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Membership of the Rosette Nebula Cluster, NGC 2244

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Abstract

Relative proper motions for 287 stars in the region of the young open cluster NGC 2244, located in the Rsette Nebula, have been determined from plates taken with the Yerkes 40-in. and the Allegheny 30-in. refractors. Probabilities of membership based on these proper motions are derived. Because probable members are chosen primarily from kinematic considerations, the sample should show a minimum photometric bias. Differential extinction across the cluster, however, is identified as a complication in the immediate interpretation of the sample in terms of color-magnitude diagrams or luminosity functions.

Keywords

open cluster stars, Rosette Nebula

Disciplines

Astrophysics and Astronomy | Other Astrophysics and Astronomy | Stars, Interstellar Medium and the Galaxy

MEMBERSHIP OF THE ROSETTE NEBULA CLUSTER, NGC 2244

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ABSTRACT

Relative proper motions for 287 stars in the region of the young open cluster NGC 2244, located in the Rosette Nebula, have been determined from plates taken with the Yerkes 40-in. and the Allegheny 30-in. refractors. Probabilities of membership based on these proper motions are derived. Because probable members are chosen primarily from kinematic considerations, the sample should show a minimum photometric bias. Differential extinction across the cluster, however, is identified as a complication in the immediate interpretation of the sample in terms of color-magnitude diagrams or luminosity functions.

I. INTRODUCTION

The young open cluster NGC 2244 (C0628 + 049) is located in the center of the well-known H II region NGC 2237–2247, the Rosette Nebula, and is part of the stellar association Mon OB2. Because of its relative brightness and proximity ($m_v - M_v = 10.76 \pm 0.07$ according to the most recent study cited below), as well as its importance in studies of the dynamics and evolution of the surrounding H II region, it has been the object of several photometric and spectroscopic studies over the last few decades (Ogura and Ishida 1981; Heiser, 1977; Morgan *et al.* 1965; Johnson 1962; Hoag and Smith 1959). Comprehensive astrometric or radial velocity studies to determine cluster membership on purely kinematic grounds, however, are sadly lacking.

An early astrometric study of the cluster (van Schewick 1958) identified 22 probable cluster members within a field of 25′ diameter in the "hole" of the Rosette Nebula. This study, however, was limited in extent and in accuracy. An unpublished study of a larger number of stars, based on plates taken at Yerkes Observatory over a 50-yr period, was undertaken by van Altena in the early 1970's. This survey yielded better, but still not wholly satisfactory results.

Through the courtesy of Prof. George Gatewood, seven additional plates (containing a total of eight exposures) taken with the Thaw Refractor at Allegheny Observatory were obtained for the purpose of the present study. Combined with ten plates taken on the Yerkes 40-in. Refractor, they have provided ample plate material to determine accurate relative proper motions for about 300 stars in the vicinity of the Rosette. An analysis of the distribution of these proper motions enables us to assign kinematic cluster membership probabilities to these stars, providing a refined sample of stars for further studies of the cluster and the surrounding nebula.

II. OBSERVATIONAL DATA

Table I lists the plates used for the determination of the proper motions. Where available, exposure information has been included, and a rough estimate of the limiting magnitude of each plate, made by visual inspection, has been listed. No filter was used for the blue-sensitive Allegheny plates, while a variety of yellow filters was used for the photovisual Yerkes plates. All plates are 8 × 10 in. in size, and since the scale of the Allegheny plates is 14.6 arcsec/mm, while the Yerkes plate scale is 10.7 arcsec/mm, the Allegheny plates cover a larger area in the vicinity of the cluster, about 48′ × 60′ as compared with 35′ × 44′ for the Yerkes plates.

The earliest Allegheny plate, No. 317, contains two exposures, both very shallow; only 11 stars could accurately be measured on each of these exposures. Approximately 450 stars were measured on each of the deep Allegheny plates, 107561, 14679, 94496, and 107519;

TABLE I. Plate data for NGC 2244.

Plate	Telescope	Exposure	Approx. limiting magnitude	Date
317	Thaw	2 exp.	12.0	18–19 Oct. 1914
14679	Thaw		14.5	6–7 Nov. 1918
F277	Yerkes	60 min	13.5	15 Nov. 1919
F284	Yerkes	25 min	13.5	9 Dec. 1919
F286	Yerkes	62 min	13.7	13 Dec. 1919
16022	Yerkes	10 min	14.4	22 Nov. 1950
π20296	Yerkes		13.9	29 Sept. 1957
π20330	Yerkes		13.9	1 Oct. 1957
94496	Thaw		14.5	6 Dec. 1961
π23995	Yerkes	5 min	14.0	28 Dec. 1972
π23996	Yerkes	10 min	14.4	28 Dec. 1972
π24002	Yerkes	5 min	14.3	2 Jan. 1973
π24003	Yerkes	5 min	14.4	2 Jan. 1973
107519	Thaw	6 min	14.4	30–31 Jan. 1974
107520	Thaw	1 min	13.0	30–31 Jan. 1974
107560	Thaw	45 s	12.5	15–16 Feb. 1974
107561	Thaw	6 min	14.3	15–16 Feb. 1974

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approximately 350 stars were measured on each of the deep Yerkes plates, 16022 and 23996; and approximately 100 stars on all the remaining plates.

All stars were scanned on the Berkeley PDS microdensitometer and the data stored on magnetic tape. Positions of each image center were derived from these tapes by fitting Gaussian profiles to the density marginal distributions (Chiu 1977; Auer and van Altena 1978; van Altena and Auer 1975) using the PDP 11/60 attached to the Yale PDS machine. The Gaussian fitting program also gave information on image diameters, which was used to provide very rough magnitudes for the astrometric data reduction program. Most of the photometric data for this study, however, were taken from the extensive study of the cluster by Ogura and Ishida, which became available during the course of our work (Ogura and Ishida 1981).

III. ASTROMETRY

a) Plate Constant and Proper Motion Solutions

The astrometric data reduction of each plate essentially follows the procedure used by Chiu and van Altena in their study of the old open cluster NGC 2506 (Chiu and van Altena 1981). A plate solution was adopted of the form

$$\begin{aligned}\Delta x = x_2 - x_1 &= a_0 + a_1 x_1 + a_2 x_1 \\ &+ a_3 x_1^2 + a_4 x_1 y_1 + a_5 y_1^2 \\ &+ a_6 (m - \overline{m}) + a_7 (m - \overline{m})^2 + a_8 x_1 (m - \overline{m}), \\ \Delta y = y_2 - y_1 &= b_0 + b_1 x_1 + b_2 y_1 \\ &+ b_3 x_1^2 + b_4 x_1 y_1 + b_5 y_1^2 \\ &+ b_6 (m - \overline{m}) + b_7 (m - \overline{m})^2 + b_8 y_1 (m - \overline{m}),\end{aligned}$$

where $\overline{m}$ is the mean apparent magnitude of the reference stars. The meaning of the various terms is discussed by Eichhorn (1974). Despite the fact that inhomogeneous plate material was used, i.e., that the plates were taken on different telescopes and through different filters, no need was found for color and color-magnification term, and no need was found for higher-order distortion terms.

The relative proper motions were derived by the central overlap method (Eichhorn and Jefferys 1971). Allegheny plate 94496, which covered the widest field, the faintest stars, and which was taken at an "intermediate epoch" between the earliest plates and the latest plates, was chosen as an initial reference plate for the central overlap program.

Because of the nearness and dispersion of the cluster, blending of star images was not a severe problem. The image center data for each plate were inspected before running the final overlap solutions. Stars with poorly determined image centers or with spurious positions resulting from misidentification or plate defects, were simply removed from the data files for that plate, and not included in the final solutions. The number of plates on which a star appears, a figure we tabulate along with other data in this study, thus reflects not only the variations in deepness and coverage of the plates, but also the quality of image center determination. We use this number to assist in assigning quality classes to the proper motions. If a star has a proper motion error less than 0".30/century (s.e.) and appears on six or more plates, it is assigned to quality class 9; if it appears on ten or more plates, it is assigned quality class 10; if it appears on five or fewer plates it is assigned quality class 5. Stars with a proper motion error exceeding 0".30/century are assigned quality class 1. The mean error of a proper motion is typically 0".06/century for stars with $V \leqslant 14$ and with quality class 9 or 10. This system parallels the classification used by Chiu and van Altena (1981).

Figure 1 includes two portions of the field of NGC 2244 taken from a Yerkes plate (π23996). Because all but two of the stars in this study were also studied photometrically by Ogura and Ishida (1981), we have adopted their numbering system. Stars 401 and 402, which are not included in their study, are identified in Fig. 1. In addition we have labeled a few of the brighter stars in the field to facilitate cross reference to their finding charts.

Table II lists the 287 stars we have measured with $V \leqslant 14.0$. The first column lists a star identification number for the photometric study of Ogura and Ishida, and refers to *their* Figs. 1 and 2. Stars 401 and 402 continue their numbering system and are shown in our Fig. 1. The next six columns list the star positions (right ascension and declination for the equinox of 1950 and epoch 1961.9) on Allegheny plate 94496 reduced to the system of four bright stars chosen from the SAO catalog. The following two columns are the relative proper motions in arcseconds per century. The tenth column lists the number of plates on which the star appears in the solutions. The eleventh column lists V magnitudes. These are taken primarily from Ogura and Ishida (1981); for the two stars not measured by them, the approximate magnitudes are derived from the image diameters on Yerkes plates. Similarly column 12 lists $B - V$ colors from Ogura and Ishida, and column 13 lists values of $E(B - V)$ derived by them in the variable-extinction study included in their paper. The value of $B - V$ for star 160, $B - V = 0.33$, was inadvertently omitted from the table. Supplemental photometric data were obtained for three additional items: V and $B - V$ values for star 402 from Johnson (1962) and $E(B - V)$ values from Morgan *et al.*, (1965). Column 14 lists membership probabilities derived as discussed in Sec. III B. Finally, column 15 lists the quality class discussed earlier.

b) Probabilities of Membership

The probabilities of membership are derived from an analysis of the distribution of relative proper motions of stars in the cluster. The technique, used for similar purposes by van Altena and Chiu (1981) and Cudworth (1976), was described in detail in van Altena and Jones

(1972). Two Gaussian functions, one for the supposed cluster stars and one for the "field," are fit to the oberved proper motion distribution in each coordinate.

The observed vector point diagram (VPD) for our measured stars is shown in Fig. 2. The direction towards the solar antapex and a line parallel to the galactic plane are also shown. The proper motion distribution looks typically elongated, but since the axis of elongation lies almost parallel to the y axis, no rotation of the vector point diagram axes was found necessary to eliminate a correlation between the x and y motions.

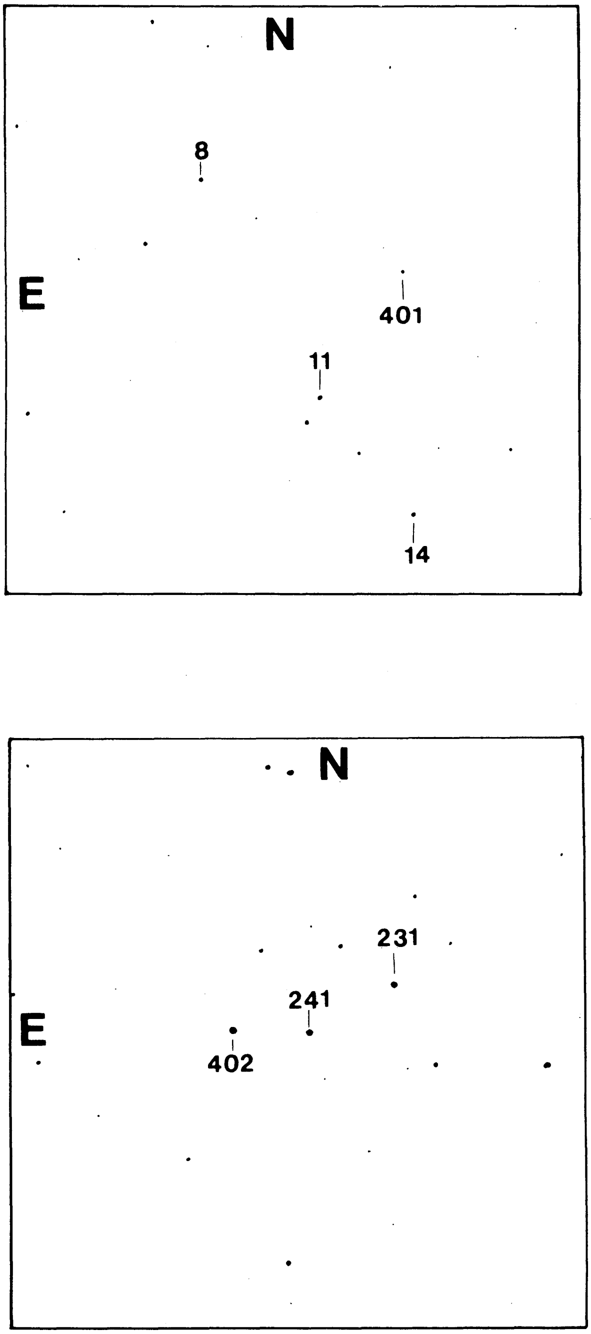

FIG. 1. (a) Finding chart for star 401 as well as a few bright stars numbered according to the study of Ogura and Ishida. The chart covers an area of 10×10 arcmin. (b) Finding chart for star 402.

In Fig. 3 we present histograms of the proper motion marginal distributions. Because of the relatively small size of our sample of stars, we have found it helpful to smooth these histograms by averaging each bin with the contents of five adjacent bins on each side, weighted with binomial coefficients. The computed fits of the "cluster" and "field" Gaussian distributions are also shown by solid lines.

The y distribution is very irregular and the fit of a Gaussian to the data is therefore poor. The source of this irregular distribution is unknown. Throughout our data reduction, no unexpected systematic trends were noticed in the scatter plots of residuals from the plate fitting. Since both blue-sensitive and yellow-sensitive plates were incorporated in the solution, a possible source of error in the y solutions might be an uncorrected color term due to atmospheric refraction. But as mentioned before, solutions for both the x and y coordinates did not yield color terms of any significance even when these were included in the procedure. The final y proper motion distribution shows no significant dependence on $B-V$. There is a suggestion that it is bimodal, but there appears to be no significant difference in any way between the stars in the clump of positive proper motions and the stars in the clump of negative proper motions. Stars in both clumps appeared on the same number of both blue and yellow plates, so systematic differences in the plates used for reduction seem to be ruled out as a source of error.

That the y motions are not totally spurious seems to be indicated by the fact that they accurately select out the blue luminous stars in the field as cluster members, and that stars with high x proper motion also seem to have high y proper motion. Nevertheless, the y parameters in Table III should be used with caution and the probabilities of membership not considered to be as reliable as in our earlier studies.

Table III lists the parameters of the computed fits to our cluster and field, based on the proper motion distributions. The probabilities of membership in Table II are based on these parameters and on the proper motion of the individual star. Clearly the segregation into cluster and field is sharper in the x coordinate than the y, due to the smaller scatter of the data in the x direction. Nevertheless, a histogram of the number of stars versus membership probability, as shown in Fig. 4, shows a clear separation of cluster and field. The sample of high-probability stars ($P \geqslant 70\%$) of quality class 9 or 10 can be reliably regarded as a uniform selection of likely cluster members; lower quality class stars should be regarded with more caution.

A comparison of our kinematic membership probabilities with previous photometric membership studies re-

TABLE II. Observational data for NGC 2244.

ID	α (1950)	δ (1950)	μ_x	μ_y	N_p	V	B-V	E(B-V)	P	Q
1	6 28 11.76	5 9 26.7	-0.48	-1.96	6	13.94	0.78	0.86	0	1
2	6 28 7.98	5 9 1.6	-0.59	-1.65	13	11.25	0.78		0	10
4	6 28 14.69	5 8 2.7	1.45	-1.09	6	13.96	0.48	0.48	0	1
5	6 28 12.35	5 4 41.1	1.10	-1.15	6	13.96	0.64		0	1
6	6 28 1.76	5 4 32.3	0.01	-0.84	6	13.83	0.67	0.69	1	1
7	6 28 14.07	5 3 37.3	-0.04	-0.93	6	13.88	0.33		0	1
8	6 28 11.65	5 1 26.0	-0.40	-0.32	6	13.30	0.34		0	9
9	6 28 14.94	5 0 35.0	-0.30	-0.48	6	13.26	0.34	0.41	0	9
11	6 28 5.40	4 58 24.1	-0.65	-1.77	10	12.37	0.54		0	10
12	6 28 6.15	4 58 4.0	-0.10	-0.90	6	13.57	0.51	0.55	0	9
14	6 28 0.31	4 56 46.5	0.22	-0.74	6	12.66	0.92		97	9
16	6 28 9.11	4 51 18.0	0.87	0.60	9	10.99	0.58		0	9
17	6 28 5.37	4 50 37.2	-1.16	-0.44	6	13.76	0.55	0.65	0	1
18	6 28 8.53	4 50 31.4	0.11	-0.84	6	13.80	0.53		1	9
20	6 28 7.31	4 48 18.4	0.13	0.62	11	12.50	0.53		98	10
21	6 28 33.16	5 15 41.5	0.35	-1.88	4	12.80	0.64		0	5
24	6 28 30.45	5 11 28.1	-0.71	-0.65	6	13.99	0.33		0	1
25	6 28 30.46	5 9 6.4	-0.16	-0.67	7	13.30	0.29	0.29	1	9
27	6 28 25.20	5 8 25.6	-0.07	-0.39	8	13.35	1.45		36	1
28	6 28 33.67	5 7 21.3	0.33	-0.36	6	13.94	1.37		10	1
29	6 28 33.14	5 6 11.3	0.02	-0.10	9	13.13	1.25		91	9
30	6 28 28.52	5 5 28.6	0.33	-0.13	14	12.72	0.40	0.48	0	10
31	6 28 33.33	5 4 10.0	1.99	-1.57	6	13.43	0.53	0.60	0	9
32	6 28 24.15	5 2 35.6	-0.64	-1.16	14	12.69	0.51		0	10
33	6 28 21.88	5 2 13.9	0.07	-0.50	6	13.95	0.62		29	1
35	6 28 21.85	4 58 18.9	-0.16	-0.25	9	12.90	0.42		34	9
36	6 28 25.09	4 57 51.9	-0.18	-0.31	8	13.21	0.21	0.25	18	9
39	6 28 34.00	4 56 49.5	-0.22	-0.12	16	12.09	0.41		29	10
40	6 28 16.88	4 54 37.6	0.16	-0.41	9	12.97	0.55	0.66	42	9
41	6 28 24.21	4 52 21.4	-0.28	-1.89	16	9.78	1.24		0	10
42	6 28 18.56	4 51 55.9	-0.91	0.27	9	12.06	0.42		0	9
43	6 28 28.76	4 50 26.2	-0.25	0.06	8	13.12	2.50		35	1
44	6 28 23.83	4 49 44.7	-0.07	0.16	9	13.00	0.37	0.62	95	9
45	6 28 29.58	4 49 35.9	0.01	-0.08	16	10.40	0.23		92	10
46	6 28 31.51	4 49 35.8	-0.24	0.32	14	12.29	0.47		62	10
47	6 28 32.76	4 49 36.8	-0.38	-0.59	9	13.27	0.36	0.71	0	9
48	6 28 26.60	4 48 43.2	0.04	-0.15	12	12.44	0.45		89	10
51	6 28 53.47	5 16 55.3	-1.17	-0.63	4	13.04	0.59		0	5
53	6 28 52.96	5 14 35.3	1.22	1.74	7	10.53	0.73		0	9
55	6 28 46.91	5 10 51.2	0.13	-0.57	6	13.67	0.48	0.48	14	1
56	6 28 49.86	5 10 30.7	-2.02	-1.72	6	12.91	0.39	0.40	0	1
57	6 28 43.99	5 10 12.1	-0.85	-1.49	11	12.57	0.54		0	10
59	6 29 42.17	5 6 52.3	0.51	0.29	6	12.16	0.21	0.39	3	1
60	6 28 48.58	5 8 12.0	-0.54	-1.81	5	13.99	0.82	0.94	0	1
61	6 28 47.38	5 5 39.3	0.00	-0.52	5	13.86	0.51	0.54	21	1

TABLE II. (continued)

ID	α (1950)	δ (1950)	μ_x	μ_y	N_p	V	B-V	E(B-V)	P	Q
62	6 28 45.84	5 4 19.9	0.03	-0.39	5	12.76	0.72	0.92	53	5
63	6 28 44.22	5 3 24.0	0.09	-0.07	3	13.99	1.72		93	1
65	6 28 44.19	5 2 23.7	0.30	-1.61	5	12.66	0.43	0.52	0	5
66	6 28 39.60	5 2 16.3	-0.23	-0.10	6	13.69	0.71		27	1
67	6 28 41.24	5 1 27.0	1.43	-0.16	11	12.99	0.69		0	10
69	6 28 51.37	5 0 23.3	-0.25	-0.13	11	12.87	0.34		16	10
70	6 28 51.28	4 59 31.9	-1.32	-0.61	14	12.33	1.23		0	1
72	6 28 48.74	4 57 29.1	-0.13	-0.75	13	12.42	0.47		0	10
74	6 28 50.32	4 56 59.8	-0.22	0.05	14	12.39	0.25	0.37	51	10
76	6 28 39.44	4 54 18.8	-3.09	-0.66	4	12.90	0.32	0.39	0	1
77	6 28 37.15	4 53 18.6	0.69	0.67	6	13.85	0.53		0	1
78	6 28 39.12	4 53 11.2	-0.16	-0.16	14	12.20	0.12		50	10
79	6 28 52.10	4 53 10.4	-0.11	0.24	16	10.57	0.12	0.40	94	10
80	6 28 54.10	4 52 50.5	-0.01	0.20	16	9.19	0.26	0.47	97	10
81	6 28 39.81	4 52 46.5	-0.25	0.08	9	12.45	-0.09		37	9
82	6 28 53.76	4 52 46.4	-0.24	0.22	8	12.81	0.11	0.13	56	9
83	6 28 41.22	4 52 23.1	-0.27	0.58	16	10.77	-0.10		49	10
84	6 28 41.50	4 52 13.7	-0.04	-0.02	18	8.12	0.08	0.49	92	10
85	6 28 38.63	4 46 33.9	0.07	-1.21	6	13.16	0.38	0.42	0	9
86	6 28 39.75	4 45 59.6	-0.62	-0.19	6	13.60	0.45	0.45	0	9
90	6 28 43.35	4 43 16.7	-0.52	-0.73	6	12.91	0.91		0	9
91	6 28 49.00	4 40 44.9	0.37	0.23	6	10.15	0.49		62	9
92	6 28 59.16	5 19 12.3	-0.62	-1.05	4	12.72	1.49		0	1
93	6 29 3.04	5 18 14.3	-0.26	-1.15	4	11.39	0.06		0	5
95	6 29 13.92	5 17 55.3	-0.22	-0.09	4	13.80	0.39	0.39	33	1
100	6 29 0.33	5 12 58.3	-0.13	-0.68	8	12.45	0.43		1	9
101	6 29 10.14	5 12 17.8	0.21	-1.14	6	13.76	0.84		0	1
102	6 29 12.10	5 11 35.7	-0.09	-0.16	6	13.41	0.91		74	1
103	6 29 2.33	5 11 18.4	-0.62	-0.13	6	13.91	0.65		0	1
105	6 29 14.37	5 9 10.8	0.54	-0.58	6	13.86	0.53	0.61	0	1
106	6 29 0.36	5 8 8.2	-0.25	0.01	14	11.82	0.89		30	10
107	6 29 3.83	5 8 0.6	0.20	-1.45	14	12.31	1.16		0	10
108	6 29 8.74	5 7 45.4	-0.13	0.02	16	11.40	0.28		83	1
109	6 29 1.91	5 7 42.2	0.04	-0.22	6	13.71	0.48	0.61	82	1
110	6 29 12.27	5 7 5.0	-0.14	-0.16	16	10.72	1.13		58	10
111	6 29 10.39	5 6 54.0	0.62	-0.11	16	12.07	1.04		0	10
112	6 29 10.96	5 6 36.4	-0.17	0.38	4	13.56	1.84		89	1
114	6 29 12.97	5 4 12.2	0.03	-0.01	18	7.56	0.19	0.48	95	10
115	6 28 58.83	5 3 48.2	-0.01	-0.04	18	7.90	0.19	0.43	93	10
116	6 29 15.07	5 1 35.3	-0.15	0.28	11	12.72	0.33	0.42	90	10
118	6 28 58.52	4 59 33.2	-0.16	-0.31	14	12.35	1.39		24	10
119	6 29 15.63	4 59 32.3	-0.64	-0.20	2	12.17	0.62	0.51	0	1
120	6 29 13.26	4 59 18.6	-0.53	0.42	14	12.32	1.95		0	10
121	6 29 15.28	4 58 51.3	-0.06	0.21	7	12.40	0.44		96	1
122	6 29 16.05	4 58 47.5	-0.12	0.04	18	6.73	0.13	0.45	86	10

TABLE II. (continued)

ID	α (1950)	δ (1950)	μ_x	μ_y	N_p	V	B-V	E(B-V)	P	Q
123	6 29 15.79	4 58 34.8	-0.22	-0.22	14	11.67	0.32	0.51	17	10
124	6 29 11.82	4 58 29.3	0.01	-0.23	6	12.96	0.39	0.40	80	9
125	6 29 13.05	4 58 27.7	-0.16	0.23	14	11.97	0.30	0.50	87	10
126	6 29 1.66	4 58 19.3	-0.07	0.29	0	13.87	0.88		0	1
127	6 28 56.86	4 58 11.1	0.07	-0.36	18	8.77	0.09		61	10
128	6 29 12.55	4 58 9.9	-0.02	0.14	13	9.32	0.19	0.46	97	10
129	6 29 2.40	4 57 42.9	0.02	-0.22	14	11.76	1.33		82	10
130	6 29 8.46	4 56 30.4	-0.11	0.27	14	11.64	0.22	0.47	94	10
131	6 29 12.15	4 56 30.0	-0.26	0.07	6	13.63	0.37	0.52	31	9
132	6 29 6.89	4 54 49.1	-0.33	-0.05	6	13.68	0.88		3	1
133	6 29 2.53	4 54 44.6	-0.12	0.30	14	11.72	0.32		94	10
134	6 29 5.81	4 54 37.0	-0.18	-0.12	6	13.75	0.72		48	1
135	6 29 6.41	4 54 19.8	-0.06	-0.70	14	11.65	0.57		2	10
136	6 29 13.75	4 54 16.4	-0.04	0.84	8	13.45	0.71	0.83	97	9
140	6 29 10.32	4 52 54.3	-0.38	0.13	7	13.84	0.44	0.44	2	9
141	6 29 10.71	4 51 49.9	0.08	0.44	6	13.91	0.51	0.60	99	1
142	6 28 56.79	4 49 57.0	-0.49	-0.65	15	10.09	0.51		0	10
143	6 29 1.77	4 49 18.7	0.33	-0.76	6	13.93	0.66		0	1
148	6 29 31.74	5 18 23.9	-0.60	-1.57	4	12.46	0.42		0	5
149	6 29 15.72	5 16 32.0	-0.03	-0.29	4	13.10	0.34		66	5
152	6 29 15.56	5 15 59.7	-0.01	0.25	4	13.09	0.30	0.30	98	5
153	6 29 30.64	5 15 39.6	-0.06	0.28	4	12.55	0.45		97	5
154	6 29 21.12	5 15 29.9	-0.15	-0.26	4	12.20	0.65		36	5
156	6 29 28.96	5 14 42.5	-1.29	0.32	8	10.69	0.55		0	9
158	6 29 21.51	5 14 23.1	-0.40	-1.39	11	10.25	0.66		0	10
159	6 29 18.40	5 14 18.7	-0.65	0.04	6	13.84	0.55	0.60	0	1
160	6 29 29.47	5 12 19.6	-0.25	0.24	7	12.68		0.41	52	9
163	6 29 31.46	5 10 42.6	-0.98	0.22	6	13.02	1.01		0	9
164	6 29 19.41	5 10 11.2	0.09	-0.16	8	13.21	0.56	0.73	88	9
167	6 29 22.97	5 7 22.6	-0.02	0.24	16	10.73	0.28	0.45	97	10
168	6 29 28.99	5 7 17.7	-0.30	0.21	7	13.68	1.37		21	1
169	6 29 19.76	5 7 8.2	0.19	-0.07	14	12.46	0.61	0.77	88	10
171	6 29 27.76	5 5 23.7	1.33	-0.80	10	12.81	0.76		0	10
172	6 29 30.28	5 4 27.8	-0.11	0.35	16	11.29	0.36	0.50	95	10
173	6 29 22.45	5 3 46.7	0.18	-0.82	16	10.28	1.10		1	10
174	6 29 18.64	5 2 48.1	-0.13	-0.15	6	13.50	0.52	0.52	64	9
175	6 29 16.51	5 2 6.4	-0.05	-0.08	6	13.39	0.33	0.43	88	9
176	6 29 27.72	5 0 58.0	1.15	0.11	8	13.28	0.54	0.63	0	9
180	6 29 30.99	5 0 14.2	-0.08	0.10	16	8.10	0.22	0.47	93	10
181	6 29 18.26	5 0 3.3	0.26	-0.80	14	11.53	0.60		0	10
182	6 29 15.91	4 59 39.6	-0.34	0.09	4	13.55	0.94		5	1
183	6 29 24.13	4 59 46.2	0.35	-0.06	16	11.33	0.50		41	10
186	6 29 34.37	4 58 48.6	-0.61	0.08	4	13.63	1.72		0	1
188	6 29 25.73	4 58 41.4	0.74	-0.67	14	11.71	0.95		0	10
189	6 29 34.75	4 58 42.0	-0.10	-0.20	16	11.15	0.15		65	10

TABLE II. (continued)

ID	α (1950)	δ (1950)	μ_x	μ_y	N_p	V	B-V	E(B-V)	P	Q
190	6 29 19.46	4 58 29.5	0.02	0.31	16	11.24	0.11	0.48	98	10
191	6 29 35.07	4 58 32.1	-0.62	0.19	6	13.64	0.82	1.01	0	1
192	6 29 30.18	4 58 11.0	-0.18	0.42	9	12.40	0.41	0.61	87	9
193	6 29 19.49	4 57 53.1	-0.05	0.26	16	10.24	0.22	0.47	97	10
194	6 29 36.06	4 57 35.0	-0.11	0.32	14	11.94	0.42	0.51	95	10
195	6 29 26.12	4 57 27.1	-0.22	0.41	14	12.14	0.30	0.39	75	10
196	6 29 34.56	4 57 28.8	-0.21	0.54	8	13.16	0.33	0.40	80	9
197	6 29 23.64	4 57 13.6	-0.17	0.28	14	12.57	0.32	0.49	87	10
198	6 29 27.97	4 57 9.8	-0.19	0.27	14	12.66	0.36	0.43	81	10
200	6 29 21.22	4 54 54.2	0.04	0.18	16	8.55	0.17	0.46	98	10
201	6 29 26.76	4 54 29.1	0.00	0.29	14	9.68	0.17	0.47	98	10
202	6 29 26.08	4 52 51.6	-0.06	0.39	6	13.38	0.20		97	9
203	6 29 29.99	4 51 38.7	0.02	0.05	18	7.14	0.32	0.54	96	10
205	6 29 24.91	4 50 44.9	-0.05	0.24	7	13.20	0.47		97	9
206	6 29 34.15	4 49 51.1	-0.05	0.51	14	11.92	0.50		98	10
207	6 29 17.35	4 49 3.2	3.31	-1.93	15	11.43	0.74		0	10
208	6 29 24.49	4 49 4.9	-0.17	0.59	6	13.91	0.53		90	1
210	6 29 27.71	4 45 35.3	0.21	0.17	11	11.50	1.29		95	10
212	6 29 20.35	4 43 41.9	0.02	0.30	12	11.99	1.87		98	10
213	6 29 17.08	4 42 3.2	-0.20	0.28	6	10.51	0.26		79	9
218	6 29 44.79	5 17 59.1	0.60	-1.57	4	12.83	0.70		0	5
219	6 29 54.08	5 18 0.8	0.40	-0.76	4	11.33	0.40		0	5
221	6 29 47.84	5 16 58.8	-0.04	-0.03	6	9.86	0.15		91	9
222	6 29 49.01	5 16 17.6	-0.08	0.15	4	11.54	0.29		94	5
223	6 29 54.49	5 15 54.2	0.17	-0.08	4	13.16	0.34	0.39	89	5
225	6 29 41.78	5 14 44.7	-0.36	0.34	8	12.09	1.25		6	9
226	6 29 37.75	5 14 2.8	1.95	0.22	6	13.65	0.48	0.59	0	1
227	6 29 36.87	5 13 22.4	0.62	-1.00	7	13.66	0.84		0	1
228	6 29 35.74	5 12 39.4	0.33	-2.53	4	13.99	1.50		0	1
229	6 29 50.34	5 10 44.0	0.76	0.32	6	13.42	0.60	0.74	0	9
230	6 29 55.25	5 10 45.2	-1.22	0.80	6	13.60	1.14		0	1
231	6 29 40.88	5 8 55.4	-0.16	0.45	13	12.56	0.51	0.67	91	10
232	6 29 42.65	5 10 6.6	0.64	-0.06	7	13.62	0.39	0.46	0	9
233	6 29 41.76	5 9 47.1	-0.14	-0.73	8	12.85	0.58	0.77	1	9
234	6 29 45.23	5 8 38.3	0.06	-0.49	14	12.33	1.86		31	10
235	6 29 43.94	5 8 33.4	-0.03	-0.19	12	11.57	1.56		81	10
236	6 29 37.32	5 6 48.8	0.33	-0.57	6	13.60	0.64	0.81	1	9
237	6 29 41.61	5 6 10.2	-0.05	-0.07	6	13.70	0.51	0.63	89	1
238	6 29 46.00	5 6 8.7	-0.02	-0.42	6	13.77	0.51	0.54	40	1
239	6 29 38.64	5 5 36.9	-0.06	0.31	16	11.10	0.29	0.40	97	10
241	6 29 43.48	5 5 1.3	-0.08	0.27	16	11.12	0.33	0.39	96	10
242	6 29 36.50	5 4 31.4	0.80	-0.93	11	12.90	1.34		0	10
245	6 29 45.06	5 1 53.3	0.06	0.24	14	12.53	0.74		98	10
249	6 29 54.44	5 0 9.9	0.00	0.20	10	12.94	0.40	0.51	97	10
252	6 29 55.05	4 59 28.8	-0.08	-0.17	6	13.08	1.39		75	9

TABLE II. (continued)

ID	α (1950)	δ (1950)	μ_x	μ_y	N_p	V	B–V	E(B–V)	P	Q
253	6 29 49.94	4 59 12.0	-0.08	0.25	16	10.78	0.41	0.52	96	10
256	6 29 40.04	4 57 6.8	-0.11	0.15	11	12.77	0.46	0.56	92	10
258	6 29 43.29	4 56 20.8	-1.06	2.18	9	13.72	0.70	0.83	0	1
259	6 29 41.41	4 55 45.3	-0.57	0.29	6	13.51	0.54		0	1
260	6 29 39.27	4 55 1.3	-0.26	0.33	14	12.22	0.55	0.49	51	10
261	6 29 51.41	4 54 51.2	-0.62	0.28	6	13.30	0.69	0.81	0	9
262	6 29 43.33	4 54 46.3	-0.73	0.13	7	13.04	0.46	0.55	0	9
263	6 29 50.11	4 54 36.5	0.01	0.27	14	12.55	1.34		98	10
264	6 29 56.08	4 54 15.1	-0.18	-0.18	5	13.50	0.76	0.93	38	5
265	6 29 41.56	4 53 55.0	-0.33	-0.42	6	13.86	0.60		0	1
266	6 29 39.94	4 53 36.4	-3.69	0.07	16	5.84	0.99		0	10
267	6 29 44.19	4 53 1.0	-0.19	0.32	11	12.84	0.63	0.77	83	10
268	6 29 37.54	4 52 49.4	-0.03	0.34	9	12.75	0.26	0.26	98	9
271	6 29 39.82	4 51 12.1	-0.17	0.06	16	10.76	0.39		75	10
273	6 29 51.64	4 50 9.8	-0.95	-0.18	6	13.66	0.74		0	1
274	6 29 44.96	4 49 18.8	-0.06	0.41	16	11.31	0.25	0.49	97	10
275	6 29 48.81	4 49 17.1	0.44	-0.53	6	14.00	0.46		0	1
276	6 29 47.11	4 47 52.1	0.08	0.74	11	12.41	0.31		98	10
277	6 29 53.47	4 47 11.8	-0.96	0.22	10	12.69	1.28		0	10
278	6 29 53.97	4 47 10.0	0.26	-2.12	16	10.21	1.04		0	10
279	6 29 55.73	4 46 55.2	-0.05	0.34	14	11.08	0.27	0.46	97	10
280	6 29 55.57	4 46 46.0	-0.05	0.27	12	10.57	0.42		97	10
281	6 29 53.72	4 46 30.1	0.18	-0.03	9	13.07	0.61		91	9
282	6 29 51.40	4 46 15.6	-0.27	0.66	12	11.60	1.13		47	10
283	6 29 41.64	4 45 24.7	-0.27	-0.17	14	10.00	1.40		8	10
288	6 29 42.87	4 42 0.7	-0.07	-0.06	6	10.53	0.22		87	9
291	6 30 6.78	5 14 40.8	-0.11	0.51	8	12.05	0.58		96	9
292	6 30 5.14	5 14 31.4	-0.25	0.92	8	11.89	0.50		42	9
293	6 30 14.74	5 10 13.1	0.22	0.51	6	11.32	1.94		97	9
295	6 30 10.04	5 9 18.2	0.90	-0.79	6	13.82	0.75		0	1
296	6 29 58.70	5 8 45.7	0.73	-0.48	6	13.80	0.59	0.73	0	1
298	6 30 4.55	5 7 18.5	0.08	0.58	10	12.57	0.63	0.83	99	10
299	6 29 59.91	5 5 39.4	-0.37	-0.11	5	13.70	0.75	0.87	1	5
300	6 29 58.62	5 4 43.9	0.54	0.17	5	13.57	0.60	0.75	1	1
301	6 30 3.36	5 3 47.8	0.02	0.27	10	12.55	0.70		98	10
302	6 30 11.93	5 3 21.0	0.06	0.25	6	13.31	1.66		98	9
303	6 30 3.26	5 2 21.4	-1.20	0.07	6	14.00	0.99	1.14	0	1
304	6 30 2.36	5 1 55.1	1.04	-0.95	13	12.22	0.65	0.87	0	10
305	6 30 7.77	5 1 42.6	0.05	0.08	15	12.10	0.39		97	10
307	6 30 11.25	5 1 13.6	0.46	-0.35	6	13.91	0.78	0.86	0	1
308	6 30 16.33	5 0 41.2	0.17	0.38	6	13.67	0.40	0.40	98	9
309	6 30 15.87	5 0 38.6	0.02	0.19	6	13.19	0.98		98	9
311	6 30 2.54	4 59 42.2	-0.02	0.43	6	13.54	0.50	0.60	98	9
312	6 30 3.78	4 59 25.3	-0.01	-0.04	10	12.51	0.42		93	10
314	6 29 56.24	4 59 8.7	-0.39	-0.35	8	13.20	1.39		0	1

TABLE II. (continued)

ID	α (1950)	δ (1950)	μ_x	μ_y	N_p	V	B–V	E(B–V)	P	Q
315	6 29 56.11	4 58 33.8	2.03	-1.27	16	11.18	0.64		0	10
317	6 30 7.25	4 57 56.1	0.63	2.42	13	11.98	0.94		0	10
319	6 30 2.37	4 55 55.2	-0.15	0.27	9	12.78	0.41		90	9
320	6 29 59.60	4 54 57.3	-0.37	-0.06	6	13.93	0.72	0.83	1	1
321	6 29 58.53	4 54 25.0	-3.90	1.09	10	12.68	0.74	0.98	0	10
322	6 30 0.75	4 53 39.0	-0.25	0.21	6	13.97	0.87	1.00	50	1
323	6 30 4.14	4 53 38.4	-0.08	0.31	11	12.56	0.52		96	10
324	6 29 59.82	4 53 17.3	-0.47	0.47	5	13.81	1.69		0	1
325	6 30 1.97	4 52 34.3	-0.20	0.59	6	11.78	0.60		83	9
327	6 30 9.83	4 51 41.1	-0.25	0.52	6	13.56	0.54	0.56	62	9
330	6 30 0.79	4 50 31.3	-0.35	-0.14	14	10.64	1.36		1	10
331	6 30 3.92	4 50 20.8	-0.04	0.27	10	12.68	0.39	0.49	97	10
332	6 30 6.50	4 49 56.3	0.06	0.10	6	13.56	0.38	0.38	97	9
333	6 29 57.89	4 49 38.6	-0.09	-0.20	6	13.68	0.37		68	9
334	6 30 12.54	4 49 33.6	-0.09	0.27	6	12.88	0.45	0.64	96	9
336	6 30 5.07	4 47 36.8	0.23	0.13	9	12.60	0.57		93	9
337	6 29 56.95	4 47 7.6	-0.11	0.29	11	12.61	0.41	0.52	95	10
338	6 30 10.66	4 45 48.2	0.30	0.53	6	13.84	0.51	0.51	91	1
339	6 30 12.73	4 45 11.9	0.00	0.14	6	13.65	1.44		97	1
340	6 30 10.97	4 44 27.8	-0.51	-0.24	6	13.03	0.80		0	9
341	6 30 1.43	4 42 57.7	0.26	-0.42	6	13.69	0.81	0.94	18	1
342	6 30 23.12	5 10 32.0	-2.45	0.51	6	12.78	0.60	0.81	0	9
343	6 30 20.73	5 10 24.5	0.37	0.29	6	13.11	0.53		65	9
344	6 30 18.63	5 10 7.8	0.90	0.60	6	13.57	0.64	0.79	0	1
345	6 30 26.98	5 8 22.9	-0.11	0.35	6	12.85	0.62	0.82	95	9
347	6 30 30.38	4 48 43.3	-0.26	-0.07	4	13.51	0.76		18	1
348	6 30 19.09	5 4 19.7	0.03	0.17	10	9.08	0.38		97	10
349	6 30 20.51	5 4 15.5	-0.15	0.35	10	12.02	0.74		92	10
350	6 30 21.84	5 4 4.8	0.00	0.00	6	13.75	0.74	0.83	94	1
351	6 30 22.07	5 3 37.3	0.27	0.76	6	13.27	0.58		93	9
352	6 30 16.96	5 2 4.6	0.42	-1.43	6	12.98	0.77	0.99	0	9
354	6 30 19.96	4 58 40.9	-0.02	0.36	8	12.19	-0.40		98	9
355	6 30 26.27	4 58 39.5	0.17	-0.12	6	13.33	0.78	0.97	87	9
356	6 30 17.85	4 58 14.9	-0.23	-0.18	6	13.70	0.49	0.49	18	1
357	6 30 25.75	4 57 1.1	-0.40	-0.12	6	13.72	0.82	0.94	0	1
358	6 30 30.62	4 55 2.8	-0.03	-0.05	10	10.12	0.32		91	10
359	6 30 21.10	4 53 9.8	-0.16	-0.21	5	13.62	0.72	0.89	41	1
361	6 30 25.11	4 51 18.1	0.62	-0.86	6	13.82	0.56	0.69	0	1
362	6 30 27.55	4 50 6.3	0.19	-1.39	6	12.47	0.56	0.73	0	9
363	6 30 24.20	4 50 1.3	0.04	-0.80	6	13.02	0.84		1	9
364	6 30 24.98	4 48 21.0	-0.68	0.39	6	12.01	1.88		0	9
365	6 30 21.02	4 47 32.3	-0.53	-0.61	8	11.86	0.59		0	9
372	6 27 28.30	5 7 56.2	-0.17	-2.96	6	11.93	0.41		0	9
375	6 27 50.00	4 47 31.4	-0.16	-0.39	8	9.52	1.89		14	9
376	6 27 54.08	4 43 32.9	-0.16	0.10	10	9.70	0.57	0.88	81	10

TABLE II. (continued)

ID	α (1950)	δ (1950)	μ_x	μ_y	N_p	V	B-V	E(B-V)	P	Q
377	6 27 57.53	4 42 30.7	-0.05	0.05	6	12.28	0.62		94	9
378	6 28 6.97	4 42 4.9	-0.86	0.94	4	13.03	0.43	0.52	0	5
379	6 28 13.26	4 41 6.7	-0.02	-0.03	8	9.06	-0.02		93	9
380	6 28 7.18	4 38 7.1	-0.10	0.30	6	9.94	-0.01		95	9
381	6 28 37.71	4 39 35.1	-0.08	0.13	8	8.88	-0.06		94	9
386	6 29 46.27	4 37 40.7	-0.10	-0.11	4	10.90	0.07		78	5
388	6 30 41.24	4 41 17.8	0.03	-0.86	4	9.14	0.14		0	5
390	6 30 51.12	4 48 19.3	-0.50	-1.33	6	11.64	0.15		0	9
391	6 31 4.79	4 48 17.3	0.09	-0.78	6	10.22	0.26		1	9
393	6 30 50.58	5 4 24.5	0.12	0.57	6	9.69	0.76		99	9
394	6 30 59.76	5 5 39.5	0.04	-0.58	6	11.13	0.40		14	9
396	6 31 5.16	5 11 41.3	0.09	0.30	6	11.10	0.15		98	9
397	6 31 4.35	5 15 20.4	-0.05	0.73	6	8.85	2.19		97	9
398	6 30 53.83	5 18 52.5	0.08	0.56	4	11.88	0.31		99	5
399	6 30 52.87	5 19 41.4	0.15	0.30	4	11.06	0.42		98	5
401	6 28 0.51	5 0 6.1	-0.18	-1.00	7	13.69			0	1
402	6 29 47.73	5 5 4.7	-0.26	-0.22	14	10.05	0.32		7	10

veals good agreement. Johnson's (1962) study of 46 bright stars in the cluster revealed 34 cluster members. We have assigned probabilities $P \geqslant 70\%$ to 29 of these stars.

Ogura and Ishida's (1981) study lists 119 members for which we have proper motions. Of these, 52 have $P \geqslant 70\%$. Here the agreement is not as good as with

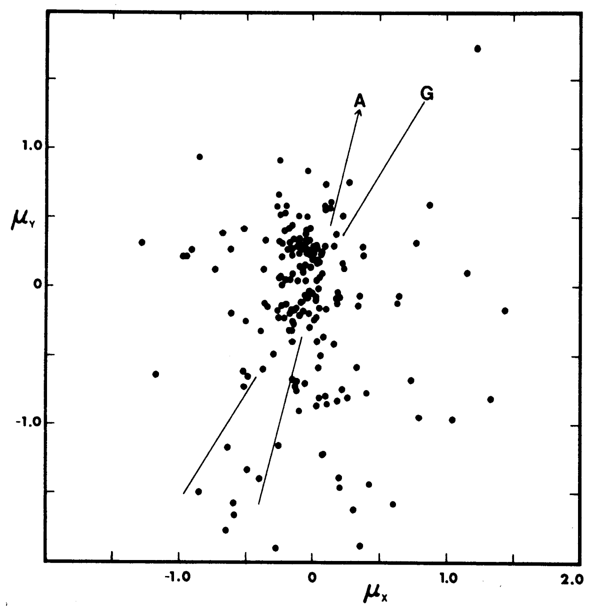

FIG. 2. The observed proper motion vector point diagram for stars with quality class $Q \geqslant 5$. The direction toward the solar apex and a line parallel to the galactic plane are indicated. The units are in arcsec per century.

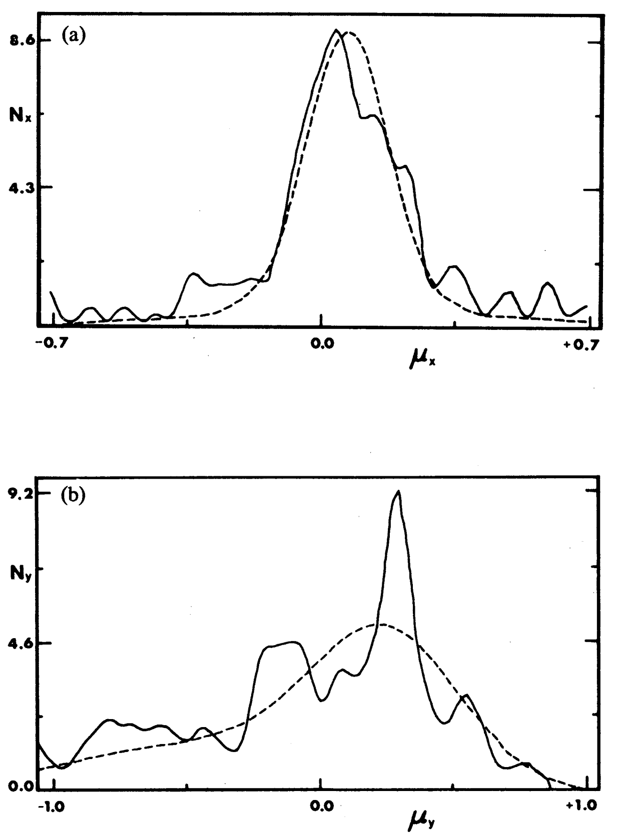

FIG. 3. The marginal distributions of the proper motion VPD. The observed distributions are drawn with a solid line, while the computed fits are drawn with dashed. (a) Histogram for X motions. (b) Histogram for Y motions. (See text for a discussion of this distribution and its fit to a Gaussian.)

TABLE III. Membership probability parameters for stars of quality class ⩾5.

Parameter	Cluster	Field
Number	89	157
x' center	0."073	0."120
y' center	+0."230	−0."371
x' dispersion	0."106	0."625
y' dispersion	0."250	0."487

Johnson, but the later study includes 400 stars, extending to fainter stars and to larger distances from the cluster center where we would expect differential extinction from gas in the Rosette nebula to produce ambiguities in the photometric results, a problem we discuss further in Sec. IV.

IV. DISCUSSION

Using the photometric data in Table II, we can examine the cluster color-magnitude diagram. Figure 5(a) shows the color-magnitude diagram for all stars measured in NGC 2244 down to $V = 14.0$. Figure 5(b) shows the same diagram restricted to stars within the same magnitude limit but with membership probability $P \geqslant 90\%$. The scatter is reduced substantially, though the differences are not as striking as in the case of NGC 2506 (Chiu and van Altena 1981).

A major reason for this scatter, no doubt, is the differential extinction across the cluster, which Ogura and Ishida find to be quite substantial (as much as 2–3-mag variation). The difference between NGC 2506 and the current study is that the stars in that cluster are subject to a uniform extinction, while the very young cluster NGC 2244, still entangled in the wisps of the Rosette, is subject to highly nonuniform absorption. Figure 5(c) shows the color-magnitude diagram corrected for absorption using the $E(B-V)$ values given by Ogura and Ishida, along with their derived value of $R = 3.2$. Only stars with $P \geqslant 90\%$ in our study are plotted.

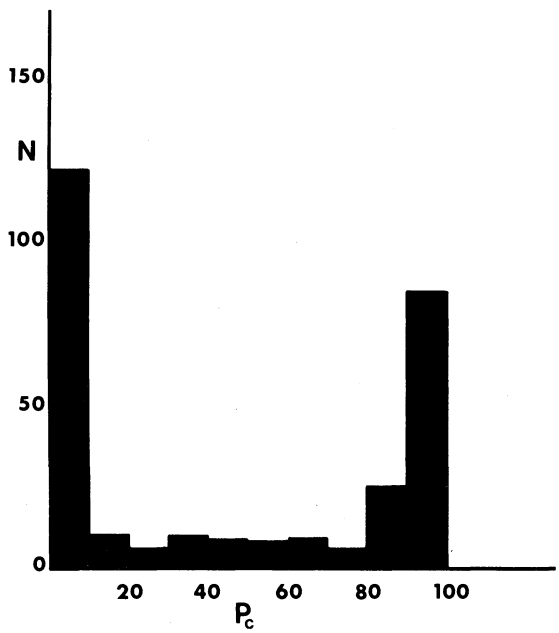

FIG. 4. Histogram of the cluster membership probabilities for all stars in the field.

Unfortunately, this sample is less free from photometric bias than our original sample, since the values of $E(B-V)$ we use were derived only for stars already selected as cluster members by plotting their photometric results in an "extinction-free" P-Q diagram, where $P = V - R(B-V)$ and $Q = (U-B) - X(B-V)$ (see also Ogura and Ishida 1976a,b). Deriving $E(B-V)$ from spectroscopic observations, as was done by Morgan *et al.* (1965), would likely produce a more trustworthy sample of true cluster members.

Photometric membership determinations are likely to be in agreement with astrometric ones for the bright members of the cluster, but as Ogura and Ishida (1981) point out, discrimination between cluster and field is difficult near the faint end of the cluster main sequence on their P-vs-Q plots. This is borne out by a comparison with our probabilities. Of the 21 stars brighter than $V = 12$ that are common to our study, all 21 are assigned $P \geqslant 70\%$. If stars brighter than $V = 13$ are included, only 38 Ogura and Ishida members out of 56 are assigned $P \geqslant 70\%$.

Differential extinction across the cluster introduces a photometric bias into even the astrometrically selected sample, since we have cut off our sample at $V = 14$ because of the limits of our photographic exposures. This is illustrated by the computer plot in Fig. 6, in which we have plotted all stars with $P \geqslant 70\%$ to the same relative scale as the original plates. Is the cluster elongated in the northeast-southwest direction as it appears at first glance?

Van Altena and Jones (1972) studied the open cluster NGC 6530, which has an age (2×10^6 yr), similar to the age (3×10^6 yr) derived by Ogura and Ishida (1981) for NGC 2244; NGC 6530 is also imbedded in the nebulosity M8, the Lagoon Nebula, as NGC 2244 is in Rosette. Van Altena and Jones note that the clumpiness of a cluster of this age could simply reflect the initial conditions at the time of star formation. This may be true in the case of NGS 2244 as well, but it is also possible that the spatial distribution which we see is affected by patchy absorption around the cluster. This is suggested by the rough alignment of the major axis of our cluster members with the regions of the surrounding Rosette Nebula where the least nebular emission is seen. In other regions of the Rosette, the limiting magnitude of our sample may simply eliminate member stars which are dimmed by the intervening nebula.

The problem would be exacerbated if any dynamical evolution of the cluster had taken place, which would tend to make the more luminous high-mass stars con-

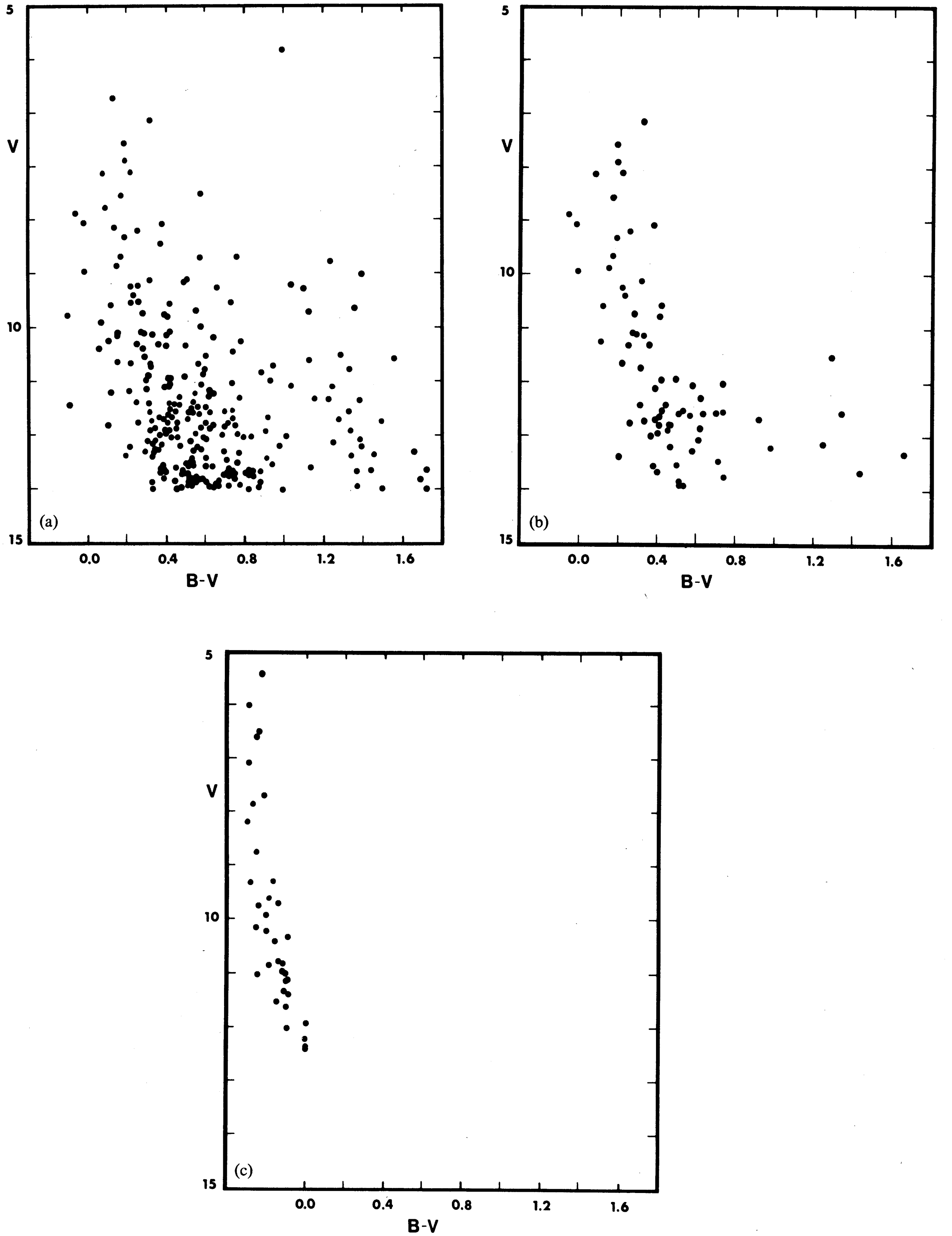

FIG. 5. Color-magnitude diagrams for the cluster. (a) All stars measured on the plates with $V \geqslant 14.0$. (b) All stars on the plates with membership probability $P \geqslant 90\%$ and lying within 25 arcmin of the plate center. (c) All stars in the cluster with membership probability $P \geqslant 90\%$ as corrected for reddening and absorption using data from Ogura and Ishida (1981).

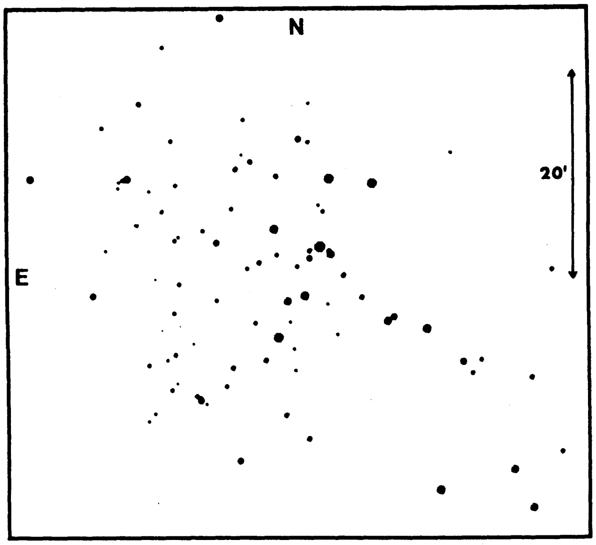

FIG. 6. Computer plot of positions of all stars in the measured field with membership probabilities $P > 70\%$. The dots are drawn with diameter increasing with brightness. Dot diameter increases by 10% for each magnitude decrease. North is up, east is left.

centrate toward the center, as has been observed in the Pleiades (van Leeuwen 1980). Since the center of NGC 2244 lies in the relatively transparent "hole" of the Rosette, while the edges of our field do not, the outer population of the cluster would be even less completely sampled by our study.

For these reasons, further work is needed to determine spectral types and color excesses for as large a sample of stars as possible before an accurate assessment of the luminosity function or spatial distribution of the cluster stars can be made.

V. SUMMARY

We have determined relative proper motions, based on a series of 18 exposures taken at the Yerkes and Allegheny Observatories, for 287 stars within a $48' \times 60'$ field centered on the Rosette Nebula cluster, NGC 2244. Membership probabilities are derived for all these stars on the basis of proper motions. While the sample is fairly complete down to $V = 14.0$, differential absorption may introduce a significant bias. Additional work on the detailed absorption distribution around the region is needed to determine reliable luminosity functions and spatial characteristics of the cluster.

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