omega$ and $180 - \omega$. This approach was adopted by McAlister (1976). At the two nodes, the magnitude of the sum of the radius vectors $\boldsymbol{r}_1 + \boldsymbol{r}_2$ is simply the sum of the magnitudes of each radius vector $r_1 + r_2$. Minimum angular separation values at the nodal passages were calculated using the nodal values of $-\omega$ and $180 - \omega$ using the spectroscopic orbit and $(a \sin i)''$. The magnitudes of the radius vectors r_1 and r_2 in an elliptical orbit are determined from $r = a(1 - e \cos \psi)$ using the auxiliary variable ψ (the eccentric anomaly) obtained using Newton's method to numerically solve Kepler's equation in the standard manner, which allows us to find the sum

$$r_1 + r_2 = (a_1 + a_2) \sin i[1 - e \cos (\psi)].$$

The apparent nodal separation $a''_{\rm nodal}$ is thus the parallax π multiplied by a:

$$a''_{\rm nodal} = \pi(r_1 + r_2) = \pi(a_1 + a_2) \sin i[1 - e \cos (\psi)].$$

This is calculated for both nodes, which for an elliptical orbit gives two values for $a''_{\rm nodal}$, which gives two values for the lower limit of the angular separation. The larger of the two values can be taken as the lower limit, which we refer to as the predicted greater nodal separation.

5. DOUBLE-LINED SPECTROSCOPIC BINARIES

Because resolved SB2s provide orbital parallaxes, these objects are the foremost binary star targets of interferometers. For the CHARA and NPOI arrays, one might consider an extreme southern declination limit of $-30°$, and our compilation yields 505 SB2s available to these instruments. Southern Hemisphere interferometers such as SUSI will be required to observe the significant number of SB2s south of $-30°$. The distribution of SB2s as a function of declination is heavily skewed toward the Northern Hemisphere, reflecting historical observational bias. It is also important that in the relatively large band of overlap between northern and southern interferometers there be a significant duplication of effort to serve as a check of the reliability of the determinations from any one instrument.

Distributions of selected properties from the 505 SB2s are shown in Figures 1–8. Considering that these distributions are due as much to observational factors as to physical factors, it is perhaps evidence of lack of bias on the part of individual observers that many of these elements fall in Poissonian distributions (appearing Gaussian in the logarithmic plots).

Of the 505 SB2s, a histogram of the estimated angular separation between components is seen to peak near 100 μas (Fig. 1). This figure shows what will be referred to as the greater nodal separation (GNS), using the higher of the separations at the two nodes. As described above, the separation at the nodes is not inclination dependent, and so the separation between the two components will be at least this large. This GNS appears remarkably Poissonian considering that it comes from more observational than physical effects, although there is a slight upturn at longer periods.

Interferometers with maximum baselines of 300–500 m are

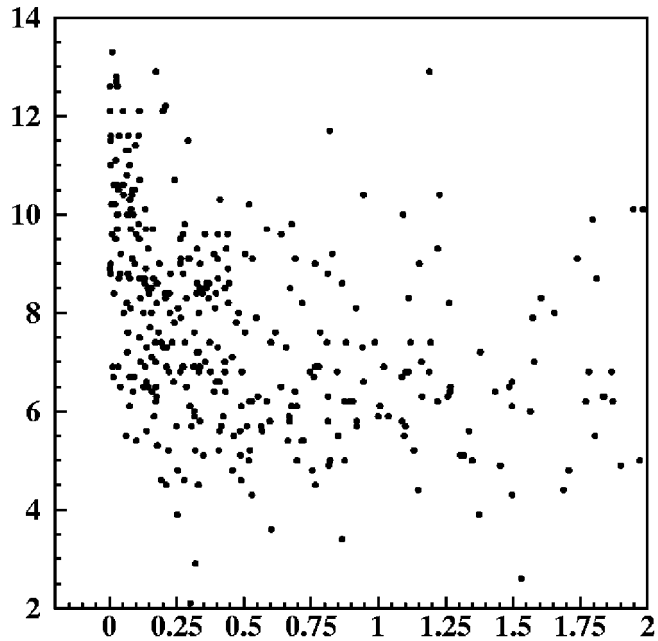

FIG. 2.—SB2s presented as a function of V magnitude (y-axis) vs. their GNSs (in mas; x-axis).

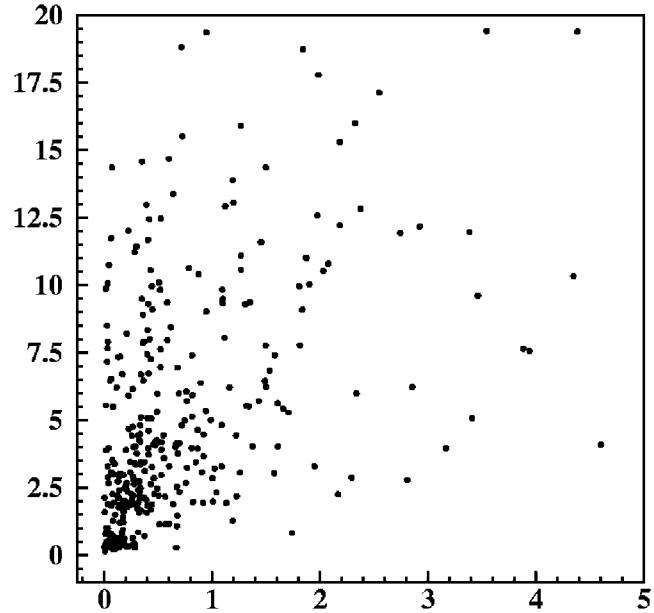

FIG. 4.—Distribution of period vs. estimated separations for SB2s having periods up to 20 days and separations up to 5 mas.

well suited to this distribution. For example, the visibility squared (the basic observational measurement from an interferometer) for a 100 μas binary observed with an interferometric baseline of 330 m at a wavelength of 550 nm will be 0.26, providing a sufficient downturn in visibility (normalized to unity for an unresolved source) to permit an accurate astrometric measurement of the angular separation. A system with a 50 μas separation will provide a V^2 value of 0.53, still permitting meaningful measurement.

Cuts were made on the set of 505 binaries to simulate instruments with resolution of 0.050, 0.1, 0.2, 1.0, and 10 mas, and the numbers of "resolvable" SB2s left are listed in Table 2. Additional columns in Table 2 list what these numbers

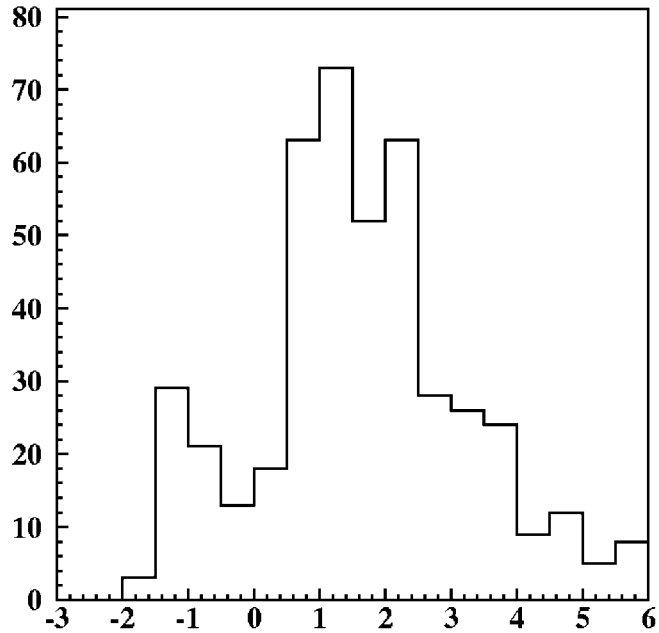

FIG. 3.—Histogram of logarithm of orbital periods in days.

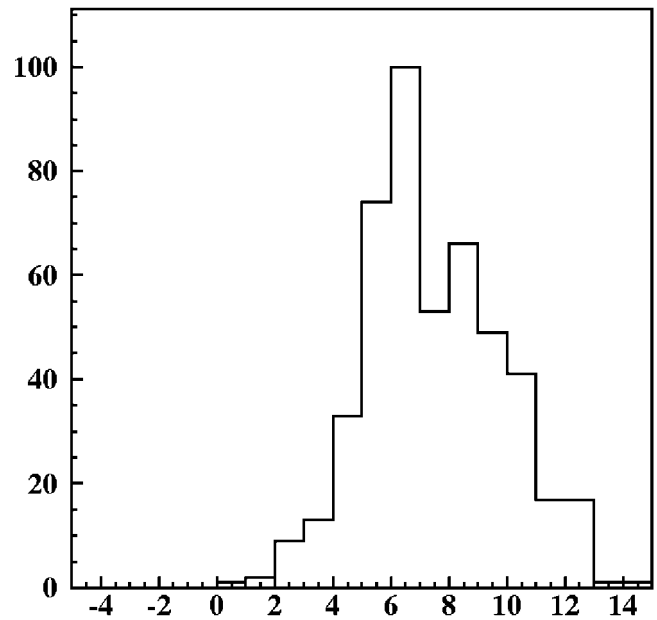

FIG. 5.—Distribution of all SB2s as a function of V magnitude.

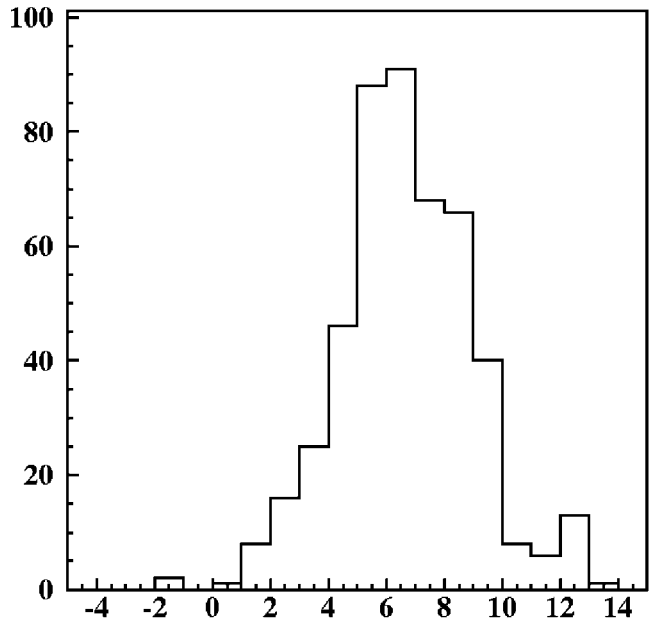

FIG. 6.—Distribution of all SB2s as a function of K magnitude.

are for instruments with limiting V magnitudes of 5, 7, 9, and 11. These systems are plotted as a function of V magnitude versus GNS in Figure 2, and it can be seen that there is a definite magnitude/separation region in which improvements in an instrument's limiting magnitude and limiting resolution will enable it to measure more SB1 systems, but beyond this region (i.e., V magnitude fainter than ~10 or 11) improvements enter a region of diminishing returns. Only a V magnitude versus expected separations plot is presented as the V magnitudes are much better known, but similar conclusions can be expected at other magnitudes.

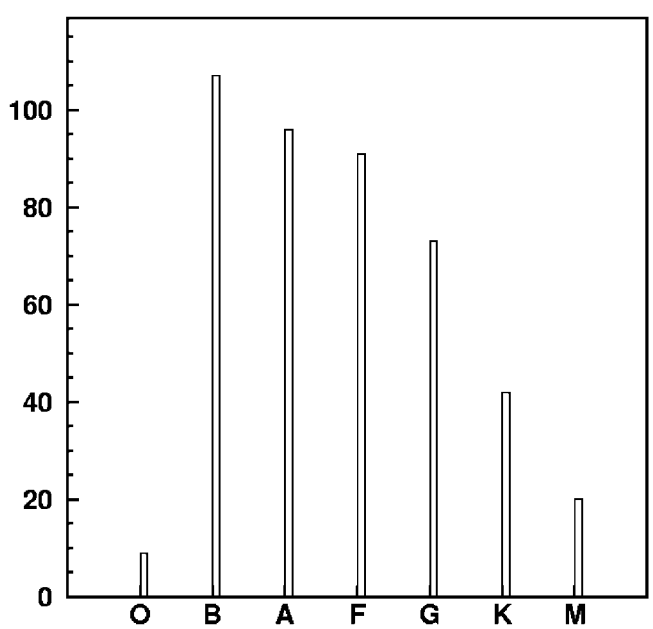

FIG. 7.—Distribution of spectral types for the full set of SB2s.

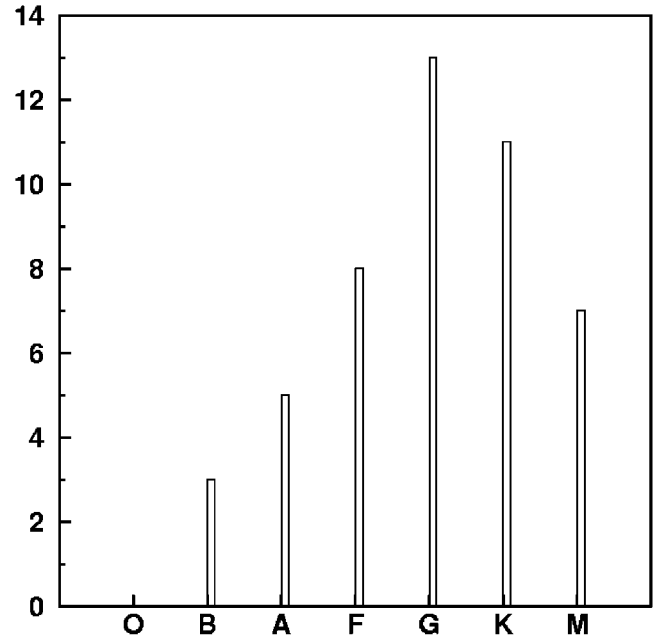

FIG. 8.—Distribution of spectral types for SB2s with predicted GNS greater than 10 mas.

We note when considering increasing baselines significantly beyond what is already available that existing interferometers are approaching the limit of diminishing returns. However, the complex arena of contact binaries remains essentially inaccessible at current baselines.

The orbital periods have such a large range that their histograms must be plotted logarithmically as is done in Figure 3. This distribution also has a roughly Poissonian appearance, although with a dip near periods of 1 day, which is expected from the observational difficulty in measuring periods close to 1 day. The peak is broad, around 10 (to perhaps 100) days. A plot of the orbital period versus this the GNS is made and is shown for periods of 0–20 days, along with expected separations from 0 to 5 mas, in Figure 4.

The histograms of the V and estimated K magnitudes, Figures

TABLE 2
RESOLVABLE SB2s

Separation (mas)	All Magnitudes	$m_V < 11$	$m_V < 9$	$m_V < 7$	$m_V < 5$
0	505	441	351	232	58
0.050	443	419	342	228	58
0.1	408	390	329	222	58
0.2	359	345	292	210	57
1.0	185	175	149	122	41
10	55	53	47	37	21

NOTE.—Number of "resolvable" SB2s for instruments with decreasing resolution capability, followed by the number of SB2s brighter than V magnitudes of 11, 9, 7, and 5.

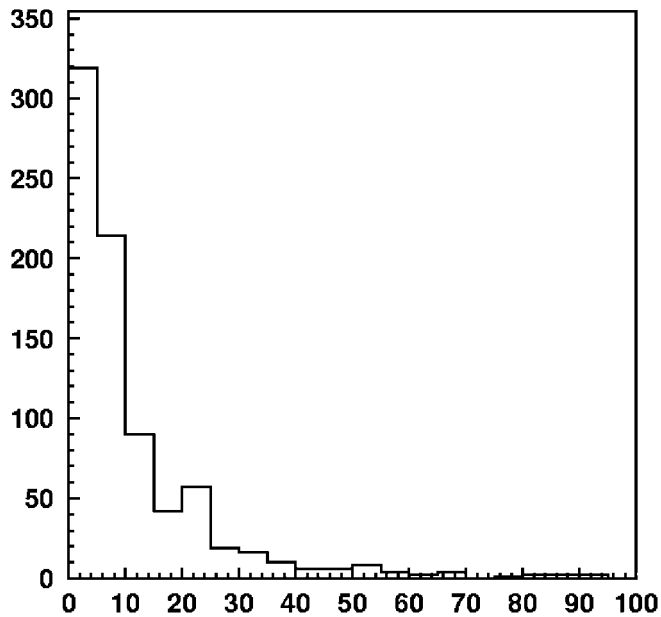

FIG. 9.—Distribution of the 814 SB1s as a function of parallax π with parallaxes between 0 and 100 mas; eight more have parallaxes greater than 100 mas.

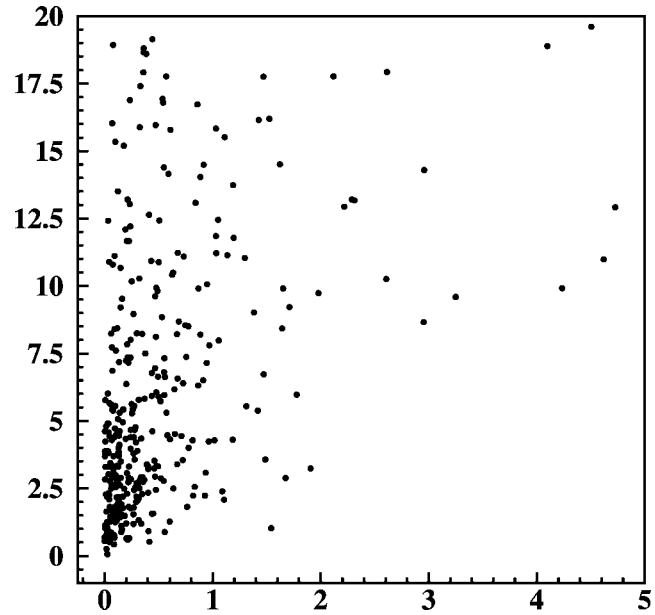

FIG. 10.—Distribution of period vs. estimated separations for SB1s having periods up to 20 days and separations up to 5 mas.

5 and 6, also appear rather Poissonian. (A Poissonian curve appears Gaussian in units of magnitude since magnitude is a logarithmic measure of intensity.)

The distribution of *V* magnitude peaks a little above 6th magnitude, with the distribution of the estimated *K* magnitude appearing similar or perhaps a fraction of a magnitude brighter (Figs. 5 and 6).

From the *V* magnitudes and the *K*-magnitude figures, it can be seen that the shape of the distribution does not vary greatly as a function of separation as would be expected. However, the distribution as a function of spectral types B–M changes considerably. (The few O-type stars are not considered because of low statistics.) Among all 505 SB2s, there are more B stars than any other type (Fig. 7), with progressively fewer A-type, F-type, and G-type SB2s, and an even greater drop in K-type and especially M-type stars. But this distribution shifts significantly when less-resolvable stars are cut, such that when only stars resolvable at 10 mas or greater are considered, which leaves 55 of the original 505 SB2s, the distribution peaks with 13 G-type stars but only three B-type stars (Fig. 8). Seven of the original 20 M-type stars can potentially be resolved. Obtaining greater resolution will apparently benefit studies of massive stars more than studies of low-mass stars.

6. SINGLE-LINED SPECTROSCOPIC BINARIES

The second important group of objects for interferometric studies of binary stars are the SB1s with large (in the sense of being accurately known) trigonometric parallaxes. The catalog has 1097 SB1s with the same declination limit as used for the SB2s that can be observed by NPOI and CHARA north of $-30°$. Of these 1097, 841 have *Hipparcos* parallaxes, with 814 having parallaxes greater than zero. We present only the numbers of potentially resolvable stars in Table 3. Only the 814 stars with *Hipparcos* parallaxes are shown here to use the more accurate *Hipparcos* values. (The 283 other stars will increase the number of stars in the table especially at smaller separations, but here we choose not to use the less accurate spectroscopic parallaxes.) The distribution of the parallaxes of these SB1 systems is shown in Figure 9 (with eight having parallaxes greater than 100 off the right side of the figure).

We described earlier why we use a value of $2.74a\pi$ to estimate the separation of SB1s. A plot of the orbital period versus this estimated separation is made for these 814 systems and is shown for periods of 0–20 days and expected separations from 0 to 5 mas in Figure 10. Taking 10 mas as a "good" (*Hipparcos*) parallax, there are 279 SB1s with good parallaxes; 147 SB1s

TABLE 3
RESOLVABLE SB1s

Separation (mas)	All Magnitudes	$m_V < 11$	$m_V < 9$	$m_V < 7$	$m_V < 5$
0	814	805	712	481	150
0.050	763	755	683	466	147
0.1	718	710	649	456	146
0.2	652	645	594	422	136
1.0	429	424	401	287	109
10	161	159	153	117	59

NOTE.—Number of "resolvable" SB1s for instruments with decreasing resolution capability, followed by the number of SB1s brighter than *V* magnitudes of 11, 9, 7, and 5.

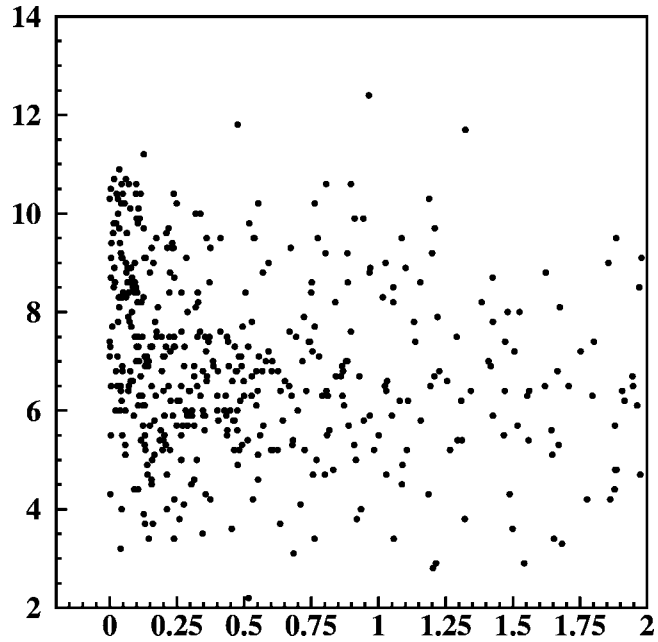

FIG. 11.—SB1s presented as a function of V magnitude (y-axis) vs. their statistical expected separations in mas, 2.74(a sin i) (x-axis).

have parallaxes greater than 20 mas, and only 39 SB1s have parallaxes greater than 50 mas.

Cuts were made on the set of 814 binaries to simulate instruments with resolutions of 0.050, 0.1, 0.2, 1.0, and 10 mas, and the numbers of "resolvable" SB1s left are listed in Table 3. Additional columns in Table 3 list what these numbers are for instruments with limiting V magnitudes of 5, 7, 9, and 11. As for SB2s, these SB1 systems are plotted as a function of V magnitude versus expected separation, this time 2.74(a sin i), in Figure 11. Again, a definite magnitude/separation region similar to that for SB2s appears inside which improvements in an instrument's limiting magnitude and limiting resolution will best increase the number of potential measurements, and improving instruments beyond this region will give diminishing returns.

7. CONCLUSIONS

Beside selecting binary stars that are bright enough and have large enough angular separations, successful interferometric observation of both components of a binary system requires that the difference in magnitudes Δm between the two stars not be too great. Magnitude difference is difficult to determine spectroscopically and so has not been compiled into any of the catalogs of spectroscopic binaries. A currently unknown fraction of the stars mentioned here will not have two components detectable by interferometers because Δm is too large. For SB2s, the distribution of Δm will be strongly biased toward smaller Δm compared with SB1s.

One might reasonably expect that interferometers could routinely detect companions producing $\Delta m \leq 3$ and reach to $\Delta m \leq 5$ with beam-combining techniques employing optical fibers or pinholes to spatially filter the beams and yield highly accurate visibilities.

Despite having strong observational selection effects, SB2s present a rich opportunity for the new long-baseline interferometers, with several hundred systems waiting to be resolved. Many of the selection effects such as favoring high inclination and the Northern Hemisphere will not have a major impact on the study of stellar properties. Other selection effects such as the bias against massive stars may more strongly affect the statistical inferences that interferometric observers make.

Currently known SB2s present an opportunity for interferometric observers to determine hundreds of fully three-dimensional orbits in absolute units, when their results are combined with spectroscopic orbits, thus accurately determining masses, diameters, and distances (hence luminosities) of hundreds of binary stars through their orbital parallaxes. (The longer baselines now available such as at CHARA [330 m] and NPOI will allow measurements of stellar diameters in binary systems that was not possible with shorter baseline instruments.) This will provide improved levels of constraints on stellar astrophysical theory. The actual number of SB2s that will be resolvable will increase rapidly the closer an interferometer gets to obtaining a resolution of 0.2 mas, but further improvement below 0.1 mas, corresponding to a 550 m baseline in V magnitude, will not yield a large increase in the number of known SB2s available for study. However, more of the more massive SB2s lie in this difficult region than do their low-mass SB2 counterparts. Finally, we note that full exploitation of spectroscopic binaries will, in many cases, require them to be revisited by spectroscopists to improve or update their spectroscopic orbital elements.

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