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THE KINEMATICS OF THE GOULD BELT: AN EXPANDING GROUP?

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ABSTRACT

New observational data are presented for 464 stars of Henry Draper type B5 and earlier, $m_v \lesssim 6.5$ and $\delta \geq -20°$, which are likely candidates for membership in a local system defined by the Gould belt. These data include new spectral types on the MK system, classified by the author on Yerkes 40-inch plates; previously unpublished *UBV* photometry, kindly furnished by Dr. D. L. Crawford of the Kitt Peak National Observatory; and new proper motions on the system of the *FK4*, calculated under the author's direction at the Kapteyn Astronomical Laboratory, Groningen, The Netherlands.

The observations have been combined to calculate space motions for the 294 program stars having well-determined distances within 600 pc. It is shown that if these stars originated within a small volume of space at some unique time in the past, the present values of the velocity gradients $\partial U/\partial X$, $\partial U/\partial Y$, $\partial V/\partial X$, and $\partial V/\partial Y$ can be used to determine the age of the group. This determination is independent of the location of the Sun, with respect to the center of the group, and of any incompleteness in observation of the group members. However, it is affected by the possible inclusion of non-members in the solution.

Least-squares solutions for the velocity gradients have been made for various subsets of the stars with calculated space motions. These solutions provide conclusive evidence for the presence of an expanding element among the nearby B stars but do not yield a unique result for its age. Two models are proposed, one in which the entire sample consists of a mixed population with an over-all expansion age of 90×10^6 years and the other in which the associations constitute an expanding subset aged 45×10^6 years and account for about 30 per cent of the total number of stars. It is shown that either of these models is compatible with the observed gradient perpendicular to the galactic plane and also with a time scale of expansion derived on purely kinematic grounds.

I. INTRODUCTION

The early history of the Gould belt has been reviewed by Bok (1937). From the time of its first observation in the nineteenth century (Herschel 1847), this concentration of the brightest stars to a plane inclined some 10°–20° to the galactic plane has been taken as possible evidence of the existence of a "local system." Shapley and Cannon (1924) showed that this effect is most pronounced in the case of the B stars brighter than $m_v = 5.26$, and Nassau and Morgan (1950) derived an extremely narrow plane of concentration for the nearest stars belonging to the "natural group" OB.

Early studies of the local system were confined principally to its spatial orientation and extent, by means of star counts and their interpretation (e.g., Charlier 1916; Seares 1928; Bok 1931). But all such investigations are severely compromised by observational selection effects and by the lack of a criterion for distinguishing members of the hypothetical subsystem from the ordinary spiral-arm population. These limitations can be circumvented by using the state of motion of the stars in question as an indication of whether or not they in fact form a cohesive group.

Eggen (1961) calculated space coordinates (X,Y,Z) and velocities (U,V,W) for 280 O and B stars brighter than the fifth apparent magnitude, using observational data drawn from a variety of sources. For the 137 best-observed stars within 300 pc, he found a velocity gradient of U on X of about 40 km sec^{-1} kpc^{-1}, attributable mainly to the presence of the Cassiopeia-Taurus and Scorpio-Centaurus aggregates, located in opposite directions from the Sun. Eggen concluded that either many more stars should be included in these two aggregates, or all the nearby O and B stars—including the associations and groups—are related as elements of a local system.

Bonneau (1965) applied the theory of expanding groups outlined by Blaauw (1952) to Eggen's data, and obtained an expansion age for the local group of 40 × 10^6 years ± 20–25 per cent. It is of interest to repeat and amplify this work for the following reasons: (1) The theory used by Bonneau can be recast in a more flexible form which omits any assumption as to the initial velocity distribution in the group, permits a more direct determination of the age, and allows for a more specific comparison with the case of pure differential rotation. (2) More recent observational data exist than were available to Eggen, especially in the form of plate material for new spectral types, and new meridian catalogues which can be used to derive more accurate proper motions. It is also important to have all the data of each kind taken, insofar as possible, by a single observer, so as to avoid systematic differences which might lead to spurious effects in the solution.

For these reasons it was decided to obtain as much new evidence as possible on the distances and motions of the probable members of the local group. The sample selected included all the stars in the *Catalogue of Bright Stars* (Hoffleit 1964) with Henry Draper spectral type B5 and earlier and north of declination −20°. The latter restriction was imposed by our intention of having all the observations made by the same observer and instruments. The magnitude limit of the *Catalogue of Bright Stars* is $m_v = 6.5$, but a few fainter stars are included in it, and these will be found in our list as well. There are 464 stars in the program defined by these limits.

II. OBSERVATIONS

a) *Spectral Types*

i) *Plate Material*

All spectra were classified on plates taken with the Yerkes 40-inch refractor and the MK spectrograph. New spectral types were obtained for all but seven of the 464 program stars, the exceptions being fainter members of close-multiple systems which cannot be satisfactorily resolved with the present equipment. The file containing all plates taken with this equipment since the construction of the spectrograph was searched for satisfactory plates of the stars in our program. In the interests of homogeneity, it was decided to use only one group of plates from the file—those obtained on Eastman 33 emulsion by or under the direct supervision of Dr. W. W. Morgan. Those stars for which no satisfactory exposures were found in this group were reobserved by the author, using the same telescope and spectrograph but with IIaO emulsion, during the winter and spring of 1966, together with sufficient standards and other stars to insure a good overlap between the two sets of plates. In all, 105 stars were reobserved. Since a somewhat narrower slit is now used on the MK spectrograph than was the practice when Morgan's original plates were taken, the new IIaO plates compare well in resolution with the finer-grained Eastman 33's.

ii) *Principles of Classification*

The primary standards used in the classification evolved out of discussions on the refinement of the MK system by Drs. W. W. Morgan, R. F. Garrison, R. E. Schild, and the author. For almost all the stars in the present program, unpublished spectral types (on the unrefined system) by Morgan or his associates were available. The stars were separated into spectral subgroups on the basis of this provisional classification, with each subgroup containing one spectral type and one luminosity class. The spectra in each subgroup were then compared with each other and with their primary standard. In the course of this comparison, secondary standards were chosen, and stars which did not fit the provisional classification were moved to a different subgroup. In particular, considerable attention was devoted to removing from luminosity class V those stars which showed slight signs of increased luminosity due to evolutionary effects. The entire procedure was then repeated to check the subgroups, based on the new classification, for self-consistency.

Table 1 gives the primary and secondary standards and the criteria used in classifying stars of spectral type O9–B8, luminosity classes III–V. The criteria listed for class V are indicators of spectral type. Those listed for classes III and IV are the luminosity indicators used to distinguish the stars in question from main-sequence stars. In practice, of course, these two operations are never completely independent. Only the most salient features of the classification system have been listed—in every case, the whole spectrum was taken into account in determining the position of the star in the two-dimensional system. In general, the practice was to base the spectral type primarily on lines due to elements or ions other than hydrogen and He I (e.g., He II, C III, O II, Si IV, Si II, Mg II). The luminosity class was then obtained from the intensity ratios of the He I lines and from the absolute intensity of the helium spectrum (especially for types B5 and later). The use of the hydrogen lines was avoided. It is to be understood that the criteria given in Table 1 apply literally only to plates taken with the same instruments as the present series. Users of a different spectrograph may naturally be led to a different choice of criteria, more suitable for their observing equipment.

All possible half-types between O9 and B5 were used, at all luminosity classes. Although primary standards were not usually available for the half-types, secondary standards presented themselves in most cases as reasonable interpolations between the full types. The only deliberate attempt to classify to half a luminosity class was the introduction of B2 IV–V, following Garrison (1967). In a few other cases, a half-class was used as an *ad hoc* interpolation.

The stars from O5 to O8 were classified on Plaskett's system as described in the *Atlas of Stellar Spectra* (Morgan, Keenan, and Kellman 1943), with the primary standards λ Cep (O6), S Mon (O7), and λ Ori (O8) and the secondary standards HD 199579 (O6) and HD 53975 (O8). No luminosity classes were given except the designation "f" for O stars with supergiant characteristics and emission features near λ4650. All possible half-types between O5 and O8 were used by interpolation.

Supergiants (luminosity classes Ia, Iab, Ib, and II) later than O8 were classified separately. About half of the forty-three supergiants in the present program are MK standards. These were checked for self-consistency, and the remaining stars were classified by comparison with them. No changes of more than half a spectral type or half a luminosity class from the classification given by Morgan, Code, and Whitford (1955) were found necessary.

iii) *The Broad-lined Stars*

In general, stars whose helium lines appeared significantly broader than in standard stars of the same spectral type were designated "n." The absolute width of the lines in the "n" stars seems to decrease in going to later types. The principal line used for comparison was λ4026; others were λλ4144 and 4387. The λ4089 line of Si IV also tends to be broadened in the earliest types. The system of the broad-lined stars may be said to be defined by the following "standards": 1 Cam (B0 IIIn), κ Aql (B0.5 IIIn), 23 Ori (B1 Vn), 113 Tau (B2 Vn), HD 36646 (B4 Vn), HD 171780 (B5 Vn), and HD 22780 (B7 Vn).

Only a few stars were designated "nn" in the present classification. They are characterized by extremely broad helium lines—with the hydrogen lines often being broadened as well—to the point where line visibility is greatly reduced. The standard of absolute line width for inclusion in this group was ζ Oph. Be stars (see below) were not designated "n" or "nn" unless they showed exceptionally great line width as compared with other emission-line stars.

iv) *The Be Stars*

A new classification scheme was developed for the Be stars, with the aim of providing a more complete description of the spectrum in the spectral type. The usual MK spectral type and luminosity class were assigned on the basis of the absorption lines alone, without reference to the emission lines. An additional "emission parameter" was then assigned, without reference to the MK type. The principal criterion for the emission parameter was the extent and intensity of the hydrogen emission. A secondary criterion was the appearance of the Fe II emission lines in the blue. The following notation was adopted for the emission parameter:

e_1: *No overt hydrogen emission.* Prototypes 66 Oph, 1H Cam. The Hβ absorption line is partially or completely filled in but is not reversed. Hγ may also show some filling-in. The Fe II lines are usually absent.

e_{1+}: Prototype 48 Per. Hβ has a narrow emission core while remaining predominantly an absorption line.

e_2: *Hβ in emission.* Prototypes ψ Per, 120 Tau. Hβ is an emission line. Hγ also is filled in but is not reversed, while the other Balmer lines are not affected. The Fe II lines are often, but not always, present.

e_{2+}: Prototype HD 45995. Hγ shows a narrow emission core, and the higher Balmer lines are slightly filled in. The Fe II lines are usually rather marked.

e_3: *Complete hydrogen emission spectrum.* Prototypes 11 Cam, HD 58050. Hβ is an emission line and the higher Balmer lines, at least through Hϵ, have emission cores. The Fe II lines are usually present, except in the earliest spectral types, but they do not dominate the spectrum.

e_{3+}: Prototype HD 41335. The Fe II lines are more prominent than at e_3, but the hydrogen emission strength is less than at e_4.

e_4: *The extreme Be stars.* Prototype χ Oph. There is intense emission in all the Balmer lines plus very strong Fe II lines (except in the earliest types). This group is similar to the Bex class discussed by Schild (1966).

The symbol "p" for Be stars has been used only for cases having some characteristic not described in the above scheme. Its use has only occasionally been necessary. Most of the emission-line stars in the present program fit unambiguously into the new classification scheme, which promises to describe the spectrum far more completely than the classification without an emission parameter and requires little more effort on the part of the observer.

b) *Photometry*

Unpublished preliminary results from a program of *UBV* photometry were very generously communicated to the author by Dr. D. L. Crawford of the Kitt Peak National Observatory. This list provided *V*-magnitudes and $B - V$ colors for 382 of the 464 stars in our program. The recent publication by Johnson (1966) of multicolor photometry of the bright stars contains considerable overlap with Crawford's list, as well as fifty-four of our program stars which were not observed by Crawford. A comparison of all the stars observed by both investigators revealed no systematic differences in their photometry. Therefore, Johnson's values were adopted for the stars not observed by Crawford. In no case was an average taken between values found by these two observers, or by any others.

Dr. C. Jaschek of the Observatorio Astronómico, La Plata, Argentina, kindly sent in advance of publication excerpts from his catalogue of references to *UBV* photometry in the literature. This bibliography enabled us to find published magnitudes and colors for four stars not observed by either Crawford or Johnson. For seven additional stars, we took unreferenced *UBV* photometry from the *Catalogue of Bright Stars* itself. Thus *UBV* photometry, largely homogeneous in authorship, was obtained for all but seventeen of the stars in our program.

c) *Calibration and Distances*

The new spectral types were calibrated for absolute magnitude by means of the narrow-band photometry of Borgman and Blaauw (1964). These authors found absolute magnitudes and intrinsic colors for a large number of early-type stars from two photometric parameters, whose calibration was based essentially on the distances of the Scorpio-Centaurus stars determined by Bertiau (1958). Of the stars directly measured by Borgman and Blaauw, 114 are in the present program. Each of these was assigned a weight on the basis of the estimated accuracy of the spectral type (with standard stars being given the highest weight and peculiar stars discounted entirely) and the probability that the star is an unresolved binary (with known spectroscopic or close visual binaries, as indicated in the *Catalogue of Bright Stars*, being given lowest weight).

The weighted mean of the measured absolute magnitudes in each subgroup of the new spectral classification was then taken. For spectral types B1–B5 and luminosity classes III–V, this method provided a very consistent calibration, with a clear separation between classes IV and V, and was therefore adopted (see Fig. 1). Weighted means for stars earlier than B1 and later than B5 were based on fewer stars and appeared less consistent; therefore, they were accepted only provisionally. The calibration of Johnson and Iriarte (1958) was adopted for the supergiants, because too few of them were measured by Borgman and Blaauw to compose meaningful averages. Moreover, the classification of the supergiants in the present program has introduced no systematic changes from the standard MK classification.

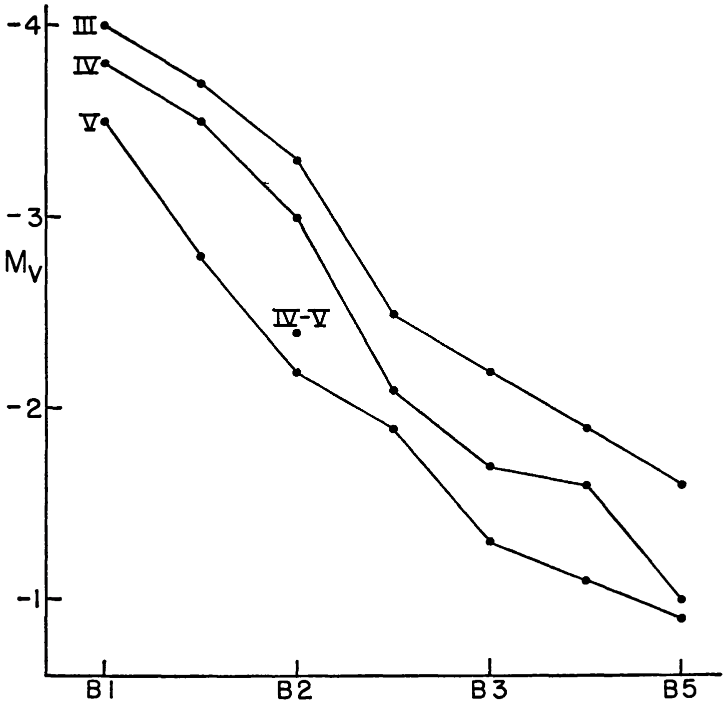

FIG. 1.—Calibration of new spectral types in the range B1–B5, III–V. Absolute magnitudes were obtained from the narrow-band photometry of Borgman and Blaauw (1964).

The intrinsic *UBV* colors adopted for all spectral types and luminosity classes were those quoted by Johnson (1963). Strictly speaking, these colors refer to the older MK types and not to the new classification. But color differences between neighboring spectral types are so small that this distinction can safely be neglected.

Assuming 3.0 as the ratio of total to selective absorption, distance moduli were calculated for all stars in the present program which the *Catalogue of Bright Stars* indicates to be members of associations or groups and which were observed to have normal spectra. A mean distance was then formed for each association or group with three or more members having calculable distances. Where there was no reason to suspect abnormalities in the reddening law, the straight mean of the individual distances was adopted. In other cases, this mean was rejected in favor of a published value based on a more detailed study of the reddening. Table 2 lists the associations and groups falling within the range of the present program and the distance adopted for each. Note that the three subgroups of the Orion association (defined as in Blaauw 1964) have been assigned differing distances. These distance differences, especially as between subgroups Ia (the northwest region) and Ic (the Sword), appear well substantiated on the basis of the present determination. Orion association stars which do not belong to any of Blaauw's subgroups (e.g., π^4 Ori) have been assigned the individual distance appropriate to their spectral type and apparent magnitude, rather than any of the mean distances. This does not imply, however, that they are suspected non-members of the association.

The adopted association distance moduli were then used to recalculate absolute magnitudes for member stars earlier than B1 and later than B5 in luminosity classes III–V. These values were averaged in with the direct measurements of Borgman and Blaauw to give added weight to the calibration for these classes. The final calibration is presented in Table 3. Values in parentheses are extrapolations from neighboring spectral types, no direct or association measurement being available.

The average deviation in the distance moduli of the association members with respect to their adopted values is 0.5 mag, leading to a probable error of 0.4 mag in the calculated distance modulus of any single star, or about 18 per cent in the distance. The presence of an additional systematic error of about half this amount cannot be discounted. Borgman and Blaauw (1964, p. 376) themselves mention some evidence for such an error in their system; and the author has found discrepancies between the total absorption A_v calculated by Borgman and Blaauw from their intrinsic colors $(N - M)_0$ and that determined from the *UBV* photometry used in the present program.

Table 4 presents the new spectral types, photometry, and distances for our program stars. The notes to Table 4 contain comments on all the peculiar spectra and references to the sources of photometry communicated by Jaschek.

d) Proper Motions

New proper motions on the system of the *FK4* (Fricke and Kopff 1963) have been derived for 460 of the program stars, the remaining four being faint members of close-binary systems. This work was carried out under the supervision of Dr. A. Blaauw during the winter of 1967, while the author was a guest at the Kapteyn Astronomical Laboratory, Groningen, The Netherlands.

All the stars in question are to be found in the Boss *General Catalogue* (1937), but we decided upon a project to improve the *GC* proper motions—first, because the *GC* is known to contain important systematic errors varying with position on the sky, which might tend to falsify the results (see, e.g., Brosche, Nowacki, and Strobel 1964); and, second, because we wished to take advantage of the many meridian catalogues which have been observed since the publication of the *GC*. In particular, three catalogues—*W3*$_{50}$ (Adams, Bestul, and Scott 1964), *Be3*$_{50}$ (Maître 1964), and *Mü 50* (Heintz 1962)—with mean epochs later than 1950 have recently been published, and these contain the majority of our program stars, since the authors have made an effort to comply with the request of Blaauw (1955) for new meridian observations of O and B stars.

Our procedure was to take the *GC* position at epoch of observation (usually near 1900) and correct it to the system of the *FK4* by means of the tables of Brosche *et al.* (1964). Intermediate positions were obtained from twenty-one meridian catalogues of mean epoch 1920 or later which were not included in the *GC* but which were used in the construction of the *FK4*. For these catalogues, systematic differences with the *FK3* (Kopff 1938) have been derived by the Heidelberg workers. Some of these differences have been published (Kopff, Nowacki, and Strobel 1964), and others were generously supplied in private communications by Dr. W. Gliese of the Astronomisches Rechen-Institut, Heidelberg. Table 5 identifies these twenty-one catalogues by their number in the *Index der Sternörter* (Kahrstedt 1961) and the reference number used by the Heidelberg workers (Fricke and Kopff 1963, p. 135). The complete references necessary to locate these catalogues in the literature can be found in either of the above lists. We give only the conventional abbreviation of the catalogue name, the place of observation, and the equinox to which the observations were referred.

Each position from an intermediate catalogue was precessed, if necessary, to equinox 1950, and any proper motion introduced by the authors of the catalogue was removed. The resulting position for equinox 1950 and epoch of observation was reduced to the system of the *FK3* by means of the tables of systematic differences described above and then to the system of the *FK4* by means of the tables of Fricke and Kopff (1963, p. 131).

Finally, positions in the four most recent catalogues—listed at the end of Table 5—were reduced to the system of the *FK4* by slightly different procedures. In the case of $W3_{50}$, systematic differences with the *FK4* are given by the authors of the catalogue itself. For *Mü 50* the author gives systematic differences with the *FK3*, to which we have added the corrections (*FK4* − *FK3*). The two catalogues $Be3_{50}$ and *Par OB* (Delhaye 1959) are not absolute but in principle were reduced to the system of the *FK3* by their respective authors. Since no systematic differences between these two catalogues and the *FK3* are available, we have added to the observed positions only the corrections (*FK4* − *FK3*).

A particular effort was made to achieve consistency in the case of double stars. In all cases in which two companions were of substantially equal brightness and separated by 1″–2″, the introduction and footnotes of each catalogue containing the star were examined to ascertain whether the brighter component or the mean had been observed. The point observed by the majority of authors was retained, and observations of a different point were rejected. No attempt was made to reduce observations of one component to the mean, or vice versa.

Each corrected catalogue position was then assigned a weight on the system of Auwers (see Kopff *et al.* 1964, pp. 2–5), in which the mean error of unit weight is 0″.396 in declination and 0ˢ.038 sec δ in right ascension. For the *GC* the probable errors ϵ_α and ϵ_δ of the position at epoch are given in the catalogue itself. These were converted directly into weights p_α and p_δ by means of the formulae

$$p_\alpha = \left(\frac{0''.384}{\epsilon_\alpha}\right)^2, \quad p_\delta = \left(\frac{0''.267}{\epsilon_\delta}\right)^2. \tag{1}$$

For the catalogues $W3_{50}$, *Mü 50*, $Be3_{50}$, and *Par OB*, "internal weights" $(p_n)_i$ were computed from the probable error of a single observation given by the catalogue authors, according to the method described by Kopff *et al.* For all other catalogues, "external weights" $(p_n)_e$—obtained by the Heidelberg workers from residuals between the corrected catalogue positions and the *FK3*—were used. These unpublished tables of external weights were graciously prepared and furnished by Dr. W. Gliese. As pointed out by Kopff *et al.*, external weights tend to be smaller than internal weights by a factor of 1–3. Thus, by following the above procedure, we have somewhat overweighted the most modern catalogues.

From the corrected and weighted positions in right ascension and declination, least-squares solutions were then made for the proper motions and the positions at equinox and epoch 1950. The calculations were performed on the Telefunken TR4 computer of the Computing Centre of Groningen University, with the help of Mr. L. Lammers. The mean error of each proper motion was computed from the residuals of the positions. In cases in which only two points were available for the solution, the mean error was computed from the weights of the positions. Mean errors calculated from the weights are of the same order of magnitude as those calculated from the residuals, indicating the basic consistency of the weighting system. In a few cases where the star was observed only in the *GC*, the *GC* proper motion was simply converted to the system of the *FK4* by means of the tables for (*FK4* − *GC*) by Brosche *et al.* (1964).

Our method of computing proper motions may be compared with that used by Morgan in the construction of the *N30* catalogue (1952). Morgan also used the *GC* position at epoch, corrected for systematic errors, as one end point in his solution. He combined all the post-*GC* catalogues into one other normal point, using somewhat arbitrary weights, and took the difference of these two points, divided by the time interval, as the proper motion. Quite apart from the fact that we have used a number of recent catalogues which were not available to Morgan—thus giving our proper motions a longer base line—our method is more rigorous in its treatment of the post-*GC* catalogues as individual points with weights directly related to their probable errors. However, Morgan exercised more care in examining the catalogues for departures from truly fundamental observational techniques, and he corrected the catalogues in such a way as to create a new fundamental system. We have made more simplified corrections with the object of reducing the catalogues to an already existing fundamental system. In general, our probable errors tend to be slightly smaller than Morgan's (for the same stars) and much smaller than those of the *GC*. But we have not, of course, attained the accuracy of the *FK4* for the relatively small number of stars which it contains.

Note that the proper motions obtained by this method (and presented in Table 6) are based on the use of Newcomb's precession constant. Before they are used in the kinematic analysis, they must be adjusted according to the most up-to-date estimate of the correction to this constant. These corrections are described in § III.

e) *Radial Velocities*

All 464 of our program stars are listed in Wilson's *General Catalogue of Stellar Radial Velocities* (1953). Few extensive observational programs for radial velocities of bright, early-type stars have been undertaken since the publication of the Wilson catalogue. However, by searching the literature we were able to find more recent observations for 110 stars in our list. Most of these observations were made on the new wavelength system of Petrie (1955), and many of them were by Petrie himself and his co-workers. No objective-prism or other low-dispersion measurements were considered.

On the basis of a study of thirty-two stars in the Cassiopeia-Taurus region, Petrie (1958) called attention to a possible systematic difference of about -2 km sec^{-1} between his velocity system and that of the Wilson catalogue. We repeated the comparison using all the stars (a total of sixty-eight) for which we were able to find measurements explicitly described as being on Petrie's system, and found the systematic difference to be only -0.59 ± 0.22 km sec^{-1}, which is not significant. Therefore, we have not made any correction to the Wilson velocities to make them conform to the new wavelength system but have simply taken weighted means between these and any more recent velocity measurements. The Wilson catalogue velocities were assigned the mean probable errors corresponding to their respective qualities (Wilson 1953, p. 7), and the recent measurements carried the probable errors calculated by their respective authors. Where only individual plate velocities were given in a recent reference, the mean was calculated and the probable error was computed from the average deviation.

Table 6 presents the proper motions and radial velocities we have calculated for the stars in the present program. The notes to Table 6 contain references to all the sources of radial velocities which were averaged in with the Wilson values and, for close double stars, an indication of which point was used in the proper-motion solution. The radial-velocity sources are collected in a separate section of the References at the end of this paper.

III. THE PRESENT STATE OF MOTION OF THE SYSTEM

The distribution in galactic coordinates of all the stars in the present program is shown in Figure 2. Figure 2, *a*, is limited to stars within 300 pc, most of which are field

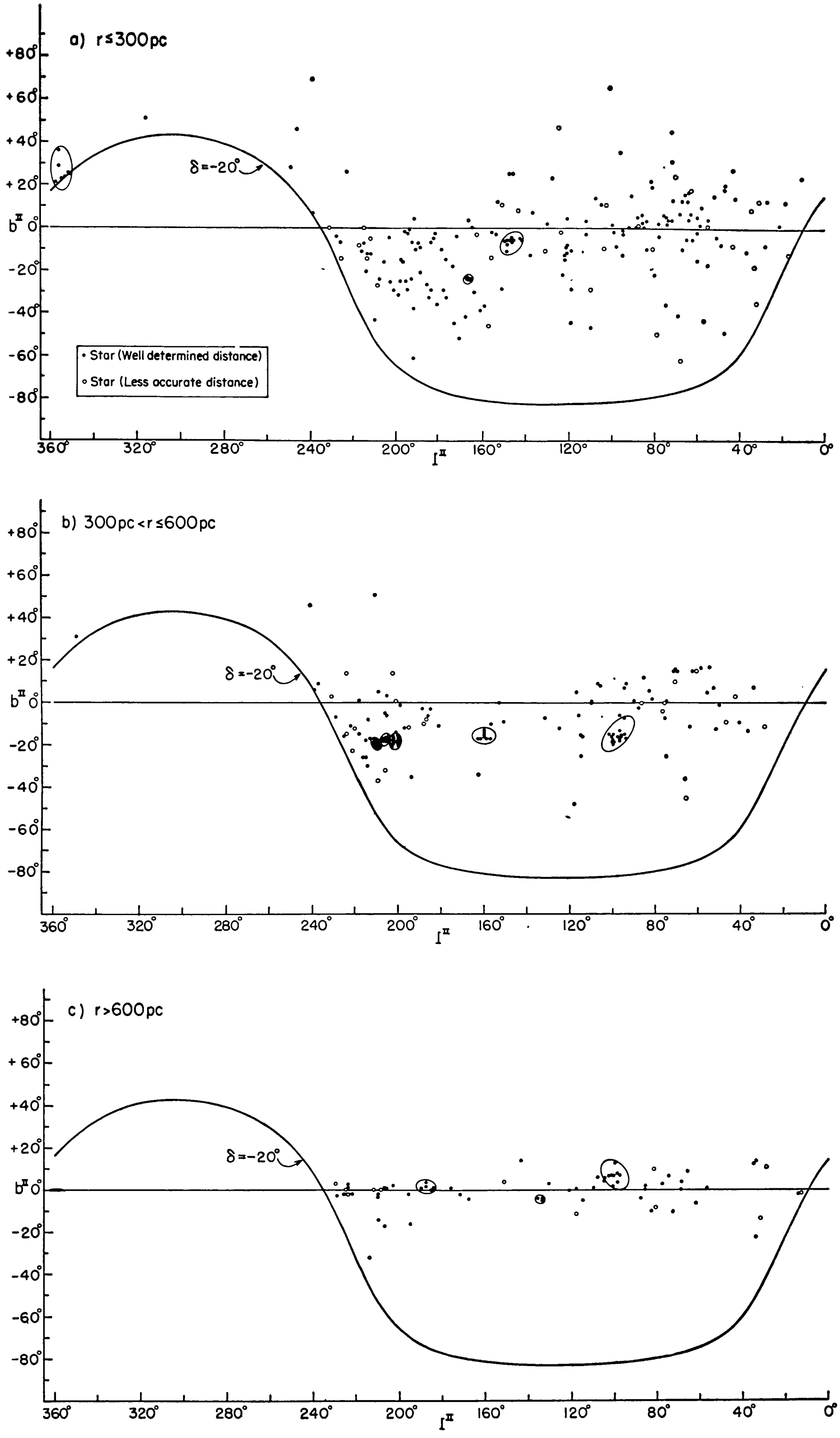

FIG. 2.—Distribution in galactic coordinates of program stars having distances (*a*) within 300 pc, (*b*) between 300 and 600 pc, and (*c*) greater than 600 pc. Association boundaries are approximate but contain a point for each star actually observed. The region below $\delta = -20°$ was not observed.

stars. These nearby stars show the well-known concentration to the inclined plane of the Gould belt: between 120° and 230° of new galactic longitude, most of the stars are below the galactic plane, while between 10° and 120°, the tendency is for the stars to lie above the galactic plane. (Most of the low-latitude region between 230° and 10° lies south of the declination limit of the present program.) Figure 2, *b*, containing the stars between 300 and 600 pc from the Sun, is dominated by the associations I Ori, II Per, and I Lac. The former two follow the Gould belt pattern, but I Lac does not. Figure 2, *c*, shows the clear concentration to the galactic plane of stars more distant than 600 pc. At this distance the Gould belt features are no longer seen. Thus these three diagrams confirm the original result of Shapley and Cannon (1924) that only the nearer B stars are confined to the Gould belt.

Therefore, stars more distant than 600 pc were excluded from the study of the state of motion of the local system. Stars whose distances were considered uncertain because of spectral peculiarities or a lack of *UBV* photometry were also rejected, as were the "runaway stars" cited by Blaauw (1964). These latter stars may be expected to have inordinately large peculiar motions, which would distort our search for systematic motions. Thus 294 of the original 464 program stars were retained for further analysis.

For these stars, the positions, proper motions, radial velocities, and distances which have been described in the preceding sections were combined into space coordinates (X,Y,Z) and velocities (U,V,W) by means of a program similar to that outlined by Murray in the Appendix to Eggen (1961). The vectors X and U point toward the galactic anticenter, Y and V in the direction of galactic rotation, and Z and W toward the galactic north pole. In the course of this calculation, which was performed by the author on the IBM 1620 computer of the Yerkes Observatory and the IBM 7094 computer of the University of Chicago Computation Center, the proper motions were adjusted for corrections to Newcomb's precession constants along the lines suggested by Morgan and Oort (1951). The actual values used for the precessional corrections were not, however, those of Morgan and Oort but were more recent estimates by Dr. W. Fricke of the Astronomisches Rechen-Institüt, Heidelberg, obtained from him in a private communication. Fricke (1966*a*, *b*) has previously maintained that the value of the luni-solar precession correction proposed by Morgan and Oort, namely, $\Delta n = 0''.30$ per century, is too small. Moreover, the so-called "motion of the equinox," or constant correction to the proper motion in right ascension, is dependent upon the proper-motion system being used. Morgan and Oort's values for the *N30* and *FK3* systems would not necessarily be valid on the system of the *FK4*. For this latter system, Fricke proposed to the present author the provisional values of $\Delta n = 0''.47$, $\Delta k = -0''.19$ per century,[1] where Δk includes both the motion of the equinox and the precessional correction term $\Delta m = \Delta n \cot \epsilon$. Thus the corrections added to the proper motions were

$$\Delta\mu_\alpha = -\Delta n \sin \alpha \tan \delta - \Delta k \ , \tag{2}$$

$$\Delta\mu_\delta = -\Delta n \cos \alpha \ . \tag{3}$$

These corrections are *not* contained in the proper motions listed in Table 6.

We have listed in Table 7 the space coordinates and velocities calculated for the 294 stars with well-determined distances within 600 pc; the probable errors in the space velocities due to uncertainties in the proper motions and radial velocities alone; and the change in each space velocity that would be produced if the assumed distance of the star were increased by 10 per cent. These latter figures serve both to indicate the magnitude

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[1] These provisional values, suggested by Fricke in December 1966, agree almost exactly with the definitive corrections which he proposed in a paper in the Joint Discussion on Modern Problems of Fundamental Astronomy at the Thirteenth General Assembly of the International Astronomical Union in August 1967.

of the error due to uncertainties in the distance scale and to facilitate recomputation of the space velocities for a distance scale other than the one adopted here.

Figure 3, *a*, shows the distribution of the 294 stars in Table 7, projected onto the galactic plane. The third quadrant, except for a small section of the Scorpio-Centaurus association which lies well above the plane, is completely obscured by the effect of observational selection. Figure 3, *b*, shows the same distribution projected perpendicular to the galactic plane along the radius vector. Despite the loss due to observational selection, the inclination of the Gould belt to the galactic plane is clearly marked in this diagram.

Figure 4, *a*, shows the velocity pattern in the galactic plane for the stars within 600 pc. Mean velocity-vectors were calculated for each of the associations and groups; the field stars in projected areas 100 parsecs square were averaged as to position and motion. Although there is an indication of outward motion in the second and fourth quadrants, the picture is considerably more chaotic than that depicted by Bonneau (1965, Fig. 31). The tendency to inward motion in the first quadrant is particularly significant. In the preparation of the present diagram and Figure 4, *b*, a solar-motion vector $U_\odot = -13.1$, $V_\odot = +14.9$, $W_\odot = +6.6$ km sec^{-1} (to be derived in § V) was removed from the stellar space motions. Bonneau used a different value for the solar motion, but the difference is not enough to alter the over-all pattern significantly.

In Figure 4, *b*, the position and velocity of each of the points in Figure 4, *a*, are projected onto the radial plane. The most striking feature of this plot is the tendency of the stars at large distances below the galactic plane to move away from, rather than toward, the plane.

IV. THEORETICAL MODEL OF AN EXPANDING GROUP

a) Motion in the Galactic Plane

Consider a coordinate system (ξ,η) rotating about the galactic center C in a circular orbit, with the angular velocity ω appropriate to the distance OC between its origin and the center. The ξ-axis points away from the galactic center, and the η-axis points in the direction of galactic rotation. Blaauw (1952) has shown, from the theory of Lindblad (1941), that, if at time $t = 0$ a star is assumed to be located at the origin of this coordinate system, the equations of its trajectory can be written

$$\begin{aligned} \xi &= s_0 \sin \chi t \sin \phi + \frac{2\omega s_0}{\chi^2}(1 - \cos \chi t) \cos \phi \,, \\ \eta &= -\frac{2\omega s_0}{\chi^2}(1 - \cos \chi t) \sin \phi + \frac{4\omega s_0}{\chi^2}\left(\frac{\omega}{\chi} \sin \chi t - At\right) \cos \phi \,, \end{aligned} \tag{4}$$

and its velocity components are then

$$\begin{aligned} \frac{d\xi}{dt} &= s_0 \cos \chi t \sin \phi + \frac{2\omega s_0}{\chi} \sin \chi t \cos \phi \,, \\ \frac{d\eta}{dt} &= -\frac{2\omega s_0}{\chi} \sin \chi t \sin \phi + \frac{4\omega s_0}{\chi^2}(\omega \cos \chi t - A) \cos \phi \,, \end{aligned} \tag{5}$$

where $s_0 \sin \phi$ and $s_0 \cos \phi$ are the ξ- and η-velocity components, respectively, of the star at $t = 0$, and

$$\omega = A - B \,, \tag{6}$$

$$\chi^2 = -4B(A - B) \,. \tag{7}$$

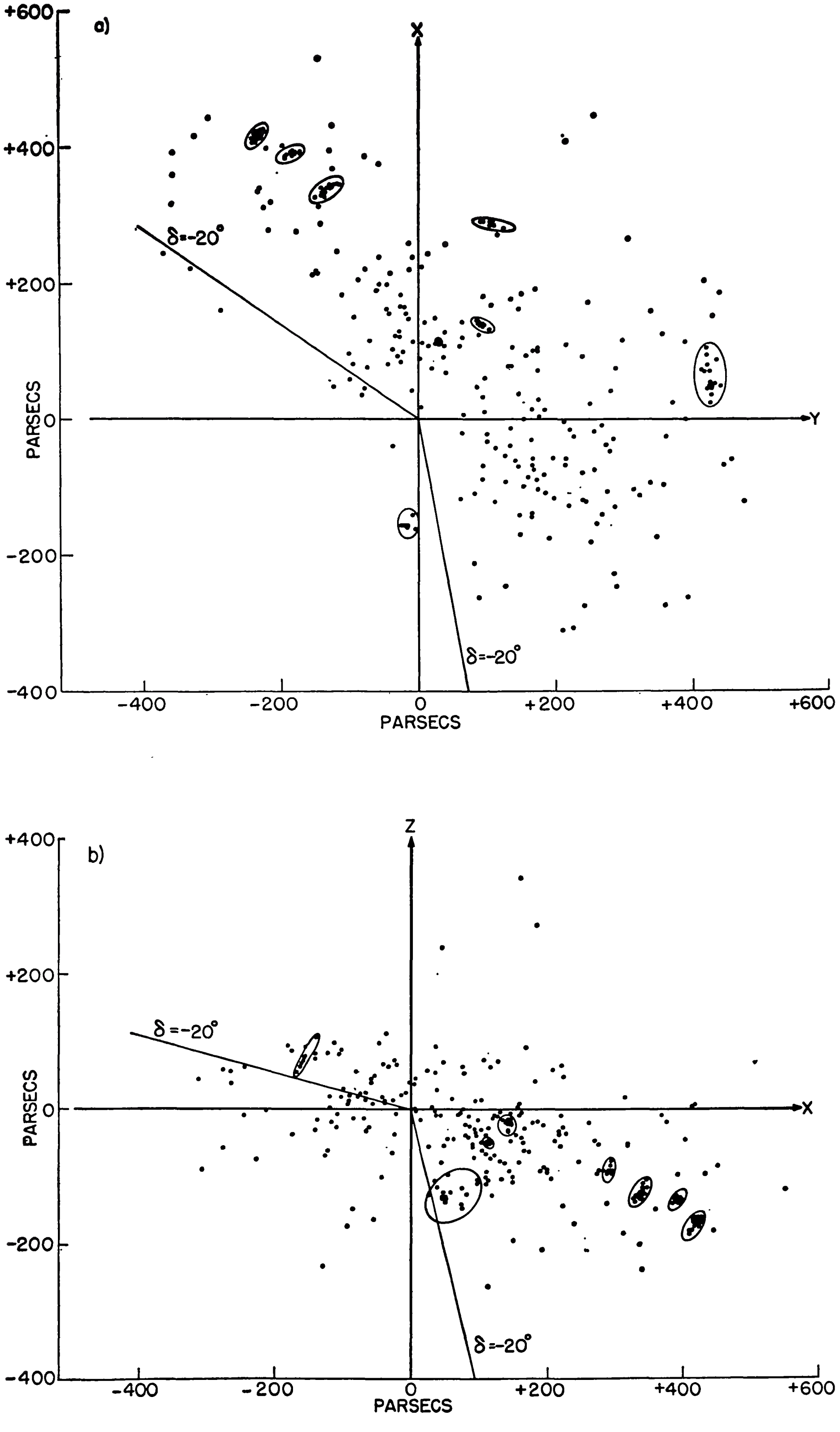

FIG. 3.—Distribution in space coordinates of stars with well-determined distances less than 600 pc (*a*) in the galactic plane and (*b*) perpendicular to the galactic plane. X-axis is directed toward the galactic anticenter, Y-axis in the direction of galactic rotation, and Z-axis toward the north galactic pole. Association boundaries are approximate but contain a point for each star actually observed. The region below $\delta = -20°$ was not observed; the appearance of some points in this region is a projection effect.

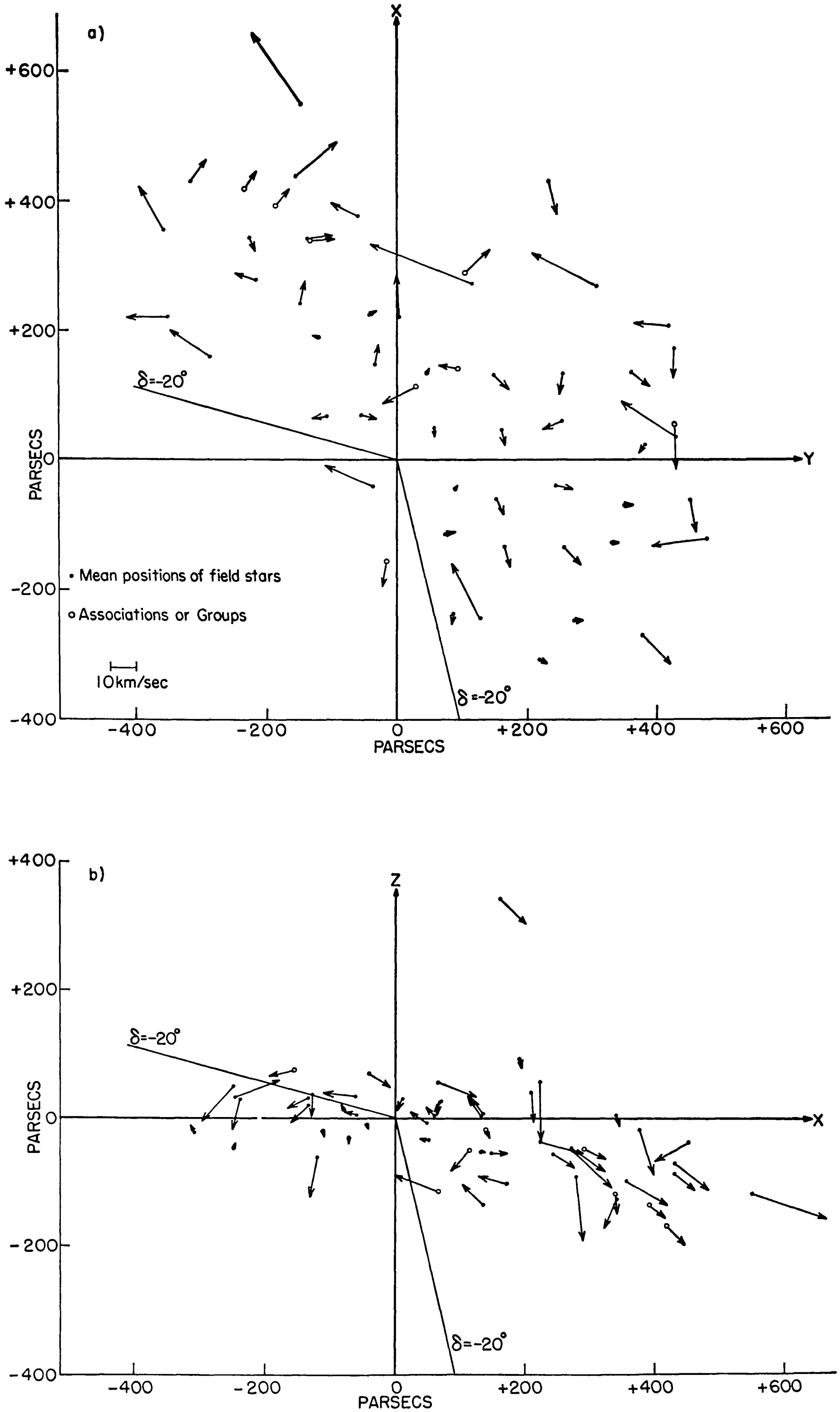

FIG. 4.—Observed velocity pattern of stars with well-determined distances less than 600 pc (*a*) in the galactic plane and (*b*) perpendicular to the galactic plane. Mean positions and velocities were calculated for associations and groups and for field stars in projected areas of 100 parsecs square in the (X,Y)-plane. A solar-motion vector $U_\odot = -13.1$, $V_\odot = +14.9$, $W_\odot = +6.6$ km sec^{-1} has been removed. The region below $\delta = -20°$ was not observed; the appearance of some points in this region is a projection effect.

A and B are, strictly speaking, the circular or dynamical Oort constants, but they are usually allowed to take on the values observed in the solar neighborhood. These equations contain the implicit assumptions that the coordinates (ξ,η) of the star remain small with respect to OC and that the only force acting on the star is the central galactic force field $\partial\Phi/\partial r$, where $\Phi(r,z)$ is the gravitational potential.

Now, if *all* the stars belonging to a certain group are assumed to have been contained in a small volume centered on the origin at $t = 0$, equations (4) and (5) can be used to calculate the velocity pattern of the group at some later time. Bonneau (1965) did this, assuming that the initial velocity distribution was isotropic with a speed $s_0 = 1$ km sec^{-1}.

However, it is desirable to eliminate any assumption about the initial velocity distribution in the group, since a real group would not necessarily expand isotropically. This can be done by treating equations (4) as a linear system with ξ and η as constants and $s_0 \cos \phi$ and $s_0 \sin \phi$ as unknowns and solving by Cramer's rule. The expressions thus obtained for $s_0 \cos \phi$ and $s_0 \sin \phi$ as functions of ξ and η are then substituted into equations (5), yielding $d\xi/dt$ and $d\eta/dt$ as functions of ξ, η, and t alone.

Assuming for the moment that the Sun is located at the origin O, these functions can be expressed in the usual galactic space coordinates and velocities by means of the transformations (Bonneau 1965)

$$\begin{gathered} X = \xi\,, \quad Y = \eta\,, \\ U = d\xi/dt - (A - B)\eta\,, \quad V = d\eta/dt + (A - B)\xi\,. \end{gathered} \tag{8}$$

Thus we obtain relations of the form

$$U = \frac{\partial U}{\partial X} X + \frac{\partial U}{\partial Y} Y\,, \quad V = \frac{\partial V}{\partial X} X + \frac{\partial V}{\partial Y} Y\,, \tag{9}$$

with

$$\frac{\partial U}{\partial X} = \frac{\alpha}{\epsilon}\,, \quad \frac{\partial U}{\partial Y} = \frac{\partial V}{\partial X} = \frac{\beta}{\epsilon} - (A - B)\,, \quad \frac{\partial V}{\partial Y} = \frac{\delta}{\epsilon}\,, \tag{10}$$

where

$$\begin{gathered} \alpha = -\frac{1}{B}\left(\frac{\omega}{\chi} \sin \chi t - At \cos \chi t\right), \quad \beta = -\frac{1}{2B}(1 - \cos \chi t)\,, \\ \delta = \frac{1}{\chi} \sin \chi t\,, \quad \epsilon = \frac{1}{2B^2}\left(1 - \cos \chi t - \frac{\chi}{\omega}\frac{At}{2} \sin \chi t\right). \end{gathered} \tag{11}$$

The gradients defined by equations (10) have the important property of being independent of the coordinates (X,Y). They have universal values throughout the expanding group, depending only on the age and being independent of the initial velocity distribution and hence of the space density distribution of the group. Therefore, they provide a suitable means of estimating the age.

Assuming that the dynamical values of A and B are the same as the locally observed values of $+15$ and -10 km sec^{-1} kpc^{-1}, respectively, we have calculated the velocity gradients $\partial U/\partial X$, $\partial U/\partial Y$, and $\partial V/\partial Y$ as functions of time. The results of these calculations are shown in Figure 5. The gradients $\partial U/\partial X$ and $\partial V/\partial Y$ are seen to be the most sensitive indicators of the age of an expanding group, the former ranging from $+100$ km sec^{-1} kpc^{-1} to zero in the time interval 10–130 $\times$ 10^6 years, while the latter covers the same range in the interval 10–90 $\times$ 10^6 years.

Blaauw (1946) has shown that the velocity components of a field star—that is, a star moving in a circular orbit—in the (ξ,η) coordinates are

$$d\xi/dt = 0\,, \quad d\eta/dt = -2\xi A\,. \tag{12}$$

Therefore, the velocity gradients in a sample of field stars—that is, a sample in pure differential rotation—would have the constant values

$$\frac{\partial U}{\partial X}=0\,,\quad \frac{\partial U}{\partial Y}=-(A-B)=-25\text{ km sec}^{-1}\text{ kpc}^{-1}\,,$$
$$\frac{\partial V}{\partial X}=-(A+B)=-5\text{ km sec}^{-1}\text{ kpc}^{-1}\,,\quad \frac{\partial V}{\partial Y}=0\,. \tag{13}$$

This particular combination of values is not matched by the velocity gradients in an expanding system of any age whatsoever.

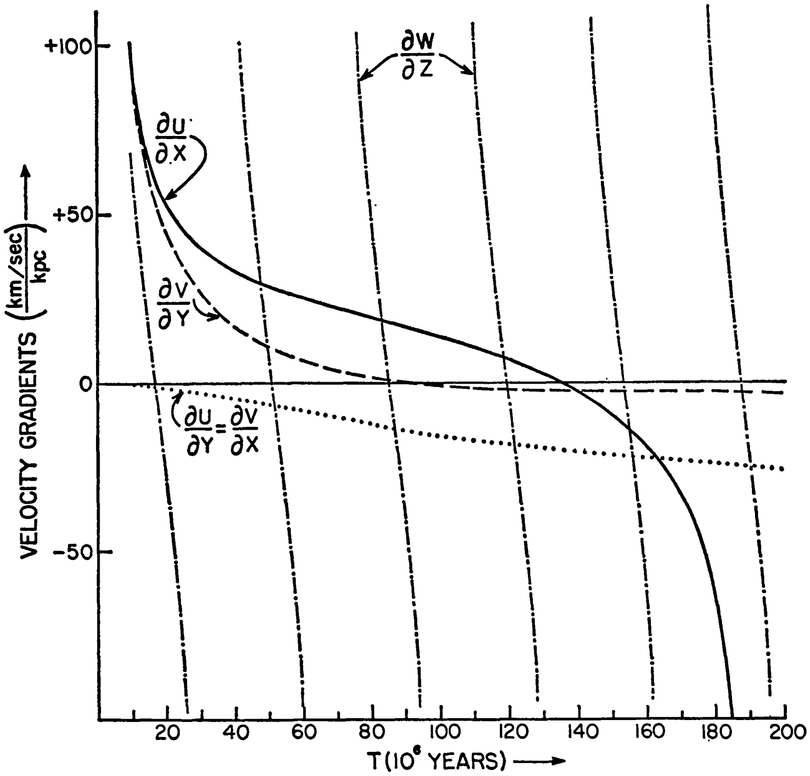

FIG. 5.—Velocity gradients in an expanding system as functions of time. In a sample of field stars in differential rotation, these gradients would have the constant values $\partial U/\partial X = 0$, $\partial U/\partial Y = -25$, $\partial V/\partial X = -5$, $\partial V/\partial Y = 0$ (km sec^{-1} kpc^{-1}).

Figure 6 shows the velocity patterns one would find in expanding systems aged 50×10^6 and 90×10^6 years, respectively, and in a system of field stars influenced only by differential rotation. These patterns were drawn by arbitrarily choosing the points on a circle of 500-pc radius, centered on the origin, and calculating the velocity vectors at these points from the appropriate gradients. It is by no means implied that all the stars in an expanding group would be located on the circle depicted.

The pattern for 50×10^6 years is comparable to Bonneau's Figure 20, and this is approximately the age he found most probable for the expanding "Local Group." However, a comparison of Figure 6 with Figure 4 indicates that an expansion age near 90×10^6 years may provide a better fit to the observed velocity pattern, especially in the first quadrant, where the observed vectors appear to be generally inward directed. This question will be taken up quantitatively in § V.

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b) *Motion Perpendicular to the Galactic Plane*

The model just developed, dealing only with motions in the galactic plane, tacitly assumes that the stars themselves are located in this plane. However, the inclination of the Gould belt to the galactic plane is so small that this should not be a damaging assumption when our observed sample is fitted to the model. The motions in the Z-direction are thus assumed to be uncoupled from the X- and Y-motions and can be used to give independent evidence concerning the age of the group.

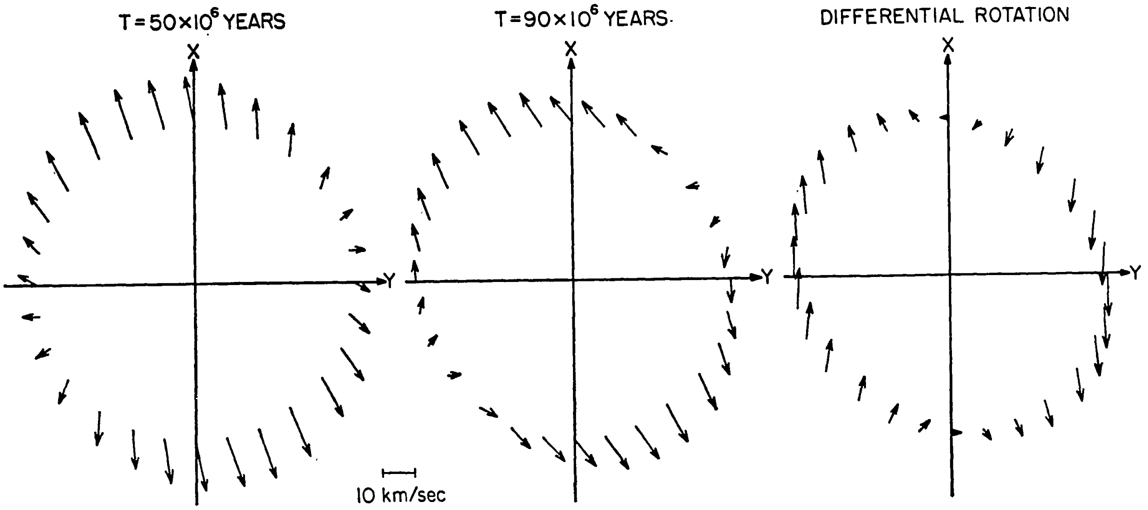

FIG. 6.—Velocity patterns in expanding systems aged 50 × 10⁶ and 90 × 10⁶ years and in a system in differential rotation. Velocity vectors were calculated for points on a circle 500 pc in radius, using the gradients of Fig. 5. These theoretical patterns are to be compared with the observed pattern in Fig. 4, *a*.

Following § 4.3 of Chandrasekhar (1942), we can write the Z-component of the equation of motion of a single star, in the present notation, as

$$Z = Z_{10} \sin n_2 t \,, \tag{14}$$

where t is the time elapsed since the star left the galactic plane, Z_{10} is a constant, and

$$n_2{}^2 = \left(\frac{\partial^2 \Phi}{\partial Z^2}\right)_0 = 4\pi G \langle \rho \rangle \,. \tag{15}$$

In equation (15), G is the gravitational constant and $\langle \rho \rangle$ is the local mean density of matter in the galactic plane.

Differentiating equation (14) with respect to t and squaring, we have

$$W^2 = n_2{}^2 Z_{10}{}^2 \cos^2 n_2 t = n_2{}^2 (Z_{10}{}^2 - Z^2) \,. \tag{16}$$

Solving equation (14) for Z_{10}, substituting in equation (16), and taking the square root, we obtain

$$W = (n_2 \cot n_2 t) Z \,. \tag{17}$$

Thus, by analogy with the preceding section, we can write

$$\frac{\partial W}{\partial Z} = n_2 \cot n_2 t \,. \tag{18}$$

Assuming $\langle \rho \rangle = 0.14\, M_\odot\, \mathrm{pc}^{-3}$ (Allen 1963, p. 236), we have calculated n_2 from equation (15) and then $\partial W / \partial Z$ as a function of t from equation (18). The results of this calculation are shown in Figure 4. The gradient $\partial W/\partial Z$ is seen to be a rapidly varying function of time and to be periodic with a period of about 35×10^6 years.

V. COMPARISON OF OBSERVATIONS AND MODEL

The variables in equations (9) and (17) refer to the positions and motions of the member stars with respect to the center of expansion of the group, while the space coordinates and velocities of Table 7 were measured with respect to the Sun. This difference may be taken into account by noting that the observed position and velocity vectors can be resolved into two components, the first representing the position and velocity of the star with respect to the center of the group and the second representing the position and velocity of the Sun with respect to the center of the group. Thus, for comparison with the observations, equations (9) and (17) can be rewritten as

$$U = \frac{\partial U}{\partial X} X + \frac{\partial U}{\partial Y} Y + C(U) , \quad V = \frac{\partial V}{\partial X} X + \frac{\partial V}{\partial Y} Y + C(V) , \quad W = \frac{\partial W}{\partial Z} Z + C(W) , \tag{19}$$

where

$$C(U) = -U_0 + \frac{\partial U}{\partial X} X_0 + \frac{\partial U}{\partial Y} Y_0 , \quad C(V) = -V_0 + \frac{\partial V}{\partial X} X_0 + \frac{\partial V}{\partial Y} Y_0 , \quad C(W) = -W_0 + \frac{\partial W}{\partial Z} Z_0 , \tag{20}$$

and X_0, Y_0, Z_0, U_0, V_0, and W_0 are the components of the Sun's position and velocity with respect to the center of the group. $C(U)$, $C(V)$, and $C(W)$ are the reflex of the solar motion with respect to the group members, i.e., the motion of the Sun relative to a hypothetical group member located at the position of the Sun. It is evident from equations (19) and (20) that the present position of the expansion center is indeterminate from the observations. It is equally evident that this indeterminacy does not affect the velocity gradients and hence the estimation of the age of the group.

The space coordinates and motions calculated in § III have been fitted to the form of equations (19) by the method of least squares, each velocity vector being assigned a weight equal to the inverse square of its probable error. This was done for several subsets of the 294 stars within 600 pc whose space motions were calculated, in order to search for an objective criterion which would separate members of the group from nonmembers. Any set composed entirely of group members, even if it is incomplete, should give values of the velocity gradients appropriate to the age of the group. But an admixture of field stars would tend to falsify the gradients. Thus solution 1 contains the entire sample; No. 2 is restricted to stars with new spectral types B3 and earlier (since, if the group is young, older stars will not be members); No. 3 is restricted to stars within 300 pc (since in some directions the group may not extend out to 600 pc); and No. 4 is restricted both as to spectral type and as to distance. To test the role of the associations in the hypothetical group, we also performed solutions 5 and 6, in which the weight of each association member was reduced to 10 per cent of the weight corresponding to its probable error, and No. 7, which contains *only* association stars.

The values of the gradients (in km sec^{-1} kpc^{-1}) and constant terms (in km sec^{-1}) found in these various solutions are shown in Table 8, followed by their probable errors in the same units. The probable errors were computed from the residuals in the least-squares solutions.

Concerning the constant terms, we may remark that except in solution 7 they do not vary appreciably from solution to solution and in fact are very close to accepted values of the reflex of the solar motion. (Allen 1963, p. 242, cites, for example, $U_\odot = -10.1$,

$V_\odot = +15.5$, $W_\odot = +7.5$ km sec^{-1} as components of the solar motion with respect to the neighboring stars.) A priori, this would not necessarily be the case, since the solar motion is usually measured with respect to a sample of stars assumed to be in a steady state. We used the negative of the values of $C(U)$, $C(V)$, and $C(W)$ found in solution 3 as a solar-motion vector in the construction of Figure 4.

Each of the gradients in the (X,Y)-plane can be used independently to obtain an expansion age for the system. Table 9 shows the ages obtained by comparing the observed value of each gradient with the theoretical curves in Figure 5.

We note immediately from Tables 8 and 9 that none of the seven solutions yields a unique expansion age from all four gradients. Of the first four solutions, No. 4 is the most inconsistent and also carries the largest probable errors. It would appear likely that this highly restrictive solution contains too few stars to be statistically significant.

In solutions 1 and 2 the gradients $\partial U/\partial X$ and $\partial V/\partial Y$ imply different but not irreconcilable expansion ages, the former tending to be somewhat greater than 100×10^6 years, while the latter lies more in the range of 60–90×10^6 years. This inconsistency does not exist in solution 3, partly because of the larger probable errors in this solution. On the sole basis of these two gradients in these three solutions, one might pose 90–95×10^6 years as a reasonable mean expansion age. The evidence of the cross-gradients $\partial U/\partial Y$ and $\partial V/\partial X$ contradicts this simple hypothesis, however. Rather than having the values expected in an expanding system, these gradients remain close to their differential-rotation values of -25 and -5 km sec^{-1} kpc^{-1}, respectively. Since it is no more plausible to interpret the present values of $\partial U/\partial X$ and $\partial V/\partial Y$ on the differential-rotation hypothesis than it is to reconcile the values of $\partial U/\partial Y$ and $\partial V/\partial X$ with a simple expansion, we might conclude from solutions 1–3 that we have evidence for the presence of both an expanding component and a differentially rotating component in our sample (possibly with initial conditions more complicated than expansion from a single point) and that a suitable estimate for the mean age of the system as a whole is 90–95×10^6 years. This description is confirmed in a qualitative way by comparing the observed velocity pattern in Figure 4, *a*, with the theoretical pattern for 90×10^6 years in Figure 6.

An alternative picture may be obtained from solutions 5–7. The former two, in which the association stars enter with a very low weight, yield parameters close to those expected for differential rotation. But the last solution, which contains only association stars, gives a value of $\partial U/\partial X$ close to the $+40$ km sec^{-1} kpc^{-1} found by Eggen (1961), and an expansion age from $\partial U/\partial X$, $\partial U/\partial Y$, and $\partial V/\partial Y$ of about 45×10^6 years, similar to that derived by Bonneau (1965). One should guard against taking this solution too literally, since the positive value found for $\partial V/\partial X$ is not capable of interpretation either as expansion or as differential rotation, and the constant terms imply very unusual values of the solar motion.[2] But the fact that the association solution (No. 7) gives strong evidence for expansion, while the expansion is nearly removed from the most general solution (No. 1) by reducing the weights of the associations (as in No. 5), is very suggestive.

A referee has pointed out that, since the motions of the stars within a given association are not independent of each other, it would be a more correct procedure to form a normal point for each association rather than to use the association members as individual points in the least-squares solutions. If this is done, a smaller number of points is available to solve for the unknown gradients and constants, and the probable errors attached to these quantities must be increased. This effect is comparatively unimportant in solutions 1–6, where the association members constitute a minority of the stars involved. But when solution 7—consisting entirely of association stars—is repeated using normal points, the values of the unknowns are unaffected, but their probable errors are increased by a factor of 3.

[2] Similar values of $U_\odot$ and $V_\odot$ were, however, found by Feast and Shuttleworth (1965) from the radial velocities of galactic clusters.

This increase in the probable errors gives more latitude in the expansion age derived from each individual gradient, but it does not alter the mean age, 45 × 10^6 years, that is estimated from the solution as a whole. Neither does it remove the inconsistency in the value of $\partial V/\partial X$, for this gradient remains positive, and greater than its probable error. Therefore, the conclusions drawn in the above discussion remain unchanged.

We may also remark that the weighting system used in our calculations has little effect on the probable errors, which were calculated from the actual residuals in each solution and thus allow for such effects as peculiar motions deviating from the assumed linear relation. This may be verified by comparing the probable errors in solutions 1 and 5, which differ only in the weights assigned to the association members.

Can the association members be identified as the expanding component in the local population? These stars make up approximately 30 per cent of the original sample. If we take a mean between the gradients in an expanding group aged 45 × 10^6 years, carrying weight 0.3, and the gradients for differential rotation, carrying weight 0.7, we find $\partial U/\partial X = +9.4$, $\partial U/\partial Y = -19.1$, $\partial V/\partial X = -5.0$, and $\partial V/\partial Y = +4.2$ km $\sec^{-1}$ kpc^{-1}. While not actually fitting any one of the observed solutions within the range of its probable errors, this calculation is sufficiently similar to solution 1, for example, to indicate that a suitably mixed model could produce the observed results. If the expanding component is to be identified with the association members, their obviously inhomogeneous distribution in space makes it likely that an accurate model for the mixed population cannot be obtained by taking a simple weighted mean of the gradients. A physical justification for isolating the association members—rather than all the youngest stars—in seeking the expanding subset could be the comment by Morgan (1953) that the associations contain all the very young stars which are still located near their birthplace. Any star of spectral type O or even B0 which is not now located in an association may be expected to have a large peculiar space motion that would perturb the gradient solution. It is clear that the expansion ages estimated here do not necessarily refer to the ages of the stars but may include a prestellar phase during which clumps of interstellar matter, spreading from the center of expansion, fragmented into protostars. A general confirmation of the range of expansion ages we find for the Local Group may be obtained on purely kinematic grounds from the equation of continuity, which can be written in two dimensions as

$$\frac{1}{N}\frac{dN}{dt} = -\left(\frac{\partial U}{\partial X} + \frac{\partial V}{\partial Y}\right), \tag{21}$$

where N is the projected number density of stars in the (X, Y)-plane. From this equation we see that the time scale of the expanding group must be of the order of

$$T = \left(\frac{\partial U}{\partial X} + \frac{\partial V}{\partial Y}\right)^{-1} \tag{22}$$

Taking, for example, the gradients and their probable errors from solution 3, we find $T = 65 \pm 15 \times 10^6$ years. This order-of-magnitude calculation is compatible with either the age of 90 × 10^6 years we estimated for our sample as a whole or the 45 × 10^6 years we found for the associations as an expanding subset.

Finally, we can see from Figure 5 that any value of the gradient $\partial W/\partial Z$ between 0 and +30 km $\sec^{-1}$ kpc^{-1}—a range which includes the observed results in all our solutions—is compatible with a set of expansion ages including both 45–50 × 10^6 and 80–85 × 10^6 years. Thus this measurement also would fit in with either of the models under discussion.

The ambiguity of the age of the group as determined from the W-gradient alone raises an interesting problem in the description of the present state of motion of the system in the Z-direction. The period of Z-oscillation of these stars is approximately 70 × 10^6 years (Oort 1965). Thus, if they all left the galactic plane at the same time, at age 45 ×

10^6 years they would have completed one half-period and would be leaving the plane in the opposite direction from their original motion. But at 90×10^6 years they would be beginning the second period and would have attained approximately their maximum distance from the plane. The former alternative seems more compatible with the large velocities away from the plane which we noted in Figure 4, *b*. But if we accept this description we must conclude that at some time in the past the Gould belt was even more highly inclined to the galactic plane than it is at present.

We have investigated the dependence of the present results on the various constants used in the calculation. Assuming Δn to be fairly well known from Fricke's recent work (1966*b*), we repeated the entire calculation of space motions and velocity gradients for an alternative value of Δk, namely, $-0\overset{''}{.}27$ per century. The gradients in the various solutions were not changed by more than 1–2 km $\sec^{-1}$ kpc^{-1}.

The expansion models were calculated for different values of A and B, up to 30 per cent greater and less than the assumed values of $+15$ and -10 km $\sec^{-1}$ kpc^{-1}, respectively. For expansion ages of 100×10^6 years and less, the theoretical gradients $\partial U/\partial X$ and $\partial V/\partial Y$ were not altered by more than the observed probable errors. The effect on the cross-gradients was somewhat greater but was not of such a nature as to change the interpretation of these gradients in any of the solutions. In other words, there was no shift from rotation to expansion or vice versa.

Because of the possibility of a systematic error in the calibration of our spectral types (see § II), we tested the role of the distance scale in our calculation by recomputing solution 1 with all the stellar distances decreased, and then increased, by 20 per cent (the estimated probable error of a single distance measurement). We found that decreasing the distance scale tended to increase $\partial U/\partial X$ and decrease $\partial V/\partial Y$, bringing them into good agreement for an expansion age of 100×10^6 years. The cross-gradients were adversely affected, however, with $\partial U/\partial Y$ becoming more negative and $\partial V/\partial X$ more positive. The reverse effect took place when the distance scale was increased—$\partial U/\partial X$ and $\partial V/\partial Y$ became more discordant, while $\partial U/\partial Y$ and $\partial V/\partial X$ approached their differential-rotation values. None of these changes was such as to alter the expansion age we would estimate from the solution as a whole.

We conclude that errors of the type considered here would not affect the picture we have drawn of the principal kinematical properties of the Gould belt system.

VI. CONCLUSIONS

Although the present investigation does not lead to a unique solution for the expansion age of the local system defined by the Gould belt, it does yield conclusive evidence for the presence of an expanding group as opposed to a sample of field stars in pure differential rotation. Two simple models of the expanding system suggest themselves on the basis of our calculations:

1. The system contains both expanding and differentially rotating components, which are mixed in some unspecified way, and has an over-all expansion age of 90×10^6 years.
2. The associations define the expanding subset, consisting of about 30 per cent of the local B-star population and having an expansion age of 45×10^6 years. The rest of the sample then follows the laws of pure differential rotation.

These models are not mutually exclusive. The second may be regarded as a particularization of the first. More complicated models, containing, for example, more than one expanding subsystem, could also be constructed to fit the observations. But there would be no way to choose among such models, on the basis of the present work.

The new observational data obtained in the course of this study—particularly the spectral types and the proper motions—form a more precise and homogeneous body of information on the bright early-type stars than has been available in the past. This information should be useful for future investigations of local galactic structure. Although the present discussion has been confined to the general kinematics of the stars within 600 pc, the author plans additional articles based on this body of data. These will deal with the internal motions in the associations and the kinematics of the stars more distant than 600 pc.

A project of this scope could not have been undertaken without the generous cooperation of a number of astronomers and observatories. The author takes pleasure in thanking Dr. W. W. Morgan for suggesting this problem and for his invaluable instruction in the art of spectral classification; Dr. A. Blaauw for his hospitality as director of the Kapteyn Astronomical Laboratory and for his guidance in the calculation of the proper motions, the construction of the models, and the calibration of the spectral types; and Dr. P. O. Vandervoort for helpful discussions on stellar dynamics.

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TABLE 1

STANDARDS AND CRITERIA FOR CLASSIFICATION*

SPECTRAL TYPE	LUMINOSITY CLASS V	LUMINOSITY CLASS IV	LUMINOSITY CLASS III
O9	10 Lac λ4541 (He II) present but<<λ4471 (He I).	No example in program.	ι Ori λ4387, λ4144 and λ4009 (all He I) weaker than at O9V. λ4089 (Si IV) and λ4650 (C III) stronger.
O9.5	σ Ori λ4541 absent. λ4200 is present. λ4686 (He II) <λ4650.	No example in program.	No example in program.
B0	υ Ori, τ Sco λ4686 = λ4650 λ4200 absent.	HD 209339 Interpolate between B0V and B0III.	1 Cam (n), HD 48434 He and H spectra weaker than at B0V. Strengthening of λ4116 (Si IV) makes λ4121 (He I) look fuzzy or double.
B0.5	HD 36960 λ4686 absent but λ4650 present. λ4089 (Si IV) weaker than at B0V while λ4387 (He I) and λ4072 (O II) are stronger.	δ Sco, λ Lep λ4009 (He I) weaker than at B0.5V, O II stronger.	κ Aql (n), 1 Cas λ4072, λ4349, λ4416 (all O II) much stronger than at B0.5V. λ3995 (N II) usually present.
B1	ω¹ Sco λ4072 strong (but not other O II lines). λ4121 (+λ4116) >λ4144 (He I). λ4089 weak.	α Vir Interpolate between B1V and B1III.	o Per, σ Sco λ4009 weaker than at B1V. λ4089, λ4349 and λ4416 stronger.
B1.5	HD 215191 λ4072 present but λ4129 (Si II) and λ4481 (Mg II) absent. λ4121 and λ4009 intermediate between B1V and B2V.	Interpolate between B1.5V and B1.5III.	Interpolate between B1III and B2III.
B2	22 Sco, 51 Cyg HD 36430, HD 43955 λ4009 and λ4387 strong. λ4121<λ4144. λ4129, λ4072 and λ4481 absent or weak.	IV-V: β Sco C, HD 36285 λ4121 stronger and λ4009 weaker than at B2V. λ4072 & λ4129 usually both present. IV: γ Peg, δ Cet λ4121~λ4144. λ4129, λ4072 & λ4481 fairly strong. λ4009 weak.	π⁴ Ori H and He spectra absolutely weaker than at B2IV and λ4009 relatively weaker. λ4072 and λ4121 relatively stronger.
B2.5	HD 36779 λ4072 absent, λ4129 present. λ4121 and λ4009 weaker than at B2V.	HD 32612 λ4121 and λ4009 stronger than at B2.5V but λ4129 stronger than at B2V.	π² Cyg Interpolate between B2III and B3III.
B3	η Aur, HD 178329 λ4121 <λ4129 <λ4144. λ4009 moderately weak. λ4481 present.	126 Tau λ4121 and λ4009 stronger than in corresponding Main Sequence type.	HD 21483 λ4121~ λ4129 but <λ4144. λ4009~λ4026 but whole He I spectrum is weak. λ4481 stronger than at B3V.
B4	90 Leo λ4129 stronger w.r.t. λ4144 than at B3V. λ4121 and λ4009 weak.	HD 176502	14 Lac Interpolate between B3III and B5III.
B5	ρ Aur, ν And λ4129 ~λ4144 but λ4121 still present. λ4481 well marked. λ4009 very weak.	τ Her, 16 Pup	δ Per, τ Ori H and He spectra much weaker than in corresponding Main Sequence type. λ4481 relatively stronger.
B6	30 (β) Sex λ4129 >λ4144. λ4121 very weak.	19 Tau	17 Tau
B7	49 Eri Interpolate between B6V and B8V.	16 Tau	η Tau
B8	18 Tau λ4481= λ4471	Interpolate between B8V and B8III.	27 Tau

*Primary standards are underlined.

TABLE 2

ADOPTED DISTANCES FOR ASSOCIATIONS AND GROUPS

Group	$V_0 - M_V$	r (pc)	Source
α Per	6.15	170	Blaauw (1963)
h+χ Per	11.79	2279	Present study
ζ Per	7.54	322	Borgman and Blaauw (1964)
Pleiades	5.55	129	Blaauw (1963)
Ia Ori	7.92	384	Present study
Ib Ori	8.33	463	Present study
Ic Ori	8.47	494	Present study
I Gem	10.87	1492	Present study
II Sco	6.20	174	Present study
I Cep	9.60	830	Blaauw (1961)
I Lac	8.29	455	Present study

TABLE 3

FINAL CALIBRATION OF NEW SPECTRAL TYPES

TYPE	M_V							
	V	IV–V	IV	III	II	Ib	Iab	Ia
O5–O8	−5.9	....	....	....	....	....	....	....
O9	−5.4	....	(−5.5)	−5.6	−6.1	−6.2	−6.2	−6.2
O9.5	−4.9	....	(−5.0)	(−5.3)	....	....	....	....
B0	−4.2	....	(−4.5)	(−5.1)	−5.7	−6.2	−6.3	−6.6
B0.5	−4.0	....	−4.1	−4.8	....	....	....	....
B1	−3.5	....	−3.8	−4.0	−5.3	−6.1	−6.3	−6.9
B1.5	−2.8	....	−3.5	−3.7	....	....	....	....
B2	−2.2	−2.4	−3.0	−3.3	−4.9	−6.0	−6.3	−7.1
B2.5	−1.9	....	−2.1	−2.5	....	....	....	....
B3	−1.3	....	−1.7	−2.2	−4.4	−5.9	−6.3	−7.1
B4	−1.1	....	−1.6	−1.9	....	....	....	....
B5	−0.9	....	−1.0	−1.6	−4.0	−5.8	−6.3	−7.0
B6	−0.5	....	−0.6	−1.4	....	....	....	....
B7	−0.5	....	(−0.6)	−1.0	....	−5.7	−6.3	−6.8
B8	....	....	−0.4	(−0.6)	....	−5.6	−6.3	−6.7

EXPLANATION OF COLUMNS OF TABLE 4

Column	
1	HD number
2	MK spectral type from present work
3	V-magnitude
4	$B - V$ color
5	Source of photometry: (A) Crawford (private communication), (B) Johnson (1966), (C) other authors (see Notes to Table 4), (D) *Catalogue of Bright Stars* (Hoffleit 1964)
6	Distance modulus
7	Distance (in parsecs) corresponding to distance modulus in col. 6
8	Remarks on distance:

None—Distance is based on the spectral type and photometry given in Table 4 and the calibration in Table 3

1—Star is a member of an association or group, for which the mean distance from Table 2 has been adopted

2—Star has spectral peculiarities but was observed directly by Borgman and Blaauw (1964), whose value of M_V has been adopted

3—Star has spectral peculiarities but has been assigned an approximate M_V from the calibration for normal stars; distance is highly uncertain

TABLE 4

SPECTRAL TYPES, PHOTOMETRY, AND DISTANCES OF BRIGHT O AND B STARS

HD	Spectrum	V	B−V	Ref	V_0-M_v	r (pc)	Com
829	B2V	6.71	−.11	A	8.52	506	
886	B2IV	2.84	−.23	A	5.81	145	
1337	O9IIINN	6.13	−.13	A	11.19	1729	3
1976	B5IV	5.57	−.13	A	6.48	198	
2729	B6V	6.17	−.10	A	6.55	204	
2905	B1IA	4.17	+.13	A	10.11	1052	
3240	B7III	5.06	−.11	A	6.03	161	
3360	B2IV	3.68	−.20	A	6.56	205	
3369	B5V	4.38	−.13	A	5.19	109	
3379	B2.5IV	5.88	−.15	A	7.77	358	
3901	B2.5V	4.81	−.11	A	6.38	189	
4142	B4V	5.63	−.11	A	6.52	201	
4180	B5III	4.62	−.08	A	5.98	157	
4727	B5V	4.57	−.16	A	5.47	124	
5394	B0.5IVE1	2.58	−.20	A	6.44	194	3
6300	B3V	6.53	−.07	A	7.44	308	
10516	B2VE4P	4.09	−.04	A	5.69	137	3
11241	B1.5V	5.50	−.17	A	8.06	409	
11415	B3VP	3.37	−.16	A	4.85	93	2
12301	B8IB	5.58	+.38	B	9.98	991	
13267	B5IA	6.38	+.33	A	11.79	2279	1
13854	B1IAB	6.47	+.28	A	11.79	2279	1
14372	B5V	6.10	−.08	A	6.76	225	
14818	B2IA	6.21	+.30	A	11.79	2279	1
14951	B7IV	5.46	−.10	A	6.00	158	3
16582	B2IV	4.06	−.21	B	6.97	248	
16908	B3V	4.65	−.14	A	5.77	143	
17081	B7V	4.25	−.14	B	4.75	89	
17543	B6V	5.21	−.06	A	5.47	124	
17769	B7V	5.48	−.09	A	5.89	151	
18537	B7III	5.23	−.05	A	6.15	170	1
18604	B6III	4.66	−.11	A	5.97	156	

TABLE 4-Continued

HD	Spectrum	V	B−V	Ref	V_0-M_v	r (pc)	Com
18883	B7V	5.51	−.11	A	5.98	157	
19268	B5V	6.30	−.01	A	6.75	224	
19374	B1.5V	6.10	−.12	A	8.51	503	
20315	B8IV	5.46	−.06	A	6.15	170	1
20336	B2.5VE1N	4.80	−.14	A	6.56	205	2
20365	B3V	5.12	−.05	A	6.15	170	1
20418	B5IV	5.02	−.06	A	6.15	170	1
20756	B5IV	5.27	−.06	A	5.97	156	
20809	B4V	5.30	−.08	A	6.15	170	1
21071	B5IV	6.06	−.08	A	6.15	170	1
21278	B4V	4.97	−.08	A	6.15	170	1
21362	B7VN	5.57	−.04	A	6.15	170	1
21428	B5V	4.66	−.08	A	6.15	170	1
21455	B6V	6.22	+.13	A	6.15	170	1
21803	B2IV	6.40	+.03	A	8.59	522	
21856	B1V	5.89	−.07	A	7.54	322	1
22192	B5VE2	4.25	−.04	A	6.15	170	1
22780	B7VN	5.55	−.07	A	5.90	151	3
22928	B5III	2.99	−.12	A	4.47	78	
22951	B1IV	4.96	−.02	A	7.54	322	1
23180	B1III	3.79	+.06	A	7.54	322	1
23288	B7IV	5.45	−.04	A	5.55	129	1
23302	B6III	3.70	−.11	A	5.55	129	1
23338	B6IV	4.29	−.11	A	5.55	129	1
23408	B8III	3.87	−.07	A	5.55	129	1
23466	B3V	5.32	−.11	A	6.35	186	
23480	B6IV	4.18	−.06	A	5.55	129	1
23625	B2.5V	6.56	+.06	A	7.54	322	1
23630	B7III	2.87	−.09	B	5.55	129	1
23793	B3V	5.06	−.14	A	6.18	172	
24131	B0.5V	5.78	−.02	A	7.54	322	1
24398	B1IB	2.87	+.11	A	7.54	322	1

TABLE 4-Continued

HD	Spectrum	V	B-V	Ref	V_0-M_v	r (pc)	Com
24504	B6V	5.38	-.08	A	5.70	138	
24534	O9.5E4P	6.35	+.26	A	7.54	322	1
24640	B1.5V	5.51	-.05	A	7.54	322	1
24760	B0.5III	2.90	-.18	A	7.40	302	
24912	O7.5	4.03	+.01	A	7.54	322	1
25204	B3IV	3.64	-.11	A	5.07	103	
25340	B5V	5.28	-.15	A	6.15	170	
25558	B3V	5.32	-.09	A	6.29	181	
25638	B0III	4.94	+.43	A	7.85	371	3
25940	B3VE1+	4.01	-.03	A	6.00	158	2
26326	B4V	5.37	-.15	C	6.38	189	
26356	B5V	5.56	-.13	A	6.37	188	
26739	B5IV	6.45	-.14	A	7.39	301	
26912	B3IV	4.27	-.07	A	5.58	131	
27192	B1.5IV	5.55	-.01	A	8.33	463	
27396	B4IV	4.84	-.04	A	6.02	160	
28114	B6IV	6.08	+.00	A	6.26	179	
28149	B7V	5.52	-.10	A	5.96	156	
28446	B0IIIN	5.77	+.16	A	9.49	790	3
28497	B1.5VE2	5.60	-.23	B	8.34	465	3
29248	B2III	3.96	-.22	A	7.20	275	
29335	B7V	5.31	-.13	A	5.81	145	
29763	B3V	4.26	-.13	A	5.35	117	
29866	B8IVN	6.09	+.06	A	6.04	161	3
30076	B2VE2	5.86	-.09	A	7.61	333	3
30211	B4IV	4.00	-.15	A	5.51	126	
30614	O9.5IA	4.29	+.02	A	9.82	920	
30836	B2III	3.68	-.16	A	6.74	223	
30870	B5V	6.11	+.08	A	6.29	181	
31237	B2III	3.69	-.18	A	6.81	230	
31327	B2.5IB	6.08	+.39	A	10.41	1207	
31331	B5V	5.97	-.11	A	6.72	221	

TABLE 4-Continued

HD	Spectrum	V	B-V	Ref	V_0-M_v	r(pc)	Com
31726	B1V	6.15	-.21	B	9.50	794	
32343	B2.5VE3	5.03	-.07	A	6.48	198	3
32612	B2.5IV	6.41	-.18	B	8.39	476	
32630	B3V	3.16	-.18	A	4.40	76	
32686	B5IV	6.05	-.13	A	6.96	247	
32990	B2V	5.50	+.06	A	6.80	229	
32991	B2VE3	5.92	+.18	A	8.66	539	2
33203	B2II+K	6.17	----	D	-----	----	
33328	B2IVN	4.25	-.19	A	7.10	263	3
34078	09.5V	5.94	+.22	A	10.60	1318	
34233	B5V	6.12	-.02	A	6.60	209	
34447	B3IV	6.48	----	D	-----	----	
34503	B5III	3.58	-.11	A	5.03	101	
34748	B1.5VN	6.33	-.12	A	7.92	384	a 1
34759	B5V	5.22	-.14	A	6.06	163	
34816	B0.5IV	4.29	-.25	B	8.30	457	
34863	B7IVNN	5.29	----	D	-----	----	
34959	B5VP	6.51	-.09	A	7.92	384	a 1
34989	B1V	5.79	-.13	A	8.90	602	
35007	B3V	5.69	-.19	A	7.92	384	a 1
35039	B2IV-V	4.72	-.18	A	7.92	384	a 1
35149	B1VN	4.99	-.15	A	7.92	384	a 1
35299	B1.5V	5.68	-.20	A	7.92	384	a 1
35337	B2IV	5.25	-.21	B	8.16	428	
35407	B4IVN	6.33	-.15	A	7.92	384	a 1
35411	B0.5VNN	3.42	-.17	A	7.92	384	a 1
35439	B1VN	4.94	-.21	A	7.92	384	a 1
35468	B2III	1.64	-.21	A	4.85	93	
35532	B2VN	6.24	-.08	A	7.96	391	3
35588	B2.5V	6.17	-.19	A	7.92	384	a 1
35671	B5V	5.42	-.10	A	6.14	169	
35708	B2.5IV	4.87	-.15	A	6.76	225	

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TABLE 4-Continued

H D	Spectrum	V	B-V	Ref	V_0-M_v	r(pc)	Com
35715	B1V	4.60	-.22	A	7.92	384	1
35912	B2V	6.41	-.19	A	7.92	384	1
36166	B2V	5.78	-.21	A	7.92	384	1
36267	B5V	4.19	-.15	A	5.06	103	
36285	B2IV-V	6.34	-.21	A	8.47	494	1
36351	B1.5V	5.47	-.19	A	7.92	384	1
36371	B5IAB	4.74	+.32	A	9.81	916	
36430	B2V	6.23	-.19	A	8.47	494	1
36485	B2IV-V	6.86	-.17	A	8.33	463	1
36486	O9.5II-III	2.23	-.23	A	8.33	463	1
36512	B0V	4.61	-.28	A	8.47	494	1
36576	B2IV-VE2	5.72	-.01	A	7.43	306	3
36591	B1IV	5.34	-.20	A	8.33	463	1
36646	B4VN	6.56	-.11	A	8.33	463	1
36653	B3V	5.63	-.14	A	6.75	224	
36695	B1V	5.38	-.20	A	8.33	463	1
36741	B2V	6.61	-.20	A	7.92	384	1
36779	B2.5V	6.23	-.18	A	8.33	463	1
36819	B2.5IV	5.38	-.09	A	7.09	262	
36822	B0.5IV-V	4.41	-.17	A	8.18	432	3
36861	O8	3.39	-.19	B	8.93	611	
36862	----	5.56	----	D	8.93	611	
36959	B1V	5.67	-.24	B	8.47	494	1
36960	B0.5V	4.79	-.26	A	8.47	494	1
37016	B2.5V	6.28	-.16	A	8.47	494	1
37017	B1.5V	6.57	-.16	A	8.47	494	1
37018	B1V	4.61	-.21	A	8.47	494	1
37020	----	6.72	.00	B	8.47	494	1
37021	----	7.96	+.24	C	8.47	494	1
37022	O6E4P	5.13	.00	B	8.47	494	1
37023	----	6.70	+.08	B	8.47	494	1
37040	B2.5IV	6.31	-.13	B	8.47	494	1

TABLE 4-Continued

HD	Spectrum	V	B−V	Ref	V_0-M_v	r (pc)	Com
37041	09.5VE3P	5.08	-.11	B	8.47	494	c 1
37043	09III	2.77	-.24	B	8.47	494	c 1
37055	B3IV	6.41	-.13	A	8.33	463	1
37128	B0IA	1.70	-.19	A	8.33	463	1
37150	B3IV	6.57	-.20	A	8.47	494	1
37202	B4IIIP	2.95	-.19	A	7.65	339	2
37209	B2IV	5.72	-.23	A	8.47	494	1
37232	B2IV-V	6.13	-.17	A	8.32	461	
37303	B1.5V	6.05	-.23	A	8.47	494	1
37356	B2IV-V	6.20	-.04	A	8.47	494	1
37367	B2IV-V	5.95	----	D	-----	----	
37438	B3IV	5.17	-.15	A	6.72	221	
37468	09.5V	3.85	-.24	A	8.33	463	b 1
37479	B2VP	6.66	-.18	A	8.33	463	b 1
37481	B1.5IV	6.65	-.19	A	9.97	986	
37490	B2IIIE1	4.58	-.11	A	7.92	384	a 1
37635	B7V	6.50	-.12	A	7.00	251	
37711	B3IV	4.86	-.14	A	6.38	189	
37742	09.5IB	1.77	-.21	B	8.33	463	1
37743	----	4.21	----	D	8.33	463	1
37744	B1.5V	6.22	-.21	A	8.33	463	1
37756	B2IV-V	4.95	-.22	A	8.33	463	1
37967	B2.5VE3	6.20	-.06	A	7.92	384	2
37971	B3IVP	6.21	-.13	B	7.70	347	3
38622	B2IV-V	2.89	-.17	A	5.08	104	
38771	B0.5IA	2.09	-.18	A	8.77	567	
39291	B2IV-V	5.36	-.21	A	7.67	342	
39698	B2V	5.92	-.17	A	7.91	382	
39777	B1.5V	6.57	-.20	A	9.22	698	
39970	A0IA	6.02	+.38	A	10.87	1492	1
40111	B1IB	4.83	-.07	A	10.87	1492	1
41117	B2IA	4.61	+.28	A	10.87	1492	1

TABLE 4-Continued

H D	Spectrum	V	B-V	Ref	V_0-M_V	r (pc)	Com
41335	B2VE3+N	5.21	-.08	A	6.93	243	3
41692	B5IV	5.39	-.14	A	6.33	184	
41753	B3IV	4.42	-.18	A	6.06	163	
41814	B3V	6.66	-.15	B	7.81	365	
42087	B2.5IB	5.78	+.20	A	10.87	1492	1
42545	B5VN	4.98	-.16	A	6.18	172	2
42560	B3IV	4.47	-.19	A	6.14	169	
42690	B2V	5.05	-.21	A	7.16	270	
42927	B3III	6.53	-.16	B	8.61	527	
43112	B1V	5.92	-.25	A	9.39	755	
43285	B6V	6.07	-.13	A	6.54	204	
43317	B3IV	6.64	-.17	A	8.25	446	
43384	B3IAB	6.24	+.44	A	10.87	1492	1
43544	B2.5VE1N	5.94	-.17	B	7.69	345	3
43955	B2V	5.31	----	D	-----	----	
44112	B2.5V	5.28	-.20	A	7.12	265	
44173	B5III	6.53	-.10	A	7.95	389	
44458	B1VE2+	5.46	-.01	D	8.21	438	3
44700	B3V	6.39	-.15	A	7.54	322	
44743	B1II-III	1.97	-.24	B	6.54	203	3
45321	B2.5V	6.17	-.16	A	7.89	378	
45542	B6III	4.16	-.13	A	5.53	128	
45546	B2V	5.07	-.19	A	7.12	265	
45725	B3VE2	3.75	-.17	A	4.96	98	3
45726	----	5.22	----	D	4.96	98	3
45727	----	5.60	----	D	4.96	98	3
45995	B2.5VE2+	6.12	-.10	A	7.66	340	3
46064	B1.5V	6.16	-.15	B	8.66	539	
46487	B5VN	5.09	-.15	A	5.96	156	3
46769	B8IB	5.79	-.01	A	11.36	1870	
47129	O8F	6.06	+.05	B	-----	----	
47240	B1II	6.16	+.14	A	10.32	1158	

TABLE 4-Continued

HD	Spectrum	V	B−V	Ref	V_0-M_V	r(pc)	Com
47432	O9.5II	6.22	+.13	A	10.83	1465	
47839	O7	4.65	−.25	A	10.34	1169	
48099	O5.5	6.35	−.05	A	11.44	1940	
48434	B0III	5.86	−.02	A	10.12	1056	3
48879	B4IV	5.13	−.17	A	6.70	219	
48977	B2.5V	5.92	−.18	A	7.70	347	
49340	B7III	5.11	−.13	A	6.11	167	
49567	B3II-III	6.15	−.14	A	9.30	724	3
49662	B6V	5.39	−.10	B	5.77	143	
50820	B3IVE3+F	6.21	+.56	B	5.63	134	3
51309	B3II	4.37	−.06	B	8.41	481	
52382	B1IB	6.50	+.19	A	11.46	1958	
52559	B2IV-V	6.56	−.02	A	8.30	457	
52918	B1IV	4.99	−.20	A	8.61	527	
53244	B8II	4.12	−.11	B	5.42	121	2
53755	B0.5IVN	6.49	−.05	B	9.90	955	3
53974	B0.5III	5.39	+.05	B	9.20	692	
53975	O8	6.47	−.10	B	11.74	2227	
54662	O6.5	6.21	+.03	B	11.06	1629	
54764	B1II	6.03	+.06	B	10.43	1219	
55879	B0III	6.04	−.18	B	10.78	1432	3
57682	O9V	6.40	−.19	A	11.44	1940	
58050	B2VE3	6.44	−.20	A	8.52	506	3
58343	B2.5IVE1	5.33	−.04	D	6.89	239	3
60325	B2IIIP	6.21	−.04	D	8.91	605	3
60855	B2VE1+	5.70	−.12	B	7.54	322	3
61068	B2III	5.66	----	D	-----	----	
65875	B2.5VE3+	6.49	−.09	A	8.00	398	3
66834	B3III	6.13	−.16	B	8.21	438	
67797	B5IV	4.40	−.15	B	5.37	119	
67880	B2.5V	5.68	−.17	B	7.43	306	
74280	B4V	4.29	−.20	A	5.39	120	

TABLE 4–Continued

HD	Spectrum	V	B−V	Ref	$V_0 - M_v$	r (pc)	Com
83754	B5V	5.05	−.15	B	5.92	153	
87015	B2.5IV	5.66	−.20	A	7.70	347	
89688	B2.5IV	6.68	−.09	A	8.39	476	
90994	B6V	5.07	−.14	A	5.57	130	
91316	B1IAB	3.85	−.14	A	10.00	1000	
100600	B4V	5.95	−.18	A	7.05	257	
104337	B1V	5.28	----	D	-----	----	
109387	B6IIIP	3.82	−.11	A	5.13	106	3
116658	B1IV	0.97	−.23	B	4.68	86	
120315	B3V	1.84	−.18	A	3.08	41	
138485	B2VN	5.50	−.14	B	7.40	302	2
138749	B6VNN	4.14	−.13	A	4.61	84	3
138764	B6IV	5.14	−.09	A	6.20	174	1
142096	B2.5V	5.03	−.01	B	6.20	174	1
142378	B5V	5.93	−.02	B	6.20	174	1
142983	B5IIIP	4.87	−.10	B	7.29	287	2
144217	B0.5V	2.63	−.08	B	6.20	174	1
144218	B2IV−V	4.92	−.02	B	6.20	174	1
145502	B2IVP	4.01	+.03	B	6.20	174	1
147394	B5IV	3.88	−.15	A	4.85	93	
148184	B1.5VE4	4.43	+.28	B	6.20	174	1
149757	O9.5VNN	2.56	+.02	B	6.50	200	2
154445	B1V	5.62	----	D	-----	----	
155763	B6III	3.17	−.11	B	4.48	79	
156633	B1.5VP	4.77	−.18	A	7.36	296	3
158148	B5V	5.53	−.13	A	6.34	185	
160762	B3IV	3.80	−.18	A	5.44	122	
161056	B1.5V	6.32	+.37	A	7.26	283	
163472	B2IV−V	5.84	+.09	A	7.25	282	
164284	B2VE1	4.69	−.05	A	6.32	184	3
164353	B5IB	3.97	+.02	A	9.44	772	
164432	B2IV	6.37	−.09	A	8.92	608	

TABLE 4-Continued

HD	Spectrum	V	B-V	Ref	$V_0 - M_V$	r (pc)	Com
164852	B3IV	5.27	-.10	A	6.67	216	
165174	B0IIIN	6.15	-.02	A	10.41	1207	3
166182	B2IV	4.35	-.18	A	7.17	272	
167771	O8	6.54	+.12	B	11.15	1698	3
167965	B7IV	5.58	-.12	A	6.18	172	3
168021	B0IB	6.43	+.27	D	11.10	1659	
168199	B5V	6.30	-.03	A	6.81	230	
168797	B3VE1	6.11	-.03	A	6.90	240	3
170111	B3V	6.52	-.11	A	7.55	324	
170580	B2V	6.70	+.10	A	7.88	377	
170650	B6IV	5.89	-.10	A	6.37	188	
170740	B2IV-V	5.91	+.27	C	6.78	227	
171406	B4V	6.58	-.12	A	7.50	316	
171780	B5VN	6.09	-.11	A	6.84	233	3
173087	B5V	6.47	-.13	A	7.28	286	
173370	B9V	5.02	-.06	A	-----	----	
174179	B3IVP	6.05	-.13	A	7.54	322	3
174237	B2.5V	5.87	-.09	A	7.38	299	
174585	B3IV	5.90	-.16	A	7.48	313	
174959	B6IV	6.08	-.11	A	6.59	208	
175156	B5II	5.04	----	D	-----	----	
176162	B5IV	5.36	----	D	-----	----	
176304	B2VP	6.73	+.24	A	7.49	315	3
176502	B4IV	6.21	-.16	A	7.75	355	
176582	B5IV	6.40	-.17	A	7.40	302	
176819	B2IV-V	6.68	+.02	A	8.30	457	
176871	B5V	5.68	-.08	A	6.34	185	
177003	B2.5IV	5.37	-.19	A	7.38	299	
177109	B5IV	6.38	-.12	A	7.26	283	
178175	B2VE1	5.54	-.10	D	7.32	291	3
178329	B3V	6.49	-.16	A	7.67	342	
178475	B6IV	5.28	-.11	A	5.79	144	

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TABLE 4-Continued

HD	Spectrum	V	B-V	Ref	V_0-M_v	r (pc)	Com
179406	B3V	5.33	+.13	A	5.64	134	
180163	B2.5IV	4.40	-.15	A	6.29	181	
180554	B4IV	4.75	-.06	A	5.99	158	
180968	B1IV	5.42	+.02	A	8.38	474	
181409	B2IV	6.59	-.19	A	9.44	772	
181858	B3IVP	6.65	-.03	A	7.84	370	3
182255	B6III	5.19	-.12	A	6.53	202	
182568	B3IV	4.98	-.12	A	6.44	194	
183144	B4III	6.32	-.07	A	7.89	378	
183362	B3VE1+	6.32	-.14	A	7.44	308	3
183537	B5VN	6.31	-.10	A	7.03	255	3
184171	B3IV	4.72	-.15	A	6.27	179	
184915	B0.5IIIN	4.96	-.01	A	8.95	616	3
184930	B5III	4.34	-.08	A	5.70	138	
185268	B5V	6.45	-.09	A	7.14	268	
185423	B3III	6.36	+.04	A	7.84	370	
185507	B2.5VP	5.18	+.02	A	6.36	187	3
185859	B0.5IA	6.52	+.39	A	11.44	1940	
185915	B6IV	6.65	+.01	A	6.80	229	
185936	B5V	6.00	-.08	A	6.66	215	
186660	B3III	6.48	+.04	A	7.96	391	
187459	B0.5II	6.44	+.18	A	10.62	1330	
187567	B2.5IVE1+	6.52	-.08	A	8.11	419	3
187811	B2.5V	4.94	-.16	A	6.66	215	
187879	B1III	5.68	-.04	A	9.02	637	
187961	B7V	6.53	-.01	A	6.70	219	
188001	O8F	6.25	+.01	A	-----	----	
188209	O9.5IA	5.65	-.09	A	11.51	2004	
188252	B2III	5.68	----	D	-----	----	
188293	B7VN	5.71	-.08	A	6.09	165	3
188439	B0.5IIIN	6.30	-.12	A	10.62	1330	3
188665	B5V	5.14	-.15	A	6.01	159	

TABLE 4-Continued

HD	Spectrum	V	B-V	Ref	V_0-M_v	r(pc)	Com
188892	B5IV	4.93	-.09	A	5.72	139	
189066	B5IV	6.02	-.16	A	7.02	253	
189178	B5V	5.45	-.11	A	6.20	174	
189432	B5IV	6.32	-.10	A	7.14	268	
189687	B3IV	5.17	-.16	A	6.75	224	
189775	B5III	6.14	-.19	A	7.74	353	
190603	B1.5IA	5.62	+.52	A	10.52	1270	
190993	B3V	5.06	-.18	A	6.30	182	
191263	B3IV	6.33	-.14	A	7.85	371	
191610	B2.5V	4.92	-.13	A	6.55	204	
191639	B1V	6.45	-.17	A	9.68	863	
191877	B1IB	6.26	-.02	A	11.85	2343	
192685	B3V	4.80	-.18	A	6.04	161	
192987	B6III	6.47	-.09	A	7.72	350	
193237	B1PE	4.78	+.41	A	-----	----	
193322	O9V	5.82	+.09	A	10.02	1009	
193536	B2V	6.45	-.13	A	8.32	461	
194335	B2VE1N	5.88	-.20	A	7.96	391	3
195556	B2.5IV	4.94	-.08	A	6.62	211	
195810	B6III	4.03	-.13	A	5.40	120	
195986	B4III	6.58	-.11	A	8.27	451	
196035	B3IV	6.47	-.14	A	7.99	396	
196662	B5III	5.30	----	D	-----	----	
196740	B5IV	5.03	-.14	A	5.97	156	
196775	B3V	5.97	-.14	A	7.09	262	
197036	B5IV	6.58	-.06	A	7.28	286	
197419	B2IV-VE3	6.68	-.16	A	8.84	586	3
197511	B2V	5.38	-.10	A	7.16	270	
197770	B2III	6.31	+.34	A	7.87	375	
198183	B6IV	4.53	-.11	A	5.04	102	
198478	B3IA	4.82	+.40	A	10.33	1164	
198625	B4V	6.31	-.06	A	7.05	257	

TABLE 4-Continued

HD	Spectrum	V	B-V	Ref	V_0-M_V	r(pc)	Com
198781	B0.5V	6.44	+.05	A	9.45	776	
198820	B3III	6.42	-.15	A	8.47	494	
199081	B5V	4.80	-.14	A	5.64	134	
199140	B2III	6.52	-.15	A	9.55	813	
199579	O6	5.96	+.04	A	10.78	1432	
199661	B2.5IV	6.23	-.17	A	8.18	432	
200120	B1.5VE2NN	4.79	-.07	A	7.05	257	3
200310	B1VN	5.40	-.20	D	8.72	554	3
201733	B4IVP	6.61	-.15	A	8.12	421	3
201819	B0.5IVN	6.53	-.14	A	10.21	1101	3
201836	B6IV	6.46	-.00	A	6.64	213	
202214	B0V	5.64	+.10	A	9.60	830	1
202654	B4IV	6.45	-.15	A	7.96	391	
202904	B2VE1+	4.28	-.08	A	6.00	158	3
203025	B3III	6.40	+.19	A	9.60	830	1
203064	O8N	5.01	-.03	A	10.07	1032	3
203245	B6V	5.74	-.14	A	6.24	177	
203467	B3IVE1	5.18	-.05	A	6.43	193	3
204172	B0IB	5.94	-.10	A	11.72	2207	
204403	B3IV	5.30	-.14	A	6.82	231	
204770	B7V	5.43	-.11	A	5.90	151	
205021	B1III	3.19	-.23	A	7.10	263	
205139	B1IB	5.53	+.13	A	9.60	830	1
205637	B2.5VP	4.72	-.16	B	6.44	194	3
206165	B2IB	4.73	+.28	A	9.60	830	1
206267	O6	5.71	+.20	A	9.60	830	1
206672	B3IV	4.66	-.11	A	6.09	165	
207198	O9II	5.95	+.30	A	9.60	830	1
207330	B2.5III	4.18	-.10	A	6.32	184	
207563	B2V	6.28	-.10	A	8.06	409	
208057	B3V	5.08	-.16	A	6.26	179	
208095	B6IV-V	5.70	-.12	A	6.24	177	

TABLE 4-Continued

HD	Spectrum	V	B-V	Ref	V_0-M_V	r(pc)	Com
208682	B2.5VE2	5.88	-.09	A	7.39	301	3
208947	B2V	6.40	-.06	A	8.06	409	
209008	B3III	6.00	-.12	A	7.96	391	
209339	B0IV	6.65	+.07	A	9.60	830	1
209409	B7IVE1	4.70	-.09	A	5.21	110	3
209419	B5III	5.78	-.12	A	7.26	283	
209481	O9VN	5.56	+.06	A	9.60	830	1
209961	B2V	6.30	-.09	A	8.29	455	1
209975	O9.5IB	5.12	+.08	A	10.27	1132	
210191	B2.5IV	5.74	----	D	-----	----	
210424	B7III	5.46	-.12	D	6.46	196	
210839	O6F	5.06	+.24	A	-----	----	
211924	B5IV	5.38	-.03	A	5.99	158	
212076	B2IV-V	5.04	-.16	A	7.20	275	
212120	B6V	4.57	-.11	A	4.98	99	
212222	B5V	6.40	-.08	A	7.06	258	
212571	B1VE1	4.68	-.03	A	7.49	315	3
212883	B2V	6.50	-.13	A	8.29	455	1
212978	B1.5V	6.16	-.14	A	8.29	455	1
213087	B0.5IB	5.52	+.36	A	9.93	968	
213420	B2IV	4.53	-.09	A	8.29	455	1
214167	B1.5V	6.46	-.15	C	8.29	455	1
214168	B1VE1	5.74	-.14	A	8.29	455	1
214240	B3IV	6.29	-.05	A	8.29	455	1
214680	O9V	4.88	-.20	B	8.29	455	1
214993	B1.5III	5.26	-.14	A	8.29	455	1
215191	B1.5V	6.43	-.12	A	8.29	455	1
216200	B4III	5.93	+.07	A	8.29	455	1
216916	B2IV	5.61	-.15	A	8.29	455	1
217050	B4IIIE1P	5.42	-.09	A	7.05	257	3
217101	B2IV-V	6.18	-.16	A	8.29	455	1
217543	B3VP	6.53	-.12	A	8.29	455	1

TABLE 4–Continued

HD	Spectrum	V	B−V	Ref	V_0-M_v	r (pc)	Com
217811	B2V	6.41	−.02	A	8.29	455	1
217891	B6VE1	4.55	−.12	A	4.99	100	3
217943	B2V	6.75	−.02	A	8.29	455	
218376	B0.5III	4.84	−.04	A	8.92	608	
218407	B2V	6.66	−.05	A	8.29	455	1
218440	B2.5IV	6.40	−.02	A	7.90	380	
218537	B3V	6.25	−.03	A	7.04	256	
219688	B5VN	4.39	−.14	A	5.23	111	3
221253	B3IV	4.88	−.13	A	6.37	188	
223128	B2IV	5.94	−.04	A	8.34	465	
223229	B3IV	6.06	−.14	A	7.58	328	
224151	B0.5II-III	6.01	+.18	A	10.66	1355	2
224544	B6IVE1+	6.51	−.13	A	7.08	261	3
224559	B4VE3N	6.52	−.10	A	8.28	453	2
224572	B1V	4.89	−.09	A	7.88	377	
225094	B3IAB	6.25	+.32	A	11.20	1737	

NOTES TO TABLE 4

10516	The region around $H\gamma$ is heavily veiled. The luminosity class was determined from the weakness of $\lambda 4121$.
11415	Shell star. Hydrogen lines are narrow and intense; helium lines are also narrow.
24534	The region between $H\beta$ and $H\gamma$ is veiled. He I $\lambda 4471$ is absent.
26326	Photometry from Hogg (1958).
34959	Shell star. Hydrogen lines are sharp but somewhat veiled; helium lines are diffuse.
37021	Photometry from Sharpless (1952).
37022	Nebular emission lines are present redward of $H\beta$.
37041	See note to HD 37022.
37202	Shell star. Hydrogen lines are strong and sharp; helium lines are broad.
37479	Helium lines are exceptionally strong.
37971	Shell star. Both hydrogen and helium lines are sharp. Mg II $\lambda 4481$ is rather strong for B3 IV.
60325	He I $\lambda 4009$ is weak and diffuse. Spectrum is otherwise normal for B2 III.
109387	Hydrogen lines are somewhat diffuse for B6 III.
142983	Shell star. A metallic spectrum is present in addition to the sharp hydrogen lines and diffuse helium lines.
145502	Hydrogen lines are strong, and $\lambda 4009$ is weak for B2 IV.
156633	Hydrogen lines are strong and shaded to the violet. He I $\lambda 4121$ is somewhat weak for B1.5 V.
170740	Photometry from Johnson (1960).
174179	Shell star. Hydrogen lines are somewhat narrow but otherwise normal.
176304	Spectral type derived from hydrogen and helium lines, but lines of Si II, Mg II, and O II are all strong.
181858	Hydrogen lines are unusually strong, especially $H\epsilon$ and $H\zeta$.
185507	Double-lined spectroscopic binary. Both components are visible in the hydrogen and helium lines.
193237	Almost all the lines in the spectrum have redward-displaced emission components. N II $\lambda 3995$ is unusually strong.
201733	Shell star. Hydrogen lines are sharp, but helium lines are diffuse.
205637	See note to HD 201733.
214167	Photometry from Harris (1955).
217050	A Be star with shell characteristics. $H\beta$ is barely reversed, and the Fe II emission lines are present. The other hydrogen lines are strong and sharp, while the helium lines are broad.
217543	Shell star. Hydrogen lines are slightly narrow and veiled; helium lines are very diffuse.

TABLE 5

POST-GC CATALOGUES USED FOR NEW PROPER MOTIONS

Name	*Index* No.	*FK4*	Place, Equinox
2 Cp 25..........	81–84	94	Cape, 1925
3 Cp 25..........	85–87	100	Cape, 1925
1 Cp 50..........	88–90	125	Cape, 1950
Cord F$_{50}$..........	110–111	111	Córdoba, 1950
2 Grw 25.........	118–121	70	Greenwich, 1925
Mü-Can$_{50}$Vert.....	256–257	140	Munich-Canberra, 1950
Ott 15$_7$...........	267–268	148	Ottawa, 1950
Nik$_{30}$Sem.........	271	103	Nikolayev, 1930
Nik$_{30}$Zim..........	272	105	Nikolayev, 1930
Ott 15$_2$...........	281	93	Ottawa, 1925
Ott 15$_3$...........	282	129	Ottawa, 1925
Pu 25 Renz.......	318–319	88	Pulkovo, 1925
Pu 30 Renz.......	323	104	Pulkovo, 1930
Pu 30 Vert........	323	102	Nikolayev, 1930
Pu 50 Nem.......	330	124	Pulkovo, 1950
Wash 14 Zod......	372	95	Washington, 1925
Wash 25 Alt......	374	96	Washington, 1925
W 40............	375	110	Washington, 1940
W 25............	376	99	Washington, 1925
W1$_{50}$.............	377	120	Washington, 1950
W2$_{50}$.............	378	133	Washington, 1950
W3$_{50}$.............	....	....	Washington, 1950
Mü 50...........	....	....	Munich, 1950
Be3$_{50}$...........	....	....	Besançon, 1950
Par OB...........	....	....	Paris, 1950

EXPLANATION OF COLUMNS OF TABLE 6

Column

1 HD number
2 Right ascension (1950), to nearest $0\overset{\mathrm{m}}{.}1$
3 Declination (1950), to nearest minute of arc
4 New annual proper motion in right ascension, on the system of the *FK4*, to nearest $0\overset{\mathrm{s}}{.}0001$
5 Probable error of proper motion in right ascension
6 New annual proper motion in declination, on the system of the *FK4*, to nearest $0\overset{\prime\prime}{.}001$
7 Probable error of proper motion in declination
8 Radial velocity in km sec^{-1} (if a reference more recent than Wilson 1953 was used, it is given in the Notes to Table 6; Notes also specify the point to which the proper motion refers, if the star is a close binary)
9 Probable error of radial velocity

TABLE 6

POSITIONS, PROPER MOTIONS, AND RADIAL VELOCITIES OF BRIGHT O AND B STARS

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
829	0 10.2	37 25	0.0002	0.0001	0.002	0.001	-9.6	0.7
886	0 10.7	14 54	0.0001	0.0001	-0.007	0.001	4.1	0.5
1337	0 15.1	51 9	-0.0004	0.0001	0.002	0.002	-31.4	0.4
1976	0 21.6	51 45	0.0015	0.0001	-0.002	0.003	-14.5	1.4
2729	0 28.5	66 15	0.0036	0.0003	0.000	0.003	-9.5	1.2
2905	0 30.1	62 39	0.0005	0.0001	0.001	0.001	-2.3	0.5
3240	0 33.3	53 54	0.0025	0.0001	0.004	0.001	1.1	1.2
3360	0 34.2	53 37	0.0022	0.0001	-0.004	0.001	2.0	0.4
3369	0 34.2	33 27	0.0011	0.0001	0.000	0.001	8.7	0.5
3379	0 34.2	14 57	0.0003	0.0001	-0.004	0.002	-6.3	1.7
3901	0 39.3	50 14	0.0014	0.0000	0.001	0.001	-4.6	0.4
4142	0 41.6	47 35	-0.0045	0.0001	0.014	0.001	-60.0	2.5
4180	0 41.9	48 1	0.0018	0.0001	-0.002	0.001	-13.6	1.5
4727	0 47.0	40 48	0.0017	0.0001	-0.015	0.001	-23.9	0.5
5394	0 53.7	60 27	0.0034	0.0001	0.000	0.001	-6.8	0.5
6300	1 1.8	50 45	0.0012	0.0001	0.000	0.003	-4.2	0.8
10516	1 40.5	50 26	0.0027	0.0001	-0.010	0.001	0.8	0.5
11241	1 48.7	54 54	0.0014	0.0001	-0.004	0.002	-9.0	1.0
11415	1 50.8	63 26	0.0053	0.0001	-0.012	0.001	-8.2	0.4
12301	1 59.3	64 9	-0.0005	0.0002	0.001	0.001	-20.0	1.2
13267	2 8.0	57 25	0.0001	0.0001	0.009	0.001	-33.8	1.2
13854	2 13.3	56 49	-0.0002	0.0002	0.004	0.002	-40.2	1.2
14372	2 17.4	47 5	0.0013	0.0003	-0.009	0.001	1.6	1.2
14818	2 21.7	56 23	0.0004	0.0001	-0.001	0.002	-46.0	1.2
14951	2 22.1	10 23	0.0014	0.0001	-0.009	0.002	4.0	2.5

TABLE 6—Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
16582	2 36.9	0 7	0.0007	0.0000	-0.002	0.001	13.0	0.5
16908	2 40.5	27 30	0.0007	0.0001	-0.009	0.001	8.8	1.0
17081	2 41.7	-14 4	-0.0006	0.0001	-0.014	0.001	15.4	1.2
17543	2 46.5	17 15	0.0004	0.0001	-0.012	0.001	8.8	0.5
17769	2 48.7	14 53	0.0020	0.0001	-0.019	0.002	17.0	1.2
18537	2 57.3	52 9	0.0031	0.0002	-0.018	0.003	-4.4	1.2
18604	2 57.0	8 43	0.0001	0.0001	-0.010	0.002	10.2	1.2
18883	2 59.8	4 9	0.0007	0.0003	0.008	0.004	11.8	1.2
19268	3 4.5	52 1	0.0029	0.0001	-0.019	0.003	6.0	1.2
19374	3 4.6	17 41	-0.0015	0.0000	0.010	0.001	23.8	1.0
20315	3 14.4	43 51	0.0023	0.0001	-0.020	0.004	0.0	2.5
20336	3 15.6	65 28	0.0017	0.0002	-0.007	0.000	12.5	1.0
20365	3 15.1	50 2	0.0024	0.0001	-0.023	0.000	-5.0	2.5
20418	3 15.6	49 55	0.0021	0.0001	-0.022	0.001	3.0	2.5
20756	3 18.3	20 58	0.0020	0.0001	-0.019	0.001	17.2	0.7
20809	3 19.7	49 2	0.0022	0.0001	-0.017	0.001	4.8	1.2
21071	3 22.4	48 57	0.0019	0.0002	-0.026	0.001	10.0	1.2
21278	3 24.5	48 53	0.0022	0.0009	-0.020	0.001	7.0	2.5
21362	3 25.3	49 41	0.0007	0.0000	-0.022	0.001	0.0	2.5
21428	3 25.8	49 20	0.0024	0.0001	-0.023	0.002	-1.0	2.5
21455	3 25.9	46 46	0.0021	0.0001	-0.028	0.004	-0.7	1.2
21803	3 29.2	44 41	0.0002	0.0001	-0.005	0.000	3.2	0.9
21856	3 29.5	35 18	-0.0004	0.0001	0.004	0.001	25.0	2.5
22192	3 32.9	48 2	0.0024	0.0001	-0.025	0.000	0.3	0.5

TABLE 6—Continued

HD	α_{1950}		δ_{1950}		μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
22928	3	39.4	47	38	0.0027	0.0001	-0.031	0.001	-9.0	5.0
22951	3	39.2	33	48	0.0010	0.0001	-0.006	0.001	27.1	0.8
23180	3	41.2	32	8	0.0008	0.0001	-0.010	0.001	18.8	0.4
23288	3	41.8	24	8	0.0012	0.0000	-0.043	0.003	1.5	1.0
23302	3	41.9	23	57	0.0012	0.0001	-0.042	0.001	7.4	0.9
23338	3	42.2	24	19	0.0016	0.0002	-0.040	0.002	5.5	0.5
23408	3	42.8	24	13	0.0015	0.0001	-0.045	0.002	7.5	0.5
23466	3	43.0	5	54	0.0014	0.0001	-0.011	0.001	15.7	1.3
23480	3	43.4	23	48	0.0015	0.0002	-0.042	0.001	4.4	1.0
23625	3	44.7	33	27	-0.0002	0.0000	0.011	0.004	21.9	0.9
23630	3	44.5	23	57	0.0016	0.0001	-0.043	0.001	5.1	0.8
23793	3	45.5	10	59	0.0018	0.0001	-0.025	0.001	16.3	0.8
24131	3	48.7	34	13	-0.0003	0.0002	-0.001	0.003	17.4	0.4
24398	3	51.0	31	44	0.0004	0.0001	-0.007	0.001	20.6	0.5
24504	3	52.4	47	44	0.0019	0.0001	-0.011	0.000	9.8	1.2
24534	3	52.3	30	54	0.0000	0.0002	-0.002	0.003	17.2	1.2
24640	3	53.2	34	56	0.0005	0.0001	-0.001	0.001	17.6	0.7
24760	3	54.5	39	52	0.0014	0.0001	-0.024	0.001	0.9	1.6
24912	3	55.7	35	39	0.0003	0.0000	0.003	0.001	70.1	1.2
25204	3	57.9	12	21	-0.0005	0.0001	-0.009	0.001	14.8	0.5
25340	3	59.0	-1	41	0.0014	0.0000	-0.012	0.002	13.5	0.4
25558	4	1.1	5	18	0.0001	0.0002	-0.007	0.000	10.7	0.8
25638	4	3.4	62	12	0.0011	0.0000	-0.001	0.003	-9.0	5.0
25940	4	5.0	47	35	0.0022	0.0001	-0.028	0.001	0.8	0.8
26326	4	7.0	-16	31	-0.0002	0.0001	0.006	0.003	13.7	1.2

TABLE 6–Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
26356	4 16.4	83 42	-0.0063	0.0002	0.014	0.001	-7.0	2.5
26739	4 11.1	-1 17	-0.0001	0.0004	-0.007	0.007	20.3	0.8
26912	4 12.8	8 46	0.0010	0.0001	-0.020	0.001	17.4	1.0
27192	4 16.4	50 48	0.0002	0.0001	-0.003	0.001	-18.1	1.5
27396	4 17.9	46 23	0.0024	0.0002	-0.038	0.004	1.3	1.2
28114	4 23.6	8 29	0.0000	0.0002	-0.003	0.005	14.0	2.5
28149	4 24.3	22 53	0.0002	0.0002	-0.018	0.006	5.0	2.5
28446	4 28.1	53 48	0.0001	0.0001	-0.001	0.001	-7.0	2.5
28497	4 26.8	-13 9	-0.0006	0.0001	0.000	0.003	12.0	2.5
29248	4 33.8	-3 27	-0.0003	0.0001	-0.003	0.001	14.4	0.8
29335	4 34.6	0 54	-0.0005	0.0002	-0.008	0.002	24.0	2.5
29763	4 39.2	22 52	-0.0002	0.0001	-0.016	0.001	12.9	0.6
29866	4 40.7	40 42	-0.0008	0.0017	-0.045	0.014	41.0	2.5
30076	4 41.7	-8 36	0.0001	0.0001	-0.002	0.001	15.1	1.2
30211	4 43.0	-3 21	0.0007	0.0001	-0.011	0.001	16.3	1.4
30614	4 49.1	66 16	0.0007	0.0001	0.010	0.001	6.1	0.5
30836	4 48.5	5 31	0.0001	0.0001	0.001	0.001	24.1	0.4
30870	4 49.0	9 54	0.0000	0.0001	-0.003	0.003	10.5	1.2
31237	4 51.6	2 22	-0.0003	0.0001	-0.002	0.001	23.0	0.4
31327	4 53.0	36 5	0.0002	0.0002	-0.011	0.001	-5.0	2.5
31331	4 52.3	0 23	0.0000	0.0002	-0.005	0.003	17.0	2.5
31726	4 55.5	-14 18	-0.0006	0.0001	-0.005	0.001	11.4	1.2
32343	5 1.8	58 54	-0.0002	0.0003	-0.004	0.002	-11.0	1.2
32612	5 1.6	-14 26	0.0001	0.0003	-0.001	0.002	16.0	2.5
32630	5 3.0	41 10	0.0026	0.0001	-0.067	0.001	7.1	0.9

TABLE 6—Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
32686	5 2.4	-3 6	-0.0007	0.0001	0.001	0.003	26.7	1.2
32990	5 5.1	24 12	0.0000	0.0001	-0.001	0.001	15.9	0.4
32991	5 4.9	21 38	-0.0002	0.0001	-0.011	0.005	18.1	1.4
33203	5 6.9	37 14	0.0001	0.0001	-0.003	0.003	8.6	1.2
33328	5 6.8	-8 49	-0.0004	0.0001	-0.003	0.001	3.0	2.5
34078	5 13.0	34 15	-0.0003	0.0001	0.049	0.002	59.1	0.5
34233	5 15.1	58 4	0.0010	0.0002	-0.018	0.003	-1.1	2.2
34447	5 14.6	-17 12	0.0002	0.0003	-0.002	0.002	12.0	2.5
34503	5 15.2	-6 54	-0.0014	0.0001	-0.009	0.001	20.1	1.2
34748	5 17.1	-1 28	-0.0005	0.0001	0.001	0.003	29.0	1.3
34759	5 18.3	41 45	0.0015	0.0001	-0.038	0.001	14.2	1.5
34816	5 17.3	-13 14	-0.0005	0.0001	-0.004	0.001	20.2	1.2
34863	5 17.7	-12 22	-0.0011	0.0002	0.007	0.002	16.0	5.0
34959	5 18.7	3 58	-0.0011	0.0002	-0.008	0.002	5.0	1.2
34989	5 19.0	8 23	0.0001	0.0001	-0.008	0.003	26.0	2.5
35007	5 18.9	-0 28	-0.0006	0.0001	0.005	0.003	7.2	1.2
35039	5 19.2	-0 26	-0.0004	0.0001	-0.001	0.001	28.8	1.2
35149	5 20.2	3 30	-0.0001	0.0002	0.004	0.001	18.0	2.5
35299	5 21.1	-0 12	-0.0003	0.0002	-0.002	0.003	22.1	1.2
35337	5 21.2	-13 58	-0.0003	0.0001	-0.005	0.004	18.2	1.2
35407	5 22.0	2 19	-0.0004	0.0003	0.012	0.001	-8.0	2.5
35411	5 22.0	-2 26	-0.0004	0.0001	-0.003	0.001	21.4	0.4
35439	5 22.1	1 48	-0.0006	0.0001	-0.002	0.002	19.3	1.2
35468	5 22.4	6 18	-0.0009	0.0001	-0.013	0.001	18.2	0.5
35532	5 23.2	16 39	-0.0004	0.0001	-0.011	0.002	31.5	1.1

TABLE 6—Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
35588	5 23.2	0 29	0.0002	0.0003	0.002	0.002	16.9	2.6
35671	5 24.2	17 55	0.0004	0.0001	-0.024	0.002	17.6	1.7
35708	5 24.6	21 54	0.0003	0.0001	-0.009	0.001	11.8	0.9
35715	5 24.2	3 3	-0.0001	0.0001	-0.007	0.001	12.2	0.5
35912	5 25.4	1 15	-0.0003	0.0000	0.003	0.001	34.2	1.2
36166	5 27.3	1 45	-0.0005	0.0002	-0.004	0.004	12.0	2.5
36267	5 28.1	5 55	0.0006	0.0000	-0.029	0.001	19.4	1.6
36285	5 27.9	-7 28	-0.0005	0.0001	0.002	0.002	11.0	1.2
36351	5 28.6	3 15	0.0000	0.0002	0.002	0.003	20.0	2.5
36371	5 29.5	32 9	-0.0002	0.0001	0.000	0.001	-0.2	0.5
36430	5 28.9	-6 45	-0.0003	0.0003	-0.004	0.002	23.0	1.2
36485	5 29.5	-0 19	-0.0003	0.0001	-0.001	0.001	21.0	2.5
36486	5 29.5	-0 20	-0.0003	0.0000	-0.001	0.001	16.0	1.2
36512	5 29.5	-7 20	0.0000	0.0002	-0.011	0.003	17.4	1.2
36576	5 30.6	18 30	-0.0002	0.0001	-0.004	0.003	44.0	2.5
36591	5 30.2	-1 38	0.0000	0.0001	-0.001	0.001	34.3	0.5
36646	5 30.6	-1 45	-0.0001	0.0001	-0.008	0.001	37.0	2.5
36653	5 31.1	14 16	-0.0003	0.0001	-0.009	0.002	19.1	1.2
36695	5 31.0	-1 11	-0.0006	0.0001	0.000	0.001	22.2	1.2
36741	5 31.4	1 22	-0.0003	0.0001	-0.006	0.005	14.2	1.2
36779	5 31.5	-1 4	0.0003	0.0001	0.000	0.002	4.0	2.5
36819	5 32.4	24 0	0.0008	0.0001	-0.016	0.001	22.8	1.0
36822	5 32.1	9 27	-0.0001	0.0001	-0.004	0.001	33.2	0.5
36861	5 32.4	9 54	0.0000	0.0001	-0.003	0.001	33.5	1.2
36959	5 32.6	-6 2	-0.0001	0.0001	-0.002	0.001	29.5	0.5

TABLE 6—Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
36960	5 32.6	-6 2	-0.0001	0.0001	0.001	0.001	27.7	0.5
37016	5 32.9	-4 27	-0.0006	0.0001	-0.001	0.003	31.0	2.5
37017	5 32.9	-4 32	-0.0006	0.0003	0.003	0.005	30.8	1.6
37018	5 32.9	-4 52	-0.0004	0.0001	-0.002	0.002	30.0	2.5
37020	5 32.8	-5 25	-0.0017	0.0004	0.009	0.027	33.4	1.2
37022	5 32.8	-5 25	-0.0005	0.0001	-0.002	0.001	28.0	2.5
37023	5 32.8	-5 25	-0.0012	0.0007	-0.018	0.011	31.0	2.5
37040	5 33.0	-4 24	-0.0002	0.0001	-0.002	0.001	30.0	2.5
37041	5 32.9	-5 27	-0.0003	0.0001	0.003	0.001	35.6	1.2
37043	5 33.0	-5 56	-0.0003	0.0001	0.003	0.001	23.5	0.4
37055	5 33.1	-3 17	-0.0006	0.0002	0.002	0.003	24.0	2.5
37128	5 33.7	-1 14	-0.0003	0.0001	-0.002	0.001	26.1	0.5
37150	5 33.8	-5 41	-0.0003	0.0001	-0.001	0.002	10.8	1.2
37202	5 34.7	21 7	0.0001	0.0000	-0.021	0.001	22.3	0.4
37209	5 34.2	-6 6	-0.0007	0.0001	0.002	0.003	29.4	1.2
37232	5 34.6	8 55	-0.0007	0.0002	0.006	0.001	42.0	2.5
37303	5 35.0	-5 58	-0.0002	0.0001	-0.006	0.003	28.8	1.2
37356	5 35.4	-4 51	-0.0006	0.0001	0.003	0.002	29.1	1.2
37367	5 36.1	29 11	0.0000	0.0001	-0.004	0.001	25.2	1.1
37438	5 36.6	25 52	0.0008	0.0001	-0.023	0.002	13.5	0.5
37468	5 36.2	-2 38	-0.0002	0.0001	0.000	0.001	29.2	1.2
37479	5 36.3	-2 37	0.0001	0.0001	-0.006	0.003	29.0	2.5
37481	5 36.2	-6 36	-0.0002	0.0001	-0.008	0.001	15.0	2.5
37490	5 36.5	4 6	-0.0003	0.0001	0.001	0.003	21.8	0.5
37635	5 37.1	-9 44	-0.0001	0.0000	-0.005	0.001	21.0	2.5

TABLE 6—Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
37711	5 38.4	16 31	0.0003	0.0001	-0.018	0.001	21.1	1.4
37742	5 38.2	-1 58	-0.0003	0.0001	0.001	0.001	18.1	0.5
37744	5 38.1	-2 51	-0.0001	0.0001	0.002	0.001	29.0	1.2
37756	5 38.3	-1 9	-0.0002	0.0001	-0.008	0.002	29.7	0.7
37967	5 40.3	23 11	0.0003	0.0001	-0.014	0.001	18.3	1.0
37971	5 39.5	-16 45	-0.0011	0.0004	-0.004	0.005	15.5	1.2
38622	5 44.9	13 53	0.0000	0.0001	-0.016	0.003	30.0	0.8
38771	5 45.4	-9 41	-0.0005	0.0001	-0.004	0.002	20.6	1.2
39291	5 49.0	-7 32	-0.0002	0.0001	0.002	0.002	20.0	2.5
39698	5 52.0	19 45	-0.0004	0.0001	-0.009	0.001	7.2	1.2
39777	5 52.1	-4 4	-0.0005	0.0002	-0.004	0.002	25.4	1.2
39970	5 53.9	24 15	0.0002	0.0001	-0.006	0.002	0.5	1.2
40111	5 54.9	25 57	-0.0001	0.0001	-0.003	0.002	8.0	2.5
41117	6 0.9	20 8	-0.0012	0.0004	-0.009	0.002	17.4	0.4
41335	6 1.8	-6 42	-0.0005	0.0001	0.003	0.004	51.0	5.0
41692	6 4.2	-4 11	-0.0008	0.0001	-0.003	0.003	20.3	1.2
41753	6 4.7	14 47	0.0003	0.0000	-0.020	0.001	23.3	0.2
41814	6 4.5	-11 10	-0.0009	0.0001	-0.008	0.002	12.9	1.2
42087	6 6.7	23 7	-0.0002	0.0001	-0.005	0.001	16.0	2.5
42545	6 9.2	16 9	0.0001	0.0003	-0.021	0.002	20.7	1.2
42560	6 9.1	14 13	0.0000	0.0001	-0.024	0.002	39.9	0.8
42690	6 9.4	-6 32	-0.0006	0.0001	0.002	0.002	28.7	0.5
42927	6 10.6	-17 45	-0.0012	0.0007	0.005	0.005	8.4	1.2
43112	6 12.3	13 52	0.0014	0.0001	-0.002	0.002	36.0	2.5
43285	6 13.0	6 5	-0.0007	0.0007	-0.025	0.010	26.0	2.5

TABLE 6–Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
43317	6 13.1	4 18	-0.0005	0.0001	-0.002	0.000	13.0	2.5
43384	6 13.9	23 46	0.0000	0.0001	-0.003	0.001	13.2	1.2
43544	6 13.9	-16 36	-0.0002	0.0004	-0.002	0.005	13.6	1.2
43955	6 16.1	-19 57	-0.0013	0.0001	0.000	0.003	23.0	5.0
44112	6 17.3	-7 48	-0.0008	0.0001	-0.005	0.001	29.0	2.5
44173	6 18.1	11 47	-0.0004	0.0002	0.001	0.001	18.8	1.2
44458	6 19.1	-11 45	-0.0013	0.0003	0.005	0.001	21.0	5.0
44700	6 20.7	3 47	0.0002	0.0001	-0.012	0.001	29.4	1.3
44743	6 20.5	-17 56	-0.0008	0.0001	0.000	0.001	33.7	0.5
45321	6 24.1	-4 34	-0.0010	0.0004	-0.003	0.004	10.0	2.5
45542	6 26.0	20 15	-0.0013	0.0001	-0.019	0.001	39.4	0.5
45546	6 25.5	-4 44	-0.0007	0.0001	-0.001	0.001	24.5	0.5
45725	6 26.4	-7 0	-0.0006	0.0001	-0.010	0.002	22.0	2.5
45726	6 26.4	-7 0	-0.0012	0.0004	-0.002	0.006	18.0	2.5
45995	6 28.4	11 17	0.0004	0.0001	-0.008	0.003	-20.0	2.5
46064	6 28.3	-13 7	-0.0004	0.0001	0.002	0.007	2.3	1.2
46487	6 31.1	-1 11	-0.0005	0.0001	-0.023	0.001	25.0	2.5
46769	6 32.7	0 56	-0.0002	0.0003	-0.004	0.005	10.2	1.2
47129	6 34.7	6 11	-0.0004	0.0002	0.004	0.003	25.5	0.4
47240	6 35.2	5 0	-0.0006	0.0001	-0.006	0.005	36.0	2.5
47432	6 36.0	1 40	-0.0002	0.0002	-0.008	0.001	58.4	1.2
47839	6 38.2	9 57	-0.0003	0.0001	-0.006	0.001	33.2	1.2
48099	6 39.3	6 24	0.0000	0.0002	0.001	0.001	31.0	1.2
48434	6 41.0	3 59	-0.0003	0.0002	0.003	0.001	34.5	1.2
48879	6 45.7	67 38	0.0012	0.0002	-0.006	0.001	5.3	1.2

TABLE 6–Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
48977	6 43.8	8 39	-0.0004	0.0001	-0.008	0.001	10.3	1.2
49340	6 48.3	68 57	0.0015	0.0001	0.010	0.001	-21.0	2.5
49567	6 46.5	1 4	-0.0005	0.0001	-0.004	0.002	23.2	1.2
49662	6 46.7	-15 5	-0.0005	0.0002	-0.002	0.003	23.0	5.0
50820	6 52.2	-1 42	-0.0003	0.0002	0.000	0.003	13.0	1.2
51309	6 53.9	-16 59	-0.0006	0.0001	-0.001	0.001	41.0	1.2
52382	6 58.3	-9 8	-0.0005	0.0001	-0.007	0.003	51.0	2.5
52559	6 59.3	5 38	-0.0007	0.0004	-0.017	0.005	33.8	1.2
52918	7 0.4	-4 10	-0.0005	0.0001	0.000	0.001	24.8	1.2
53244	7 1.5	-15 33	-0.0006	0.0001	-0.007	0.001	30.0	2.5
53755	7 3.5	-10 35	-0.0008	0.0001	-0.005	0.003	16.0	5.0
53974	7 4.3	-11 13	-0.0007	0.0002	0.002	0.002	31.0	2.5
53975	7 4.3	-12 19	-0.0004	0.0002	0.008	0.003	33.0	2.5
54662	7 7.0	-10 16	-0.0005	0.0003	0.002	0.005	58.0	2.5
54764	7 7.3	-16 9	-0.0011	0.0003	-0.011	0.003	6.4	1.2
55879	7 12.1	-10 14	-0.0007	0.0001	-0.001	0.003	32.6	0.5
57682	7 19.6	-8 53	0.0002	0.0001	0.010	0.002	23.0	1.2
58050	7 21.6	15 37	-0.0001	0.0001	-0.006	0.002	38.1	1.2
58343	7 22.4	-16 6	-0.0002	0.0002	-0.028	0.001	-4.5	0.5
60325	7 31.1	-14 14	-0.0002	0.0003	-0.010	0.003	21.7	1.2
60855	7 33.8	-14 23	-0.0006	0.0001	-0.005	0.002	21.1	1.2
61068	7 34.5	-19 35	-0.0010	0.0001	0.004	0.001	22.0	2.5
65875	7 58.2	-2 45	-0.0005	0.0002	-0.003	0.001	48.1	1.8
66834	8 2.5	-19 35	-0.0009	0.0001	-0.002	0.003	13.8	1.2
67797	8 6.8	-19 6	-0.0014	0.0001	-0.011	[illegible]	[illegible]	[illegible]

TABLE 6—Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
67880	8 7.2	-16 6	-0.0012	0.0001	-0.018	0.001	32.9	1.2
74280	8 40.6	3 35	-0.0013	0.0001	-0.002	0.001	21.0	2.5
83754	9 37.9	-14 6	-0.0023	0.0001	-0.028	0.001	18.0	2.5
87015	10 0.0	22 11	-0.0010	0.0001	-0.011	0.003	3.0	2.5
89688	10 18.5	2 33	-0.0006	0.0001	-0.009	0.001	5.0	2.5
90994	10 27.7	-0 23	-0.0033	0.0001	-0.029	0.003	11.6	1.2
91316	10 30.2	9 34	-0.0006	0.0001	-0.007	0.001	42.0	0.5
100600	11 32.1	17 4	-0.0005	0.0001	-0.007	0.001	18.7	1.2
104337	11 58.3	-19 23	-0.0014	0.0001	0.001	0.003	1.7	1.2
109387	12 31.4	70 4	-0.0122	0.0001	0.008	0.001	-11.3	0.4
116658	13 22.6	-10 54	-0.0028	0.0001	-0.034	0.001	0.8	0.5
120315	13 45.6	49 34	-0.0131	0.0001	-0.016	0.001	-10.8	0.8
138485	15 30.1	-16 41	-0.0010	0.0001	-0.013	0.001	6.4	3.3
138749	15 30.9	31 32	-0.0018	0.0001	-0.013	0.001	-25.0	2.5
138764	15 31.7	-9 1	0.0002	0.0008	-0.032	0.001	-4.1	1.0
142096	15 50.4	-20 1	-0.0009	0.0001	-0.022	0.001	-3.0	2.0
142378	15 52.1	-19 14	-0.0008	0.0001	-0.017	0.003	-6.0	2.5
142983	15 55.4	-14 8	-0.0010	0.0001	-0.019	0.002	-5.6	1.2
144217	16 2.5	-19 40	-0.0003	0.0002	-0.024	0.001	-1.7	0.5
144218	16 2.5	-19 40	-0.0010	0.0001	-0.024	0.003	-4.7	1.2
145502	16 9.1	-19 20	-0.0008	0.0001	-0.030	0.002	-7.0	2.5
147394	16 18.2	46 26	-0.0017	0.0001	0.036	0.001	-13.8	0.5
148184	16 24.1	-18 21	-0.0003	0.0001	-0.024	0.000	-5.1	1.2
149757	16 34.4	-10 28	0.0006	0.0001	0.022	0.001	-10.7	3.7
154445	17 3.0	-0 50	0.0004	0.0001	0.002	0.001	19.2	0.8

TABLE 6—Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
155763	17 8.6	65 47	-0.0042	0.0001	0.019	0.001	-14.1	0.5
156633	17 15.5	33 9	-0.0005	0.0001	-0.006	0.001	-21.0	0.5
158148	17 24.7	20 7	0.0003	0.0003	0.016	0.003	-29.5	1.2
160762	17 38.1	46 2	-0.0010	0.0001	0.004	0.001	-20.0	0.5
161056	17 41.1	-7 3	-0.0006	0.0002	-0.014	0.003	26.0	2.5
163472	17 53.8	0 41	-0.0006	0.0002	0.002	0.002	-17.6	1.0
164284	17 57.8	4 22	0.0003	0.0001	-0.004	0.002	-11.0	2.5
164353	17 58.1	2 56	-0.0001	0.0001	-0.006	0.001	-1.6	0.4
164432	17 58.4	6 16	-0.0002	0.0003	-0.003	0.002	-16.5	2.0
164852	18 0.2	20 50	0.0000	0.0001	-0.009	0.001	-14.9	1.2
165174	18 2.1	1 55	0.0000	0.0001	-0.003	0.001	17.0	2.5
166182	18 6.6	20 48	0.0000	0.0001	-0.006	0.001	-14.5	0.5
167771	18 14.5	-18 29	0.0001	0.0002	-0.003	0.001	9.0	5.0
167965	18 14.1	42 8	-0.0003	0.0001	0.001	0.001	-20.5	0.5
168021	18 15.8	-18 38	0.0004	0.0001	-0.004	0.004	1.1	2.1
168199	18 15.8	13 45	-0.0001	0.0001	0.000	0.003	-20.7	1.2
168797	18 19.0	5 25	-0.0003	0.0003	-0.007	0.003	-9.0	2.5
170111	18 24.7	26 25	0.0001	0.0003	0.001	0.001	-18.0	2.5
170580	18 27.6	4 2	0.0000	0.0001	-0.007	0.001	-18.5	0.4
170650	18 27.5	23 50	0.0002	0.0000	-0.001	0.004	-17.0	5.0
170740	18 28.7	-10 50	0.0010	0.0001	-0.015	0.003	-11.8	0.5
171406	18 31.5	30 51	0.0003	0.0003	-0.004	0.004	-4.0	2.5
171780	18 33.4	34 25	0.0001	0.0001	0.013	0.001	-13.0	5.0
173087	18 40.3	34 42	-0.0002	0.0002	0.004	0.002	-19.0	2.5
173370	18 42.3	2 0	0.0006	0.0001	-0.015	0.003	-13.0	2.5

TABLE 6–Continued

HD	α_{1950}		δ_{1950}		μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
174179	18	40.1	31	42	-0.0004	0.0001	0.000	0.005	-15.0	1.2
174237	18	45.6	52	56	0.0006	0.0001	0.001	0.001	-20.0	5.0
174585	18	47.9	32	45	0.0002	0.0002	-0.002	0.001	-16.5	1.2
174959	18	49.9	36	29	0.0011	0.0009	0.028	0.013	-20.7	1.2
175156	18	51.9	-15	40	-0.0004	0.0002	-0.012	0.002	-2.0	1.2
176162	18	56.6	-12	55	0.0003	0.0001	-0.020	0.001	-13.0	2.5
176304	18	56.9	10	4	0.0003	0.0001	0.000	0.001	-17.2	0.8
176502	18	57.1	40	37	0.0002	0.0001	0.005	0.001	-19.0	1.2
176582	18	57.5	39	9	-0.0004	0.0003	0.006	0.005	-14.0	2.5
176819	18	59.2	20	46	0.0000	0.0001	-0.001	0.001	-10.3	1.2
176871	18	59.3	26	13	0.0003	0.0001	-0.005	0.004	-14.0	2.5
177003	18	59.0	50	28	0.0002	0.0001	0.012	0.001	-19.0	2.5
178175	19	5.3	-19	22	0.0007	0.0001	-0.003	0.003	-20.3	1.2
178329	19	4.7	41	20	0.0001	0.0001	0.000	0.003	-21.2	0.5
178475	19	5.5	36	1	-0.0002	0.0000	-0.001	0.001	-18.0	2.5
179406	19	10.0	-8	1	0.0009	0.0001	-0.007	0.001	-15.4	1.1
180163	19	12.1	39	4	-0.0002	0.0001	0.001	0.001	-8.2	0.5
180554	19	14.1	21	18	-0.0003	0.0001	-0.007	0.002	-17.0	2.5
180968	19	15.6	22	56	0.0006	0.0001	-0.007	0.002	1.0	2.5
181409	19	17.2	33	18	-0.0013	0.0001	-0.025	0.001	10.0	2.5
181858	19	19.6	-8	18	-0.0001	0.0001	-0.020	0.001	-12.6	1.1
182255	19	20.8	26	10	0.0000	0.0001	-0.005	0.001	-12.2	0.5
182568	19	22.2	29	31	0.0011	0.0001	0.014	0.002	-21.0	2.5
183144	19	25.3	14	11	0.0004	0.0000	0.000	0.003	4.0	2.5
183362	19	25.8	37	50	0.0001	0.0003	-0.004	0.003	-16.2	1.2

TABLE 6–Continued

HD	α_{1950}		δ_{1950}		μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
183537	19	27.2	20	11	0.0001	0.0001	-0.016	0.003	-42.7	1.2
184171	19	29.9	34	21	0.0000	0.0001	0.001	0.002	-21.8	0.5
184915	19	34.2	-7	8	-0.0001	0.0001	-0.007	0.001	-18.7	2.1
184930	19	34.1	-1	24	0.0001	0.0002	-0.026	0.001	-22.0	2.5
185268	19	35.2	29	13	0.0005	0.0003	0.004	0.005	-20.1	1.2
185423	19	36.3	3	16	0.0001	0.0001	0.002	0.001	-1.0	2.5
185507	19	36.7	5	17	0.0002	0.0001	-0.003	0.001	-4.8	0.5
185859	19	38.3	20	22	0.0002	0.0002	-0.005	0.002	5.2	1.2
185915	19	38.5	23	36	0.0012	0.0006	-0.018	0.006	-20.0	5.0
185936	19	38.8	13	42	-0.0004	0.0001	-0.011	0.002	-14.2	1.2
186660	19	43.3	-3	0	-0.0001	0.0001	0.002	0.001	-17.4	1.2
187459	19	46.9	33	19	0.0000	0.0003	-0.001	0.004	-10.0	5.0
187567	19	47.9	7	46	-0.0001	0.0001	-0.001	0.001	-28.0	2.5
187811	19	48.9	22	29	0.0017	0.0001	-0.014	0.003	-26.0	2.5
187879	19	48.9	40	28	-0.0003	0.0001	-0.001	0.002	-3.0	0.4
187961	19	49.9	10	13	0.0001	0.0003	-0.013	0.003	-12.6	1.2
188001	19	50.1	18	24	-0.0002	0.0002	-0.008	0.001	9.4	2.4
188209	19	50.5	46	54	-0.0006	0.0001	0.001	0.003	-6.2	1.2
188252	19	50.6	47	48	-0.0014	0.0001	-0.005	0.001	-18.3	1.2
188293	19	51.9	-8	22	0.0006	0.0001	0.024	0.001	-6.0	5.0
188439	19	51.5	47	41	-0.0010	0.0001	0.000	0.002	-65.0	2.5
188665	19	52.3	57	24	0.0001	0.0001	0.012	0.001	-25.0	2.5
188892	19	54.1	38	21	0.0004	0.0001	0.000	0.005	-30.1	1.2
189066	19	54.9	36	7	0.0001	0.0003	-0.005	0.003	-23.0	1.2
189178	19	55.5	40	14	0.0000	0.0001	0.008	0.001	-26.2	1.2

TABLE 6–Continued

HD	α_{1950}		δ_{1950}		μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
189432	19	56.8	37	58	0.0001	0.0003	0.008	0.001	-14.4	1.2
189687	19	58.1	36	54	-0.0001	0.0000	0.004	0.001	-4.0	2.5
189775	19	57.9	51	55	0.0002	0.0002	0.007	0.004	-16.2	1.2
190603	20	2.6	32	5	-0.0005	0.0003	-0.007	0.001	21.1	1.2
190993	20	4.7	23	28	0.0011	0.0001	0.001	0.002	-5.4	1.2
191263	20	6.3	10	35	0.0000	0.0001	0.005	0.001	-38.2	1.2
191610	20	7.6	36	41	-0.0001	0.0001	0.016	0.001	-13.6	0.5
191639	20	8.5	-9	0	0.0000	0.0001	0.001	0.002	-7.0	2.5
191877	20	9.2	21	44	-0.0005	0.0001	-0.014	0.003	-18.0	2.5
192685	20	13.1	25	26	0.0005	0.0001	-0.001	0.002	-2.0	2.5
192987	20	14.6	36	54	0.0004	0.0006	0.004	0.008	-6.0	2.5
193237	20	15.9	37	53	-0.0003	0.0001	-0.004	0.001	-8.9	0.5
193322	20	16.3	40	35	-0.0003	0.0001	-0.001	0.001	-7.0	2.5
193536	20	17.2	46	10	-0.0003	0.0002	-0.002	0.001	-8.9	1.2
194335	20	21.9	37	19	0.0000	0.0001	0.002	0.002	-31.0	2.5
195556	20	28.5	48	47	0.0008	0.0001	0.010	0.001	-22.0	2.5
195810	20	30.8	11	8	0.0008	0.0001	-0.020	0.001	-19.3	0.5
195986	20	31.1	43	1	0.0000	0.0002	0.008	0.003	-16.9	0.5
196035	20	31.9	20	49	0.0008	0.0001	0.002	0.003	3.1	1.2
196662	20	36.5	-15	8	-0.0002	0.0001	-0.021	0.002	-5.0	2.5
196740	20	36.4	23	56	0.0008	0.0001	-0.005	0.003	-22.0	2.5
196775	20	36.8	15	40	0.0002	0.0001	-0.016	0.002	2.0	2.5
197036	20	37.7	45	29	0.0001	0.0001	0.006	0.002	-15.1	1.2
197419	20	40.4	35	17	-0.0004	0.0001	-0.010	0.002	-6.8	1.2
197511	20	40.7	50	10	-0.0003	0.0001	0.008	0.001	-3.3	1.2

TABLE 6-Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
197770	20 42.0	56 56	-0.0006	0.0003	0.002	0.003	-15.0	2.5
198183	20 45.5	36 18	0.0006	0.0001	-0.006	0.001	-23.0	2.5
198478	20 47.2	45 56	-0.0002	0.0001	-0.001	0.001	-8.0	0.5
198625	20 48.2	46 28	-0.0001	0.0001	0.024	0.001	-15.0	2.5
198781	20 48.4	63 51	-0.0018	0.0002	-0.002	0.003	-27.3	1.2
198820	20 50.0	32 40	0.0000	0.0002	-0.004	0.003	-18.0	2.5
199081	20 51.5	44 12	0.0006	0.0000	-0.001	0.001	-19.5	1.2
199140	20 52.2	28 20	0.0004	0.0001	-0.004	0.004	-8.0	0.5
199579	20 54.8	44 44	-0.0004	0.0002	0.002	0.002	-5.8	0.5
199661	20 54.9	56 42	0.0003	0.0002	0.008	0.001	-19.0	2.5
200120	20 58.1	47 20	0.0001	0.0001	0.006	0.001	1.0	2.5
200310	20 59.4	45 58	0.0005	0.0001	0.004	0.001	-10.0	2.5
201733	21 8.2	45 18	0.0008	0.0002	0.004	0.002	9.0	1.2
201819	21 9.0	36 6	-0.0007	0.0003	0.003	0.003	-6.0	1.2
201836	21 8.8	47 29	-0.0002	0.0006	0.008	0.009	-8.8	1.2
202214	21 10.5	59 47	-0.0009	0.0001	0.002	0.001	-16.2	1.2
202654	21 13.9	47 46	0.0007	0.0002	0.004	0.001	-26.0	5.0
202904	21 15.9	34 41	0.0009	0.0001	0.003	0.001	4.0	1.2
203025	21 15.9	58 24	-0.0011	0.0001	0.012	0.003	-17.2	1.2
203064	21 16.6	43 44	0.0004	0.0001	-0.004	0.002	1.0	1.2
203245	21 17.8	49 18	-0.0011	0.0003	0.017	0.006	-23.0	1.2
203467	21 18.3	64 40	0.0002	0.0000	0.010	0.000	-18.0	2.5
204172	21 23.7	36 27	0.0006	0.0001	-0.008	0.001	2.8	1.2
204403	21 25.3	36 54	-0.0001	0.0001	0.003	0.001	-20.0	2.5

TABLE 6–Continued

HD	α_{1950}		δ_{1950}		μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
205021	21	28.0	70	20	0.0015	0.0001	0.013	0.001	-6.7	1.0
205139	21	29.6	60	14	0.0001	0.0001	0.008	0.001	-14.5	1.2
205637	21	34.3	-19	41	0.0013	0.0001	-0.004	0.001	-23.7	0.5
206267	21	37.4	57	16	-0.0007	0.0001	-0.001	0.001	-7.8	0.5
206672	21	40.3	50	58	0.0004	0.0001	0.007	0.001	-8.2	1.2
207198	21	43.5	62	14	-0.0010	0.0004	0.002	0.002	-18.4	1.2
207330	21	44.9	49	5	0.0003	0.0001	0.005	0.001	-12.3	1.2
207563	21	47.1	20	14	0.0005	0.0001	0.000	0.007	-15.1	0.8
208057	21	50.8	25	41	0.0006	0.0000	0.003	0.001	-12.0	2.5
208095	21	50.3	55	34	0.0018	0.0001	0.002	0.001	-6.5	1.2
208682	21	54.2	65	5	-0.0005	0.0001	0.007	0.003	-14.5	1.2
208947	21	55.9	65	55	0.0001	0.0002	0.007	0.001	2.4	1.2
209008	21	57.6	6	29	0.0009	0.0001	0.012	0.002	-5.4	0.4
209339	21	59.2	62	15	-0.0005	0.0001	0.002	0.002	-20.2	1.2
209409	22	0.7	-2	24	0.0015	0.0001	-0.004	0.001	9.9	1.7
209419	22	0.0	52	38	0.0010	0.0001	0.007	0.002	-22.0	1.2
209481	22	0.4	57	46	-0.0006	0.0001	0.004	0.001	-7.5	1.2
209961	22	3.9	47	59	-0.0004	0.0001	-0.001	0.005	-17.8	0.5
209975	22	3.6	62	2	-0.0008	0.0003	0.003	0.002	-12.8	0.5
210191	22	6.2	-18	46	-0.0003	0.0001	0.002	0.003	-5.2	1.2
210424	22	8.0	-11	49	0.0019	0.0001	-0.010	0.002	2.5	1.2
210839	22	9.8	59	10	-0.0018	0.0001	-0.004	0.001	-74.0	2.5
211924	22	17.9	5	32	0.0010	0.0001	0.005	0.002	-7.4	1.0
212076	22	19.1	11	57	0.0006	0.0001	0.008	0.001	9.6	1.2
212120	22	19.0	46	17	0.0023	0.0003	-0.001	0.005	-9.5	1.2

TABLE 6—Continued

HD	α_{1950}		δ_{1950}		μ_{α}	P.E.(μ_{α})	μ_{δ}	P.E.(μ_{δ})	ρ	P.E.(ρ)
212222	22	19.7	41	50	0.0008	0.0004	0.004	0.003	-17.7	1.2
212571	22	22.7	1	7	0.0014	0.0001	0.012	0.001	4.0	2.5
212883	22	24.5	37	11	-0.0003	0.0003	-0.002	0.001	-8.6	0.7
212978	22	25.2	39	33	-0.0002	0.0001	0.003	0.000	-16.8	1.2
213087	22	25.5	64	53	-0.0008	0.0003	0.002	0.003	-14.7	1.2
213420	22	28.3	42	52	-0.0005	0.0001	-0.003	0.001	-8.0	1.2
214167	22	33.6	39	22	-0.0008	0.0002	0.003	0.003	-13.5	1.2
214168	22	33.6	39	23	-0.0003	0.0001	-0.001	0.001	-11.0	2.5
214240	22	33.8	49	49	0.0001	0.0001	0.005	0.002	-15.3	0.5
214680	22	37.0	38	47	0.0001	0.0001	0.003	0.001	-9.6	0.4
214993	22	39.2	39	58	-0.0002	0.0001	0.006	0.002	-14.4	0.5
215191	22	40.6	37	32	0.0000	0.0001	-0.004	0.002	-17.8	1.2
216200	22	48.1	41	41	0.0002	0.0001	0.002	0.001	-15.3	2.0
216916	22	54.1	41	20	0.0000	0.0001	0.002	0.002	-10.8	0.8
217050	22	54.9	48	25	0.0011	0.0001	0.000	0.001	-11.3	1.2
217101	22	55.4	39	2	-0.0001	0.0001	0.001	0.001	-15.5	1.2
217543	22	58.6	38	26	0.0000	0.0003	-0.008	0.002	-16.8	0.6
217811	23	0.5	43	47	-0.0004	0.0001	0.000	0.001	-8.5	0.4
217891	23	1.3	3	33	0.0007	0.0001	-0.010	0.001	0.7	0.5
217943	23	1.3	60	11	0.0003	0.0003	0.004	0.001	-17.0	2.5
218376	23	4.5	59	9	0.0007	0.0000	0.004	0.001	-8.5	1.2
218407	23	5.0	45	48	-0.0004	0.0002	0.010	0.001	-16.1	0.6
218440	23	5.1	59	27	0.0006	0.0002	0.008	0.001	-4.6	1.2
218537	23	5.7	63	22	0.0006	0.0001	0.005	0.001	-35.9	1.2

TABLE 6—Continued

HD	α_{1950}	δ_{1950}	μ_α	P.E.(μ_α)	μ_δ	P.E.(μ_δ)	ρ	P.E.(ρ)
221253	23 27.7	58 16	0.0022	0.0001	0.010	0.001	-15.4	0.4
223128	23 44.2	66 30	0.0006	0.0007	0.001	0.006	-14.0	1.2
223229	23 45.1	46 33	-0.0003	0.0003	0.004	0.001	-24.0	5.0
224151	23 53.0	57 8	-0.0005	0.0001	0.003	0.001	-25.5	0.5
224544	23 56.3	32 6	0.0014	0.0004	0.005	0.007	-5.9	1.2
224559	23 56.2	46 8	0.0022	0.0004	0.004	0.003	-2.4	1.1
224572	23 56.5	55 29	0.0008	0.0001	0.003	0.003	-12.6	1.2
225094	0 0.8	63 22	-0.0024	0.0007	-0.002	0.005	-43.0	2.5
177109	19 0.0	33 33	0.0005	0.0002	0.000	0.003	-22.9	1.2
206165	21 36.6	61 51	-0.0011	0.0002	0.000	0.001	-13.2	1.2

NOTES TO TABLE 6

829	Petrie (1958)
1337	Mannino (1959); Abhyankar (1959)
1976	Petrie (1958); Blaauw and van Albada (1963); center of light
3360	Petrie (1958)
3379	Feast, Thackeray, and Wesselink (1957)
3901	Petrie (1958); Blaauw and van Albada (1963)
4180	Petrie (1958)
6300	Petrie (1958)
11241	Petrie (1958); Blaauw and van Albada (1963)
11415	Petrie (1958)
16908	Petrie (1958); Blaauw and van Albada (1963)
18537	Bright component
19374	Blaauw and van Albada (1963)
20336	Petrie (1958); Blaauw and van Albada (1963)
20756	Petrie (1958); Blaauw and van Albada (1963)
21803	Petrie (1958)
22951	Blaauw and van Albada (1963)
23180	Blaauw and van Albada (1963); Lynds (1960); center of light
23288	Abt *et al.* (1965)
23302	Abt *et al.* (1965)
23338	Abt *et al.* (1965)
23408	Abt *et al.* (1965)
23466	Petrie (1958); Blaauw and van Albada (1963)
23480	Abt *et al.* (1965)
23625	Blaauw and van Hoof (1963); bright component*
23630	Abt *et al.* (1965)
23793	Petrie (1958); bright component
24131	Blaauw and van Albada (1963)
24640	Blaauw and van Albada (1963)
24760	Petrie (1958)
25340	Petrie (1958); Blaauw and van Albada (1963)
25558	Petrie (1958)
25638	Bright component
25940	Petrie (1958); Blaauw and van Albada (1963)
26739	Feast *et al.* (1957)
26912	Petrie (1958)
27912	Petrie (1958); Blaauw and van Albada (1963)
28446	Bright component
29248	Struve *et al.* (1952*b*)
29763	Petrie and Ebbinghausen (1961)
30211	Petrie (1958); Blaauw and van Albada (1963)
30836	Bouigue and Castanet (1954)
31237	Miczaika (1950)
32630	Petrie (1958)
32990	Petrie (1958)
32991	Petrie (1958); Blaauw and van Albada (1963)
33203	Mean of two components
34078	Bright component
34233	Petrie (1958)
34759	Petrie (1958); Blaauw and van Albada (1963)
35411	Miczaika (1951*a*); mean of two components
35532	Blaauw and van Albada (1963)
35588	Blaauw and van Albada (1963); Duflot (1953)
35671	Petrie (1958)
35708	Petrie (1958)
35715	Chopinet (1953); bright component
36267	Petrie (1958); center of light
36351	Mean of two components
36591	Bright component
36646	Mean of two components
36819	Petrie (1958)
37017	Blaauw and van Albada (1963)
37018	Mean of two components
37040	Bright component
37043	Miczaika (1951*b*); Pearce (1953*b*)
37202	Underhill (1952)
37209	Bright component
37367	Petrie (1958); Blaauw and van Albada (1963)
37438	Petrie (1958)
37468	Center of light
37711	Petrie (1958); center of light
37756	Pearce (1953*a*); Barbier-Brossat (1954)
37967	Petrie (1958)
38622	Petrie (1958)
41117	Underhill (1960)
41753	Petrie (1958); Ebbighausen and Petrie (1959)
42545	Petrie (1958); Blaauw and van Albada (1963)
42560	Blaauw and van Albada (1963)
44458	Bright component
44700	Petrie (1958)
45726	Mean of components B and C
47129	Abhyankar (1959)
49662	Mean of two components
53755	Bright component
53974	Center of light
65875	Blaauw and van Albada (1963)
100600	Bright component
109387	Underhill (1954)
116658	Struve *et al.* (1958)
120315	Petrie (1958)
138485	Feast *et al.* (1957)
138764	Buscombe and Morris (1960). For this and the other Scorpio-Centaurus stars, the measurements of van Hoof, Bertiau, and Deurinck (1963) were rejected because of their large systematic error
142096	Buscombe (1962)
142378	Center of light
142983	Ringuelet-Kaswalder (1963)
144217	Abhyankar (1959)
145502	Center of light
149757	Buscombe and Morris (1960)
154445	Petrie and Pearce (1962); Feast *et al.* (1957)
163472	Petrie and Pearce (1962); Feast *et al.* (1957)
164353	Underhill (1960); Feast *et al.* (1957)
164432	Petrie and Pearce (1962)
168021	Feast, Thackeray, and Wesselink (1955); center of light
170580	Petrie and Pearce (1962); Feast *et al.* (1957)
170740	Feast *et al.* (1955)
176304	Petrie and Pearce (1962); Feast *et al* (1957)
179406	Feast *et al.* (1955)

* An arithmetic error has been detected in the tabulated μ_δ for this star. The correct value is $-0''.001 \pm .002$.

NOTES TO TABLE 6—*Continued*

180968	Bright component
181858	Petrie and Pearce (1962)
184915	Feast *et al.* (1955)
187879	Batten (1962)
188001	Underhill (1958)
189432	Bright component
192685	Bright component
193332	Bright component
198478	Underhill (1960)
199140	Petrie (1954)
200310	Bright component
202214	Mean of two components
205021	Struve *et al.* (1953)
207563	Petrie and Pearce (1962); Feast *et al.* (1957)
208682	Mean of two components
209008	Petrie and Pearce (1962); Feast *et al.* (1957)
209409	Feast *et al.* (1957)
209481	Petrie (1962)
211924	Petrie and Pearce (1962); Feast *et al.* (1957)
212883	Blaauw and van Albada (1963); bright component
214680	Blaauw and van Albada (1963)
214993	Struve (1951)
216200	Blaauw and van Albada (1963)
216916	Struve *et al.* (1952*a*)
217543	Blaauw and van Albada (1963)
217811	Blaauw and van Albada (1963)
217891	Feast *et al.* (1955)
218407	Struve, Huang, and Zebergs (1959)
218537	Center of light
221253	Petrie (1958)
223229	Center of light
224559	Petrie (1958)
224572	Bright component

EXPLANATION OF COLUMNS OF TABLE 7

Column	
1	HD number
2– 4	Space coordinates to nearest parsec
5–10	Space velocities in km sec^{-1}, each followed by its probable error in the same units; these probable errors contain only the uncertainties due to the proper motions and radial velocities
11–13	Change in U, V, and W, respectively, that would be produced if the assumed distance of the star were increased by 10 per cent. Units are km sec^{-1}

TABLE 7

Space Coordinates and Velocities of Stars with Well-determined Distances Less than 600 pc

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
829	191	419	-210	2.1	1.8	-14.2	1.2	-3.2	1.5	0.6	-0.6	-0.7
886	33	94	-105	-0.7	0.6	-3.2	0.5	-8.7	0.5	-0.2	-0.6	-0.6
1976	93	171	-37	4.0	1.0	-20.0	1.3	-4.9	3.1	1.1	-0.8	-0.8
2729	105	175	13	13.2	1.8	-18.5	1.5	-6.8	2.6	1.8	-1.0	-0.6
3240	81	137	-24	15.3	1.0	-8.1	1.1	-1.7	1.0	1.5	-0.9	-0.2
3360	104	174	-32	16.6	0.5	-9.3	0.5	-9.7	0.6	1.6	-1.1	-0.9
3369	47	83	-53	9.6	0.5	1.7	0.5	-6.8	0.7	0.6	-0.5	-0.3
3379	112	214	-264	0.6	2.1	-18.0	2.5	-5.8	2.6	0.3	-1.4	-1.0
3901	96	158	-40	7.9	0.2	-11.0	0.3	-2.7	0.6	1.0	-0.7	-0.4
4142	102	165	-52	-65.2	1.7	-24.7	2.2	25.4	0.9	-3.5	2.5	1.0
4180	80	129	-40	4.1	0.9	-19.6	1.3	-1.7	1.0	1.1	-0.8	-0.5
4727	62	97	-46	-4.4	0.5	-28.6	0.5	-1.9	0.4	0.8	-1.0	-1.1
6300	173	247	-63	11.1	1.6	-14.3	1.5	-4.8	3.9	1.3	-1.1	-0.6
11241	270	304	-48	12.1	1.1	-24.3	1.4	-9.2	3.8	1.8	-1.8	-1.0
14372	164	146	-50	11.3	2.2	-13.1	2.1	-8.4	1.7	1.0	-1.4	-0.8
16582	150	24	-196	13.9	0.5	-13.3	0.6	-7.5	0.5	0.6	-1.5	0.3
16908	110	60	-69	9.6	0.9	-5.9	0.6	-8.1	0.6	0.3	-1.0	-0.4
17081	43	-9	-78	1.2	0.7	-5.3	0.5	-16.4	1.1	-0.6	-0.4	-0.3
17543	92	36	-75	6.4	0.8	-6.3	0.9	-9.7	0.8	-0.0	-0.9	-0.4
17769	112	38	-94	20.6	1.3	-21.3	1.4	-11.4	1.3	0.8	-2.6	-0.1
18537	134	104	-17	13.0	1.4	-24.6	1.5	-4.4	2.0	1.6	-2.2	-0.5
18604	113	24	-105	4.9	1.1	-7.1	1.2	-11.5	1.2	-0.3	-0.9	-0.5
18883	109	13	-112	14.9	2.3	-2.4	3.0	-2.3	2.3	0.7	-0.3	0.6
19268	178	134	-20	25.3	1.4	-24.8	1.7	-7.7	2.6	2.0	-2.8	-0.7

TABLE 7—Continued

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
20365	139	96	-18	9.8	2.1	-24.7	1.6	-8.0	0.6	1.4	-2.2	-0.9
20418	140	95	-18	14.9	2.1	-18.4	1.5	-9.3	1.0	1.2	-2.0	-0.9
20756	130	38	-77	22.0	0.7	-21.3	0.6	-8.3	0.6	0.8	-2.6	0.0
20809	141	93	-19	15.8	1.2	-16.4	1.1	-5.2	1.1	1.2	-1.9	-0.5
21071	142	92	-19	20.5	1.3	-15.9	1.4	-12.8	1.3	1.2	-2.1	-1.2
21278	143	91	-18	18.1	4.3	-16.7	5.2	-6.9	4.3	1.2	-2.0	-0.6
21362	142	92	-16	6.9	2.1	-13.1	1.4	-14.2	0.5	0.7	-1.3	-1.4
21428	143	91	-17	12.7	2.2	-23.1	1.7	-7.2	1.5	1.4	-2.3	-0.7
21455	144	87	-23	12.3	1.3	-24.7	2.0	-11.1	2.7	1.3	-2.4	-1.1
21803	449	253	-83	7.1	1.2	-10.9	1.3	-15.0	1.0	0.4	-1.2	-1.4
21856	282	124	-93	17.8	2.5	16.3	2.3	-10.7	2.3	-0.4	0.7	-0.3
22192	145	87	-18	13.8	0.5	-24.2	0.4	-7.5	0.3	1.4	-2.4	-0.7
22928	67	38	-8	-0.7	4.3	-17.8	2.5	-3.3	0.6	0.7	-1.3	-0.4
22951	288	111	-93	32.6	1.4	-11.5	2.2	-6.8	2.2	0.8	-2.1	0.1
23180	289	103	-98	23.3	0.7	-16.9	1.6	-11.0	1.7	0.6	-2.3	-0.5
23288	115	28	-52	2.1	0.9	-26.4	1.5	-13.6	1.5	0.1	-2.7	-1.3
23302	115	28	-52	7.4	0.8	-24.7	0.5	-15.5	0.6	0.1	-2.6	-1.2
23338	115	29	-52	7.4	0.9	-26.4	1.4	-11.9	1.3	0.3	-2.8	-1.0
23408	115	28	-51	8.4	0.7	-27.6	1.2	-15.2	1.1	0.2	-2.9	-1.2
23466	150	-3	-110	16.4	1.3	-22.3	1.3	-3.6	1.4	0.4	-2.2	0.6
23480	115	27	-52	5.7	1.2	-27.1	1.3	-12.6	1.2	0.2	-2.8	-1.1
23625	291	105	-90	17.5	0.8	18.9	4.2	0.4	4.6	-0.2	1.2	0.7
23630	115	27	-51	6.7	0.8	-27.9	0.5	-12.7	0.5	0.2	-2.9	-1.1
23793	145	7	-93	15.9	1.0	-31.1	1.3	-7.7	1.3	0.2	-3.2	0.1
24131	293	105	-84	13.2	1.6	6.4	3.8	-12.7	3.9	-0.3	0.1	-0.8

TABLE 7—*Continued*

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
24398	294	94	-92	21.6	0.7	-8.7	1.1	-11.9	1.1	0.3	-1.5	-0.6
24504	121	65	-10	15.4	1.1	-8.1	0.8	-0.2	0.6	0.7	-1.3	0.1
24534	294	90	-95	15.4	1.9	0.4	3.9	-10.4	3.9	-0.0	-0.4	-0.5
24640	294	104	-78	19.7	1.2	-3.3	2.2	-2.8	2.2	0.4	-0.9	0.1
24760	274	114	-53	14.2	1.5	-38.5	1.1	-14.6	1.1	1.3	-3.9	-1.4
25204	90	3	-51	10.0	0.5	-1.8	0.4	-12.5	0.4	-0.3	-0.2	-0.5
25340	131	-28	-104	11.7	0.9	-22.9	1.2	-1.3	0.8	0.1	-2.1	0.7
25558	151	-14	-99	6.6	1.2	-8.5	1.7	-8.3	1.8	-0.2	-0.8	-0.2
26326	119	-70	-129	11.0	1.9	-2.9	1.8	-8.4	1.2	0.2	0.2	0.1
26356	107	135	75	-16.1	1.5	6.0	1.8	-5.4	1.1	-1.2	1.1	-0.3
26739	240	-58	-173	9.8	5.7	-14.0	9.0	-17.0	7.3	-0.6	-1.0	-0.5
26912	114	-8	-63	13.7	0.9	-18.0	0.8	-8.9	0.8	-0.2	-1.7	-0.1
27192	412	212	5	-12.6	1.7	-14.9	2.1	-8.4	2.3	0.3	-0.7	-0.8
27396	146	65	-7	14.5	1.4	-30.5	2.3	-9.4	2.5	1.3	-3.1	-0.9
28114	159	-18	-81	11.2	2.7	-5.2	3.5	-7.8	3.0	-0.1	-0.4	-0.1
28149	148	15	-47	3.5	2.5	-12.2	3.7	-9.2	3.3	-0.1	-1.3	-0.8
29248	222	-78	-143	7.5	0.9	-6.7	1.1	-12.4	1.1	-0.4	-0.3	-0.5
29335	122	-33	-70	16.1	2.3	-8.0	1.8	-17.6	2.1	-0.4	-0.3	-0.6
29763	113	7	-30	10.9	0.6	-6.0	0.4	-10.4	0.5	-0.2	-0.7	-0.7
30211	103	-39	-62	11.0	1.2	-15.1	0.6	-5.5	0.8	-0.2	-1.0	0.2
30836	199	-46	-89	22.0	0.5	-7.2	0.9	-7.5	0.9	0.0	-0.2	0.2
30870	167	-27	-65	8.6	1.4	-5.1	2.1	-5.0	1.8	-0.1	-0.4	-0.1
31237	201	-59	-96	17.8	0.8	-6.8	1.3	-13.7	1.1	-0.2	-0.1	-0.4
31331	190	-62	-95	11.8	2.6	-11.0	2.9	-8.9	3.0	-0.3	-0.6	-0.2

TABLE 7—Continued

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
32630	74	19	0	13.4	0.9	-22.9	0.3	-6.9	0.3	0.6	-2.5	-0.7
32686	206	-87	-104	20.7	2.0	-3.8	2.4	-19.1	1.7	-0.2	0.6	-0.8
32990	226	3	-38	15.5	0.5	-1.6	1.7	-4.1	1.8	-0.0	-0.2	-0.1
34233	182	94	43	8.6	2.3	-16.2	2.3	-6.3	2.0	1.0	-1.6	-0.6
34503	81	-44	-41	12.5	1.0	-7.0	0.6	-17.3	0.6	-0.4	0.2	-0.9
34748	329	-142	-138	24.0	2.7	-4.9	3.8	-18.4	2.7	-0.1	0.6	-0.8
34759	158	38	8	21.4	1.5	-27.1	1.1	-6.8	1.1	0.8	-3.0	-0.8
34816	337	-234	-202	6.9	2.2	-11.7	3.1	-20.6	3.7	-0.8	-0.1	-1.2
34959	346	-116	-118	-4.7	2.0	1.5	4.2	-31.5	4.9	-0.9	0.3	-3.0
35007	333	-139	-132	8.8	2.6	10.3	4.2	-9.5	3.8	0.3	1.3	-0.7
35039	333	-139	-132	22.7	1.6	-8.7	2.8	-17.5	3.2	-0.2	0.2	-0.8
35149	345	-120	-118	18.7	2.5	-1.3	3.7	-2.6	4.7	0.3	0.4	0.3
35299	334	-140	-128	16.4	2.6	-9.2	4.8	-13.6	5.1	-0.3	-0.1	-0.6
35337	312	-227	-185	5.1	5.7	-15.5	5.7	-14.5	4.5	-0.8	-0.6	-0.7
35407	342	-128	-119	1.4	2.6	22.5	5.5	5.7	7.7	0.9	2.0	0.3
35411	327	-151	-134	14.1	1.3	-9.5	2.1	-16.4	1.9	-0.4	-0.1	-0.9
35439	340	-130	-121	13.8	2.0	-3.0	3.0	-19.3	2.3	-0.3	0.4	-1.3
35468	86	-26	-26	14.0	0.5	-6.9	0.5	-12.4	0.5	-0.3	-0.2	-0.7
35588	336	-138	-123	16.5	2.9	-9.3	5.0	2.9	6.4	0.2	-0.3	0.8
35671	165	-21	-28	13.8	1.7	-21.1	1.4	-9.5	1.1	-0.3	-1.9	-0.7
35708	223	-15	-28	10.7	0.9	-11.8	1.3	-3.4	1.1	-0.1	-1.1	-0.2
35715	344	-126	-114	4.8	1.2	-14.9	2.8	-10.1	3.3	-0.6	-1.1	-0.6
35912	339	-136	-118	31.8	1.6	-6.3	1.9	-12.6	1.2	0.2	0.6	-0.2
36166	341	-135	-113	6.2	4.0	-4.9	6.4	-16.2	5.8	-0.4	-0.1	-1.3
36267	95	-31	-27	12.4	1.5	-19.9	0.7	-7.9	0.5	-0.5	-1.4	-0.3

TABLE 7—Continued

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
36285	397	-233	-180	10.1	3.0	3.4	3.6	-12.3	2.8	0.1	0.9	-0.8
36351	346	-129	-107	19.2	3.1	-6.5	4.9	-1.9	5.2	0.1	0.0	0.4
36430	401	-229	-176	12.1	3.0	-15.6	7.3	-16.7	10.0	-0.7	-0.5	-0.9
36485	403	-178	-141	16.3	2.3	-7.6	2.8	-12.7	3.8	-0.2	0.0	-0.6
36486	403	-178	-141	11.9	1.3	-5.7	1.2	-11.2	0.8	-0.2	0.0	-0.6
36512	398	-234	-177	-1.8	3.9	-30.2	5.8	-12.8	6.5	-1.6	-2.2	-0.7
36591	398	-187	-145	27.9	1.6	-18.9	3.3	-8.6	3.9	-0.2	-0.5	0.2
36646	398	-188	-144	22.2	2.6	-29.5	2.7	-19.0	2.4	-1.0	-1.4	-0.8
36653	216	-42	-39	15.7	1.3	-9.8	2.1	-11.9	2.1	-0.3	-0.6	-0.9
36695	400	-185	-142	17.9	1.8	-1.5	3.3	-20.2	4.0	-0.1	0.7	-1.3
36741	340	-141	-109	6.8	4.1	-11.6	6.6	-13.8	4.3	-0.6	-0.6	-1.0
36779	401	-185	-140	3.4	3.1	-10.3	3.6	10.1	2.8	-0.0	-0.9	1.1
36819	261	-13	-21	21.4	1.0	-25.7	1.4	-1.6	2.0	-0.1	-2.5	0.0
36959	404	-229	-167	20.8	1.9	-19.0	3.4	-10.8	4.2	-0.3	-0.5	-0.1
36960	405	-229	-167	23.3	1.9	-13.3	2.6	-7.2	2.4	0.1	-0.0	0.2
37016	412	-220	-160	23.3	4.8	-7.9	6.3	-24.8	5.3	-0.3	0.6	-1.5
37017	412	-221	-160	28.3	6.2	-1.2	10.2	-20.7	11.0	0.3	1.3	-1.1
37018	410	-223	-162	21.3	3.4	-13.1	4.4	-19.7	4.5	-0.4	0.0	-1.0
37020	408	-226	-164	36.7	35.6	27.9	45.2	-47.9	29.7	0.9	4.3	-3.7
37022	408	-226	-164	19.3	2.7	-10.5	3.6	-22.0	4.3	-0.4	0.2	-1.3
37023	408	-226	-164	-0.3	14.4	-25.0	21.9	-59.6	22.6	-2.6	-1.1	-4.9
37040	412	-220	-160	21.7	2.7	-16.7	3.6	-13.8	4.3	-0.3	-0.3	-0.4
37041	407	-226	-164	32.4	2.0	-9.6	2.6	-13.6	2.4	0.3	0.7	-0.2
37043	405	-229	-166	22.4	1.8	-4.2	2.6	-9.6	2.4	0.3	0.7	-0.2

TABLE 7—Continued

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
37128	400	-188	-137	19.6	0.9	-11.8	1.6	-14.9	2.0	-0.3	-0.1	-0.7
37150	406	-229	-163	6.7	2.9	-4.8	3.6	-9.3	2.9	-0.2	0.0	-0.6
37209	404	-232	-164	25.4	3.8	-1.2	5.1	-24.1	4.8	0.1	1.3	-1.4
37232	433	-126	-96	42.9	2.6	8.9	4.3	-19.7	5.7	0.3	2.0	-1.1
37303	405	-232	-162	14.9	3.7	-23.4	5.1	-17.2	4.8	-0.9	-1.0	-0.8
37356	411	-225	-157	27.0	2.8	-0.7	4.2	-19.9	4.5	0.3	1.3	-1.1
37438	221	-7	-10	12.4	0.5	-27.1	1.9	-4.5	1.4	-0.1	-2.7	-0.4
37468	394	-199	-138	24.3	1.9	-12.3	2.5	-10.8	2.3	-0.1	0.0	-0.2
37479	394	-199	-138	17.5	4.4	-27.1	5.6	-8.3	3.9	-0.7	-1.5	0.0
37490	348	-132	-93	20.1	2.1	-3.9	3.9	-9.3	2.8	0.0	0.4	-0.4
37635	196	-130	-87	12.4	2.2	-16.0	1.7	-8.8	1.1	-0.4	-0.5	-0.1
37711	185	-33	-24	17.1	1.4	-19.6	1.1	-7.6	1.0	-0.3	-1.6	-0.5
37742	397	-198	-132	16.1	1.6	-4.0	2.5	-9.1	2.3	0.1	0.4	-0.4
37744	394	-203	-136	26.5	1.3	-11.0	1.7	-5.8	2.0	0.2	0.2	0.3
37756	401	-193	-129	16.4	2.3	-24.8	3.5	-18.6	2.8	-0.9	-1.2	-1.0
38622	100	-24	-13	26.9	0.8	-13.6	1.1	-7.6	0.8	-0.2	-0.7	-0.4
38771	443	-305	-180	9.0	3.5	-12.1	4.6	-22.2	5.1	-0.7	-0.1	-1.6
39291	275	-178	-99	17.8	2.8	-8.0	2.7	-5.2	2.1	0.2	0.2	0.1
39698	377	-60	-19	4.8	1.3	-10.2	2.7	-17.3	3.2	-0.2	-0.9	-1.7
41692	153	-94	-38	16.2	1.6	-8.1	2.0	-12.7	1.9	-0.1	0.2	-0.9
41753	157	-42	-8	18.4	0.2	-20.7	0.4	-5.3	0.3	-0.4	-1.5	-0.4
41814	278	-217	-94	2.5	2.4	-7.7	2.5	-24.8	2.1	-0.7	-0.0	-2.1
42560	163	-46	-6	33.4	0.9	-27.1	1.4	-10.2	1.0	-0.5	-1.6	-0.9
42690	218	-149	-55	25.7	1.6	-10.0	1.9	-11.9	1.6	0.2	0.6	-0.6
42927	358	-357	-148	18.9	9.0	18.0	13.2	-27.6	21.6	1.3	2.4	-2.5

TABLE 7—Continued

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
43285	186	-81	-18	15.5	4.6	-25.1	9.3	-21.3	10.5	-0.8	-1.5	-1.9
43317	402	-188	-46	11.7	2.3	-2.5	2.2	-14.1	3.7	-0.0	0.3	-1.3
44112	210	-154	-49	21.0	2.2	-15.4	1.9	-18.2	1.4	-0.2	0.1	-1.3
44173	368	-127	-9	19.8	1.4	0.1	2.7	-7.3	4.9	0.2	0.6	-0.7
44700	288	-143	-25	17.7	1.5	-29.9	1.8	-4.4	1.7	-0.9	-1.7	-0.2
45321	310	-211	-50	9.3	4.8	1.3	7.1	-23.4	10.1	0.1	0.7	-2.2
45542	125	-27	10	38.4	0.5	-13.4	0.9	-11.9	1.1	0.0	-0.5	-1.5
45546	217	-149	-34	21.4	0.7	-9.7	0.9	-12.5	1.2	0.1	0.4	-0.9
46064	391	-357	-98	7.4	12.6	5.7	11.6	-4.2	8.4	0.6	0.7	-0.4
48879	168	106	92	6.4	1.1	-2.9	0.9	4.3	1.2	0.2	-0.5	0.2
48977	315	-145	17	7.0	1.5	-10.7	2.3	-11.8	3.1	-0.2	-0.6	-1.2
49340	126	83	72	-22.0	1.9	-5.1	1.3	-4.4	1.2	-0.6	0.5	0.5
49662	98	-102	-18	16.0	3.7	-15.8	3.8	-5.8	2.0	0.0	0.1	-0.3
51309	315	-359	-56	30.4	2.4	-25.8	2.1	-15.7	2.4	0.3	0.5	-1.1
52559	398	-222	39	21.3	5.7	-36.6	9.4	-30.0	12.5	-0.8	-2.0	-3.3
52918	415	-325	6	25.0	2.2	-8.4	2.6	-10.0	2.7	0.5	0.7	-1.0
53244	80	-90	-9	18.6	1.7	-23.0	1.9	-6.7	0.6	-0.1	-0.1	-0.4
66834	225	-373	48	17.6	4.4	-7.5	3.0	-14.8	4.5	1.1	0.4	-1.6
67797	61	-101	15	11.3	1.3	-16.8	1.3	-8.0	1.2	0.2	-0.1	-1.0
67880	167	-252	48	13.8	1.6	-35.4	1.5	-24.0	1.6	-0.4	-0.8	-2.9
74280	78	-74	53	20.2	1.7	-11.6	1.6	1.6	1.2	0.6	0.1	-0.8
83754	49	-126	71	12.4	1.1	-26.5	2.1	-16.7	1.4	0.7	-1.2	-2.5
87015	185	-112	271	15.0	3.1	-14.7	4.3	-12.5	2.8	1.3	-1.4	-1.5
89688	159	-288	344	9.9	2.5	-14.5	2.8	-9.8	2.5	0.8	-1.1	-1.3

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
100600	46	-77	241	8.0	1.1	-10.7	0.9	15.0	1.2	0.5	-0.5	-0.3
116658	-39	-38	67	7.6	0.4	-18.1	0.4	-4.7	0.4	0.8	-1.8	-0.5
120315	3	17	37	15.9	0.2	-21.0	0.4	-3.7	0.7	1.7	-1.7	0.6
138764	-140	-10	103	-7.1	4.7	-15.4	6.6	-17.9	5.8	-1.0	-1.6	-1.5
142096	-155	-25	75	3.8	1.8	-18.1	1.0	-5.3	1.2	0.1	-1.9	-0.4
142378	-155	-23	75	6.6	2.3	-14.0	1.8	-4.5	1.9	0.1	-1.5	-0.2
144217	-158	-19	70	-0.7	1.0	-15.3	1.6	-9.9	1.6	-0.2	-1.5	-0.9
144218	-158	-19	70	5.1	1.2	-20.3	1.8	-5.7	1.6	0.1	-2.1	-0.4
145502	-160	-15	67	5.2	2.3	-22.6	1.4	-10.9	1.5	-0.1	-2.3	-0.8
147394	-20	63	66	20.3	0.3	-6.8	0.4	-7.0	0.4	1.7	0.3	0.3
148184	-163	-6	61	2.1	1.1	-15.9	0.5	-10.5	0.7	-0.3	-1.6	-0.9
155763	7	64	45	7.2	0.5	-16.0	0.4	-3.0	0.4	0.8	-0.5	0.5
158148	-121	112	85	29.9	2.4	-5.7	2.6	-14.3	3.0	1.1	1.2	-0.1
160762	-32	99	63	7.7	0.4	-17.5	0.5	-7.3	0.4	0.3	-0.1	0.3
161056	-263	89	57	-30.9	2.9	-11.6	4.2	5.0	4.1	-0.7	-2.0	-0.0
163472	-245	126	61	16.3	1.6	-10.5	2.9	5.6	3.7	0.1	-0.3	0.9
164852	-139	148	73	2.8	1.3	-13.4	1.2	-11.5	1.1	-0.7	-0.3	-0.6
166182	-175	190	86	3.7	1.4	-12.2	1.5	-11.4	2.2	-0.6	-0.2	-0.7
168199	-167	149	54	15.0	2.2	-12.8	2.2	-6.4	2.3	-0.0	0.1	-0.2
170111	-180	253	94	11.9	1.9	-10.2	3.2	-11.9	5.0	0.2	0.4	-0.7
170580	-310	210	43	8.6	1.4	-18.1	1.9	-11.8	1.9	-0.7	-0.8	-1.0
170740	-212	82	-2	8.7	1.1	-10.8	2.6	-22.7	2.3	-0.2	-0.7	-2.3
171406	-154	260	93	-1.8	5.4	-0.9	3.8	-14.1	5.1	-0.4	0.2	-1.3
173087	-121	246	83	12.3	2.7	-14.0	2.7	-6.0	3.2	0.4	0.2	-0.1
174237	-36	275	112	6.0	1.1	-12.7	4.6	-20.4	2.0	0.4	0.6	-1.3

TABLE 7—*Continued*

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
174585	-139	269	79	6.0	1.4	-11.8	1.8	-14.6	3.4	-0.1	0.2	-1.0
174959	-80	183	56	36.0	11.6	-4.3	5.6	-11.0	11.0	2.8	1.4	-0.5
176502	-112	322	98	15.0	2.1	-11.8	1.3	-12.8	1.5	0.9	0.5	-0.8
176582	-102	273	80	10.8	7.2	-11.3	3.5	-0.7	5.8	0.6	0.1	0.3
176819	-275	360	58	4.8	2.6	-7.8	2.3	-9.9	3.9	-0.1	0.0	-0.9
176871	-98	154	31	5.0	3.2	-11.5	2.6	-10.7	2.1	-0.2	0.0	-0.8
177003	-46	278	99	20.1	1.0	-13.7	2.4	-9.7	1.2	1.7	0.4	-0.3
178329	-101	314	88	7.1	4.0	-16.8	1.3	-14.2	2.8	0.1	0.3	-0.9
178475	-54	130	32	5.8	1.2	-16.2	2.3	-5.7	0.7	-0.1	-0.0	-0.2
179406	-117	63	-19	14.5	1.0	-8.5	0.7	-8.4	0.6	0.1	-0.1	-1.1
180163	-59	167	40	2.9	1.1	-7.1	0.6	-3.5	0.8	0.0	0.0	-0.2
180554	-91	129	12	4.9	1.9	-17.1	2.2	-3.7	1.4	-0.5	-0.3	-0.2
180968	-262	393	40	-5.9	4.0	0.5	3.2	-32.1	4.3	-0.5	-0.0	-3.2
182255	-101	174	19	2.4	1.1	-12.0	0.7	-7.2	1.0	-0.4	-0.2	-0.6
182568	-88	172	22	24.9	2.0	-9.5	2.4	-11.8	1.7	1.5	0.9	-0.9
183144	-244	288	-9	1.3	4.3	5.9	4.0	-15.3	2.9	0.4	0.3	-1.5
184171	-67	165	23	8.9	1.5	-19.3	0.7	-6.1	1.0	0.1	0.1	-0.3
184930	-108	82	-26	9.7	2.1	-26.3	1.6	-6.1	1.8	-0.8	-1.3	-1.0
185268	-117	240	19	16.3	5.8	-13.6	2.9	-11.5	5.1	0.8	0.4	-1.0
185423	-274	242	-58	3.5	2.4	1.1	2.4	-5.3	1.9	0.3	0.2	-0.5
185915	-116	197	2	3.1	6.8	-21.0	5.7	-29.7	8.5	-0.7	-0.4	-3.0
185936	-135	166	-17	-1.0	1.8	-19.4	1.6	-2.8	2.0	-1.0	-0.8	-0.4
186660	-305	227	-91	13.7	1.4	-10.1	1.3	3.7	1.7	0.0	0.0	-0.0
187811	-108	186	-8	13.6	2.5	-23.5	2.5	-31.0	2.2	0.1	-0.1	-3.2

TABLE 7—Continued

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
188665	1	154	41	8.2	0.6	-24.2	2.4	-6.5	1.0	0.8	-0.0	-0.0
188892	-38	133	13	9.8	2.6	-27.8	1.3	-8.4	1.7	0.2	0.1	-0.6
189066	-78	240	17	2.9	3.8	-22.5	1.7	-11.4	3.9	-0.4	-0.1	-1.0
189178	-43	168	18	12.1	0.6	-23.8	1.2	-3.2	0.6	0.6	0.1	-0.0
189432	-74	257	21	13.2	2.1	-11.0	1.4	-3.0	3.5	0.9	0.3	-0.2
189687	-65	214	15	4.1	1.4	-2.8	2.4	-1.8	0.8	0.3	0.1	-0.2
189775	-24	345	71	13.0	6.1	-14.0	1.4	-8.2	4.3	1.2	0.2	-0.5
190993	-84	161	-15	9.7	1.4	-2.3	1.3	-13.6	1.2	0.7	0.2	-1.4
191263	-225	285	-76	28.3	2.4	-25.7	1.8	6.2	3.2	0.5	0.4	-0.2
191610	-56	196	7	15.7	0.7	-9.8	0.5	4.5	0.7	1.2	0.3	0.5
192685	-67	146	-15	3.0	1.7	-1.6	2.4	-7.8	1.5	0.2	0.0	-0.8
192987	-91	338	6	11.2	12.6	-3.0	4.2	-10.7	12.5	1.0	0.3	-1.1
193536	-57	455	47	-6.1	3.5	-8.9	1.4	-8.4	4.1	-0.7	-0.0	-0.7
195556	-14	209	21	14.3	0.7	-20.4	2.5	-7.7	0.7	1.3	0.1	-0.5
195810	-65	95	-34	7.5	0.5	-22.1	0.5	-7.9	0.5	-0.3	-0.7	-1.3
195986	-65	446	15	16.1	5.4	-14.7	0.9	-0.8	5.1	1.4	0.2	-0.0
196035	-171	348	-78	13.4	3.6	4.9	2.6	-23.0	3.2	1.5	0.2	-2.2
196740	-60	141	-28	10.7	1.9	-21.3	2.4	-7.8	1.7	0.2	-0.1	-1.2
196775	-126	219	-69	-11.7	2.1	-10.3	2.5	-19.1	1.8	-1.1	-1.2	-1.9
197036	-28	284	13	8.8	2.2	-14.2	1.2	-3.5	1.8	0.7	0.1	-0.3
197511	-8	269	24	6.0	1.5	-3.4	1.2	2.5	1.2	0.6	-0.0	0.3
197770	25	370	59	-3.4	5.3	-14.6	2.6	-2.3	4.8	-0.2	0.0	0.0
198183	-21	100	-8	4.7	0.9	-23.0	2.4	-5.1	0.8	-0.0	-0.1	-0.7
198625	-17	256	8	22.7	1.7	-14.0	2.5	13.1	1.7	2.2	0.1	1.4
198820	-120	475	-63	-2.7	6.9	-21.3	3.2	-14.5	6.8	-0.7	-0.4	-1.7

TABLE 7—Continued

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
199081	-12	133	0	3.9	0.3	-19.3	1.2	-6.6	0.3	0.2	0.0	-0.7
199661	36	427	56	14.2	3.1	-19.6	2.5	-6.1	3.1	1.6	-0.1	-0.4
201836	-2	213	-1	4.6	7.7	-8.7	1.2	2.0	7.6	0.4	0.0	0.2
202654	1	391	-5	14.3	2.8	-26.2	5.0	-13.2	2.8	1.4	-0.0	-1.3
203245	5	177	0	3.0	3.9	-23.1	1.2	12.3	3.9	0.4	-0.0	1.2
204403	-24	226	-40	3.2	1.2	-19.8	2.5	1.3	1.3	0.1	-0.0	-0.2
204770	38	143	30	-14.4	1.7	7.9	2.5	-4.4	1.8	-1.5	0.5	-0.5
205021	77	243	64	15.1	0.7	-11.3	1.0	-2.9	0.7	1.7	-0.5	-0.1
206672	16	164	-4	5.0	1.0	-8.8	1.2	-1.5	1.0	0.6	-0.1	-0.2
207330	15	183	-10	3.7	0.6	-12.8	1.2	-2.0	0.6	0.5	-0.1	-0.3
207563	-94	358	-174	13.3	8.7	-18.8	6.8	-10.4	9.4	1.0	-0.6	-1.7
208057	-29	164	-66	8.6	0.5	-12.4	2.3	-1.9	1.0	0.7	-0.1	-0.6
208095	29	174	4	9.8	1.0	-8.0	1.2	-11.1	1.1	1.1	-0.2	-1.1
208947	115	387	64	9.3	2.4	-0.3	1.4	0.6	2.5	0.9	-0.3	0.0
209008	-129	287	-233	32.2	3.5	1.9	2.6	-6.4	3.0	3.0	0.6	-1.0
209419	44	279	-9	11.8	1.7	-24.3	1.2	-5.8	2.2	1.5	-0.3	-0.7
209961	52	449	-48	-10.4	6.5	-17.4	0.7	-5.7	8.4	-0.8	0.0	-0.8
210424	-87	94	-148	15.4	1.2	-14.6	1.7	-21.6	1.2	1.7	-1.6	-2.0
211924	-42	112	-103	12.7	1.5	-7.3	1.3	-1.8	1.3	1.1	-0.2	-0.7
212076	-56	214	-163	12.5	1.4	7.5	1.4	-10.6	1.4	1.4	0.0	-0.5
212120	13	97	-15	7.6	1.8	-11.9	1.2	-7.3	2.2	0.9	-0.3	-0.9
212222	24	251	-57	9.9	5.1	-20.1	1.7	-4.1	4.5	1.2	-0.3	-0.8
212883	27	434	-133	-9.8	7.4	-10.6	2.1	-7.3	5.1	-0.9	-0.2	-1.0
212978	39	438	-119	-2.4	1.4	-16.8	1.2	1.7	0.9	-0.1	-0.1	-0.3

TABLE 7—Continued

HD	X	Y	Z	U	P.E.(U)	V	P.E.(V)	W	P.E.(W)	δU	δV	δW
214167	49	434	-127	-15.1	5.3	-10.0	2.0	8.5	5.4	-1.4	0.3	0.5
214168	49	434	-127	-9.0	2.1	-12.1	2.5	-5.5	2.6	-0.8	-0.2	-0.9
214240	92	442	-57	3.9	3.2	-16.7	0.8	-0.7	4.0	0.7	-0.2	-0.3
214680	50	432	-133	4.0	2.1	-11.7	0.8	-3.5	2.5	0.5	-0.3	-0.6
214993	58	433	-127	0.3	3.6	-13.2	1.2	6.7	4.0	0.2	0.0	0.3
215191	50	429	-144	-7.0	3.7	-22.0	1.7	-11.8	4.0	-0.5	-0.5	-1.7
216200	76	432	-121	3.3	2.0	-18.1	2.0	-4.9	2.6	0.6	-0.4	-0.9
216916	83	429	-128	-0.3	2.5	-12.5	1.1	-3.7	3.8	0.2	-0.2	-0.7
217101	75	425	-144	-4.2	3.2	-16.7	1.6	-2.6	2.9	-0.2	-0.2	-0.7
217543	77	422	-150	-11.7	6.2	-22.9	2.3	-19.4	4.7	-0.9	-0.7	-2.5
217811	100	429	-115	-10.3	2.8	-7.9	1.1	-4.6	1.8	-0.8	0.0	-0.7
217943	156	428	3	1.6	4.9	-18.6	2.9	-4.8	3.4	0.7	-0.3	-0.5
218407	113	429	-103	-2.7	4.1	-12.6	1.6	15.8	3.1	0.1	0.3	1.2
218440	131	357	-4	10.8	2.6	-8.8	1.5	1.2	2.5	1.2	-0.5	0.1
218537	95	237	14	-6.9	1.2	-35.7	1.2	-4.2	1.6	0.6	-0.2	-0.2
221253	72	174	-9	10.3	0.9	-20.9	0.5	0.0	0.6	1.6	-0.7	-0.1
223128	207	414	38	1.2	8.2	-15.2	4.6	-11.5	13.1	0.7	-0.3	-1.0
223229	117	295	-83	-11.1	4.2	-20.7	4.8	5.7	1.9	-0.2	0.1	-0.0
224572	162	338	-42	6.3	2.2	-17.6	1.4	-4.4	4.7	1.2	-0.6	-0.6

TABLE 8

LEAST-SQUARES SOLUTIONS FOR VELOCITY GRADIENTS

Solution No.	N	r (pc)	Sp.	Assoc. Wt.	$\partial U/\partial X$	$\partial U/\partial Y$	$C(U)$	$\partial V/\partial X$	$\partial V/\partial Y$	$C(V)$	$\partial W/\partial Z$	$C(W)$
1.....	294	≤600	All	Normal	+10.7±2.8	−24.1±3.0	+12.6±0.5	+ 0.6±3.0	+ 2.7±2.5	−14.8±0.4	+20.0±3.8	− 6.7±0.2
2......	181	≤600	≤B3	Normal	+12.4±2.5	−20.6±2.7	+12.7± .4	+ 5.2±3.1	+ 4.6±2.6	−14.2± .5	+13.0±3.8	− 7.0± .3
3......	166	≤300	All	Normal	+14.3±4.5	−29.7±4.7	+12.7± .6	− 4.5±4.9	+ 2.4±5.2	−14.7± .6	+23.9±5.5	− 6.5± .3
4......	64	≤300	≤B3	Normal	+18.6±4.8	−24.0±5.0	+12.5± .7	+ 8.5±6.4	+15.0±7.0	−14.8± .8	+15.4±6.4	− 6.7± .4
5......	294	≤600	All	Reduced	+ 5.0±3.1	−30.1±3.2	+13.5± .5	− 0.6±3.4	+ 3.0±2.9	−14.0± .5	+18.6±3.8	− 6.3± .2
6......	181	≤600	≤B3	Reduced	+ 6.0±2.7	−25.3±2.7	+13.6± .4	− 0.6±3.7	+ 7.7±3.3	−14.1± .6	+13.6±3.9	− 6.8± .2
7......	94	≤600	All	Total	+37.5±3.3	− 2.5±3.5	+ 5.6±0.8	+14.1±3.6	+ 7.2±2.8	−20.4±0.8	+ 6.2±5.6	− 9.7±0.4

TABLE 9

EXPANSION AGE DERIVED FROM INDIVIDUAL VELOCITY GRADIENTS

SOLUTION No.	$t(10^6$ years)			
	$\partial U/\partial X$	$\partial U/\partial Y$	$\partial V/\partial X$	$\partial V/\partial Y$
1...........	100–115	≥145	≤30	65– 95
2...........	95–110	≥120	....	60– 80
3...........	85–110	≥190	≤65	60–145
4...........	70–100	≥125	....	35– 55
5...........	115–130	....	≤40	65– 95
6...........	110–125	≥165	≤40	50– 70
7...........	30– 40	≤ 50	....	50– 70