THE URSA MAJOR GROUP

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ABSTRACT

The Ursa Major group is investigated in detail. It is shown that a small, compact cluster can be distinguished from the large, ill-defined stream. An introduction to the problem is given in Section I. Section II contains a summary of the previous work on the group, together with a bibliography. In Section III the position of the convergent point is determined from the proper motions of the nucleus stars. It is shown that these proper motions determine the position of this point quite accurately. New measurements of the radial velocities of the brighter nucleus stars are discussed in Section IV and are used to determine the space velocity of the cluster. The results indicate that a velocity may be found which agrees with the individual parallaxes and radial velocities within their expected uncertainty, but the systematic differences between the results from these two sets of data cannot be completely removed. In Section V, the results of a search for new members within 20 parsecs of the center of the nucleus are described. A list of members and a description of the cluster are given. Section VI contains a list of all stars which have been assigned to the Ursa Major stream and compares the observed and the computed data for these stars. New spectral types and spectroscopic absolute magnitudes are given for those stars for which the agreement between the observed and the computed data is best and which are north of declination −30°. Section VII summarizes the results of the investigation.

I. INTRODUCTION

Information gained from the study of moving clusters has played an important role in both stellar astronomy and astrophysics, by furnishing fairly accurate data on the absolute magnitudes of stars too distant to be reached effectively by trigonometric methods. As a result, the nearest open clusters have been studied extensively. Unfortunately, in spite of numerous investigations, the status of the Ursa Major cluster is far from satisfactory. The long lists of members of the cluster are strikingly discordant; the space velocity of the group and thus the parallaxes of the cluster members have been uncertain by as much as 20 per cent; and even the existence of the group has been doubted. In the present investigation some of the causes of these problems are examined, the uncertainty in the space velocity of the cluster is diminished, and the current state of knowledge about the cluster is presented.

The Ursa Major group can be considered as composed of two subgroups: a moderately compact cluster of stars sharing *accurately* the same space motion and an extended stream of stars possessing *approximately* the same space motion. It is well known that the five central stars in the Big Dipper and five fainter ones in the same region of the sky are moving with velocities which are equal within the errors of observation. Moreover, these stars are collected in a volume of space less than 10 parsecs across. On the other hand, the stars of the extended Ursa Major group seem to fill a volume of space which is limited only by the effects of observational selection, a volume which contains not only the sun but also the Hyades, the Pleiades, and the Coma clusters. In this paper we shall refer to the compact group in Ursa Major as the "nucleus" or "cluster" and to the extended group as the "Ursa Major stream." However, the gravitational interactions between the members of the cluster are much smaller than between members of such compact groups as the Pleiades or the Hyades clusters.

The following is a list of some of the symbols and abbreviations used in this paper:

A, D = Right ascension and declination of the convergent point

L, B = Galactic longitude and latitude of the convergent point or of the solar apex

R	=	Difference in velocity between the space motion of a star or group of stars and that of the cluster
V	=	Velocity of the cluster
X, Y, Z	=	Rectangular galactic co-ordinates of the star referred to the center of the nucleus. X points to galactic longitude 0°; Y, to galactic longitude 90°; and Z, to the north galactic pole.
GC	=	*General Catalogue*
FK3	=	*Dritter Fundamentalkatalog des Berliner Astronomischen Jahrbuchs*
NFK	=	*Neue Fundamentalkatalog*
PGC	=	*Preliminary General Catalogue*
λ	=	Angular distance between a star and the convergent point
ρ	=	Radial velocity of a star in kilometers per second
μ_α, μ_δ	=	Components of proper motion in right ascension and declination, respectively
π_{tr}	=	Trigonometric parallax of a star
π_{sp}	=	Spectroscopic parallax of a star
π_{cl}	=	Parallax of a star computed on the assumption that it shares the motion of the cluster

II. DISCUSSION OF THE LITERATURE

In 1869 Proctor called attention to the fact that the available proper motions were not distributed at random but that rather, in many regions of the sky, several stars seemed to share a common motion (45).* Among others, he pointed out the remarkable group in Ursa Major of stars moving toward the solar apex. Three years later, Huggins published radial velocities for the seven stars of the Big Dipper which confirmed the hypothesis that the five central stars share a common space motion not shared by the other two (29). Moreover, he remarked that these five stars, which are of approximately equal brightness, also have similar spectra.

Since that time, numerous attempts have been made to determine more accurately the position of the convergent point and the amount of the cluster motion. Two basic methods have been used for most of these determinations. One is attributed to Bohlin, although it was used by Klinkerfues thirty years earlier (30). The essential reasoning on which Bohlin's method is based is the following: The proper motion of each cluster member defines a great circle through the radiant and convergent points. Therefore, the poles of these circles must lie on another great circle, every point of which is 90° distant from the convergent point. In turn, the poles of this latter circle must be the convergent and the radiant points. Unfortunately, the five bright stars in the Ursa Major nucleus lie approximately on the great circle defined by their motions. This means that the poles of the proper-motion circles are badly clustered, and a position for the convergent point determined by this method is necessarily uncertain. This method has not been used extensively for the nucleus stars alone.

The method of differential corrections—the standard method of treating nonlinear equations by least squares—has proved to be more fruitful. In this method the equations expressing the observed quantities as functions of the elements of the motions are dif-

* Numbers in parentheses refer to numbered entries in the bibliography on p. 240.

ferentiated. Then the differences between the observed and the predicted amounts of the proper motions, the radial velocities, or the tangential motions are used to compute small corrections to the preliminary cluster elements. Besides its simplicity, this method has the important advantage of minimizing the residuals in the observed quantities rather than in functions of these quantities. Moreover, the constants in the equations of condition contain only the position of the star and the assumed preliminary position of the convergent point and are thus known exactly, while in Bohlin's and Charlier's methods the constants contain errors in the proper motions which are reflected in the final position of the convergent point.

Haas assumed that the space velocity and parallax of each cluster member was the same and computed the three components of the space velocity from the observed radial velocities and proper motions (21). This method is equivalent to determining the position of the convergent point from the change in the radial velocities and proper motions as a function of position in the sky. In theory the method is open to no objections, but in practice it seems unwise to disregard the most accurate data available, the position angles of the proper motions. The method also involves the unnecessary assumption that all the members considered are at the same distance from the sun.

Hertzsprung has published several short notes suggesting faint stars which may be members of the nucleus (24, 25), but Haas seems to have been the only person to search for such stars systematically. By consulting the catalogues from the Cincinnati Observatory, the Yale proper motions determined for the A.G. stars and the difference (Vatican catalogue − Helsingfors A.G. catalogues), he extended the list of nucleus stars to include 26 members. These stars defined the main sequence as far as M0, but there were radial velocities only for the brighter ones. As we shall see in Section V, the radial velocities rule out all but two others.

In 1909 Hertzsprung noticed that two stars, in widely separated regions of the sky, 37 UMa and α CrB, also possessed proper motions directed toward the convergent point of the Ursa Major motions (23). This discovery led him to make a systematic search for members of the group outside the region of the Big Dipper. From the stars which then had the best proper motions, he selected eight new members. He determined the position of the convergent point in two ways, both based on the proper motion of Sirius. The velocity of the group was computed in the usual way and checked by the observed tangential velocity of Sirius.

Shortly later, Ludendorff criticized the high weight given to Sirius in determining the position of the convergent point, arguing that the motions of the members of the group might not be strictly parallel (35). He redetermined this position from the directions of the proper motions of all group members but did not obtain an appreciably different result.

During the next decade, Hertzsprung and Oppenheim compiled new lists of cluster members which were discussed by Bottlinger (7) and Ledersteger (32), respectively. The latter used a new method, introduced by Oppenheim (40), to determine the position of the convergent point, but this is essentially a mathematical modification of Bohlin's method.

With the accumulation of observational data, it became possible to distinguish stream members on the basis of common space motion. As early as 1915, Plummer noted four F-type members of the stream in this way, as a by-product of his discussion of the space motions of F-type stars using hypothetical parallaxes[1] (44), and Dziewulski used the space motions of individual members with known parallaxes to compute the cluster elements (14). By 1930, radial velocities and parallaxes were available for most of the bright stars and a new interest arose in compiling lists of members of the Ursa Major and other streams. In that year Mohr investigated all A- and F-type stars with complete

[1] These were computed on the assumption that the true space motion of each star is parallel to the galactic plane.

proper motion, radial velocity, and parallax data (37). Using R, the difference between the space motion of the star and that of the cluster, as a criterion, he concluded that 35 per cent of the A-type stars and 8 per cent of the F-type stars which he examined belonged to the Ursa Major stream. This result increased the membership of the group to 96 stars. In a similar way, Bertaud found 94 stars with R less than 10 km/sec (3). Nassau and Henyey used the criterion that R is less than 9.5 km/sec to pick stream members from among the stars in the *Yale Catalogue of Bright Stars* (38). One out of every 24 stars examined satisfied this test. These authors did not claim that field stars had been eliminated from their list or that the group of stars thus distinguished had any physical significance, but they treated these stars as a cluster in their further discussion. Later, Nassau decided that there were few, if any, field stars present among the stars with R less than 7.5 km/sec (39). Furthermore, he concluded that both the distribution of spectral types and a large percentage of binaries served to distinguish the stream stars from the field stars.

By 1939 the list of stream members had grown greatly, and many stars were included for which the status in the group was doubtful. In that year Smart published two papers in which he examined more critically the stars from Bottlinger's and Plummer's lists (47) and those from Henyey and Nassau's lists (49). He subjected each star in these lists to three tests: (*a*) agreement between the observed and the computed position angles of the proper motion, (*b*) agreement between the computed and observed radial velocities, and (*c*) agreement between the computed and both the spectroscopic and the trigonometric parallaxes. Of the 135 stars examined, 42 were retained as definite members of the group, and 52 additional stars were retained as possible members. The definite members from the first paper were used to compute the position of the convergent point by Bohlin's method. Since Smart found that the velocity of the cluster as computed from the radial velocities of the members was somewhat uncertain, he determined the velocity of the group from the trigonometric parallax and proper motion of Sirius. He also determined this velocity by using all stars with large trigonometric parallaxes, but, as the result was not appreciably different (Sirius still received 40 per cent of the weight), he adopted the value which he had determined from Sirius alone.

About the same time, Bartholeyns treated both a new list of members which he had found from space motions (1) and a number of stars from older lists in much the same way (2). He also included three small tables of stars which appeared to be members on the basis of new or incomplete data.

In 1941 Gliese examined the space motions of all stars in the FK3 for which radial velocities and parallaxes were available (17). After attempting to allow for galactic rotation and for any systematic errors present in the observational data, he considered the distribution of the velocity vectors of these stars. He studied each of the moving clusters, determining its boundary as the edge of the region in which there was a higher concentration of velocities than normal. Although he did not define what constituted a significant deviation from the normal concentration of velocity vectors, he distinguished 80 stars as members of the Ursa Major stream. However, even after excluding these stars and a similar set of members of the Taurus stream, he found traces of the two streams in his further discussions.

Each investigator has recomputed the cluster elements, using different lists of members, different data, and different methods. However, all reliable determinations have given values near $A = 306°$, $D = -37°$, and $V = 18$ km/sec.

Several attempts have been made to find a change in the motion of the stream stars with their space positions (2, 9, 11, 16). In each case, the investigator believed that such a systematic variation existed. Mlles Canavaggia and Fribourg, and Bartholeyns each found that the motion of the stream stars is consistent with a rotation of the group about its center but not with differential galactic rotation. However, the problem is a difficult one, and the results are not conclusive.

In a short note published in 1911, Turner called attention to the fact that the members of the Ursa Major group listed by Hertzsprung lay approximately in a plane which is nearly perpendicular to the plane of the galaxy and to the direction of the motion of the cluster (51). Guthnick and Prager (18) and Nassau and Henyey have confirmed this suggestion, while Oppenheim, Ledersteger, and Horn-d'Arturo (28) found that the stars were distributed in three planes which contained their motions. A description of the space distribution of the stream members depends largely on the list of members chosen and is of little worth unless the effects of observational selection are eliminated or at least recognized.

Recently, Delhaye has studied the dispersion of the velocities among the members of the Ursa Major stream on the basis of the space motions of about 2000 stars brighter than 6.5 mag. (13). A plot of all velocities for the A- and F-type stars (exclusive of the stars in the nuclei of the Ursa Major and Taurus clusters) showed that there were more velocities near the Ursa Major velocity than in the diametrically opposite portion of the diagram. Allowing for field stars, the distributions of both the radial velocities and the proper motions of the stars with velocities within 10 km/sec of that of the Ursa Major group "indicate that there is a real concentration of velocities toward the motion of the Ursa Major nucleus. At the same time, they show that the space motions of the members of the extended Ursa Major stream are not identical, but have a real dispersion, the amount of which may be estimated as between 2 and 3 km/sec in one coordinate."

In addition to the papers which treat the Ursa Major stream as an exact concept, many have been written on the appearance of this stream as a velocity maximum in studies of the distribution of space velocities. Early in the study of stellar motions Kapteyn noticed an apparent tendency for stars to move in nearly opposite directions. The stars moving in these preferred directions, which were known as Kapteyn's streams I and II, became identified with the Taurus and the Ursa Major streams, respectively. Three-quarters of the stars which B. Boss assigned to stream II (6) have appeared among the lists of members of the Ursa Major group.

With the development of the theory of galactic rotation, Kapteyn's streams were recognized as a natural consequence of this rotation. Thus it has become important to decide whether the Ursa Major stream can be distinguished from stream II. Opinion on this question varies. In a recent investigation of the space motions of early A-type stars, Bourgeois and Coutrez found that there is no trace of either the Ursa Major or the Taurus streams in their results (8). On the other hand, Wilson and Raymond (52) and Gliese have found that it is impossible to represent the observed distribution of space velocities by a single velocity ellipsoid because of the presence of the Ursa Major and Taurus streams. Lindblad suggested that the deviation of the vertex of star-streaming from its expected direction of about 325° to a direction of about 345° is a result of the existence of the Ursa Major stream (33).

Various authors have attempted to decide whether the condensations of velocities in the regions of the scattered moving clusters are significant or mere chance deviations from a uniform distribution. Allowing for the effects of star-streaming but not for those of solar motion, Dziewulski concluded that the stars whose proper-motion circles pass near the convergent point belong to a physically significant group but that the number of spurious members increases rapidly as larger residuals are allowed (15). Had he been able to consider the distances of the stars as well as the proper motions, his argument would have been still stronger.

In 1932 Bertaud conducted a similar investigation using space motions (3). His results are given in Table 1. He, too, concluded that the group is real, with a definite concentration of motions toward the motion of the nucleus stars. However, as the allowed tolerance in the velocity residuals is increased, the space motion found for the group deviates somewhat from that of the central stars toward the direction of star-streaming.

In a personal communication Dr. J. H. Oort stated that, among the stars brighter than

6.5 mag. with known space motions, 22 stars of types A–G are within a cube 10 km/sec on a side and centered on the motion of the Ursa Major nucleus. The ellipsoidal distribution of velocities predicts that 5.6 stars will be found in such a cube.

The evidence seems to favor the existence of the Ursa Major stream. There is a real concentration of velocities near the velocity of the nucleus group, but the limits of the stream are ill defined.

III. THE DETERMINATION OF THE POSITION OF THE CONVERGENT POINT

The position of the convergent point of the Ursa Major group has been computed many times, but, since 1910, only one determination has been based on the nucleus stars alone. In view of the finite dispersion among the space velocities of the stream members, it seems essential to determine this quantity from the motions of the nucleus stars.

The data from which the position of the convergent point can be found are the proper motions, the radial velocities, and the parallaxes of the individual stars. Bohlin's and Charlier's methods depend only on the proper motions; the method of differential corrections can be based on any or all of the three types of data; a determination from the

TABLE 1

THE CONCENTRATION OF SPACE VELOCITIES TOWARD THAT OF THE NUCLEUS STARS

Maximum Residual in Space Velocity (Km/Sec)	No. of Stars*	Observed No. / Expected No.	Maximum Residual in Space Velocity (Km/Sec)	No. of Stars*	Observed No. / Expected No.
10	109	1.3	4	36	2.6
8	87	1.5	2	15	3.7
6	59	1.9			

* The nucleus stars and the stars α CMa, α CrB, and ξ Eri have been excluded in compiling this table.

space motions depends on a combination of the three types. Since the intrinsic accuracies of the proper motions, radial velocities, and tangential velocities are quite different, it seems advisable to treat the three sets of data separately, as far as possible. For this reason and for the reasons discussed in Section II, it was decided that the method of differential corrections was the most satisfactory one to use for a new determination of the position of the convergent point.

Equations were written relating each of the observed quantities cot θ, ρ, and 4.74 μ/π, with the elements of the cluster motion. When differentiated, these yielded the equations of condition:

$$\Delta \cot \theta = l \Delta A + m \Delta D \,,$$

$$\Delta \rho = g \Delta A + h \Delta D + \cos \lambda \Delta V \,,$$

$$\Delta \left(\frac{4.74\mu}{\pi} \right) = g \cot \lambda \Delta A + h \cot \lambda \Delta D + \sin \lambda \Delta V + \frac{4.74\mu}{\pi} P \,,$$

where

P = A correction to the system of the parallaxes such that $\pi_{\text{true}} = \pi_{\text{sp}}(1 + P)$;

$l \sin (\alpha - A) = \csc (\alpha - A) \sin \delta - \cos \delta \cot (\alpha - A) \tan D$;

$m \sin (\alpha - A) = \cos \delta \sec^2 D$;

$g = V \cos \delta \cos D \sin (\alpha - A)$;

$h = V \sin \delta \cos D - V \cos \delta \sin D \cos (\alpha - A)$

The work was so arranged that the set of equations of condition for each type of data could be treated separately or combined with the others.

Oort and his co-workers have investigated the systematic errors of the GC and the FK3 proper motions and have compared these errors with the systematic differences between the two catalogues.[2] Their results indicate that the GC proper motions in right ascension are to be preferred over those in the FK3; for the proper motions in declination, the FK3 system is preferable. In addition, a correction should be applied to each system to allow for errors in the precession constants used. In this paper the proper motions used are those from the GC,[3] to which the following corrections have been applied: (*a*) a correction for the errors in the precession constants and a correction for the effect of galactic rotation taken from tables given by Smart[4] and (*b*) the corrections $\Delta\mu_\alpha'$ and $\Delta\mu_\delta'$ necessary to reduce the proper motions in declination to the FK3 system. These have been taken from tables given by Kopff of the systematic differences between the GC and the FK3 motions.[5] The radial velocities will be discussed in Section IV. In computing the tangential motions, the spectroscopic parallaxes have been employed in this section. They are more concordant than are the trigonometric parallaxes, and the term P allows for any systematic error arising from the uncertainty in the zero point of the absolute-magnitude scale. The position of the convergent point and the value of the stream velocity found by Smart have been used as preliminary values.

TABLE 2

THE WEIGHTS USED IN THE LEAST-SQUARES SOLUTIONS

Star	Weights: cot θ	Weights: ρ	Weights: 4.74μ/π	Star	Weights: cot θ	Weights: ρ	Weights: 4.74μ/π
37 UMa	1600	6	9	78 UMa	1600	6	9
β UMa	2500	24	9	HD 115043	900	12	9
γ UMa	2500	3	9	ζ UMa A	2500	24	9
δ UMa	2500	3	9	ζ UMa B	0	24	0
HR 4867	900	1.5	9	80 UMa	1600	3	9
ε UMa	2500	1.5	0				

TABLE 3

THE SOLUTIONS FOR THE POSITION OF THE CONVERGENT POINT

Solution	*A*	*D*	*V*	*P*
Smart's	306°7±1°3	−39°5±0°7	19.1 km/sec	....
Proper motions	306.2±0.5	−37.1±1.2	....	....
Combined solution	306.4±1.9	−37.4±4.6	17.9±0.5	0.05±0.14

The amount and mean errors of the observed quantities will be found in Table 15. Table 2 lists the weights assigned to each quantity for each star. It will be noticed that the proper motions are given much more weight than are the other types of data. Table 3

[2] See, e.g., *B.A.N.*, **9**, 417, 424, 1943.

[3] The proper motion for the stars near the nucleus which are too faint to be included in the GC have been taken from *Trans. Yale U. Obs.*, **4**, 1925, **7**, 1937.

[4] *M.N.*, **101**, 37, 1941.

[5] *A.N.*, **269**, 160, 1939.

gives the stream elements found by Smart and those obtained in the present investigation from the proper motions alone and from the solution combining the three sets of data. Solutions were also made from the radial velocities and from the tangential motions separately. In these cases the position of the convergent point is determined only by the variations in the observed quantities across the nucleus region. The uncertainty in these solutions is so large that they are of no interest.

At first sight, it seems surprising that the probable errors of A and D are less in the solution from the proper motions alone than in the combined solution. This happens because the additional data contribute little weight, while two additional unknowns are introduced. Further, the uncertainties in the radial and tangential velocities are forced on the determination of A and D in the combined solution, as well as on the determination of V. As a result of these effects and of the high accuracy of the proper-motion data, the solution from the position angles alone is to be preferred, although the results are not appreciably different. Table 4 indicates how well the position angles of the proper motions of the nucleus stars are satisfied by this position; the agreement in the case of the radial velocities and parallaxes will be discussed in Section IV (see Table 12).

TABLE 4

RESIDUALS FROM THE ADOPTED POSITION OF THE CONVERGENT POINT

Star	$\Delta\theta$	Star	$\Delta\theta$	Star	$\Delta\theta$
37 UMa	$+1\overset{\circ}{.}5$	HR 4867	$+2\overset{\circ}{.}2$	ζ UMa A	$-1\overset{\circ}{.}9$
β UMa	-0.1	ϵ UMa	-2.5	ζ UMa B	$+2\overset{\circ}{.}3$
γ UMa	-0.1	78 UMa	-0.8	80 UMa	$-2\overset{\circ}{.}4$
δ UMa	$+0.5$	HD 115043	$+2.3$		

IV. THE RADIAL AND SPACE VELOCITIES OF THE NUCLEUS STARS

Although the point of convergence of the motions of the Ursa Major nucleus stars can be found quite accurately from the large proper motions of these stars, a determination of the space velocity of the cluster must depend on either the radial velocities or the parallaxes. The parallaxes are about $0\overset{''}{.}040$, and the individual trigonometric determinations may be uncertain by 20 per cent or more. Since the stars are mainly early A-type stars and many have poor lines, there are discordances among the numerous measurements of their radial velocities. Some of the determinations were based on only a few plates; others indicated that the velocities of several of the stars were variable, without further confirmation or disproof. For these reasons it was considered worth while to remeasure these radial velocities in an attempt to strengthen the value of the speed of the cluster. Table 5 gives the radial velocities available for these stars in Moore's catalogue.[6]

Dr. W. P. Bidelman kindly agreed to obtain the plates for this purpose. These were taken with the Cassegrain glass spectrograph of the McDonald Observatory, which gives a dispersion of 26 A/mm at $H\gamma$. The dispersion is such that the kilometers per second per millimeter is reasonably large but the star lines, while broadened by rotation, are not widened to the extent that they are particularly difficult to measure. The spectra are wide and well exposed, and the cores of the hydrogen lines can be measured with reasonable ease. Plates of other stars in the same region of the sky were taken at the same time as those of the nucleus stars, in order to afford a check on the system of the velocities. Table 6 contains a summary of the plates obtained. The spectral type, line quality, and the measured radial velocity are given for each of the nucleus stars.

[6] *Lick Obs. Bull.*, Vol. **18**, 1932.

TABLE 5*

PREVIOUSLY PUBLISHED RADIAL VELOCITIES FOR THE NUCLEUS STARS

Star	Measures (Km/Sec)	Mean (Km/Sec)
37 UMa	W − 9.9±2.2 L −13.0±1.3	−12.4±1.2
β UMa	Pot −15.5±0.6 var? L −11.4±0.1 Y −10.6±1.3	−12.1±0.1
γ UMa	L −12.9±3.0 M −13.4±1.8 P +30.3 Y − 5.8±2.7	−11.1±1.3
δ UMa	L −15.8±3.0 Y − 9±15 Vn −10 ±7	−12 ±6
HR 4867	W − 9.5±3.1 L −10.2±3.3	− 9.7±2.2
ε UMa	Pot −11.9	SB O Ludendorff
78 UMa	L − 9.2±1.5 W − 3.1±1.6	− 7.2±1.2
HD 115043	L − 7.9±1.3	
ζ UMa A	M − 9.6 O Hadley Pot −12.0 O Ludendorff Vn − 8 O Hnatek	− 9.9
ζ UMa B	Y − 7.4±0.7 var L −10.8±1.3 Pot −12.5±0.7 O −23.6±1.2	− 9.2±0.1*
80 UMa	Y + 0.1±2.5 L −12.5±0.4	− 2.0±2.1*

* The notation used in this table is that of Moore's catalogue of radial velocities.

TABLE 6

SUMMARY OF THE McDONALD VELOCITIES FOR THE BRIGHT NUCLEUS STARS

Name	Sp. Type	Line Quality	No. of Plates	Measured Velocity	Corrected Velocity
37 UMa	F1 V	Fair	10	−17.3±0.7	−14.6
β UMa	A0 V	Fair	10	−13.3±0.7	−10.6
γ UMa	A0 V	Poor	15	−16.6±0.9	−13.9
δ UMa	A3 V	Poor	14	−20.6±1.5	−17.9
HR 4867	F6 V	Good	10	−20.0±0.4	−17.3
ε UMa	A0 p	Good	10	− 8.1±0.3	− 5.4
78 UMa	F2 V	Fairly poor	10	−17.7±0.9	−15.0
HD 115043	G2 V	Good	5	−11.8±0.3	− 9.1
ζ UMa A	A2 V	Fair	14	− 8.0±1.0	− 5.3
ζ UMa B	A2 m	Fair	10	−15.4±0.7	−12.7
80 UMa	A5 V	Poor	14	−10.3±1.2	− 7.6

Each plate was measured in the direct and reverse direction at the same sitting, as the systematic error in setting on the broad lines characteristic of many of the stars changed perceptibly from time to time. Care was taken to choose comparison lines of nearly the same strength, since the strong ones were broadened asymmetrically. An investigation showed that the asymmetrical broadening is not sufficient to affect the measures noticeably in the range of line strengths used; it may account, at least partly, for the systematic difference between the McDonald and the Lick velocities.

Table 7 gives the wave lengths used for the star lines. For the lines in the A- and early F-type stars, which are essentially unblended, they have been taken from the *Revised Multiplet Table*;[7] for the later-type stars measured, the wave lengths are from the list recommended by the I.A.U.[8] except that the *RMT* wave lengths have been retained for the strong lines also measured in the earlier-type stars. For each star the velocity was also determined from each line separately. The results are given in Table 8, where the velocity from each line has been compared with the velocity from $H\gamma$, in order to make the results from the various stars comparable. ζ UMa A has not been included because

TABLE 7

ADOPTED WAVE LENGTHS

Wave Length	Identification	Wave Length	Identification
3933.664	*Ca* II K	4260.479	*Fe* I
3970.076	$H\epsilon$	4271.545	*Fe* I blend
4005.256	*Fe* I	4307.927	*Fe* I
4045.818	*Fe* I	4320.816	*Sc* II, *Ti* II
4063.621	*Fe* I	4340.468	$H\gamma$
4067.979	*Fe* I	4351.770	*Cr* I
4071.742	*Fe* I	4383.555	*Fe* I
4101.737	$H\delta$	4385.381	*Fe* II
4130.884	*Si* II	4404.752	*Fe* I
4143.722	*Fe* I blend	4427.258	*Ti* I, *Fe* I
4202.054	*Fe* I	4443.802	*Ti* II
4226.742	*Ca* I	4468.493	*Ti* II
4233.167	*Fe* II	4481.228	*Mg* II
4254.350	*Cr* I		

the plates of this star were taken at random phases and the lines measured differed according to whether the star lines appeared sharp, diffuse, or widely double. A correction was applied to the velocities of this star to allow for the small difference in amplitude between the two components.

The difference between the velocity measured for each plate and the mean velocity of the star was computed for each of the stars with moderately good lines. These were then grouped according to the date on which the plates were taken and the hour angle at the middle of the exposure. Table 9 summarizes the results, together with the mean error of the mean, computed from the range of the residuals, and the number of plates included in the mean (in parentheses). A systematic hour-angle effect is apparently absent, as is to be expected for a well-built instrument used near the meridian.

The measured velocities for the six standard stars are collected in Table 10, together with the Lick velocity, the difference McDonald minus Lick, and the number of plates measured. The McDonald velocities are definitely more negative than those from Lick. From the six stars the mean correction to the McDonald system is $+2.7\pm0.6$ km/sec, and a correction of this amount has been applied to the measured velocities in Table 6.

[7] *Contr. Princeton U. Obs.*, No. 20.

[8] *Trans. I.A.U.*, **5**, 193, 1935.

The differences McD − Lick for the corrected velocities of the nucleus stars show a large scatter, but the mean amount is McD − Lick = -0.8 ± 1.5 km/sec. Because of the meager data, a single correction was applied independently of spectral type.

While this investigation was in progress, R. M. Petrie, at Victoria, was conducting a similar investigation into the velocities of the cluster stars, using a dispersion of 11 A/mm. He obtained a number of plates of each star and took great care to reduce his measures to the Lick system. Table 11 compares the Victoria (Petrie) velocities, the velocities from Moore's catalogue, the Lick velocities, and the McDonald velocities. For most of the stars the agreement is good. ε UMa is a spectrum variable for which a velocity variation has been announced by several observers. There is no evidence of

TABLE 8

MEAN RESIDUALS: LINE − 4340

Line	γ UMa	δ UMa	80 UMa	ε UMa	β UMa	λ UMa	84 UMa	ζ UMa B
3933	+9.5	−0.5	−1.9	+1.4	+ 1.5	− 2.1	+0.4	+0.4
3970	...	...	...	...	...	...	−1.1	...
4005	...	...	...	...	...	...	...	+1.5
4045	...	...	...	+1.6	− 2.4	− 5.3	−0.4	−3.9
4063	...	...	...	+0.5	+ 0.1	− 8.8	−7.0	−7.9
4067	...	...	...	...	+10.2	+ 7.4	...	−6.7
4101	+1.6	−4.3	−5.6	−2.2	− 4.2	− 6.3	−1.4	−2.7
4130	...	...	...	...	+ 2.1	− 2.5	...	...
4233	...	...	...	+5.9	− 3.4	+ 4.0	+3.2	...
4254	...	...	...	+4.7	...	...	+5.5	−1.2
4260	...	...	...	...	...	...	...	−8.3
4340	0	0	0	0	0	0	0	0
4351	...	...	...	+8.0	+ 1.9	+ 6.7	+4.5	...
4383	...	...	...	...	...	+ 2.0	...	−1.1
4385	...	...	...	...	...	...	...	−7.9
4404	...	...	...	...	...	...	...	−1.2
4443	...	...	...	...	+ 6.1	− 1.7	...	...
4468	...	...	...	...	+ 4.3	+13.2	...	...
4481	+5.4	...	+9.6	−1.9	+ 6.6	+ 0.6	−1.9	...
4340−mean	−3.4	+1.6	+0.1	−1.8	− 1.2	+ 0.6	−2.1	+3.2

Line	78 UMa	37 UMa	15 UMa	HR 4867	θ Boo	47 UMa	HD 115043	Sun
3933	...	...	+ 0.3	...	...	...	...	...
4005	...	− 8.3	− 4.8	−4.8	−6.8	−6.1	−8.9	− 3.5
4045	−20.1	− 2.8	− 5.4	+1.1	−3.3	−4.1	−3.5	+ 2.0
4063	−15.7	− 7.0	−10.7	−0.6	−3.5	−2.8	−3.6	+ 2.7
4071	−11.1	− 6.8	−11.6	−1.1	−0.5	0	−0.3	+ 3.2
4101	− 7.4	− 4.1	− 1.5	−2.4	−3.8	−4.2	−7.1	0
4143	...	...	...	...	...	−3.3	+0.6	+ 7.6
4202	...	...	...	...	...	+1.0	+1.6	+ 4.5
4226	...	...	...	...	...	+4.8	+7.1	+11.5
4254	+ 0.1	− 7.4	...	+3.9	−0.4	−6.2	−2.4	− 6.3
4260	− 7.6	−14.7	−12.2	−4.1	−6.9	−7.4	−8.6	...
4307	...	...	...	...	...	−1.4	−6.2	+ 1.0
4320	...	...	...	...	...	−1.2	−4.6	+ 2.4
4340	0	0	0	0	0	0	0	0
4383	...	− 4.7	...	−4.0	−8.3	−7.2	−8.8	− 7.7
4404	− 8.5	− 5.4	...	+1.7	−0.1	−0.6	−2.5	+ 2.1
4427	...	...	...	...	...	+3.8	−1.2	+ 0.9
4340−mean	+ 9.2	+ 6.3	+ 6.0	+1.0	+3.4	+1.6	+2.9	− 1.8

TABLE 9

THE VELOCITY RESIDUALS AS A FUNCTION OF THE DATE AND THE HOUR ANGLE

Date	East				West			Mean
	1½ Hours	1 Hour	½ Hour	0 Hour	½ Hour	1 Hour	1½ Hours	
Apr. 3	0.0 ±1.8 (2)	−1.6 ±0.5 (3)	−1.6 ±0.3 (2)	−1.2 ±0.7 (4)	+1.4 ...... (1)	0.0 ...... (1)	......	−0.88 ±0.27 (13)
Apr. 4	......	......	+0.4 ±1.3 (4)	−0.3 ±0.8 (10)	+1.6 ±1.6 (2)	−0.1 ±1.8 (4)	......	+0.08 ±0.15 (20)
Apr. 8	......	......	......	......	−1.5 ±0.7 (4)	+0.3 ±1.0 (9)	−0.8 ±1.2 (4)	−0.37 ±0.22 (17)
Apr. 9	......	......	−0.2 ±1.2 (5)	−1.1 ±0.8 (3)	+2.1 ±0.4 (2)	......	......	−0.01 ±0.35 (10)
Apr. 15	......	......	+1.6 ±0.4 (2)	......	−0.8 ±0.9 (4)	+0.1 ±1.0 (7)	+0.2 ±0.9 (5)	+0.09 ±0.12 (18)
Apr. 16	......	......	+0.7 ...... (1)	+0.4 ±0.9 (3)	0.0 ±1.4 (2)	+1.2 ±0.9 (4)	......	+0.67 ±0.18 (10)
Apr. 17	......	+0.6 ±0.9 (2)	−0.8 ±0.8 (2)	+0.2 ...... (1)	+0.1 ±1.1 (2)	+0.5 ±1.2 (4)	+1.0 ±0.4 (2)	+0.31 ±0.15 (13)
Mean	0.0 ±1.8 (2)	−0.7 ±0.7 (5)	−0.02 ±0.23 (16)	−0.45 ±0.13 (21)	−0.01 ±0.34 (17)	+0.34 ±0.07 (29)	−0.02 ±0.11 (11)	......

TABLE 10

RADIAL VELOCITIES OF THE STANDARD STARS

Star	Lick Velocity	McD Velocity	McD−L	No. of Plates
15 UMa	− 1.0±0.4	− 5.6±0.7	−4.6	4
λ UMa	+17.5±1.2	+17.2±0.7	−0.3	8
47 UMa	+13.0±0.9	+ 8.2±0.6	−4.8	8
84 UMa	− 4.8±1.3*	− 2.7±1.6	+2.1	5
θ Boo	−11.2±0.4	−15.5±0.4	−4.3	14
Sun	+0.5†	− 1.0±0.6	−1.5	3

* No Lick velocity is available for this star. This is a mean of the velocities from Victoria, Yerkes, and Mount Wilson.

† Computed.

variation in the measures of the McDonald plates, but, as these were taken within an interval of 2 weeks, a long period or irregular variation is not excluded. The velocity of ζ UMa A from the McDonald plates is somewhat more uncertain than that of other observers because of the scatter in the phase at which the plates were taken; Petrie's measures were made at the time of gamma-velocity. It is possible that HR 4867 is a spectroscopic binary, with a long period. The McDonald plates show no appreciable variation, but the disagreement between them and the Lick and Mount Wilson velocities, as well as the probable errors of these determinations, are larger than would be expected for a late F-type star.

In order to reduce the scatter among the individual velocities and, at the same time, to keep the system as uniform as possible, the Lick, Victoria, and McDonald velocities were combined to form the means also given in Table 11. These mean velocities were then used, together with the convergent point derived in Section III, to determine the speed of the cluster as 15.7±0.8 km/sec. Allegheny Observatory has published trigonometric parallaxes for eight of the ten nucleus stars. There is also another determination of the

TABLE 11

RADIAL VELOCITIES OF THE NUCLEUS STARS

Star	Lick	Petrie	McD	Adopted Mean
37 UMa	−13.0	− 9.8	−14.6	−12.5
β UMa	−11.4	−12.5	−10.6	−11.5
γ UMa	−12.9	−13.6	−13.9	−13.5
δ UMa	−15.8	−14.6	−17.9	−16.1
HR 4867	−10.2	....	−17.3	−13.8
ε UMa	− 8.0	....	− 5.4	− 6.7
78 UMa	− 9.2	− 8.7	−15.0	−11.0
HD 115043	− 7.9	....	− 9.1	− 8.5
ζ UMa A	− 9.9*	− 7.4	− 5.3	− 9.3
ζ UMa B	−10.8	−10.2	−12.7	−11.2
80 UMa	−12.5	− 9.1	− 7.6	− 9.2

* Mean of the Potsdam, Michigan, and Vienna orbits.

parallax available for several of these stars, but, as these add little weight to the Allegheny values, they were omitted in order to keep the observational data uniform. A combination of these parallaxes and the corrected proper motions yields the value 18.4±1.3 km/sec for the speed of the cluster and 0″.040±0″.004 for the mean parallax of the nucleus. An unweighted mean of the two determinations, 17.0 km/sec, appears to be the best value available. Table 12 shows the agreement between the observed radial velocities and parallaxes and those computed from this mean. Although the difference between the results of the two determinations is somewhat larger than might have been expected from their mean errors, the individual residuals are satisfactorily small. Table 13 summarizes the elements of the cluster motion.

V. THE NUCLEUS

The ten stars which we have called the nucleus stars form a condensation in a stream which extends as far as observations permit us to reach. The question naturally arises as to whether there are any other stars which are more closely associated with the nucleus than with the remainder of the stream. In order to investigate this question, the volume of space within 20 parsecs of the center of the nucleus has been considered more carefully. The choice of this region was governed by three considerations: the proper motions are fairly large throughout most of this area; the stars all have parallaxes greater than

0″.020; and, since this region extends to four times the radius of the nucleus itself, it is possible to estimate the boundary of the condensation.

Among the brighter stars, only the ones already distinguished as nucleus members exhibit any concentration. Only four of the stars discussed in Section VI lie within the region considered and have space velocities accurately parallel to those of the nucleus stars. Since the discovery probability for such stars would be high, there are probably only nine nucleus members brighter than 6.5 mag.

To ascertain whether there are any members of the cluster among the fainter stars, two searches were made. The first, among the stars in the GC, covered all areas containing stars within 20 parsecs of the center of the nucleus, with the exceptions of a belt within 10° of the line on which the proper motions of the cluster stars are indistinguishable from those of stars moving toward the solar antapex, and of the region within 25° of the radiant of the cluster. The second search, in the *Transactions of the Yale University Observatory*, Volumes **4** and **7**, covered the area between the declinations +50° and +60° and between the right ascensions of 10^h and 14^h. However, the latter search revealed only one star not previously listed by Haas, and this was later ruled out by its radial velocity.

TABLE 12

RESIDUALS FROM THE ADOPTED CLUSTER VELOCITY

Star	Velocities		Parallaxes	
	Comp.	Obs.	Comp.	Trigonometric
37 UMa	−14.9	−12.5	0″.043	0″.033±0″.018
β UMa	−14.4	−11.5	.046	.047± .009
γ UMa	−13.3	−13.5	.042	.027± .011
δ UMa	−12.7	−16.1	.044	.050± .009
HR 4867	−11.8	−13.8	.041	.038± .016
ε UMa	−11.6	− 6.7	.043	....
78 UMa	−11.4	−11.0	.043	.030± .016
HD 115043	−11.0	− 8.5	.041	....
ζ UMa A	−10.6	− 9.3	.045}	.041± .011
ζ UMa B	−10.6	−11.2	.043}	
80 UMa	−10.5	− 9.2	0.043	0.039±0.015

TABLE 13

THE ADOPTED CLUSTER ELEMENTS

1900 Equatorial Elements	1900 Galactic Elements	Motion in Local Centroid	Assumed Solar Motion
$A=306°.2$	$L=332°.8$	$L=2°$	$L=23°.5$
$D=-37°.1$	$B=-36°.4$	$B=-6°$	$B=+21°.6$
$V=17.0$ km/sec	$V=17.0$ km/sec	$V=29$ km/sec	$V=19.6$ km/sec

Both searches were conducted similarly. Among the stars with proper motions greater than 0″.030/year, those were selected for which the position angle of the proper motions agreed approximately with the direction of motion of a cluster star in the same position. If the star's radial velocity was available, it was used as a second criterion. For each star selected in this way, the GC proper motion was corrected and the direction compared with that computed for the star from the elements of the cluster motion. If the position-angle residual was less than 20° and could be eliminated by a change of less than five times the published probable error in the proper motion, the cluster parallax was used to compute the galactic rectangular co-ordinates of the star. In this way, 35 stars were selected which lay within 20 parsecs of the center of the nucleus and which might be members of the cluster on the basis of existing data. For each of these stars spectroscopic parallaxes and/or radial velocities were obtained. These ruled out the majority of the stars selected.

A one-prism spectrograph attached to the 40-inch refractor was used to obtain the plates for the spectroscopic parallaxes in this section and in Section VI. This is the spectrograph used for the Yerkes spectral atlas[9] and all spectral types are on the system of that atlas unless otherwise noted. The radial-velocity plates were taken with the $f/2$ glass spectrograph of the McDonald Observatory by Messrs. Hiltner, Code, and Braun, and have a dispersion of 75 A/mm at $H\gamma$.

Figure 1 shows all stars within 20 parsecs of the center of the nucleus which apparently share the cluster motion accurately, including the five stars found in the present investigation. It appears that thirteen of the stars form a compact group, $10 \times 6 \times 4$ parsecs across. The remaining stars are probably members of the stream. It is interesting to note that the dimensions of this cluster are about average for a poor cluster showing little contrast with the background,[10] although the total membership of thirteen stars (fifteen, if the components of ζ UMa are counted separately) makes it a very poor cluster indeed. Raab lists only two clusters with less than twenty members.[11] Moreover, since his figures are based on counts on the Franklin Adams charts, his estimates probably include only the brighter stars and are minimum values.

Table 14 gives for each cluster star the name, the HD number, the position, the apparent magnitude, the HD spectral type, and the rectangular galactic co-ordinates referred to the center of the nucleus. Stars 5 and 6 were included in Haas's list[12] and 6 was also suggested as a possible member by Hertzsprung.[13] Table 15 contains the relevant observational data and compares this with the computed data. For the stars brighter than 7.5 mag. the spectral types in this table have been given by W. W. Morgan. The three K-type stars have been added as a result of the present investigation; the remaining stars were used in the above discussion of the motion of the nucleus stars. The two members from Haas's list are included here rather than in Section VI.

Figure 2 illustrates the H-R diagram of the cluster. There are no giants, although the peculiar star ϵ UMa lies above the main sequence. There is no indication that the ending of the main sequence at K3 is not the result of incomplete observational data. The faintest star in the cluster is 9.2 mag. pg, and it is improbable that the Yale catalogues are complete even to this limit.

It is interesting to note that, of the four stars later than G0, three show emission at H and K.[14] The emission in HD 115043 is weak and would be missed except on fairly high dispersion, but that in the two K-type stars is quite strong. Thus 75 per cent of the stars in this cluster later than G0 show emission at H and K as compared with 70 per cent of the stars G5 and later in the Hyades[14] and with 6 per cent of the stars of spectral types G0–K4 among the proper-motion stars.[15] The latter two percentages are minimum

[9] Morgan, Keenan, and Kellman, *An Atlas of Stellar Spectra* (Chicago: University of Chicago Press, 1943).

[10] Trumpler, *Lick Obs. Bull.*, **14**, 154, 1930.

[11] *Lund Medd.*, Ser. II, No. 28, 1922.

[12] *A.N.*, **241**, 233, 1931.

[13] *B.A.N.*, **9**, 286, 1942.

[14] HD 115043 and 110463 are included in the list of stars with emission at H and K by Joy and Wilson, *Ap. J.*, **109**, 231, 1949. The discovery of H and K emission in HD 109011 is apparently new.

[15] Joy, *Ap. J.*, **105**, 96, 1947.

values, since some plates may not be sufficiently exposed in the region of the K line to show the emission; but the difference between 6 per cent for stars in general and 70 per cent for members of the two open clusters must indicate a real difference. However, HD 124752 shows no strong emission lines.

Table 16 contains a list of the remaining stars for which radial velocities were measured. The spectral types of the three standard-velocity stars are from the I.A.U. list;[16] those marked by an asterisk were estimated from the radial-velocity plates rather than from plates taken specifically for spectral classification. The five plates of standard stars are not sufficient to secure the system of these velocities. The discrepancy for HD 107328 is much larger than would be expected from the run of the mean errors for the other stars. The velocities from the two plates of this star agree within 1 km/sec, and no combina-

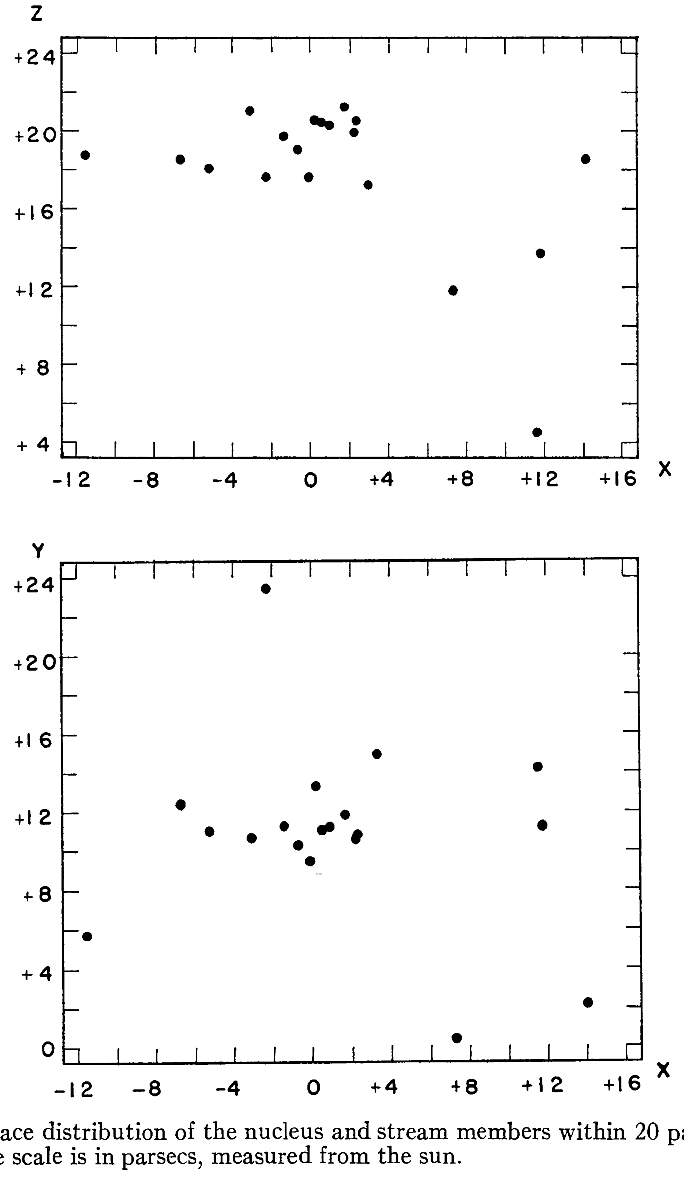

FIG. 1.—The space distribution of the nucleus and stream members within 20 parsecs of the center of the nucleus. The scale is in parsecs, measured from the sun.

[16] *Trans. I.A.U.*, 5, 191, 1935.

tion of lines measured will give a velocity as low as the catalogue velocity for the star. Since the other two standard-velocity stars yielded satisfactory residuals, no attempt has been made to correct the system. Also, the velocity found by R. E. Wilson for HD 110463 is in excellent agreement with that found from the McDonald plates (53). The agreement of the velocities from different plates of the same star indicates an average mean error per plate of 5 km/sec.

It is usually thought that a loose cluster, such as the Ursa Major cluster, is unstable, since there can be no important gravitational interaction between members. The shearing effects of galactic rotation will disrupt such a cluster if all members have the same linear velocity. Also, since the density of the nucleus is barely that of the field of stars through which the cluster moves, encounters with field stars will tend to disintegrate it further.

TABLE 14

THE MEMBERS OF THE URSA MAJOR NUCLEUS

No.	Name	HD No.	α_{1900}	δ_{1900}	m	Sp.	X	Y	Z
1......	37 UMa	91480	$10^h 28^m 7$	+57°36′	5.16	F0	−6.2	+0.9	−1.0
2......	β UMa	95418	10 55.8	56 55	2.44	A0	−4.8	−0.5	−1.5
3......	γ UMa	103287	11 48.6	54 15	2.54	A0	−2.6	−0.8	+1.5
4......	δ UMa	106591	12 10.5	57 35	3.44	A2	−0.9	−0.2	+0.2
5......	....	109011	12 26.5	55 40	8.1	K0	−0.2	−1.2	−0.4
6......	....	110463	12 37.2	56 17	8.4	K0	+0.4	−2.0	−1.9
7......	HR 4867	111456	12 44.3	60 52	5.87	F5	+0.7	+1.8	+1.0
8......	ϵ UMa	112185	12 49.6	56 30	1.68	A0p	+0.9	−0.4	+0.9
9......	78 UMa	113139	12 56.4	56 54	4.89	F0	+1.4	−0.3	+0.8
10......	....	115043	13 9.5	57 14	6.74	G0	+2.2	+0.4	+1.7
11	ζ UMa A ζ UMa B	116656 116657	13 19.9	55 27	2.40 3.96	A2p A2	+2.7	−0.9	+0.5
12......	80 UMa	116842	13 21.2	55 30	4.02	A5	+2.8	−0.7	+1.0
13......	....	124752	14 10.3	68 03	8.2	K0	+3.8	+3.8	−2.3

TABLE 15

DATA CONCERNING THE NUCLEUS MEMBERS

No.	μ	θ_o	θ_c	ρ_o	ρ_c	π_{tr}	π_c	Sp.	M_c
1.........	0″074±0″002	60°0	58°5	−12.5±1.0	−14.9	0″033±0″018	0″043	F1 V	+3.2
2.........	.087± .001	67.8	67.9	−11.5±0.6	−14.4	.047± .009	.046	A0 V	+0.5
3.........	.094± .001	84.5	84.6	−13.5±1.0	−13.3	.027± .011	.042	A0 V	+0.5
4.........	.106± .001	85.1	85.6	−16.1±1.5	−12.7	.050± .009	.044	A3 V	+1.7
5*........	.111± .021	93.1	90.8	−12.4±1.7	−12.3	....	.045	K2 V	+6.4
6†........	.127± .021	90.0	90.8	− 5.8±1.5	−12.0	....	.050	K3 V	+6.9
7.........	.107± .005	91.1	88.9	−13.8±1.0	−11.8	.038± .016	.041	F6 V	+3.9
8‡........	.113± .001	92.5	95.0	− 6.7±1.0	−11.6	....	.043	A0 p	−0.2
9.........	.114± .003	95.0	95.8	−11.0±1.0	−11.4	.030± .016	.043	F0 V	+3.3
10§........	.115± .006	104.6	102.3	− 8.5±0.6	−11.0	....	.041	G2 V	+4.8
11A.......	.126± .001	99.6	101.5	− 9.3±0.5	−10.6	.041± .011	.044	A2 V	+1.3
11B‖......	.122± .003	103.8	......	−11.2±0.8	....	....	......	A2 m	+2.1
12.........	.120± .002	98.1	101.5	− 9.2±1.5	−10.5	0.039±0.015	.043	A5 V	+2.2
13.........	0.149±0.016	129.0	126.2	− 5.6±2.0	− 9.8	....	0.043	K0 V	+6.4

* H and K emission; the emission lines give the velocity −4 km/sec.

† H and K emission; the emission lines give the velocity −4 km/sec.

‡ A spectrum variable (see *An Atlas of Stellar Spectra*, p. 18).

§ H and K emission. ‖ A metallic-line star. The K line type is A2, but the type obtained from the metallic lines is A7.

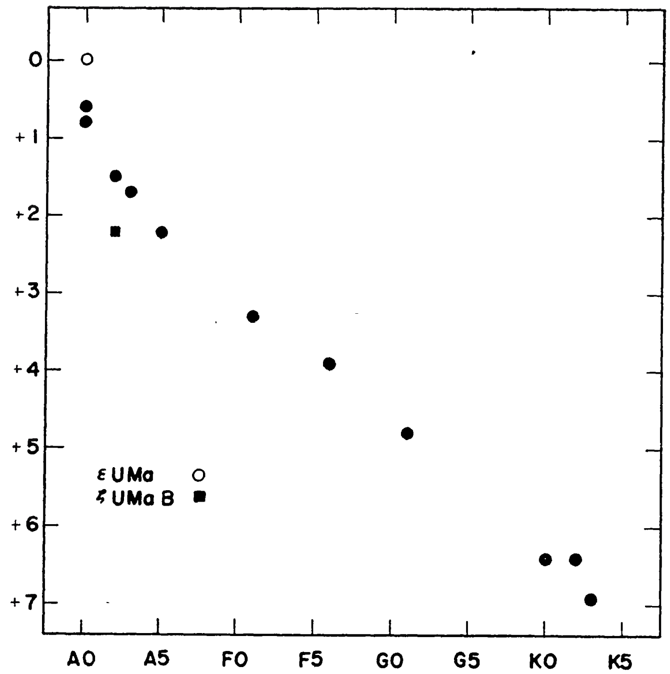

FIG. 2.—The H-R diagram for the Ursa Major nucleus

TABLE 16

NONCLUSTER STARS MEASURED FOR RADIAL VELOCITY

Star	ρ_c	ρ_o	No. of Plates	M_c	Sp.	Remarks
HD 77624	−15.2	−36.5	3	+8.3	G8 III*	
84703	−13.6	+30.4	3	+7.2	F8 V*	
86987	−13.2	−11.8	3	+6.6	F5 V*	
88009	−15.0	−12.3	3	+5.6	K2 III	
88270	−15.1	+ 1.9	5	+8.0	F2 VI	
89449	+ 6.2	+10.4	2	....	F5	Standard-velocity star
90915	−14.7	− 1.2	5	+6.2	G0 V*	
94426	−14.8	+ 9.4	4	+5.0	F8 V	
94686	−12.0	−21.7	4	+4.9	F8 V	Stream member
98618	−14.2	+12.8	4	+5.1	G5 V	
107328	+35.4	+53.4	2	....	K1	Standard-velocity star
114762	+49.6	+50.3	1	....	F9	Standard-velocity star
115349	− 9.5	−45.7	2	+8.4	G2 V	
140625	− 6.7	−30.0	2	+6.3	K0 V	
149907	+ 2.6	− 7.8	3	+5.4	K0 III*	
151044	− 3.0	− 0.1	1	+5.0	F8 V	Stream member
160291	+ 0.2	−24.1	2	+5.6	F6 V*	
238179	−11.4	−34.4	3	+6.8	G8 V	(21)
238208	−11.0	−41.9	3	+6.3	K2 V	(21)
BD+8°2658	− 6.7	+11.3	1	+9.1	K0 V*	

Shearing effects will play no role if the stars in the cluster have the same angular momentum in their revolution about the galactic center rather than the same linear velocity. Instead, the stars will move together in epicycles about the same circular orbit.[17] The investigations of Mlles Canavaggia and Fribourg and of Bartholeyns indicate that the latter may be the case, although their results are highly uncertain. The high velocity of the cluster with respect to the local standard of rest leaves little chance for strong gravitational interactions between cluster members and field stars. Following the method of analysis developed by Chandrasekhar,[18] it is found that a member of the cluster will probably change its kinetic energy with respect to the center of the nucleus by less than 20 per cent in a time of 3×10^9 years. This means that the lifetime of the cluster is of the same order as the galactic time scale.

These arguments also apply to the extended stream, but, in this case, any dispersion in velocities already existing among the members will disrupt the group much more rapidly.

VI. STREAM STARS

That the overlap among the numerous lists of members of the Ursa Major stream is surprisingly small has been mentioned earlier. Since most of the authors possessed similar observational data, the differences must be laid to varying treatments of these data. The method which has been used most frequently to pick up stream members has been to calculate space velocities for all stars and to include as stream members all stars with velocities agreeing with the cluster velocity within a given tolerance. This is by far the simplest method of finding stream members and has the added advantage that the resulting space velocities are useful in other studies. However, the effects of observational errors, which are different in the different components of the velocity, are badly confused. Thus, in order to allow for a large observational uncertainty in the tangential velocities computed from small parallaxes, a large tolerance is necessary, while this tolerance may be completely unallowable when applied to the direction of a large proper motion. Thus this method tends to pick up most stars which might be stream members, but it is uncritical. Some of the differences between the various lists made in this manner can be attributed to different choices of the cluster velocity; others arise from the different tolerances permitted in the velocity residuals. Among the recent investigators, only Smart, Bartholeyns, and Delhaye have treated the proper motions, radial velocities, and parallaxes separately.

To facilitate statistical studies of the Ursa Major stream, the numerous lists of members have been combined and are repeated in this section. Dr. J. H. Oort has kindly sent me an unpublished list of stars brighter than 6.5 mag. with space motions differing from that of the cluster by less than 10 km/sec in each co-ordinate. This list is also included in this section, although many of the stars are probably not members of the stream. It is improbable that more than a very few stream stars brighter than 6.5 mag. with known space motions have been omitted from this combined list of stream members; the list is very incomplete among the fainter stars. Table 17 gives for each star the name, another identification, the 1900 position, the apparent magnitude, the HD spectral type, and a reference to the paper listing the star. These references are indicated by the number of the paper in the bibliography. The two stream stars discovered as a result of the investigation discussed in Section V are marked by an asterisk in the references, while the stars included on Oort's list but not on any list of stream members are designated by O. If four or more authors have listed the same star independently, it is considered to be generally recognized as a stream member, and no individual reference is given. The 69 stars north of declination $-30°$ which are most likely to be stream members are marked by an asterisk following the number of the star. Star No. 91 is also probably a stream member.

[17] See S. Chandrasekhar, *Principles of Stellar Dynamics* (Chicago: University of Chicago Press, 1942), sec. 4.3.

[18] *Ap. J.*, **93**, 285, 1941.

TABLE 17

Stars Listed by Various Authors as Members of the Ursa Major Stream

No.	Name	HR No.	α(1900)	δ(1900)	m	Sp.	Reference
14	36 Psc	59	$0^h11^m.4$	+ 7°41'	6.19	G5	0
15		60	0 11.6	+60 59	5.80	G5	0
16	θ And	63	0 11.9	+38 8	4.44	A2	2, 16, 37
17*	σ And	68	0 13.1	+36 14	4.51	A2	17, 38
18	44 Psc	97	0 20.3	+ 1 23	5.99	G5	17
19		157	0 32.0	+34 51	5.62	G5	0
20	32 And	175	0 35.7	+38 55	5.42	G5	0
21	μ Phe	180	0 36.6	-46 38	4.65	K0	17, 38
22		196	0 39.6	+54 40	5.47	A0	2, 16, 38
23	φ^2 Cet	235	0 45.1	-11 11	5.24	F5	
24*	η And	271	0 51.9	+22 53	4.62	G5	0
25		276	0 52.7	+13 9	6.44	G5	0
26	39 And	290	0 57.3	+40 48	5.86	A2	
27	27 Cet	315	1 0.6	-10 31	6.41	G5	0
28	β Phe	322	1 1.6	-47 15	3.35	K0	32
29	80 Psc	330	1 3.2	+ 5 7	5.67	F0	7, 16
30	44 And	340	1 4.6	+41 33	5.74	G0	0
31	33 Cet	347	1 5.4	+ 1 55	6.20	K0	0
32*	89 Psc	378	1 12.6	+ 3 5	5.28	A2	
33	ρ Psc	413	1 20.9	+18 39	5.32	F0	16, 37
34	ω And	417	1 21.7	+44 53	4.96	F5	
35	40 Cas	456	1 30.5	+72 32	5.50	K0	37
36*		461	1 31.6	+57 28	5.74	K0	0
37		485	1 36.0	+29 32	6.02	K0	0
38	ν Psc	489	1 36.2	+ 4 59	4.68	K0	0
39	π Scl	497	1 37.6	-32 49	5.28	K0	2, 38
40		498	1 37.6	-37 20	5.64	A0	32
41		501	1 37.7	-50 33	6.72	A2	32
42		513	1 41.0	- 6 14	5.53	G5	0
43	1 Ari	530	1 44.6	+21 47	6.2, 7.6	F5, A2	0
44	χ Cet	531	1 44.7	-11 11	4.77	F0	17, 38, 44
45		534	1 45.6	+10 33	5.94	F0	
46		541	1 47.1	-50 42	6.05	A0	2, 7, 32
47	55 And	543	1 47.3	+40 14	5.63	K0	0
48	λ Ari	569	1 52.4	+23 7	4.83	A5	2, 3, 38
49	48 Cas	575	1 53.8	+70 25	4.61	A3	
50	50 Cas	580	1 54.9	+71 56	4.06	A2	17
51	49 Cas	592	1 56.0	+75 38	5.30	G5	0
52	HD 12350		1 56.0	+70 43	7.64	F0	2
53	ε Tri	599	1 57.1	+32 48	5.44	A2	37
54	γ And	603-4	1 57.8	+41 51	2.28	K0	3
55	55 Cas	640	2 6.6	+66 3	6.15	F5+A2	17
56*		647	2 7.6	+47 1	6.03	F0	13, 38
57	65 ξ^1 Cet	649	2 7.7	+ 8 23	4.54	G5	2, 17
58	7 Tri	655	2 10.0	+32 54	5.26	A0	3, 16, 37
59	7 Per	662	2 11.0	+57 3	6.15	K0	2
60*		710	2 21.2	-15 47	5.84	A2	
61	HD 15929		2 28.5	-46 19	7.01	G5	32
62	λ^1 For	744	2 28.9	-35 5	5.88	K0	32
63*	ν Cet	754	2 30.6	+ 5 9	5.02	G5	17
64*		797	2 37.1	+10 19	6.27	A0	
65	γ Cet	804	2 38.1	+ 2 49	3.58	A2	16, 37
66	η^1 For	835	2 43.5	-35 58	6.51	K0	32
67	ν Hyi	872	2 51.1	-75 29	4.70	K2	38
68*		875	2 51.6	- 4 7	5.27	A2	16, 17, 37
69	ε Ari	887-8	2 53.5	+20 56	5.25	A2	13
70		892	2 53.7	- 3 11	5.20	A2	3, 38
71*		906	2 56.2	+81 5	5.95	A2	3
72	τ^3 Eri	919	2 58.0	-24 1	4.16	A3	17
73		958	$3^h 7^m.1$	+ 6°17'	5.84	G5+A2	0

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TABLE 17 (continued)

No.	Name	HR No.	α(1900)	δ(1900)	m	Sp.	Reference
74	32 Per	1002	$3^h14^m.7$	+42°58'	4.98	A2	
75		1016	3 17.0	-24 0	5.67	G5	0
76*		1046	3 22.4	+55 6	4.98	A2	16, 37
77		1112	3 34.5	+59 39	5.98	K0	0
78	ν Per	1135	3 38.4	+42 16	3.93	F5	
79		1143	3 39.1	-37 38	4.64	K2	38
80		1195	3 45.7	-36 30	4.24	K0	2, 17, 38
81*		1327	4 11.3	+64 54	5.40	G0	38
82	54 Per	1343	4 13.9	+34 19	5.10	G5	17
83	66 Tau	1381	4 18.4	+ 9 14	5.06	A2	2, 3, 38
84*	ξ Eri	1383	4 18.7	- 3 58	5.23	A2	
85*		1448	4 28.8	+ 5 21	5.78	A0	
86		1483	4 34.2	-12 19	5.02	A2	0
87	R Dor	1492	4 35.6	-62 16	4.8-6.8	Mc	32
88*	2 Aur	1551	4 45.9	+36 32	5.04	K2	0
89	7 Cam	1568	4 49.3	+53 35	4.44	A2	16, 37
90	ε Lep	1654	5 1.2	-22 30	3.29	K5	0
91	β Eri	1666	5 2.9	- 5 13	2.92	A3	
92		1686	5 6.1	+79 7	5.16	F8	2, 17, 37
93	14 Aur	1706	5 8.9	+32 34	5.14	A2	13
94	18 Ori	1718	5 10.5	+11 14	5.50	A0	2,3
95	HD 34496		5 12.7	-33 39	7.02	G5	32
96		1752	5 14.8	+29 28	5.72	A0	16, 37
97	σ Aur	1773	5 17.8	+37 18	5.22	K5	0
98	29 Ori	1784	5 19.1	- 7 54	4.21	K0	0
99	17 Cam	1802	5 20.7	+62 59	5.75	K5	0
100	β Lep	1829	5 23.9	-20 50	2.96	G0	17
101	HD 36094		5 24.1	-32 30	6.88	G5	32
102		1866	5 28.4	+54 22	5.96	K5	0
103*	38 Ori	1872	5 29.0	+ 3 42	5.32	A2	2, 3, 38
104	23 Cam	1943	5 34.9	+61 26	6.39	G5	0
105*	ο Aur	1971	5 38.2	+49 47	5.52	A0	3, 17
106*	γ Lep	1982-3	5 40.3	-22 29	3.83	F8	
107*	τ Aur	1995	5 42.2	+39 9	4.64	K0	38
108	υ Aur	2029	5 46.5	+55 41	4.92	A2	
109	136 Tau	2034	5 47.0	+27 35	4.54	A0	17
110*	χ^1 Ori	2047	5 48.5	+20 16	4.62	F8	
111*	β Aur	2088	5 52.2	+44 56	2.07	A0p	
112		2174	6 3.8	+ 2 31	5.58	A0	32
113	γ Mon	2227	6 10.0	- 6 15	4.09	K0	0
114*	42 Aur	2228	6 10.1	+46 27	6.46	F0	13
115*	8 Gem	2230	6 10.2	+24 0	6.11	G5	0
116		2233	6 10.5	- 0 28	5.68	F5	32
117	2 Lyn	2238	6 10.8	+59 3	4.42	A0	16, 37
118*	RR Lyn	2291	6 18.0	+56 20	5.50	A3	2, 16, 37
119	ζ Col	2296	6 18.5	-33 23	3.98	G5	2, 38
120		2395	6 28.6	- 1 9	5.02	B3	32
121	γ Gem	2421	6 31.9	+16 29	1.93	A0	17
122	ν^3 CMa	2443	6 33.5	-18 9	4.65	K0	0
123	ψ^5 Aur	2483	6 39.5	+43 41	5.34	G0	37
124	ψ^6 Aur	2487	6 40.0	+48 54	5.28	K0	17, 38
125*	α CMa	2491	6 40.8	-16 35	-1.58	A0	
126		2514	6 43.2	- 1 12	5.66	A5	32
127		2551	6 47.4	+ 8 30	5.76	A5	32
128	37 Gem	2569	6 49.2	+25 30	5.77	G0	0
129*	16 Lyn	2585	6 50.3	+45 13	4.80	A2	3, 23
130	ω Gem	2630	6 56.3	+24 21	5.21	K0	17
131	64 Aur	2753	7 11.1	+41 4	5.75	A3	3, 38
132*	λ Gem	2763	7 12.3	+16 43	3.65	A2	
133	65 Aur	2793	$7^h15^m.4$	+36°57'	5.21	K0	32

TABLE 17 (continued)

No.	Name	HR No.	α(1900)	δ(1900)	m	Sp.	Reference
134	59 Gem	2816	$7^h18^m.3$	+27°50'	5.71	F0	16, 37
135	ε CMi	2828	7 20.2	+ 9 28	5.07	G5	0
136	6 CMi	2864	7 24.2	+12 13	4.85	K0	16, 17
137	α Gem	2890,1	7 28.2	+32 6	1.99	A0	32
138		2967	7 36.4	+14 27	5.81	Mb	0
139		2998	7 39.9	-44 55	5.22	G5	32
140	9 Pup	3064	7 47.1	-13 38	5.34	G0	32
141*		3131	7 55.4	-18 7	4.64	A2	
142	4 Cnc	3132	7 55.7	+25 22	6.20	A0	38
143		3182	8 2.8	+68 46	5.48	G5	17
144	12 Cnc	3184	8 3.1	+13 56	6.26	F5	13
145	ζ Cnc	3208-10	8 6.5	+17 57	5.56	G0	0
146		3212	8 6.7	- 7 28	5.36	G5	0
147		3221	8 7.4	+60 41	6.36	F0	
148	29 Lyn	3235	8 9.5	+59 53	5.52	A5	3
149	30 Lyn	3254	8 12.4	+58 3	5.94	F2	13
150		3263	8 14.3	+60 57	6.48	G5	0
151		3279	8 16.9	-19 46	5.56	G0+A3	0
152	π¹ UMa	3391	8 30.3	+65 22	5.69	G0	2, 38
153	9 Hya	3441	8 37.1	-15 35	4.98	K0	38
154	45 Cnc	3450	8 37.7	+13 3	5.67	A3+G	
155	46 Cnc	3464	8 39.2	+31 4	6.14	K0	0
156	ε Hya	3482	8 41.5	+ 6 47	3.48	F8	0
157	δ Vel	3485	8 41.9	-54 21	2.10	A0	2, 3, 38
158		3512	8 45.8	-32 25	5.23	G5	2, 38
159		3570	8 52.4	-54 35	5.72	F5	2
160	α Cnc	3572	8 53.0	+12 15	4.27	A3	
161	66 Cnc	3587	8 55.3	+32 39	5.83	A2	2, 3, 38
162	ι Cnc	3595	8 56.9	+24 51	5.45	A0	2, 3, 38
163	α Vol	3615	9 0.9	-66 0	4.18	A5	
164	τ Cnc	3621	9 2.0	+30 3	5.38	G5	0
165	ξ Cnc	3627	9 3.6	+22 27	5.22	G5	0
166		3636	9 4.4	-11 57	5.81	K0	0
167	79 Cnc	3640	9 4.6	+22 24	6.09	G5	0
168	16 UMa	3648	9 6.4	+61 50	5.23	F8	13
169	18 UMa	3662	9 9.0	+54 26	4.89	A5	37
170		3676	9 10.8	+47 14	5.70	A0	
171	ω Leo	3754	9 23.1	+ 9 30	5.52	G0	0
172	23 UMa	3757	9 23.6	+63 30	3.75	F0	16, 17, 37
173	10 LMi	3800	9 28.1	+36 51	4.62	G5	17, 38
174		3809	9 28.8	+40 4	4.99	K0	0
175	42 Lyn	3829	9 32.1	+40 41	5.24	A5	16, 37
176		3850	9 35.7	+31 43	6.08	K5	2
177	φ UMa	3894	9 45.3	+54 32	4.54	A2	
178*	ν¹ Hya	3903	9 46.7	-14 23	4.29	K0	38
179		3954	9 58.0	+54 23	5.74	F5	0
180*	21 LMi	3974	10 1.5	+35 44	4.47	A5	2, 3, 38
181*	34 Leo	3998	10 6.3	+13 51	6.41	F5	2, 3, 38
182*	ζ Leo	4031	10 11.1	+23 55	3.65	F0	
183	HD 89882		10 17.2	+58 19	9.0	G5	21
184	27 LMi	4075	10 17.3	+34 25	5.83	A3	17
185	45 Leo	4101	10 22.4	+10 16	5.87	A0	3, 38
186	HD 91347		10 27.7	+49 42	7.57	F8	
187	35 LMi	4150	10 30.6	+36 51	6.27	F2	0
188	HDE 237917		10 32.2	+58 13	8.8	K0	21
189	37 LMi	4166	10 33.1	+32 30	4.77	G0	0
190	50 Leo		10 33.5	+16 38	6.62	F2	32
191	μ Vel	4216	10 42.5	-48 54	2.84	G5	38
192	ω UMa	4248	10 48.2	+43 43	4.84	A0	3
193*	HD 94686		$10^h50^m.7$	+80°13'	7.23	F8	*

TABLE 17 (continued)

No.	Name	HR No.	α(1900)	δ(1900)	m	Sp.	Reference
194	61 Leo	4299	$10^h56^m.7$	- 1°57'	4.97	Ma	2, 38
195	δ Leo	4357	11 8.8	+21 4	2.58	A3	
196	ι Leo	4399	11 18.7	+11 5	4.03	F5	
197	τ Leo	4418	11 22.8	+ 3 24	5.18	K0	
198		4465	11 31.0	+28 20	5.82	A3	32
199*	ζ Crt	4514	11 39.7	-17 48	4.90	G5	
200	HD 104620		11 57.7	+58 0	9.1	G	21
201	α Crv	4623	12 3.3	-24 10	4.18	F2	16, 37
202	5 CVn	4716	12 19.2	+52 7	4.97	K0	38
203		4725	12 20.2	+24 29	6.08	K0	32
204	HD 108134		12 20.3	+61 14	7.41	G0	25
205	20 Com	4756	12 24.7	+21 27	5.72	A2	32
206	HD 108875		12 25.5	+10 16	7.9	F2	32
207*		4803	12 32.4	-26 35	5.44	F0	13
208		4837	12 38.5	- 1 2	6.08	G0	0
209	ι Cru	4842	12 39.8	-60 26	4.68	K0	2, 38
210	34 Vir	4855	12 42.2	+12 30	6.05	A3	32
211		4859	12 43.1	+63 20	5.83	A5	
212*	29 Com	4865	12 43.9	+14 40	5.64	A0	
213*	41 Vir	4900	12 48.8	+12 58	6.34	A3	
214	HD 112394		12 51.3	+57 39	9.0	K0	21
215	HDE 238179		12 55.3	+55 12	8.9	K0	21
216	HDE 234006		13 1.1	+51 31	9.0	F8	21
217	BD+51°1808		13 1.2	+51 33	9.4		21
218	49 Vir	4955	13 2.6	-10 12	5.26	K0	38
219		4960	13 4.2	+10 33	5.95	K0	32
220		4998	13 9.5	+11 52	5.81	K5	32
221	HDE 238208		13 10.7	+57 32	9.0	K0	21
222		5009	13 11.5	+81 1	6.32	G5	38
223*	γ Hyd	5020	13 13.5	-22 39	3.33	G5	16, 17
224	HDE 238224		13 19.5	+58 25	9.0	M0	21
225*	78 Vir	5105	13 29.1	+ 4 10	4.93	A2p	
226		5110	13 30.3	+37 42	4.96	F0	16, 37
227		5162	13 38.4	+65 20	5.70	A0	32
228		5164	13 39.0	+23 12	6.41	K2	32
229*	83 Vir	5165	13 39.1	-15 41	5.71	G0	17
230	HD 120528		13 44.9	+53 44	8.8	G5	21
231*		5214	13 46.7	+35 16	6.57	A2	
232		5220	13 47.4	+12 40	5.99	A2	16, 32, 37
233*	τ Vir	5264	13 56.6	+ 2 2	4.34	A2	
234	κ Boo	5328-9	14 9.9	+52 15	4.60	A5	
235		5343	14 11.4	+19 23	5.84	A5	
236	18 Boo	5365	14 14.4	+13 28	5.31	F0	
237*		5373	14 15.7	+39 15	5.98	A2	
238		5467	14 35.1	+54 27	5.52	A0	2, 16, 37
239		5473	14 35.9	+13 58	5.98	A5	32
240*	ζ Boo	5477-8	14 36.4	+14 9	4.43	A2	13
241		5492	14 39.6	+61 41	6.17	F2	13, 31, 32
242	38 Boo	5533	14 45.7	+46 32	5.76	F5	0
243	ξ Boo	5544	14 46.8	+19 31	4.64	G5	7, 16
244		5573	14 52.4	+ 0 14	5.71	K0	32
245		5575	14 52.5	+16 47	5.78	K0	32
246*	45 Boo	5634	15 2.9	+25 16	5.03	F0	
247	δ Boo	5681	15 11.5	+33 41	3.54	K0	0
248*	8 Ser	5721	15 18.6	- 0 40	6.10	F0	
249	η CrB	5727-8	15 19.1	+30 39	5.58	G0	
250	34 Lib	5750	15 25.0	-16 16	5.86	K0	0
251	ν^1 Boo	5763	15 27.3	+41 10	5.15	K5	0
252*	α CrB	5793	15 30.5	+27 3	2.31	A0	
253	τ^7 Ser	5804	$15^h31^m.9$	+16°27'	5.88	F0	0

TABLE 17 (continued)

No.	Name	HR No.	α(1900)	δ(1900)	m	Sp.	Reference
254	41 Lib	5814	$15^h33^m.1$	-18° 58'	5.53	G5	32
255		5815-6	15 33.3	- 8 28	6.54	F8	0
256		5830	15 35.1	+47 8	5.78	F0	2, 17, 37
257*	τ^6 Ser	5840	15 36.4	+16 21	5.97	G5	
258	χ Ser	5843	15 37.1	+13 10	5.26	A0p	
259	α Ser	5854	15 39.3	+ 6 44	2.75	K0	17
260		5859	15 40.4	+ 5 46	5.56	A0	16, 32, 37
261*	β Ser	5867	15 41.6	+15 44	3.74	A2	
262		5886	15 45.1	+62 55	5.13	A2	
263		5887	15 45.2	+55 41	5.79	A2	16, 37
264	ω Ser	5888	15 45.2	+ 2 30	5.33	K0	38
265	ψ Sco	6031	16 6.5	- 9 48	4.91	A2	37
266	16 Sco	6033	16 6.7	- 8 17	5.49	A3	2, 16, 37
267		6035	16 6.9	+16 55	5.90	A0	37
268	υ CrB	6074	16 12.7	+29 24	5.73	A0	2, 16, 37
269*		6076	16 13.3	-19 58	6.38	K0	0
270		6094	16 17.3	-38 58	5.40	G0	2
271	ζ TrA	6098	16 17.7	-69 52	4.93	G0	2, 16
272	(23 Her)	6110	16 19.1	+32 34	6.20	A2	3, 37
273	ω Her	6117	16 20.8	+14 16	4.53	A0p	
274	30 Her	6146	16 25.3	+42 6	5.02	Mb	
275	η Her	6220	16 39.5	+39 7	3.61	K0	16, 17
276*	HD 151044		16 39.8	+50 9	6.64	F5	*
277	18 Dra	6223	16 40.2	+64 47	5.00	K0	0
278		6227	16 40.8	+15 56	5.78	Mb	32
279	20 Oph	6243	16 44.3	-10 36	4.73	F5	16, 17, 37
280*	52 Her	6254	16 46.3	+46 10	4.86	A2p	2, 3, 38
281*	56 Her	6292	16 50.9	+25 54	6.33	K0	2, 38
282	ϵ^1 Ara	6295	16 51.6	-53 0	4.15	K2	17
283	ε UMi	6322	16 56.2	+82 12	4.40	G5	0
284	61 Her	6346	16 59.9	+35 33	6.75	Mb	32
285	ν Ser	6446	17 15.2	-12 45	4.35	A0	16, 37
286		6474	17 19.0	-24 9	6.26	K0	0
287		6481	17 20.0	+16 24	5.69	A2	
288	θ Sco	6553	17 30.1	-42 56	2.04	F0	0
289	α Oph	6556	17 30.3	+12 38	2.14	A5	17
290	26 Dra	6573	17 33.9	+61 57	5.31	F8	32
291		6575	17 34.1	+ 2 5	6.35	K0	0
292		6618	17 41.9	+53 51	5.70	A0	
293	ψ Dra	6636-7	17 43.7	+72 12	4.90	F5	17
294		6666	17 47.5	-10 52	6.34	G5	32
295	1 Sgr	6801	18 5.6	-23 43	5.13	K0	0
296	ξ Pav	6855	18 14.0	-61 32	4.25	K2	17
297		6861	18 15.4	-24 58	6.36	Mb	0
298		6917	18 22.1	+29 46	5.71	A2	
299*		6993	18 32.5	- 0 24	5.80	A0	
300	ϵ^1 Lyr	7051-2	18 41.0	+39 34	5.06	A3	37
301	5 Aql	7059	18 41.3	- 1 4	5.68	A0	3, 13
302	110 Her	7061	18 41.4	+20 27	4.26	F5	37
303	8 Aql	7101	18 46.1	- 3 26	6.04	A3	2, 13
304		7137	18 50.7	+50 35	4.97	G5	0
305	10 Aql	7167	18 54.2	+13 46	5.94	A3p	2, 3,
306	11 Aql	7172	18 54.5	+13 29	5.37	F5	0
307		7186	18 55.8	-15 25	6.38	G5	0
308*	16 Lyr	7215	18 58.6	+46 48	5.06	A5	2
309		7267	19 4.2	+16 42	6.46	F5	2,38
310		7278	19 7.1	-66 50	5.57	A5	2
311	1 Sge	7301	19 11.0	+21 3	5.62	A3	
312	43 Sgr	7304	19 11.8	-19 8	5.03	K0	17
313		7311	$19^h12^m.7$	+49° 54'	6.34	G5	0

TABLE 17 (continued)

No.	Name	HR No.	α(1900)	δ(1900)	m	Sp.	Reference
314*	59 Dra	7312	$19^h12^m.8$	+76°24'	5.06	F0	2, 38
315	ρ' Sgr	7340	19 15.9	-18 2	3.95	A5	16, 37
316	2 Sge	7369	19 19.9	+16 45	6.03	A0	16, 37
317		7382	19 20.8	+43 12	5.95	G5	0
318	35 Aql	7400	19 24.0	+ 1 45	5.77	A0	
319*		7451	19 31.7	+51 1	5.65	F5	
320	π Aql	7544	19 44.0	+11 34	5.70	F2	0
321		7545	19 44.5	+69 6	5.90	A0	3, 38
322		7555	19 45.9	+38 28	6.21	G5	38
323*	18 Sge	7746	20 11.9	+21 17	6.16	K0	0
324	24 Vul	7753	20 12.5	+24 22	5.45	K0	16
325		7781	20 15.9	+55 5	5.97	A0	
326		7784	20 16.6	+39 5	6.24	A0	2, 16, 37
327	ρ Cap	7822	20 23.1	-18 9	4.96	F0	
328	40 Cyg	7826	20 23.9	+38 7	5.45	A0	2, 3, 38
329	41 Cyg	7834	20 25.3	+30 2	4.09	F5p	0
330	ε Del	7928	20 38.8	+14 43	4.53	A5	
331	ψ Cap	7936	20 40.2	-25 38	4.26	F8	16
332	ω Cap	7980	20 45.8	-27 18	4.24	Ma	17
333	32 Vul	8008	20 50.3	+27 41	5.24	K5	0
334	γ Mic	8039	20 55.2	-32 39	4.71	G5	17, 38
335	η Cap	8060	20 58.7	-20 15	4.93	A3	16, 37
336		8071	21 0.1	+41 14	6.33	F2	7, 16
337	ζ Cyg	8115	21 8.7	+29 49	3.40	K0	17
338	ε Eql	8123	21 9.6	+ 9 36	4.61	F5	37
339	ι Cap	8167	21 16.7	-17 16	4.30	K0	0
340		8170	21 17.1	+39 55	6.46	F8	2, 38
341	35 Cap	8207	21 21.6	-21 38	6.03	K0	38
342	7 Cep	8227	21 25.8	+66 22	5.42	B5	2
343	6 PsA	8230	21 26.2	-34 23	5.99	A2	32
344*	ρ Cyg	8252	21 30.2	+45 9	4.22	K0	
345*		8263	21 32.4	- 0 50	6.27	A2	
346	26 Aqr	8287	21 37.1	+ 0 50	5.80	K5	38
347*	76 Cyg	8291	21 37.5	+40 21	6.05	A0	7
348	HD 206874		21 39.9	+28 19	6.90	A5	3
349	15 Peg	8354	21 48.0	+28 20	5.62	F5	0
350	28 Aqr	8390	21 56.0	+ 0 7	5.75	K0	0
351*		8407	21 58.9	+44 10	5.52	A0	
352*	32 Aqr	8410	21 59.6	- 1 23	5.23	A3	
353*	π Peg	8454	22 5.5	+32 41	4.38	F5	
354*		8461	22 7.0	+15 33	6.06	K0	2
355*		8473	22 8.3	+71 37	6.36	B9	2
356	μ^2 Gru	8488	22 10.4	-42 8	5.19	G5	38
357	HD 212005		22 16.1	+24 26	8.3	K0	2
358	σ Aqr	8573	22 25.3	-11 11	4.89	A0	
359	ο Peg	8641	22 37.1	+28 47	4.85	A0	
360	66 Aqr	8649	22 38.2	-19 21	4.88	K5	38
361	η Peg	8650	22 38.3	+29 42	3.10	G0	0
362	HD 215812		22 42.7	- 4 45	6.75	G0	32
363	τ Aqr	8679	22 44.3	-14 7	4.21	K5	0
364	ι Cep	8694	22 46.1	+65 40	3.68	K0	
365	γ PsA	8695	22 47.0	-33 24	4.52	A0	3, 38
366		8708	22 49.2	+44 13	5.62	A0	0
367	ζ Aqr	8709	22 49.4	-16 21	3.51	A2	
368		8726	22 52.0	+49 12	5.10	K0	0
369*	4 And	8804	23 3.1	+45 51	5.56	K5	0
370	58 Peg	8821	23 5.0	+ 9 17	5.34	B8	38
371	γ Tuc	8848	23 11.6	-58 47	4.10	F2	17
372	9 And	8864	23 13.6	+41 14	5.90	A3	16, 37, 38
373	99 Aqr	8906	$23^h20^m.8$	-21°11'	4.52	K5	2, 38

TABLE 17 (continued)

No.	Name	HR No.	α(1900)	δ(1900)	m	Sp.	Reference
374*	15 And	8947	$23^h29^m.7$	+39°41'	5.50	A0	3
375	μ Scl	8975	23 35.4	-32 38	5.33	K0	2, 32
376*	λ Psc	8984	23 36.9	+ 1 14	4.61	A5	7, 16
377	21 Psc	9022	23 44.3	+ 0 31	5.77	A2	3, 16, 37
378		9057	23 52.0	+42 6	6.04	F5	16, 37
379	ψ Peg	9064	$23^h52^m.6$	+24°35'	4.75	Ma	17, 38

TABLE 18

Probable Members of the Ursa Major Stream

No.	μ	±	θ_o	$\Delta\theta$	ρ_o	±	$\Delta\rho$	π_{tr}	±	π_{cl}	Sp.	M_{sp}	M_{cl}
17	".069	± ".003	239°.3	+17°.1	- 9.9	± 3.0	- 9.8	".015	± ".013	".019	A2 V	+1.2	+0.9
20	.011	.004	240.9	+15.3	- 5.1	0.4	- 3.6			.003	G5 III	+0.3	-2.2
23	.319	.003	225.3	- 8.8	+ 7.7	0.4	- 0.1	.063	.010	.100	F8 IV	+2.7	+5.2
24	.051	.003	218.7	- 8.4	- 8.8	1.3	- 9.9	.001	.009	.014	G5 III	+0.3	+1.1
25	.013	.004	228.0	0.0	+15.2	2.7	+12.2			.004	G5 III	+0.3	-0.6
26	.021	.004	247.2	-18.5	+ 3.3	1.0	+ 6.5			.006	A7 V	+2.4	-0.3
27	.045	.004	228.6	- 5.6	+12.8	1.8	+ 6.0			.014	K0 III	+0.2	+2.1
29	.316	.002	235.9	+ 5.4	+ 6	9	+ 2.4	.020	.016	.090	F0 V	+3.0	+5.4
32	.051	.002	250.5	+19.4	+ 4.8	2.8	+ 1.2	.011	.006	.015	A3 V	+1.6	+1.2
36	.011	.006	225.0	-12.9	- 8.1	2.1	- 1.3			.003	G5 II	-1.6	-1.9
37	.013	.004	251.6	+19.7	+ 5.2	0.7	+ 7.6			.004	K0 III	+0.2	-1.0
43	.016	.004	243.5	+11.5	+ 3.6	2.1	+ 5.0	.017	.009	.004	G0 III + A	+1.0	-0.5
44	.174	.002	240.3	+ 5.9	- 0.9	1.2	+ 1.6			.050	F2 III	+1.1	+3.3
45	.072	.003	250.6	+18.7	+10.6	1.3	+10.0			.020	F0 V	+3.0	+2.4
53	.018	.004	222.3	+12.3	+ 2.6	2.7	+ 6.6			.005	A2	+1.2	-1.1
56	.085	.006	246.9	+ 6.4	- 8.3	1.2	- 1.5	.047	.011	.026	F5 V	+3.7	+3.5
60n	.073	.006	231.1	- 3.2	+ 7.0		+ 4.0	.011	.013	.021	A7p		+2.5
63	.037	.002	227.2	- 6.0	+ 5.0	0.6	+ 6.1	.004	.013	.010	G5 III	+0.3	0.0
64	.029	.003	231.8	- 2.1	+ 4.7	3.3	+ 7.3			.008	A1	+0.8	+0.8
65	.211	.002	223.1	- 9.9	- 9.2	2.2	- 7.9	.040	.006	.059	A3 V	+1.6	+2.5
68	.051	.007	213.1	-19.7	- 8.6	3.9	- 7.9			.014	A3 V	+1.6	+1.0
69	.014	.002	252.9	+16.6	- 6.9	1.3	- 1.8	.011	.018	.004	A2 V	+1.2	-1.5
71n	.050	.003	258.5	-10.7	- 2.5	1.6	+ 7.8	.017	.013	.018	A7m		+2.2
72	.169	.003	251.1	+17.9	- 9.7	2.2	-12.2	.043	.013	.048	A5 V	+2.2	+2.6
75	.036	.006	212.4	-19.3	+11		+ 9.5			.010	G5 II	-1.6	+0.7
76	.043	.003	256.6	+ 0.3	+ 0.7	3.0	+10.9	.018	.007	.015	A3 V	+1.6	+0.8
81	.028	.004	255.5	- 9.0	-18.5	0.6	- 6.7			.011	G2 III	+0.7	+0.6
83	.014	.003	245.2	+12.3	- 1.5	1.6	+ 6.5			.006	A2	+1.2	-1.8
84	.075	.003	218.6	- 9.7	-10.7	4.2	- 4.9	.009	.006	.022	A2	+1.2	+1.9
85	.020	.006	239.5	+ 8.7	- 7.2	1.6	+ 0.7			.006	A2	+1.2	+0.3
88	.025	.004	248.6	- 3.4	-16.5	0.3	- 4.3			.010	K3 III	-0.2	0.0
89	.020	.003	281.3	+12.7	- 7.9	SB0	+ 5.0			.009	A0 V	+0.5	-0.8
91	.124	.002	228.4	+ 4.7	- 7	4	+ 0.7	.050	.010	.039	A3 III	-0.4	+0.8
103	.034	.004	238.2	+13.5	- 9	6	+ 1.4	.010	.013	.012	A2	+1.2	+0.9
105n	.011	.003	259.7	-16.8	- 8.4	2.4	+ 5.9	.015	.013	.009	A0p		-0.6
106	.470	.004	221.0	+ 2.6	- 9.7	0.4	- 5.3	.122	.006	.135	F6 V	+3.9	+4.5
			217.2	- 1.2	- 9.7	1.2					K2 V	+6.3	+6.9
107	.034	.003	222.6	-18.4	-19.5	0.6	- 5.1	.003	.009	.018	G8 III	+0.3	+0.9
110	.203	.003	245.0	+ 9.6	-13.6	0.3	- 0.3	.104	.009	.092	G0 V	+4.5	+4.4
111	.052	.002	265.6	- 1.9	-18.1	SB	- 3.3	.037	.006	.029	A2 IV	+0.1	+0.1
114	.044	.004	291.3	+13.7	- 7.6	4.0	+ 7.5			.027	F0 V	+3.0	+3.6
115	.014	.004	225.0	-13.2	-20.9	1.9	- 6.5			.007	G5 III	+0.3	+0.3
118n	.028	.006	317.9	+20.0	-12.7	SB	+ 2.2			.016	A5m		+2.2
122	.012	.003	221.6	+15.7	- 1.5	± 0.4	+ 6.7	.008	.015	.004	G5 III	+0.3	-2.4
125	1".325	± ".002	203°.8	- 0°.6	- 7.5	St.vel.	+ 1.3	".373	± ".003	".426	A1 V	+0.8	+1.6

TABLE 18 (continued)

No.	μ	±	θ₀	Δθ	ρ₀	±	Δρ	π_{tr}	±	π_{cl}	Sp.	M_{sp}	M_{cl}
129	″.021	± ″.003	264°.6	+13°.1	- 9.1	± 3.4	+ 6.9			″.017	A2 V	+1.2	+1.0
132	.057	.002	225.7	+10.8	-13.8	2.8	+ 1.5	″.040	± ″.010	.037	A3	+1.6	+1.5
135	.012	.003	194.1	-12.3	- 7.6	0.7	+ 6.9	.001	.013	.006	G5 III	+0.3	-1.0
138	.009	.006	192.5	-12.3	-16.4	1.8	- 1.0	.002	.013	.006	M2 III	-0.2	-0.3
140	.346	.002	189.1	- 0.5	-19.6	0.6	- 9.0	.060	.006	.123	G0 V	+4.5	+6.3
141	.050	.004	183.4	- 4.6	-12	4	- 2.4			.017	A3 V	+1.6	+0.8
151	.025	.007	173.2	- 9.5						.008	G2 III + A	+0.7	+0.8
152	.090	.003	342.6	-19.7	-11.2	0.4	+ 3.7			.053	G0 V	+4.5	+4.3
153	.097	.004	178.2	+ 1.3	- 2.1	0.9	+11.5	.023	.010	.034	G8 III	+0.3	+2.6
155	.005	.003	168.7	+ 9.6	-12.9	1.8	+ 4.0	.003	.013	.013	G5 III	+0.3	+1.7
162	.006	.003	161.6	+ 9.3	-16.3	1.5	+ 0.2			.007	A0	+0.5	-0.3
169	.080	.002	43.4	+14.8	-16.9	3.4	- 0.8			.069	A5	+2.2	+4.1
178	.040	.003	143.1	-16.9	-14.5	0.4	- 4.7	.018	.010	.014	G5 III	+0.3	0.0
180	.053	.003	88.9	-10.9	-16.8	2.5	- 0.8			.044	A5	+2.2	+2.7
181	.057	.003	130.7	- 9.6	-16.5	1.0	- 2.1			.030	F6 V	+3.9	+4.2
182	.024	.002	112.2	-11.9	-18.7	2.2	- 3.5	.010	.009	.015	F0 II-III	-0.8	-0.5
193	.086	.013	38.0	- 4.3	-21.7	2.8	- 9.7			.052	F8 V	+4.3	+4.9
195	.200	.001	132.0	+ 8.5	-23.2	2.2	-10.0	.050	.007	.089	A4 V	+1.8	+2.3
196	.189	.002	113.7	-17.5	- 9.7	0.6	+ 1.9			.072	F2 V	+3.3	+3.4
197	.027	.002	121.3	-17.2	- 9.1	0.3	0.0	.032	.007	.019	G8 II	-1.9	+1.6
199	.055	.002	133.5	+ 2.8	- 4.6	0.6	+ 0.8	.025	.013	.016	G5 III	+0.3	+0.9
201	.099	.003	115.8	-15.3	+ 4.4	0.6	+ 7.5	.056	.015	.028	F2 V	+3.2	+1.4
203	.073	.004	122.2	+ 3.3	- 5.4	0.6	+ 5.2	.003	.018	.026	K0 III	+0.2	+3.2
207	.122	.004	140.7	+ 6.1	- 0.8	0.9	+ 0.5	.033	.013	.034	F2 V	+3.2	+3.1
208n	.102	.004	146.3	+15.8	+ 0.2	0.6	+ 6.3			.030	G8 IIIp		+3.5
212	.045	.003	128.7	+ 4.3	- 7.0	2.1	- 1.0			.013	A2	+1.3	+1.2
213n	.060	.003	114.9	-10.4	- 3.8	3.1	+ 3.8			.019	A7p		+2.7
214	.105	.012	108.4	+10.6						.040	G5 IV-V	+4.3	+7.0
215	.096	.019	112.0	+14.6	-34.4	2.2	-23.0			.036	G8 V	+5.7	+6.7
218	.022	.002	114.2	-13.9	- 9.1	0.6	- 8.4	.022	.009	.006	K2 III	+0.1	-0.9
221	.108	.019	111.8	+14.4	-41.9	6.0	-30.9			.040	K2 V	+6.3	+7.0
223	.088	.002	122.4	- 8.4	- 5.4	0.3	- 5.3	.026	.010	.025	G5 III	+0.3	+0.3
224	.088	.019	99.2	+ 0.7						.032	M0 V		+6.5
225n	.050	.003	121.2	+19.5	-10.9	0.7	- 0.5	.018	.007	.018	A2p		+1.2
229	.015	.003	118.3	-10.3	+ 0.5	1.9	+ 0.5			.004	G0 II	-1.7	-1.3
230	.137	.022	114.1	+ 7.7						.047	G5 V	+5.2	+7.2
231	.034	.004	112.8	- 4.9	-12.3	2.4	- 4.6			.011	A3	+1.7	+1.8
233	.028	.002	140.7	+17.7	- 2.1	1.8	+ 3.5	.015	.007	.008	A5 III	0.0	-1.1
234	.064	.003	91.8	- 3.2	-14.9	0.3	- 6.3	.010	.010	.018	F0 V	+3.0	+0.9
235n	.055	.003	123.1	- 1.1	+ 6.3	2.1	+10.6			.016	A6m		+1.8
236	.111	.003	105.7	-20.0	- 1.9	0.9	+ 1.0			.031	F2 V	+3.2	+2.8
237	.027	.004	121.3	+ 2.0	-12.6	2.2	- 5.8			.008	A2	+1.3	+0.5
240	.057	.002	109.4	-15.3	- 6.2	1.8	- 0.9	.008	.018	.017	A2	+1.3	+0.6
241	.078	.004	112.6	-12.6	- 6.8	1.6	+ 1.9	.018	.009	.025	F2 III	+1.1	+3.2
243	.169	.002	126.3	- 0.3	+ 4.2	0.2	+ 6.4	.147	.009	.048	G8 V	+5.7	+3.2
246	.251	.003	132.4	+ 5.2	- 7.0	0.6	- 4.7	.063	.012	.071	F5 V	+3.7	+4.3
248	.078	.003	112.6	-14.9	- 2.7	2.5	- 5.8			.022	F0 V	+3.0	+2.8
249	.235	.002	144.3	+16.1	- 6.5	SB	- 4.1	.068	.012	.066	G2 V	+4.8	+4.7
251	.013	.002	116.5	-10.7	- 9.4	0.7	- 5.3	.021	.010	.004	K5 III	-0.2	-1.9
252	.151	.001	126.9	- 2.7	+ 1.0	SB0	+ 2.3	.053	.015	.042	A0 V	+0.5	+0.4
256	.151	.003	144.4	+17.4	- 2.3	2.7	+ 2.5	.010	.016	.044	F2 V	+3.2	+4.0
257	.031	.003	114.9	-15.4	+ 3.3	1.0	+ 2.2			.009	G5 III	+0.3	+0.8
260	.028	.006	113.0	-16.3	- 7.3	0.6	-10.6			.008	A2 V	+1.3	+0.1
261	.083	.002	124.6	- 5.0	- 1.5	2.8	- 8.7	.034	.010	.026	A2 IV	+0.3	+0.8
264	.055	.003	148.3	+19.1	- 3.5	0.6	- 7.7	.031	.015	.016	G8 III	+0.3	+1.3
268	.026	.003	133.4	- 0.7	+ 6.4	3.1	+ 6.4			.007	A3 V	+1.7	0.0
269	.014	.004	126.0	- 1.2	+ 8.0	1.8	+ 0.5			.004	K5 III	-0.2	-0.6
273n	.071	.002	143.0	+ 8.9	- 5.3	0.7	- 9.2	.033	.009	.020	A0p		+1.0
276	″.164	″.009	131.8	- 6.1	- 0.1		+ 2.9	.035	.009	.047	F8 V	+4.3	+5.0
280n	″.059	± ″.003	152°.6	+13°.6	- 1.4	± 0.6	+ 0.5	″.004	± ″.012	″.017	A2p		+1.0

TABLE 18 (continued)

No.	μ		θ_o	$\Delta\theta$	ρ_o		$\Delta\rho$	π_{tr}		π_{cl}	Sp.	M_{sp}	M_{cl}
281	″023 ±	″003	142°2	+ 2°9	- 0.4 ±	1.2	- 3.2			″007	G5 III	+0.3	+0.5
289	.257	.001	151.4	+ 9.6	+15	3	+ 7.7	″047 ±	″007	.079	A5 III	0.0	+1.6
298	.025	.006	139.7	-15.0	+ 8.5	SB	+ 3.4			.007	A2 V	+1.3	-0.1
299	.023	.004	156.8	+ 9.9	+13.3	2.7	+ 1.2			.009	A2	+1.3	+0.6
301n	.023	.003	151.2	+ 2.7	+18	4	+ 5.7			.009	A2m		+0.5
306	.121	.003	173.8	+16.6	+16.0	0.6	+ 6.2	.035	.012	.041	F8 V	+4.3	+3.6
308	.081	.004	166.3	+ 4.1	+ 8.1	3.1	+ 7.0	.031	.009	.023	A7	+2.4	+1.9
314	.127	.003	155.2	- 9.1	- 3.9	0.7	+ 3.0	.046	.009	.039	F2 V	+3.2	+3.0
319	.188	.003	170.5	+ 1.1	+ 1.0	1.6	+ 0.6	.035	.010	.052	F8 V	+4.3	+4.2
323	.021	.004	174.6	- 1.5	- 4.1	1.6	-13.7			.007	K1 III	+0.2	+0.4
325	.021	.003	185.4	+ 7.2	- 2.8	1.0	+ 3.2	.000	.009	.006	A2	+1.3	-0.2
326	.018	.003	180.0	+ 2.4	0.0	3.0	- 4.1			.005	A3 V	+1.7	-0.3
332	.007	.003	206.5	+ 6.4	+ 9.0	0.4	- 7.7	.004	.015	.011	K5 III	-0.2	-0.6
340	.205	.013	184.5	-12.7	+ 1.2	SBO	-13.8			.014	F8 V	+4.3	+2.2
341	.038	.003	221.8	+ 6.1	+23.4	3.7	+ 7.4			.032	K5 III	-0.2	+3.6
344	.088	.003	191.2	- 1.9	+ 6.9	0.3	+ 4.9	.004	.010	.025	G5 III	+0.3	+1.2
345	.025	.004	220.6	+19.1	+16.9	2.5	+ 3.8			.011	A2	+1.3	+1.5
347	.042	.003	191.0	- 3.2	var			.008	.018	.012	A2	+1.3	+1.4
351	.030	.004	202.2	+ 7.4	- 1.2	2.7	- 3.3			.008	A0	+0.5	+0.2
352n	.050	.003	198.8	-18.0	+20.4	SB	+ 5.0	.010	.006	.033	A5m		+2.8
353	.020	.002	204.0	+ 3.2	+ 2.2	2.5	- 2.6	.003	.010	.006	F5 II	-2.0	-1.7
354	.015	.003	203.2	- 0.3	+10.9	1.9	+ 1.8			.005	K1 III	+0.2	-0.5
355	.021	.004	198.1	- 3.1	- 2.8	1.6	+ 3.0			.006	A0	+0.5	+0.2
360	.037	.004	226.1	- 6.4	+21.6	0.3	+ 7.5	.010	.015	.019	K3 III	-0.2	+1.3
367	.045	.001	239.5	+10.1	+18.0	1.0	+ 4.7	.042	.010	.020	A3 V	+1.7	0.0
369	.029	.003	200.3	- 9.8	- 6.5	1.3	- 6.1			.008	K5 III	-0.2	+0.1
373	.077	.003	222.4	-15.4	+15.6	0.4	+ 2.8	.003	.010	.033	K5 III	-0.2	+2.1
374	.042	.003	199.3	-15.9	+12.8	2.8	+10.0	.011	.009	.012	A1 V	+0.8	+0.9
376	.195	.002	221.9	+ 0.1	+12.1	0.6	+ 0.8	″024 ±	″012	.050	A5	+2.2	+3.1
379	″041 ±	″003	232°0	+12°0	- 4.3 ±	0.7	- 7.6			″012	M3 III	-0.2	+2.8

Notes to Table 18

60. A strontium star. The Sr II lines λ 4077 and λ 4215 are very strong. The blends near λλ 4172, 4130, and just to the red of Hδ are also well marked. There is no evidence of spectral variability.

71. A metallic-line star. The K line and the hydrogen lines indicate a type of A7 but the metallic-line spectrum is that of an F2 star.

105. This star is spectroscopically similar to ε UMa. The K line is sharp and weak; the blend at λ 4171 is strong.

118. The type from the metallic lines is F0; the hydrogen lines are about as strong as in an A7 star.

208. This star appears to be a high-velocity giant.

213. The hydrogen lines are too weak for the weakness of the K line.

225. See An Atlas of Stellar Spectra, p. 18.

235. The metallic-line type is F2; the hydrogen-line type, F0.

273. This star is also similar to ε UMa, although the normal metallic spectrum is slightly stronger. The K line is very weak; λ 4171 and λ 4077 are strong.

280. A strontium star. λ 4077 of Sr II is very strong and the blends at λ 4171 and λ 4130 are well marked.

301. 5 Aql A is a metallic-line star. The type from the metallic lines is A7 while that from the hydrogen lines is A5. The K line is also somewhat weak in 5 Aql B, an F0 star.

352. The metallic-line type is F0; that from the hydrogen lines is A7.

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TABLE 19

Stars Probably Not Members of the Ursa Major Stream

No.	μ		θ_o	θ_c	ρ_o		ρ_c	π_{tr}		π_{cl}	M_{cl}
14	″027	± ″003	250°2	225°3	+ 0.8	± 0.9	+ 6.2			″008	+ 0.7
15	.004	.004	75.9	224.1	- 4.6	2.4	- 5.2			.001	- 4.2
16	.052	.003	250.8	221.5	+ 0.7	1.5	- 0.3			.015	+ 0.3
18	.018	.002	231.8	228.0	- 3.3	0.7	+ 6.9			.006	+ 2.6
19	.015	.003	258.7	224.4	- 0.7	0.7	- 0.4			.004	- 1.4
21	.026	.003	283.5	254.7	+16.5	0.2	+11.5	″001	± ″015	.010	- 0.4
22	.022	.004	280.3	228.3	- 8.3	1.6	+ 4.9			.006	- 0.6
28	.035	.003	283.2	254.9	- 1.2	0.2	+10.8	.018	.015	.013	+ 1.0
30	.140	.004	253.4	229.5	-10.7	0.6	- 3.1			.040	+ 3.7
31	.011	.003	180.0	230.8	- 2.6	1.9	+ 4.5			.003	- 1.4
33	.025	.003	297.3	230.0	- 8.5	1.6	+ 0.5			.007	- 0.4
34	.352	.002	103.4	232.5	+10.4	0.6	- 4.5	.024	.009	.102	+ 5.1
35	.016	.002	194.1	242.9	- 4.0	0.6	- 8.4			.005	- 1.0
38	.021	.002	280.8	190.4	+ 0.4	0.3	+ 1.1	.032	.009	.006	- 1.4
39	.058	.004	254.1	241.8	+10.4	1.3	+ 7.9			.018	+ 1.0
40	.049	.004	243.4	244.1	+20	6	+ 8.4			.016	+ 1.9
41	.034	.006	244.2	251.8			+ 9.7			.012	+ 2.3
42	.032	.004	201.8	233.5	+11.3	1.3	+ 3.9			.009	+ 0.1
46	.060	.006	266.2	250.3			+ 9.0			.020	+ 2.6
47	.004	.003	236.3	235.0	- 6.9	1.2	- 4.7	.002	.018	.001	- 4.4
48	.089	.002	262.9	233.0	+ 0.1	1.6	- 2.3	.026	.013	.026	+ 2.4
49	.062	.003	274.6	248.4	- 4.2	1.8	- 8.9	.026	.007	.020	+ 1.1
50	.046	.001	299.9	249.5	-12.5	1.9	- 9.1			.015	- 0.1
51	.023	.004	219.8	252.0	0.0	0.9	- 9.4	.021	.013	.007	- 0.5
52	.038	.003	256.9	249.0	- 9.1	4.2	- 9.0			.012	- 3.0
54	.067	.001	139.9	236.9	-11.7	0.2	- 5.5	.005	.006	.020	- 1.2
55	.006	.002	225.0	248.6	-12.3	2.8	- 8.8			.002	- 2.4
57	.021	.001	259.2	232.8	- 4.9	1.2	- 0.3	.018	.012	.006	- 1.6
58	.038	.003	189.2	236.0	- 1.3	1.8	- 4.6			.011	+ 1.4
59	.017	.003	290.6	244.7	-10.8	1.6	- 8.0			.005	- 0.4
61	.048	.004	246.7	241.9			+ 7.3			.015	+ 2.9
62	.028	.004	225.0	237.8			+ 5.7			.008	+ 0.4
66	.057	.006	230.7	236.5			+ 5.1			.017	+ 2.7
67	.033	.006	244.2	252.2	+ 4.7	0.6	+ 9.5	.004	.013	.011	- 0.1
70	.062	.007	207.0	232.6	- 7.2	0.6	- 1.4	.013	.013	.017	+ 1.4
73	.005	.004	270.0	233.6	+ 3.6	2.8	- 3.4			.001	- 4.2
74	.055	.003	277.9	247.8	- 6.6	2.4	- 9.1	.021	.009	.018	+ 1.4
77	.001	.004	315.0	262.0	-10.4	1.8	-10.8			.004	- 1.0
78	.009	.002	276.3	249.7	-13.0	0.7	- 9.9	.016	.010	.003	- 3.7
79	.116	.004	231.0	230.0	+ 9.9	0.5	+ 2.8	.024	.013	.033	+ 2.2
80	.070	.003	223.3	229.1	+ 2.0	0.7	+ 2.3	.021	.015	.020	+ 0.7
82	.021	.003	244.6	247.6	-27.4	0.5	-10.8			.008	- 0.4
86	.053	.004	258.0	225.2	+ 7.4	1.0	+12.1	.037	.015	.015	+ 1.0
87	.108	.007	217.5	225.4	+26.1	1.5	+ 5.7			.032	var
90	.081	.002	160.5	220.1	+ 1.0	0.3	- 3.9	.009	.009	.023	+ 0.1
92	.172	.002	332.7	302.0	- 9.9	0.3	-11.7	.054	.007	.066	+ 4.3
93	.022	.003	310.6	249.6	- 9.7	SB	-12.9			.009	- 0.1
94	.008	.004	194.0	231.2	- 8.0	1.2	-10.7			.003	- 2.1
95	.023	.006	223.3	216.6			- 1.9			.006	+ 1.2
96	.008	.004	76.0	246.5	-18.7	SB	-13.0			.003	- 1.3
97	.011	.003	158.2	255.7	-19.2	0.9	-13.5	.004	.009	.005	- 1.3
98	.048	.004	195.8	221.2	-18.2	0.4	- 7.7	.007	.006	.015	+ 0.1
99	.006	.002	188.2	290.2	-18.8	0.7	-13.3			.003	- 0.9
100	.094	.002	178.2	215.2	-13.5	± 0.2	- 1.0	″009	± .009	.026	+ 0.1
101	″036	± ″006	210°4	214°9			- 2.5			″010	+ 1.9

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TABLE 19 (continued)

No.	μ		θ_o	θ_c	ρ_o		ρ_c	π_{tr}		π_{cl}	M_{cl}
102	″002	± ″004	333°5	281°2	+ 0.6	± 0.6	-13.9			″001	- 4.0
104	.002	.004	296.5	292.0	- 3.6	1.3	-13.7			.001	- 3.6
108	.020	.003	329.1	288.1	-12.5	1.0	-14.3			.010	- 0.1
109	.017	.002	151.9	244.0	-16.1	SB	-13.9	″019	± ″010	.008	0.0
112	.021	.003	166.0	218.7			-11.5			.008	+ 0.1
113	.019	.002	183.0	214°1	- 4.8	0.4	-10.0	.012	.006	.007	- 1.7
116	.273	.006	215.6	215.9	-35.8	3.7	-11.2	.039	.015	.101	+ 5.8
117	.023	.002	342.4	299.7	- 3.8	0.7	-14.5	.032	.016	.012	- 0.2
119	.069	.004	204.2	205.6	- 2.4	SB	- 4.0	.015	.012	.018	+ 0.2
120	.019	.004	191.9	212.1	+25	6	-11.7			.007	- 0.8
121	.066	.001	132.0	225.8	-11.3	SBO	-14.3	.040	.009	.034	- 0.4
123	.161	.002	0.4	279.0	-23.7	0.7	-15.8	.065	.009	.122	+ 5.7
124	.006	.003	329.0	292.1	- 9.0	0.9	-15.7			.006	- 1.7
126	.057	.007	222.9	205.9			-12.0			.023	+ 2.5
127	.058	.007	235.5	214.0			-13.7			.027	+ 3.0
128	.042	.003	298.4	235.5	-11.5	1.0	-15.5			.030	+ 3.2
130	.003	.003	251.6	232.1	- 8.8	0.6	-15.6	.013	.007	.002	- 3.3
131	.019	.002	308.7	280.5	-15.0	3.1	-16.4			.021	+ 2.4
133	.090	.003	253.2	265.0	+23.2	0.6	-16.5	.022	.009	.105	+ 5.4
134	.022	.003	46.8	235.7	- 5.0	1.9	-16.2			.021	+ 2.3
136	.016	.002	172.9	207.4	-15.4	0.4	-14.9	.027	.010	.009	- 0.4
137	.197	.001	236.8	242.9	- 1.2	SBO	-16.6	.073	.004	.250	+ 7.2
139	.565	.007	186.7	189.0	+22.5	0.4	- 2.1	.051	.015	.159	+ 6.3
142	.024	.004	131.6	206.2			-16.5			.029	+ 3.5
143	.009	.002	353.7	350.5	- 8.5	0.6	-10.9			.071	+ 4.7
144	.018	.003	170.5	192.4	-14.1	2.8	-15.6			.013	+ 1.8
145	.154	.002	137.2	193.0	- 8.1	0.3	-16.0	.039	.006	.127	+ 6.1
146	.044	.007	237.0	186.0	-11.3	0.6	-12.1			.017	+ 1.5
147	.016	.004	291.8	351.3	-16.2	1.5	-15.6			.011	+ 1.6
148	.002	.003	270.0	350.6	-19.6	1.8	-15.6			.001	- 4.5
149	.060	.003	76.4	351.4	-15.9	0.9	-15.8			.046	+ 4.3
150	.009	.003	116.6	353.4	- 5.9	0.6	-15.5			.006	+ 0.4
154	.004	.003	56.4	173.8	-18.8	1.8	-15.5			.003	- 2.0
156	.195	.001	252.9	176.5	+36.8	SBO	-10.9	.012	.009	.071	+ 2.7
157	.083	.003	163.1	176.6	+ 2.2	2.2	+ 0.1			.023	- 1.1
158	.050	.006	168.3	176.6	- 7.8	1.0	- 5.9			.015	+ 1.1
159	.091	.006	154.0	175.6	- 1.5		+ 0.3			.025	+ 2.7
160	.051	.001	130.2	166.9	-13.5	0.7	-15.3			.033	+ 1.9
161	.002	.003	270.0	171.9	-12.8	2.0	-12.0			.001	- 4.2
163	.102	.003	177.2	172.8	+ 8	4	+ 0.7	.047	.016	.028	+ 1.4
164	.027	.003	273.7	136.5	-13.1	0.6	-16.7			.044	+ 3.6
165	.008	.002	60.3	154.0	- 7.4	1.2	-16.3			.008	- 1.2
166	.028	.006	117.5	170.4			-11.0			.010	+ 0.8
167	.011	.003	68.2	153.3	- 7.1	2.5	-16.3			.011	+ 1.3
168	.032	.002	180.0	18.0	-14.0	SB	-15.3	.042	.007	.021	+ 1.8
170	.022	.003	64.4	27.9	-12.1	SB	-16.0			.018	+ 2.0
171	.057	.003	95.0	157.6	- 5.4	0.7	-14.7	.028	.015	.032	+ 3.0
172	.111	.001	76.0	24.2	- 8.2	1.9	-15.0	.037	.009	.066	+ 2.8
173	.026	.002	155.4	96.7	-11.7	0.4	-16.6			.033	+ 2.2
174	.026	.004	300.6	100.6	-11.9	0.5	-16.6			.034	+ 2.6
175	.016	.004	277.1	77.6	- 2.0	1.8	-16.6			.020	+ 1.7
176	.032	.006	97.1	65.1	-12.2	3.4	-16.4			.035	+ 3.8
177	.018	.002	333.6	46.8	-12.2	0.9	-15.7	.018	.019	.013	+ 0.1
179	.025	.004	251.6	41.6	-16.6	0.4	-15.8			.019	+ 2.1
183	.086	.021	88.7	50.2			-14.9			.050	+ 7.5
184	.017	.003	205.0	104.5	-12.7	3.1	-15.7			.013	+ 1.4
185n	.010	.003	84.3	139.8	-10.0	2.7	-13.4			.005	- 0.6
186	.292	.006	63.3	70.7	-25.9	1.2	-15.4	″032	± ″007	.192	+ 9.0
187	.055	.004	137.9	99.9	-24.2	± 2.1	-15.5			.037	+ 4.2
188	″050	± ″022	87°7	57°2			-14.8			″028	+ 6.1

TABLE 19 (continued)

No.	μ	±	θ_o	θ_c	ρ_o	±	ρ_c	π_{tr}	±	π_{cl}	M_{cl}
189	″006	″003	59°0	109°9	- 6.8	0.6	-16.2	″015	″010	″005	- 1.7
190	.064	.003	70.7	132.2			-13.6			.031	+ 4.2
191	.087	.003	125.7	153.4	+ 6.9	0.2	+ 0.4			.024	- 0.3
192	.054	.002	119.0	87.6	-17.4	SB	-15.1			.033	+ 2.4
194	.045	.003	153.4	131.6	-13.1	0.9	-10.3	.028	.015	.016	+ 1.0
198	.025	.003	87.7	113.9			-13.1			.011	+ 1.0
200	.090	.021	112.3	59.0			-11.4			.034	+ 6.8
202	.017	.003	40.2	95.6	-13.0	0.4	-12.4	.036	.010	.007	- 0.8
204n	.138	.015	87.9	95.7	-39.6	0.9	-12.4			.053	+ 6.0
205	.043	.002	138.8	121.1			-10.1			.015	+ 1.6
206	.077	.004	133.4	127.0			- 8.5			.025	+ 4.9
209	.122	.007	120.5	139.8	+ 8.9	0.4	+ 6.0	.032	.012	.036	+ 2.5
210	.049	.003	112.9	126.0			- 8.7			.016	+ 2.1
211	.017	.004	100.0	95.8	-18.0	0.4	-10.7			.006	- 0.3
216	.018	.022	306.9	100.8			-11.1			.004	+ 2.0
217	.024	.012	125.0	101.0			-11.1			.009	+ 4.2
219	.018	.007	99.5	125.7	- 0.4	1.0	- 6.7			.005	+ 6.1
220	.091	.004	124.7	120.9			- 8.1			.029	+ 3.1
222	.016	.003	317.2	78.6	-10.5	2.8	-10.8			.006	+ 0.2
226	.090	.003	95.7	112.6	+ 6.6	SBO	- 8.9	.019	.009	.030	+ 2.4
227	.054	.003	106.1	97.7			-10.5			.019	+ 2.1
228	.063	.003	126.0	120.3	+ 9.1	0.4	- 6.5			.019	+ 2.8
232	.027	.004	107.1	125.2	-17.1	0.7	- 4.6			.008	+ 0.5
238	.022	.003	136.8	114.8	+ 1.9	3.0	- 8.1			.007	- 0.2
239	.061	.004	116.1	126.8			- 1.8			.017	+ 2.1
242	.074	.003	181.5	127.6	- 5.4	2.5	- 0.2			.021	+ 2.4
244	.071	.003	110.7	127.3	+19.6	0.4	+ 1.6	.034	.012	.020	+ 2.3
245	.005	.003	101.3	127.4	-16.0	0.4	- 1.4			.001	- 4.2
247	.143	.002	147.6	126.5	-12.7	0.4	- 3.6	.026	.010	.041	+ 1.7
250	.019	.003	96.0	123.9	- 1.7	2.2	+ 6.1			.009	- 0.3
253	.076	.004	97.6	129.7	- 0.4	3.9	- 0.7			.021	+ 2.6
254	.117	.003	133.0	122.9			+ 7.1			.036	+ 3.4
255	.036	.004	139.6	127.6	+ 3.0	1.5	+ 5.3			.010	+ 1.5
258	.042	.003	106.7	130.2	+ 1.4	1.3	+ 1.8			.012	+ 0.7
259	.145	.001	70.2	129.6	+ 3.0	0.2	+ 2.9	.045	.010	.041	+ 0.8
262	.067	.002	144.7	124.6	- 5.6	2.4	- 7.0	.013	.007	.020	+ 1.2
263	.016	.004	47.5	126.4	- 2.5	1.3	- 5.9			.005	- 0.7
265	.018	.003	206.6	126.3	- 6.1	1.2	+ 7.3			.006	- 1.2
266	.039	.003	90.0	126.9	+ 5.5	3.6	+ 7.1	.017	.012	.012	+ 0.9
267	.006	.003	51.3	132.8	-12.6	3.1	+ 2.5			.002	- 2.6
270	.078	.006	92.9	108.4	+10.1	0.6	+11.3	.052	.013	.029	+ 2.7
271	.226	.006	61.5	78.9	+ 8.5	SBO	+11.7	.086	.012	.087	+ 4.6
272	.017	.006	110.6	135.4	- 6.3	3.3	0.0			.005	- 0.3
274	.028	.003	92.0	136.0	+ 3.3	0.7	- 1.7			.008	- 0.4
275	.090	.001	155.2	137.8	+ 7.9	0.3	- 0.7	.053	.009	.025	+ 0.7
277	.013	.003	161.6	134.1	+ 0.3	0.3	- 6.1	.021	.015	.004	- 2.0
278	.050	.004	146.3	136.7	-18.8	2.1	+ 4.5	.019	.010	.014	+ 1.6
279	.132	.001	135.9	127.5	- 0.5	0.4	+ 9.4			.044	+ 3.0
282	.021	.003	357.3	91.4	+23.1	0.7	+13.0	.001	.012	.009	- 1.1
283	.018	.001	67.6	141.2	-11.4	SB	- 9.0	.015	.015	.006	- 1.7
284	.047	.004	134.1	141.5	-12.2	2.8	+ 0.9	.005	.012	.013	+ 2.5
285	.042	.015	83.2	128.6	+ 4.7	1.9	+11.1	.022	.010	.015	+ 0.2
286	.017	.003	61.9	119.0	+20.0	2.5	+12.6			.007	+ 0.6
287	.028	.004	161.6	142.2	+10.8	1.0	+ 5.0			.008	+ 0.2
288	.010	.003	90.0	95.8	+ 1.4	2.2	+13.9			.005	- 4.5
290	.567	.003	153.0	147.3	-12.8	0.6	- 0.1	.066	.007	.016	+ 6.4
291	.043	.006	121.1	138.0	- 1.2	0.9	+ 9.7			.015	+ 2.2
292	.027	.004	116.6	146.8	+ 1.8	3.6	- 2.3			.008	+ 0.2
293	.260	.002	175.2	145.3	-10.2	0.6	- 6.6	″048	″006	.079	+ 3.4
294	″063	″004	123°9	133°1			+12.2			″025	+ 3.3

TABLE 19 (continued)

No.	μ		θ_o	θ_c	ρ_o		ρ_c	π_{tr}		π_{cl}	M_{cl}
295	″024	± ″004	145°2	121°8	+ 4.4	± 0.4	+14.2	″010	± ″012	″012	+ 0.5
296	.010	.006	330.9	55.8	+12.2	SB	+14.4			.005	- 2.3
297	.008	.006	50.2	120.8	+ 3.1	3.0	+14.6			.004	- 0.6
300	.065	.002	14.3	158.5	-33.5	1.5	+ 2.8	.015	.006	.018	+ 1.3
302	.331	.002	181.5	156.2	+23	0.4	+ 7.8	.051	.010	.104	+ 4.4
303	.025	.003	182.3	148.3	+12	3	+12.9			.011	+ 1.2
304	.022	.003	185.2	160.8	+ 8.2	0.6	+ 0.4			.006	- 1.2
305	.049	.003	183.5	157.5	+14.6	0.9	+ 9.7			.016	+ 2.1
307	.002	.003	270	140.7	+20.8	1.5	+14.8			.001	- 3.6
309	.097	.010	196.2	160.8	+ 9.8	SB	+ 9.3	.041	.015	.032	+ 4.1
310	.018	.007	160.6	31.3	+11.5	2.2	+14.4			.009	+ 0.4
311	.042	.003	67.7	17.6	-22.8	2.4	+ 8.3			.013	+ 1.2
312	.022	.002	212.3	140.9	+15.3	1.0	+15.5	.002	.012	.015	+ 0.9
313	.006	.006	99.4	165.1	+ 6.0	1.2	+ 0.5			.002	- 2.2
315	.034	.003	310.2	143.7	+ 1.8	1.9	+15.5	.044	.012	.023	+ 0.8
316	.009	.003	212.0	163.6	+12.0	SB	+ 9.5			.003	+ 1.6
317	.028	.004	142.3	166.6	- 0.3	0.9	+ 1.4			.008	+ 0.5
318	.030	.003	187.6	161.4	+16.8	1.3	+12.8			.013	+ 1.3
320	.018	.003	93.2	168.4	+12.1	2.1	+11.0			.007	- 0.1
321	.025	.004	130.1	171.6	0.0	0.7	- 4.8			.007	+ 0.1
322	.011	.003	131.2	172.0	+10.1	0.7	+ 4.1			.003	- 1.4
324	.021	.003	127.4	186.4	+15.2	0.7	+ 8.1	-.004	.009	.007	- 0.3
327	.030	.001	209.2	179.0	+19.5	1.6	+16.1	.046	.009	.026	+ 2.1
328	.069	.003	197.7	179.8	- 0.2	1.5	+ 4.4	.019	.010	.020	+ 2.0
329	.012	.003	85.2	179.4	-18.8	0.5	+ 6.7	.004	.007	.004	- 2.9
330n	.047	.002	203.8	183.6	+ 9.9	0.4	+10.5	.008	.009	.017	+ 0.7
331	.163	.003	195.9	192.0	+25.8	0.7	+16.7	.093	.015	.023	+ 6.1
333	.002	.002	63.5	184.9	+ 8.1	1.3	+ 7.2	.002	.010	.001	- 7.2
334	.012	.003	59.0	218.0	+17.6	0.2	+16.8	.029	.015	.025	+ 1.7
335	.050	.002	223.3	187.3	+23.8	1.3	+ 9.1	.047	.012	.017	+ 1.1
336	.049	.004	174.2	191.1	-10.5	1.6	+ 3.3			.014	+ 2.1
337	.054	.001	175.8	188.7	+16.9	0.6	+ 6.5	.021	.010	.016	- 0.4
338	.304	.003	176.5	191.3	-15.4	0.4	+11.5	.060	.006	.115	+ 5.0
339	.035	.002	81.9	206.4	+11.5	0.3	+15.7	.027	.013	.026	+ 1.4
342	.016	.003	217.6	191.8	+ 1.2	3.0	- 4.1	.006	.016	.005	+ 1.1
343	.011	.006	236.3	251.9			+16.7			.016	+ 2.0
346	.003	.003	161.6	202.0	+ 9.9	2.5	+12.7			.001	- 4.2
348	.049	.003	173.0	195.2	+ 4.2	SBO	+ 6.5			.015	+ 2.8
349	.084	.003	222.1	197.7	+16.3	1.9	+ 7.4			.026	+ 2.7
350	.012	.003	128.7	206.5	+ 6.7	2.1	+12.6			.005	- 0.8
356	.015	.006	222.3	267.7	+12.5	1.0	+15.6	.006	.013	.011	+ 0.4
357	.018	.007	19.4	203.4	+ 2	2	+ 6.8			.005	+ 1.8
358	.029	.001	195.3	221.5	+13.5	0.9	+13.5	.017	.009	.013	+ 0.6
359	.024	.002	182.4	207.2	+ 6.6	0.7	+ 5.0			.007	+ 0.9
361	.029	.001	143.5	206.7	+ 4.4	SB	+ 4.9	-.002	.010	.008	- 2.4
362	.243	.003	304.1	219.6	-22.8	2.7	+12.0	.028	.007	.096	+ 5.8
363	.038	.002	199.9	220.4	+ 1.0	0.6	+12.3	.010	.012	.015	+ 0.2
364	.135	.001	206.9	220.7	-12.4	0.3	+ 0.3	.038	.009	.038	+ 1.6
365	.041	.003	234.0	256.1	+16.5	1.8	+14.9	.040	.016	.024	+ 1.4
366	.015	.004	233.1	208.6	+ 7.9	2.5	+ 3.6	.016	.013	.004	+ 1.4
368	.006	.004	80.6	208.1	- 9.5	0.4	- 0.5	.000	.012	.002	- 0.5
370	.013	.003	243.5	216.6	+ 8.8	2.4	+ 8.6			.004	- 1.7
371	.094	.003	330.0	291.5	+18.4	0.4	+ 4.6	.038	.012	.047	+ 2.5
372	.009	.004	192.5	212.0	- 3.9	SB	+ 9.3			.003	- 1.7
375	.111	.004	241.6	250.2	+14.1	0.6	+13.3	″024	± ″012	.050	+ 3.8
377	.023	.003	185.0	217.7	+ 9.4	2.4	+ 8.8			.007	+ 0.3
378	″009	± ″004	120°5	218°4	- 7.4	± 1.3	- 6.9			″003	- 1.6

For each star in this list, the position angle of the proper motion, the radial velocity, and the parallax were computed on the assumption that the star shares the velocity of the cluster. These are given in Tables 18 and 19, together with the corrected GC proper motion, its observed position angle, the observed radial velocity, and the trigonometric parallax if this is contained in Schlesinger's catalogue.[19] Table 18 contains those stars north of declination −30° which might be stream members according to the agreement of these data, while Table 19 contains the remaining stars. Spectral types on the system of the Yerkes atlas and spectroscopic absolute magnitudes are also given in Table 18 for comparison with the cluster absolute magnitudes. An "n" following the number of the star indicates a remark at the end of the table.

In considering the tables in this section, it is important to keep in mind the dispersion in space velocities found by Delhaye. Thus, for example, the proper motion and parallax of Sirius are known accurately enough to exclude the possibility that this star has exactly

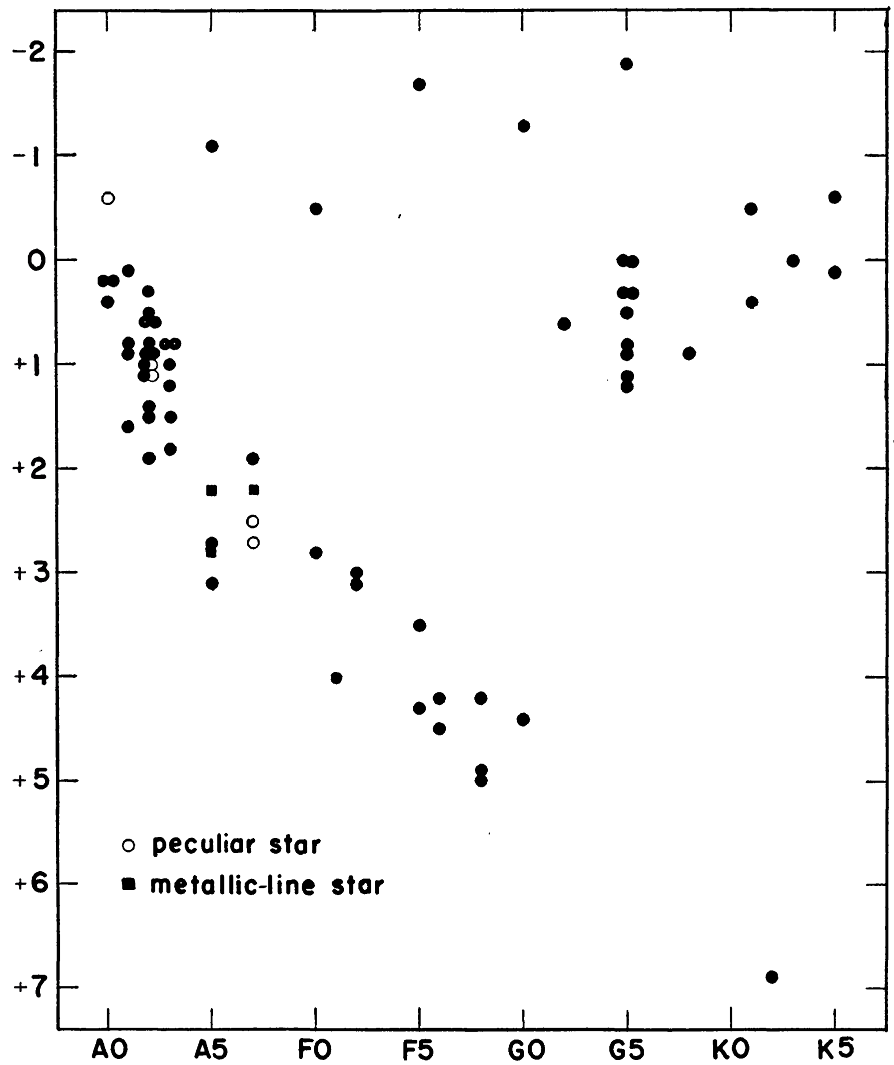

FIG. 3.—The H-R diagram for the Ursa Major stream

[19] *General Catalogue of Stellar Parallaxes* (New Haven: compiled at the Yale University Observatory, 1935).

the same motion as the nucleus stars, but the difference of $1\frac{1}{2}$ km/sec is well within a dispersion of 2 or 3 km/sec. If the adopted speed of the cluster were changed to agree with the tangential motion of this star, as suggested by Hertzsprung and Smart, the radial velocity would no longer agree. The latter is also well determined, as Sirius is a standard-velocity star with good lines.

As a check on the hypothesis that there is a stream of stars having approximately the same space motion as the nucleus stars, the space velocity of the stream was determined from the radial velocities of 87 stars, chosen primarily on the basis of the agreement of their tangential motions with the space motion of the cluster. These stars gave 16.7 km/sec as the velocity of the stream. The agreement of this value with the determination, $V = 17.0$ km/sec, for the nucleus is well within the observational uncertainty.

Figure 3 shows the H-R diagram for the stream. Both observational errors and the dispersion in tangential velocities contribute to the scatter in the diagram. On the other hand, only stars for which the cluster absolute magnitudes agree with the spectroscopic

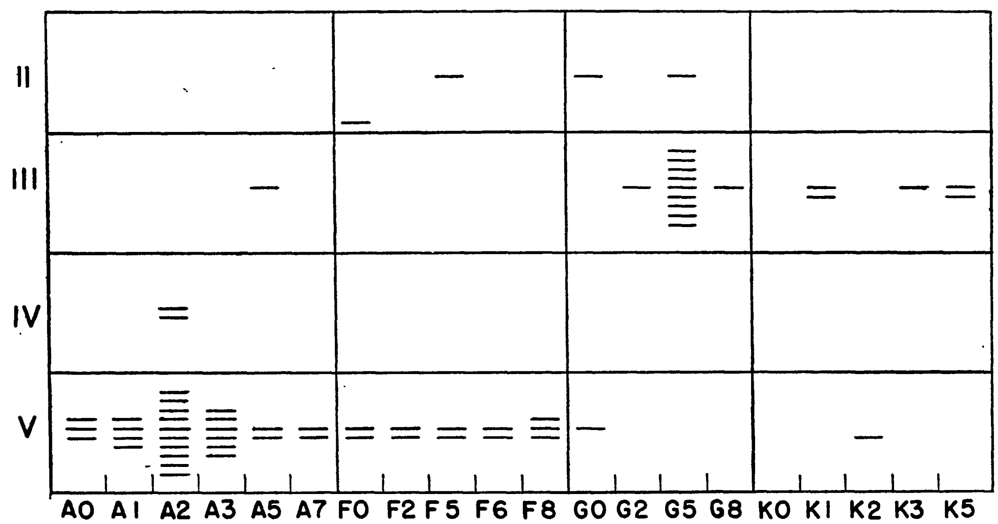

FIG. 4.—The observed distribution of stream members among the various spectral types

absolute magnitudes within 1 mag. were selected as stream members. That this criterion probably did not introduce a serious selection effect is shown by the fact that the main sequence is nowhere as wide as 2 mag. and has less than half this width in most portions of the diagram. Some of the width in the early A-type stars may be due to the failure to separate the various luminosity classes in this region.

Figure 4 illustrates the distribution of stream members among the various spectral types. The A-type stars for which no luminosity classes were determined have been plotted as class V stars. The scatter in Figure 3 has little effect on this figure, since the data have been obtained purely spectroscopically. However, the effect of incompleteness below 6.5 mag. is very evident in the presence of only one main-sequence star later than G0. The five peculiar stars and the three metallic-line stars have not been included in this diagram.

VII. SUMMARY

The Ursa Major group can be divided into two parts, a compact nucleus, similar in size to an ordinary loose galactic cluster, and an extended stream, limited primarily by incomplete observational data for distant stars.

The nucleus, which is located about 23 parsecs from the sun, occupies a roughly ellipsoidal region, $4 \times 6 \times 10$ parsecs in diameter. The shortest diameter is perpendicular to the galactic plane, the longest, in the direction of motion of the cluster. The nucleus consists of a peculiar A star, a metallic-line star, and twelve stars which define the main sequence from A0 to K3. The limit at the faint end is probably set by the lack of observational data for faint stars, but there are no early-type stars or giants in the cluster.

The proper motions of these stars are large and define the position of the convergent point accurately, but the speed of the cluster is less satisfactorily known. The results from the tangential and radial velocities differ by more than would be expected from the mean errors of the two determinations, although the average of the results agrees with the individual observations.

The density of the nucleus, about 0.1 solar mass/psc^3, is comparable to the density of the average star field through which it moves. However, because of the high velocity of the cluster with respect to the local centroid, the effects of encounters with field stars will be small and the cluster can have remained in essentially its present condition for the duration of the galactic time scale, 3×10^9 years. A more slowly moving aggregation of this type would have been disrupted much more quickly.

The stream stars show no concentration toward the nucleus. Therefore, the stream has probably not resulted from the disruption of a compact group of which the nucleus is now the only remnant. Instead, the stream stars are scattered throughout the region, about 100 parsecs in radius, in which we have good observational data for the bright stars. An appreciable dispersion may exist among the velocities of the stream stars, but it is fairly small, and the mean velocity of the group is close to that of the nucleus stars.

The existence of relatively large observational errors, together with the dispersion in velocities, makes it impossible to segregate the stream stars definitively. Sixty-nine stars which are likely to be stream members have been distinguished. Although the membership of the stream is probably larger than this list would indicate, these stars are representative of the group. Like the nucleus, the stream contains no B-type stars, but it differs from the nucleus by having a number of giant stars.

The motion of the Ursa Major stream is directed toward a point 30° distant from the vertex of star-streaming or of Kapteyn's stream II. The number of stars moving with the velocity of the Ursa Major group exceeds the number predicted on the basis of the ellipsoidal distribution by a factor of 4. Moreover, the dispersion about the mean velocity is small. Thus the Ursa Major stream is real, but it is often difficult to decide whether a particular star belongs to the stream. If numerous spurious members are to be avoided, care must be taken to choose only stars with velocities close to that of the group.

In conclusion, I wish to thank Dr. W. W. Morgan, particularly, for his kind advice throughout the investigation; Dr. J. H. Oort both for the use of unpublished data and for many helpful suggestions; Drs. R. M. Petrie and J. Delhaye for the use of their papers before publication; and the other members of the Yerkes Observatory for their discussions of various phases of the problem.

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