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# THE SIRIUS SUPERCLUSTER IN THE FK5

OLIN J. EGGEN
National Optical Astronomy Observatories,[1] Cerro Tololo Inter-American Observatory, Casilla 603, La Serena, Chile

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## ABSTRACT

Fifty-five stars in the FK5 or with PPM(H) quality proper motions are discussed as members of the Sirius supercluster. The convergent point of the supercluster motion is $(A, D) = (20^{h}55, -38^{\circ}1)$ and the space velocity is $V_T = 18.6 + 0.005X$ km/s, where $X$ is the radial distance of the members from the Sun. The member stars indicate [Fe/H] Hyades − [Fe/H] Sirius = 0.18 dex from both photometric and spectroscopic evidence. The bulk of the supercluster members fall into two age groups, $6.3\times10^8$ and $10^9$ yr on the basis of models with convective overshoot. However, there are also members with ages of $2.5\times10^8$ and $1.5\times10^9$ yr. The youngest stars include HR 2491 ($\alpha$ CMa) and HR 3615 ($\alpha$ Vol), both of which are A type of stars with close companions. The oldest stars are three Am objects, two of which are equal component binaries and one of these, HR 140122, is a visual binary with an orbit that deserves confirmation by speckle observations. The available observations of chromospheric activity in Mg II ($h$ and $k$) are quantized, as a function of Log $L_{\rm BOL}$, into three well-defined groups for both Sirius supercluster and Hyades cluster dwarfs. For 20 supercluster members with cluster parallax greater than 0.03 arcsec the ratio of $\pi$(cluster)/$\pi$(trigonometric) $= 0.95 \pm 0.20(\sigma)$. The cluster M39, with a modulus of 7.25 mag, may be a member of the supercluster but the available astrometry does not allow confirmation of this.

## 1. INTRODUCTION

The common motion of ten stars in Ursae Major (the "dipper" or "plough" stars) has been known for many years (e.g., Höffler 1897). Hertzsprung (1909) demonstrated that the cluster covers a much larger region, including such bright stars as Sirius ($\alpha$ CMa) and Alphekka ($\alpha$ CrB). The Ursae Majoris stars present a narrow (6°) aspect in declination with a wider one (20°) in right ascension and the difficulties produced by these circumstances, in the determination of the convergent point ($A$, $D$) of the proper motions, are discussed extensively by Brown (1950). Essentially these difficulties arise from the fact that the stars lie near a great circle that also contains the convergent point, making uncertain an exact determination of that point. Various discussions have lead to ($A$, $D$) $= (20^{h}0, -32^{\circ}4)$ (Petrie & Moyls 1953), $(20^{h}15, -31^{\circ}2)$ (Wielen 1978), $(20^{h}25, -32^{\circ})$ (Brown 1950) and $(19^{h}85, -26^{\circ}3)$ (Hubrig & Schwan 1991). Utilizing the wider distribution of all the bright members of what will be called the Sirius supercluster leads to

$$(A,D) = 20^{h}55, -38^{\circ}1 \text{ (Eggen 1984a).} \tag{1}$$

Previously (Eggen 1992a), it was found that the members of the young disk population superclusters, Pleiades, IC 2391, and Hyades, show the results of an expansion, in addition to the expected, apparent rotation forced by the requirement that members have isoperiodic, galactic orbits. The rotation term arises from the variation in period with radial distance from the Sun and affects the $V$ velocity. The total space motion relative to the Sun is affected by the expansion,

$$(V_{\rm TOT})^2 = U^2 + V^2 + W^2, \tag{2}$$

where the $U$, $V$, and $W$ vectors are directed away from the galactic center, in the direction of galactic rotation and toward the North Galactic Pole, respectively.

The rotation term is $dV/dX = -(B-A) = 0.026$ km/s/pc (Woolley 1965), and the expansion term was previously found to be the same for all three young disk population superclusters, $dV_{\rm TOT}/dX = 0.045$ km/s/pc. The apparent variation of $V_{\rm TOT}$ with $X$ for each supercluster depends on the distribution of the velocity amongst the $U$, $V$, $W$ vectors;

| | Sun | Pleiades | IC 2391 | Hyades | |
|---|---|---|---|---|---|
| $U$ | 0 | +11.6 | +20.8 | +40.0 | km/s |
| $V$ | 0 | −20.7 | −15.9 | −17.0 | km/s |
| $W$ | 0 | −10.4 | −8.3 | −2.0 | km/s |
| $V_{\rm TOT}$ | | 25.9 | 27.4 | 43.5 | km/s |
| $dV_{\rm TOT}/dX$ | | 0.025 | 0.038 | 0.045 | km/s/pc. |

Because the $V$ velocity lags behind the Sun in all three superclusters, the effect of the rotation term is to numerically reduce the $V$ velocity and therefore $V_{\rm TOT}$, whereas the expansion term increases $V_{\rm TOT}$ and the observed dependence of $dV_{\rm TOT}/dX$ is the resultant of the two effects. In the Hyades supercluster, for example, the $U$ velocity dominates to such an extent that the rotation term has little influence.

All three superclusters lag behind the Sun in $V$ velocity and precede the Sun in $U$ velocity. They also have another common feature, as will be discussed below, in that the heavy element abundance is [Fe/H] = +0.1 dex. The Sirius supercluster has ($U$, $V$, $W$) (−15, +1, −11) km/s and

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TABLE 1. Members of the Sirius supercluster with $(b-y)_0 \leqslant 0.1$ mag.

| HR | b-y | $m_1$ | $c_1$ | $\beta$ | E(b-y) | $V_0$ | Mod | X pc | $V_{TOT}$ km/sec |
|---|---|---|---|---|---|---|---|---|---|
| 3131 | 0ᵐ049 | 0ᵐ158 | 1ᵐ128 | 0ᵐ836 | 0ᵐ018 | 4ᵐ54 | 4ᵐ7 | +47 | 19.0 |
| 378 | 0.034 | 0.173 | 1.116 | 2.891 | 0.021 | 5.08 | 4.4 | +28 | 18.9 |
| 1666 | 0.070 | 0.182 | 1.092 | 2.846 | 0.014 | 2.74 | 2.3 | +24 | 18.7 |
| | | | | | | | | +26 | 18.8 |
| 3644 | 0.087 | 0.205 | 0.980 | 2.845 | 0.007 | 5.56 | 4.3 | +17 | 17.5 |
| 4295 | −0.005 | 0.157 | 1.088 | 2.880 | 0.007 | 2.30 | 1.95 | +12 | 20.6 |
| 4554 | 0.006 | 0.153 | 1.113 | 2.885 | 0.020 | 2.36 | 2.10 | + 9 | 19.0 |
| | | | | | | | | +13 | 19.0 |
| 5054 | 0.004 | 0.176 | 1.074 | 2.907 | 0.010 | 2.98 | 1.85 | + 4 | 17.9 |
| 2491 | $\pi$ (TRIG) $\approx$ 0.378 arcsec | | | | 0.000 | −1.46 | −2.9 | + 2 | 17.1 |
| | | | | | | | | + 3 | 17.5 |
| 3615 | 0.077 | 0.188 | 0.960 | 2.871 | 0.034 | 4.60 | 3.15 | − 9 | 19.8 |
| 5793 | 0.000 | 0.144 | 1.060 | 2.871 | 0.021 | 2.14 | 1.96 | −10 | 17.1 |
| | | | | | | | | −10 | 18.45 |
| 5373 | 0.039 | 0.164 | 1.084 | 2.896 | 0.038 | 6.16 | 5.4 | −15 | 18.4 |
| 5867 | 0.046 | 0.160 | 1.132 | 2.866 | 0.029 | 3.55 | 3.35 | −28 | 17.8 |
| | | | | | | | | −22 | 18.1 |

precedes the Sun in $V$ while following in $U$. Also the heavy element composition is near [Fe/H]=0 to −0.1 dex. These differences may be of importance in explaining the fact that, unlike the other superclusters, the Sirius supercluster members do not show any evidence for an expansion term in their motions. The supercluster members of spectral type of about A3 and earlier ($b-y \lesssim 0.1$ mag) listed in Table 1 will be discussed in the next section but here the results of four-color and H$\beta$ photometry (Hauck & Mermilliod 1980) are used with the calibration of indices in Eggen (1977) to obtain the photometric moduli listed in the Table. The star HR 4865, for which the available data is discrepant has been omitted. These moduli are used in the relation

$$V_{TOT}=4.74\times v\times Dis\ (\mathrm{pc})\sin^{-1}\lambda \tag{3}$$

to obtain the total space motion. The values of $v$ are the total proper motion directed toward the convergent point and $\lambda$ is the angle between that point and the star. Unfortunately the identified members of the supercluster cover a relatively small range of radial distance, $X$, from the Sun but the mean values of $X$ and $V_{TOT}$ are represented by closed circles in Fig. 1. The straight line in the figure represents the expected effect of the rotation term, $dV/dX$ =0.026 km/s on $V_{TOT}$,

$$V_{TOT}=18.6+0.005\ \mathrm{km/s/pc}. \tag{4}$$

The meager material certainly does not confirm, but it does not deny, the rotation effect. More importantly, the expansion term of the size found for the Pleiades, IC 2391, and Hyades superclusters, $dV_{YOT}/dX=0.045$ km/s/pc, is probably excluded. In the following discussion only the effect of Eq. (4) will be considered.

## 2. FK5 AND PPM(H)

Twenty-five supercluster members in FK5 are listed in Table 2, together with the FK5 proper motion, the total proper motion, $v$, directed toward the convergent point (1), and the peculiar velocity from the proper motion alone,

$$P.V.=4.74Dis(\mathrm{pc})\ \tau, \tag{5}$$

where $\tau$ is the proper motion perpendicular to the direction of the convergent point. The total space motion is 18.5 $+0.005X$ km/s. The moduli ("Mod") are based on $\pi$ $=4.74v/V_{TOT}\sin\lambda$, where $\lambda$ is the angular distance of the Star from $(A, D)$.

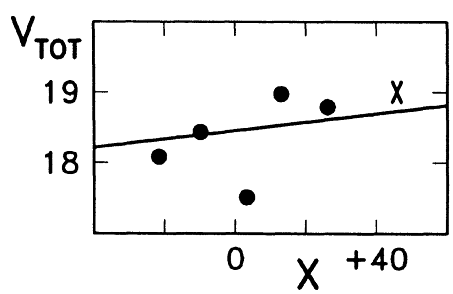


FIG. 1. The correlation of $X$ and $V_{TOT}$ for the stars in Table 1.

TABLE 2. Sirius supercluster members in FK5.

| HR | Name | $\mu_\alpha$ | $\mu_\delta$ | $\upsilon$ | P.V. | X | $V_T$ | Mod. | Sp.T |
|---|---|---|---|---|---|---|---|---|---|
| | | 0.001 arcsec | | | km/sec | pc | km/sec | | |
| 378 | 89 Psc | − 464 | − 247 | 513 | −2.3 | +28 | 18.75 | 4.38 | A3 V |
| 531A | $\chi$ Cet | −1460 | − 932 | 1727 | −0.55 | + 8 | 18.65 | 1.70 | F3 III |
| 1195 | | − 462 | − 515 | 686 | +2.35 | +19 | 18.7 | 3.66 | G8 III |
| 1666 | $\beta$ Eri | − 941 | − 812 | 1236 | −1.8 | +24 | 18.7 | 2.30 | A3 III |
| 1983 | $\gamma$ Lep | −2911 | − 3713 | 4706 | −1.25 | + 5 | 18.6 | −0.50 | F6 V |
| 2088 | $\beta$ Aur | − 574 | − 1 | 574 | −0.15 | +33 | 18.8 | 2.70 | A2 IV |
| 2491 | $\alpha$ CMa | −5464 | −12077 | 13262 | +0.15 | + 2 | 18.6 | −2.94 | A0 V |
| 3131 | | − 20 | − 387 | 386 | +1.6 | +47 | 18.85 | 4.69 | A2 V |
| 3615 | $\alpha$ Vol | − 7 | − 955 | 951 | −1.8 | − 8 | 18.55 | 3.00 | Am |
| 3644 | $\epsilon$ Pyx | + 17 | − 476 | 474 | −2.0 | +18 | 18.7 | 4.45 | Am |
| 4141 | 37 UMa | + 672 | + 394 | 779 | −0.15 | +13 | 18.65 | 1.84 | F1 V |
| 4295 | $\beta$ UMa | + 820 | + 342 | 888 | 0.0 | +11 | 18.65 | 1.73 | A0 V |
| 4466 | | + 361 | − 495 | 612 | +0.7 | −21 | 18.5 | 4.02 | Am |
| 4514 | $\zeta$ Crt | + 314 | − 297 | 427 | +2.15 | −14 | 18.55 | 4.69 | G8 III |
| 4554 | $\gamma$ UMa | + 953 | + 117 | 959 | +0.45 | + 9 | 18.65 | 1.96 | A0 V |
| 4660 | $\delta$ UMa | +1037 | + 93 | 1041 | +0.15 | + 8 | 18.65 | 1.93 | A3 V |
| 4905 | $\epsilon$ UMa | +1116 | − 60 | 1117 | +0.3 | + 6 | 18.65 | 2.00 | Ap |
| 5054 | $\zeta$ UMa A | +1215 | − 204 | 1231 | +0.5 | + 5 | 18.6 | 1.95 | A2 V |
| 5055 | $\zeta$ UMa B | | | | | | | | Am |
| 5634 | 45 Boo | +1847 | − 1659 | 2476 | −1.25 | − 6 | 18.55 | 0.97 | F5 V |
| 5793 | $\alpha$ CrB | +1209 | − 891 | 1499 | +1.2 | −11 | 18.55 | 2.07 | A0 V |
| 5867 | $\beta$ Ser | + 668 | − 453 | 801 | +2.25 | −29 | 18.45 | 3.43 | A2 V |
| 7025 | | + 137 | − 271 | 304 | −0.45 | +42 | 18.85 | 5.22 | A2 V |
| 8039 | $\gamma$ Mic | − 20 | − 54 | 58 | NOTE | −67 | 18.35 | 4.76 | G6 III |
| 8252 | $\rho$ Cyg | − 233 | − 941 | 969 | −0.65 | + 1 | 18.6 | 3.03 | G5 III |

Note to Table 2.

HR 8039 Within 7° of the antapex of motion. Total proper motion adopted.

Röser & Bastian (1991, PPM) have compiled a catalogue of proper motions of stars north of the equator. A subset of these stars, PPM(H), have high precision motions and include the 30 supercluster members in Table 4. GC stars south of the equator, that are also in at least three of the subsequent catalogs, Cape 25(1) (Jackson 1949), Cape 50(1) (Jackson 1953), Perth 70 (Høg & Von Der Heide 1976), Washington 50/1 (Hughes & Scott 1982), and Carlsberg (1988), yield new proper motions that are of PPM(H) quality. A few northern PPM stars have been elevated to H quality because of subsequent inclusion in Carlsberg catalogues.

Tables 3 and 5 contain additional information for stars in Tables 2 and 4, respectively. The computed radial velocities are based on

$$\rho(\text{comp}) = V_T \cos \lambda. \tag{6}$$

The available intermediate band photometry (Hauck & Mermilliod 1980, Eggen unpublished) with the calibrations in Eggen (1971, 1977, 1990b) is used to determine the reddenings and luminosities, $M_v$(PHOT). The values of $a$ for the AF type stars is from

$$a = (b-y) + 0.18(u-b-1.36) \text{ (Strömgren 1966).} \tag{7}$$

The main-sequence stars with $B-V > 0.3$ mag are listed in Table 6 and shown in the $(M_v, B-V)$ plane of Fig. 2 where the continuous curve represents the Hyades cluster main sequence (Schwan 1991) with a modulus of 3.35 mag. Twelve stars with $B-V < 0.9$ mag have Geneva photometry available (Rufener 1988) and values of $(B2-V1)$ and the reddening free parameter $m_2 = (B2-B1) - 0.457(B2-V1)$ are also listed in Table 6 and shown in Fig. 3. The continuous curve in the figure is for Hyades main sequence stars (Hauck 1973). The observed displacement of $m_2$ from the Hyades indicates [Fe/H] Hyades − [Fe/H] Sirius = 0.10 dex, or solar abundance for the Sirius supercluster members. The Pleiades (Eggen 1986a,b) and IC 2391 (Eggen 1991) superclusters have the metallicities of the Hyades stars. The metallicity difference accounts for the displacement from main sequences in Fig. 2.

TABLE 3. Additional data for stars in Table 2.

| HR | $\rho$ Obs. | $\rho$ Clus. | E(b−y) | $V_o$ | $(B-V)_o$ | $M_V$ Phot. | $M_V$ Clus. | $a_o$ | Note |
|---|---|---|---|---|---|---|---|---|---|
| 378 | + 5 Var | + 4.2 | 0.021 | 5.08 | 0.04 | +0.65 | +0.7 | 0.035 | |
| 531A | 0 Var | + 5.0 | 0.00 | 4.67 | 0.33 | +2.8 | +2.97 | 0.324 | X |
| 531B | 0 Var | + 5.0 | 0.00 | 6.76 | 0.63 | +4.85 | +5.05 | --- | X |
| 1195 | + 2.0 | + 3.0 | 0.005 | 4.17 | 0.94 | +0.6 | +0.51 | --- | |
| 1666 | − 8.0 | − 8.0 | 0.014 | 2.74 | 0.115 | +0.45 | +0.45 | 0.100 | |
| 1983A | − 8 Var | − 5.6 | 0.000 | 3.60 | 0.47 | +4.1 | +4.10 | --- | X |
| 1983B | − 8.5 | − 5.6 | 0.000 | 6.15 | 0.94 | +6.4 | +6.65 | --- | X |
| 2088 | −17.1 | −16.3 | 0.010 | 2.60 | 0.02 | 0.0 | −0.10 | 0.031 | X |
| 2491 | − 8.0 | − 9.0 | 0.005 | −1.46 | −0.01 | +1.35 | +1.45 | −0.021 | X |
| 3131 | −12 Var | −10.2 | 0.018 | 4.53 | 0.055 | −0.15 | −0.15 | 0.058 | |
| 3615 | + 5 Var | + 5.3 | 0.034 | 4.60 | 0.105 | +1.45 | +1.60 | 0.000 | X |
| 3644A | − 8 Var | − 6.6 | 0.007 | 5.66 | 0.17 | +1.25 | +1.21 | 0.124 | X |
| 3644BC | --- | − 6.6 | 0.00 | 10.78 | 0.90 | --- | +6.25 | --- | X |
| 4141 | −15 Var | −16.5 | 0.005 | 5.15 | 0.33 | +3.15 | +3.31 | 0.240 | |
| 4295 | −13 Var | −16.1 | −0.007 | 2.30 | −0.02 | +0.45 | +0.57 | 0.000 | |
| 4466 | + 5.0 | + 1.4 | 0.002 | 5.25 | 0.25 | +1.58 | +1.23 | 0.180 | |
| 4514 | − 4.6 | − 5.7 | −0.002 | 4.72 | 0.98 | +0.3 | +0.03 | --- | |
| 4554 | −14 Var | −14.9 | −0.020 | 2.26 | 0.00 | +0.3 | +0.40 | 0.019 | |
| 4660 | −14 Var | −14.3 | 0.016 | 3.24 | 0.065 | +1.0 | +1.31 | 0.054 | |
| 4905 | −11 Var | −13.0 | 0.00 | 1.76 | −0.02 | --- | −0.25 | 0.006 | X |
| 5054 | NOTE | −12.0 | 0.010 | 2.98 | 0.02 | --- | +1.03 | 0.012 | X |
| 5055 | −10 Var | −12.0 | 0.010 | 3.95 | 0.13 | --- | +2.02 | 0.091 | X |
| 5634 | − 6 Var | − 3.0 | 0.00 | 4.92 | 0.40 | +3.8 | +3.95 | 0.283 | |
| 5793 | + 1.4 | − 1.8 | 0.021 | 2.14 | −0.03 | +0.25 | +0.07 | −0.009 | X |
| 5867A | − 1 Var | − 1.2 | 0.029 | 3.55 | 0.06 | +0.3 | +0.12 | 0.066 | X |
| 5867B | + 2 Var | − 1.2 | --- | 9.92 | 1.00 | --- | +6.49 | --- | X |
| 5867C | --- | − 1.2 | --- | 8.16 | 0.655 | --- | +4.73 | --- | X |
| 5867D | --- | − 1.2 | --- | 10.47 | 1.13 | --- | +7.04 | --- | X |
| 7025 | −11.2 | −10.0 | --- | 6.15 | --- | --- | +0.93 | --- | X |
| 8039 | +17.6 | +17.0 | 0.004 | 4.64 | 0.88 | +0.6 | +0.12 | --- | |
| 8252 | + 6.0 | + 1.7 | 0.022 | 3.92 | 0.85 | --- | +0.89 | --- | |

Notes to Table 3.

531 AB separated by 184 arcsec. B is HD 11131.

1983 AB separated by 100 arcsec. B is HR 1982.

2088 Eclipsing variable, P = 3.96 d.

2491 Visual binary, P = 50.04 yr and a = 7.55 arcsec. The companion is a white dwarf. The mean masses are 2.15 and 1.0 solar masses for A and B, respectively. (See discussion by Eggen and Iben 1988).

3615 Equal component spectroscopic binary.

3644 BC is 18 arcsec from A. BC is an equal component binary with 0.2 arcsec separation. The combined light of BC has (V, B−V, U−B) = (10.00, 0.90, 0.545) mag. One speckle observation of A showed a companion at 0.16 arcsec but this needs confirmation.

4905 Spectrum variable, 5.09 d. Possible spectroscopic binary.

5054/5 Separated by 14 arcsec. 5054 is a spectroscopic binary, P = 20.5 d and equal components of 2.45 solar masses (see discussion in Eggen and Iben 1988).

5793 Eclipsing binary, P = 17.4 d. The masses and radii of A and B are, respectively, (2.6, 0.9) $\odot$ and (3.0, 0.9) $\odot$. The luminosity of the B component is $M_V$ = +5.1 mag (see discussion by Eggen and Iben 1988).

5867 AB and CD are separated by 15 arcmin, AB by 30 arcsec and CD by 6 arcsec.

7025 B−V not available.

TABLE 4. Supercluster members with PPM(H) motions.

| HR (HD) | Name | $\mu_\alpha$ 0.001 arcsec | $\mu_\delta$ | $v$ | P.V. km/sec | X pc | $V_T$ km/sec | Mod. | Sp.T |
|---|---|---|---|---|---|---|---|---|---|
| (2710) | 46 Psc | − 17 | − 21 | 27 | +1.25 | + 44 | 18.8 | 5.80 | gG7 |
| 647 | | − 75 | − 86 | 93 | +1.6 | + 28 | 18.75 | 2.96 | F5 V |
| 1321 | | −101 | −114 | 150 | +2.5 | + 21 | 18.75 | 1.92 | G5 IV |
| 1322 | V774 Tau | −113 | −110 | 157 | +1.6 | + 20 | 18.7 | 1.82 | G0 V |
| (29457) | | − 70 | − 20 | 73 | −0.2 | + 38 | 18.8 | 2.92 | F2 |
| (41593) | | −126 | −107 | 165 | −0.3 | + 15 | 18.7 | 0.93 | K0 V |
| 3512 | | + 1 | − 51 | 51 | −0.65 | + 16 | 18.7 | 4.11 | G5 III |
| 3552/3 | 17 Hya | + 4 | − 30 | 30 | +0.45 | + 49 | 18.85 | 4.90 | Am |
| 3647 | | + 2 | − 27 | 27 | −0.9 | − 2 | 18.6 | 5.80 | Am |
| 3974 | 21 LMi | + 50 | − 3 | 49 | +1.2 | + 15 | 18.65 | 2.06 | A7 V |
| 3998 | 34 Leo | + 28 | − 41 | 50 | −0.4 | + 19 | 18.7 | 3.13 | F6 V |
| (100043) | | + 38 | − 50 | 61 | −0.5 | − 3 | 18.6 | 3.83 | F2 V |
| (109011) | | +111 | + 7 | 111 | +1.15 | + 7 | 18.65 | 1.90 | K2 V |
| 4803 | | + 80 | − 90 | 120 | −0.55 | − 13 | 18.55 | 2.56 | F2 V |
| 4865 | 29 Com | + 28 | − 22 | 36 | −0.6 | − 10 | 18.55 | 4.87 | A1 V |
| 4867 | | +108 | − 1 | 108 | −0.45 | + 8 | 18.65 | 2.04 | F5 V |
| (112196) | | + 46 | − 30 | 55 | −0.3 | − 4 | 18.6 | 3.89 | F9 V |
| 4931 | 78 UMa | +113 | − 13 | 114 | −0.2 | + 6 | 18.65 | 1.98 | F2 V |
| (115043) | | +114 | − 18 | 115 | −0.15 | + 6 | 18.65 | 2.04 | G2 V |
| 5062 | 80 UMa | +116 | − 19 | 117 | +0.7 | + 5 | 18.6 | 2.06 | A5 V |
| 5373 | | + 21 | − 15 | 26 | −1.65 | − 17 | 18.5 | 5.66 | A2 V |
| (140122) | ADS 9747 | + 15 | − 12 | 19 | +0.2 | −145 | 17.8 | 6.44 | Am |
| 5492 | Dh Dra | + 73 | − 32 | 80 | −0.55 | + 6 | 18.65 | 3.10 | F2 V |
| 5876 | | + 28 | − 2 | 28 | −0.35 | − 78 | 18.12 | 5.05 | A5 IV |
| 6292 | 56 Her | + 16 | − 21 | 26 | −0.9 | − 82 | 18.2 | 5.82 | G5 III |
| 6981AB | | + 36 | − 89 | 96 | −1.25 | − 24 | 18.5 | 2.77 | G2 V |
| 7312 | 59 Dra | + 47 | −123 | 131 | +0.95 | + 8 | 18.65 | 2.17 | A9 V |
| 7451 | | + 31 | −187 | 189 | −0.75 | − 2 | 18.6 | 1.58 | F7 V |
| 8291 | 76 Cyg | − 13 | − 47 | 49 | −0.75 | − 2 | 18.6 | 4.48 | A2 V |
| 8507 | | − 40 | − 57 | 69 | −1.3 | − 13 | 18.55 | 2.96 | F3 V |

### 3. THE DIPPER (PLOUGH) STARS

Nine UMa stars ($\beta$, $\gamma$, $\delta$, $\epsilon$, $\zeta^1$, $\zeta^2$, 37, 78, and 80) UMa, are shown as clear circles in the ($M_v$,$\underline{a}$) plane of Fig. 4. The isochrones are computed from the temperatures and gravities of stellar models with convective overshoot (Maeder & Meynet 1991, $Z$=0.02) and model atmospheres by Lester *et al.* (1986). An additional three stars are shown as crosses and labeled in the figure (Sirius, $\beta$ Aur, and $\alpha$ CrB). The dipper star $\epsilon$ UMa, a peculiar A star and Magnetic variable, appears at the commencement of hydrogen shell burning after central hydrogen exhaustian. The Hyades supercluster contains HR 4915 ($\alpha^2$ CnV), also a peculiar A-type star with a magnetic field and in the same evolutionary state (Eggen 1992, Hubrig & Schwan 1991).

The dipper stars appear to represent at least two ages (6.3 and $10\times10^8$ yr) whereas Sirius is younger ($2.5\times10^8$ yr) but $\beta$ Aur and $\alpha$ CrB, like the bulk of the dipper stars, are near $6.3\times10^8$ yr. The observed radii and masses of Sirius, $\beta$ Aur, and $\alpha$ CrB, compared with the model values are,

| | Mass $\mathcal{M}_\odot$ | | Radii $\mathcal{M}_\odot$ | |
|---|---|---|---|---|
| | Model | Obs | Model | Obs |
| Sirius ($1.5\times10^8$ yr) | 2.2 | 2.15 | 1.75 | 1.8 |
| $\beta$ Aur AB ($6.3\times10^8$ yr) | 2.6 | 2.6 | 3.75 | 3.4: |
| $\alpha$ CrB A ($6.3\times10^8$ yr) | 2.6 | 2.5 | 3.15 | 3.0, |

where the radius of Sirius is from angular diameter measures (Hanbury Brown *et al.* 1974). The components of Sirius, $\beta$ Aur, and $\alpha$ CrB are discussed in the notes to Table 3.

### 4. SUPERCLUSTER

The supercluster members brighter than $M_v$=3.5 mag and in Tables 3 and 5 are represented by clear circles in

TABLE 5. Additional data for stars in Table 4.

| HR (HD) | ρ Obs. | ρ Clus. | E(b−y) | $V_o$ | $(B-V)_v$ | $M_V$ Phot. | $M_V$ Clus. | a | Note |
|---|---|---|---|---|---|---|---|---|---|
| (2410) | +6.2 | + 3.8 | 0.00 | 6$^m$6 | — | — | +0$^m$8 | — | X |
| 647A | −8.1 | − 5.7 | 0.00 | 6.0 | 0.40: | — | +3.6 | — | X |
| 1321 | −7.5 | − 7.4 | 0.00 | 6.93 | 0.69 | +5.0 | +5.02 | — | X |
| 1322 | −8.1 | − 7.4 | 0.00 | 6.31 | 0.59 | +4.65 | +4.49 | — | X |
| (29457) | — | −13.3 | 0.00 | 6.58 | 0.045 | +3.5: | +3.66 | — | X |
| (41593) | −12.5 | −14.5 | 0.00 | 6.36 | 0.81 | — | +5.43 | — | |
| 3512 | −7.8 | − 9.7 | 0.024 | 5.12 | 0.84 | +1.05 | +1.01 | — | |
| 3552/3 | −15 Var | −13.2 | 0.00 | 6.80 | 0.20 | +1.75 | +1.90 | 0.140 | X |
| 3647 | −1.3 | − 0.8 | 0.020 | 6.40 | 0.145 | +0.35 | +0.60 | 0.121 | |
| 3974 | −17.8 | −17.6 | 0.00 | 4.49 | 0.18 | +2.0 | +2.43 | 0.133 | X |
| 3998A | −16.0 | −16.0 | 0.00 | 6.9 | 0.44: | — | +3.25 | — | X |
| (100043) | — | − 7.7 | 0.00 | 7.07 | 0.36 | +3.35 | +3.24 | 0.234 | X |
| (109011) | −12.4 | −13.8 | 0.00 | 8.09 | 0.93 | — | +6.19 | — | |
| 4803 | −0.9 | − 1.2 | 0.002 | 5.45 | 0.32 | +2.8 | +2.89 | 0.228 | |
| 4865 | −8V? | − 9.1 | −0.001 | 5.70 | 0.02 | — | +0.74 | 0.040 | |
| 4867 | −13 Var | −13.3 | −0.003 | 5.84 | 0.46 | +3.8 | +3.80 | — | |
| (112196) | −8.0 | −10.0 | 0.00 | 7.00 | 0.565 | +3.25 | +3.11 | — | |
| 4931 | −12 Var | −12.9 | 0.00 | 4.93 | 0.36 | +3.2 | +2.95 | 0.251 | X |
| (115043) | −10 Var | −12.4 | 0.00 | 6.84 | 0.60 | +5.0 | +4.80 | — | |
| 5062 | −15 Var | −11.9 | 0.030 | 3.90 | 0.12 | +1.8 | +1.84 | 0.085 | |
| 5373 | −11 Var | − 8.0 | 0.038 | 6.16 | 0.00 | +0.6 | +0.50 | 0.052 | |
| (140122) | +3 Var | + 3.9 | 0.030 | 7.92 | 0.16 | +2.0 | +1.48 | 0.145 | X |
| 5492 | −7 Var | − 9.9 | 0.00 | 6.45 | 0.40 | +3.4 | +3.35 | 0.260 | X |
| 5876 | +15V? | +12.1 | 0.035 | 6.44 | 0.16 | +1.7 | +1.39 | 0.099 | |
| 6292A | +IV? | + 2.5 | 0.003 | 6.00 | 0.90 | — | +0.18 | — | X |
| 6292B | — | + 2.5 | — | 10.70 | 0.67 | — | +4.88 | — | X |
| 6981 | +8.4 | + 8.7 | 0.00 | 6.97 | 0.53 | +4.2 | +4.20 | — | X |
| 7312 | −5.0 | − 8.0 | 0.00 | 5.13 | 0.31 | — | +2.96 | — | |
| 7451 | 0.0V? | 0.0 | 0.000 | 5.72 | 0.48 | +3.9 | +4.14 | — | |
| 8291 | +3 Var | + 3.2 | 0.03 | 5.97 | 0.03 | (+0.2) | +1.9 | 0.032 | X |
| 8507 | +14.8 | +12.9 | 0.00 | 6.39 | 0.44 | +3.5 | +3.3 | — | |

Notes to Table 5.

(2410) (B−V) not available.

647 ADS 1709, ΔV = 0.48 mag. The integrated light has (V, B−V) = (6.06, 0.40). P = 144.7 yr and a = 0.908 arcsec giving a total mass of 1.74 solar masses.

1331/2 Separated by 65 arcsec. 1322 is a spotted star similar to the sun.

(29547) Radial velocity not available.

3552/3 Equal components separated by 4 arcsec.

3974 δ Sct var, P ~ 0.1 d.

3998 ADS 7674, ΔV = 0.5 mag. An accurate orbit from speckle observations will soon be available. A preliminary estimate is P = 12.5 yr and a = 0.15 arcsec.

(100043) Radial velocity not available.

4931 ADS 8739, ΔV = 2.4 mag. P = 115.7 yr and a = 1.256 arcsec with a mass sum of 2.3 solar masses.

(140122) ADS 9747, equal components. P = 56.1 yr and a = 0.160 arcsec but these elements are unreliable. The pair is now opening out and speckle observations should lead to an accurate orbit.

5492 Δm = 2 mag, 4 arcsec. δ Sct var, P = 0.08 d.

6292 Three observations of the common proper motion companion give (V, B−V, U−B) = (10.80, 0.70, 0.15) mag.

6981 Equal components separated by 2 arcsec.

8291 More intermediate band photometry is needed.

TABLE 6. Main-sequence supercluster members.

| HR (HD) | (B-V)$_o$ | $M_V$ | $m_2$ | (B2-V1) | HR (HD) | (B-V)$_o$ | $M_V$ | $m_2$ | (B2-V1) |
|---|---|---|---|---|---|---|---|---|---|
| 53133 | 0$^m$63 | +5$^m$05 | -- | -- | 4867 | 0.46 | +3.80 | -0.486 | 0.249 |
| 1321 | 0.64 | +5.02 | -0$^m$358 | 0$^m$415 | (109011) | 0.93 | +6.19 | -0.174 | 0.602 |
| 1322 | 0.59 | +4.49 | -0.427 | 0.330 | 4931 | 0.36 | +2.95 | -0.483 | 0.160 |
| (29457) | 0.445 | +3.66 | -- | -- | (115043) | 0.60 | +4.80 | -0.410 | 0.356 |
| 1983A | 0.47 | +4.10 | -0.472 | 0.260 | 5492 | 0.40 | +3.35 | -0.489 | 0.188 |
| 1983B | 0.94 | +6.65 | -0.115 | 0.593 | 5634 | 0.46 | +3.95 | -0.486 | 0.309 |
| (41593) | 0.81 | +5.43 | -0.259 | 0.502 | 5867B | 1.00 | +6.49 | -- | -- |
| 3644BC | 0.90 | +6.25 | -- | -- | 5867C | 0.655 | +4.73 | -- | -- |
| 3998A | 0.44: | +3.75 | -- | -- | 5867D | 1.13 | +7.04 | -- | -- |
| 3998B | 0.53: | +4.45 | -- | -- | 6292 | 0.69 | +4.88 | -- | -- |
| 4141 | 0.33 | +3.3 | -0.496 | 0.137 | 6981 | 0.53 | +4.20 | -- | -- |
| (100043) | 0.36 | +3.24 | -- | -- | 7312 | 0.31 | +2.96 | -0.503 | 0.105 |
| 4803 | 0.32 | +2.89 | -0.502 | 0.129 | 7451 | 0.48 | +4.14 | -0.469 | 0.252 |

Fig. 5, where the isochrones are from Fig. 4. The dipper stars are represented by closed circles. The supercluster stars extend the age range from the dipper stars to include $1.5\times10^9$ yr, and the three oldest objects are all Am stars;

| | $M_v$ | $a$ | Sp. T. |
|---|---|---|---|
| HR 4466 | +1.25 | 0.100 | Am |
| HR 3552/3 | +1.9 | 0.140 | Am |
| HD 140122 | +1.5 | 0.145 | Am. |

HR 3552/3 is a wide binary of equal components, separated by 4 arcsec and HD 140122 is a close, visual binary (ADS 9747). An orbit for HD 140122 was published by van Biesbroeck (1960) with $P=55.2$ yr and $a=0.135$ arcsec, giving a total mass of 5.9, or individual masses of 2.95 solar masses. The orbit is dramatically confirmed in period by recent speckle observations made when the computed and the observed separations were both near 0.07 arcsec (e.g., McAlister & Hartkopf 1990) but more speckle observations are needed to accurately determine $\underline{a}$, which ranges from 0.12 to 0.19 arcsec in available orbits.

These oldest stars of the Sirius supercluster are also represented by closed circles in Fig. 6 and some USPC ($\delta$Sct) variables in the Hyades and Praesepe clusters (Eggen 1992, and Table 7) are represented by clear circles. Unlike the Sirius supercluster, with maximum age near $1.5\times10^9$ yr, the USPC in the Hyades and Praesepe clusters are near the middle of the age range in the Hyades supercluster (Eggen 1992).

The red giants are listed in Table 8, which also contains the reddening free indices $m_2=[B1-B2]-0.457[B2-V1]$ and $g=[B1-B2]-1.357[V1-G]$ from the Geneva photometry (Rufener 1988), and the CN index, adjusted for gravity effects, $C_m=(41-42)-1.666[(45-48)-0.45(42-45)-0.792]$ (McClure 1970). The values of $\Delta$[Fe/H] $=$[Fe/H] (Hyades)$-$[Fe/H] (Star) are from the high dispersion spectroscopic results by McWilliam (1990), with [Fe/H] (Hyades) based on the mean of HR 1346, 1373, 1409, and 1411.

The stars are represented in the ($M_v$, $B-V$) plane of Fig. 7(a) with clear and filled circles and the isochrones for $8\times10^8$ and $10^9$ yr is from Maeder & Meynet (1991). The nine youngest red giants in the Hyades supercluster (Eggen 1992) are shown as crosses. The standard models gave an age of near $3\times10^8$ yr for these stars (Eggen 1992) but the convective overshoot models used here approximately double that age. The metallicity parameter, $m_2$, in Fig. 7(b) indicates a small difference, near 0.015 mag, be-

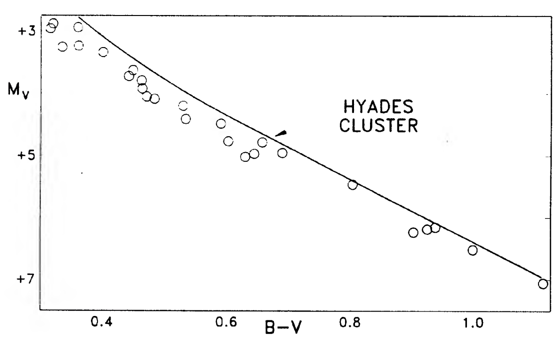


FIG. 2. (a) ($B-V$, $M_v$) diagram for main-sequence members of the Sirius supercluster. The continuous curve is the main sequence of Hyades cluster stars.

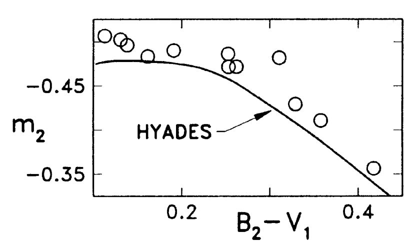


FIG. 3. The ($B2-V1$, $m_2$) diagram for the stars in Fig. 2. The continuous curve represents the Hyades cluster main-sequence stars.

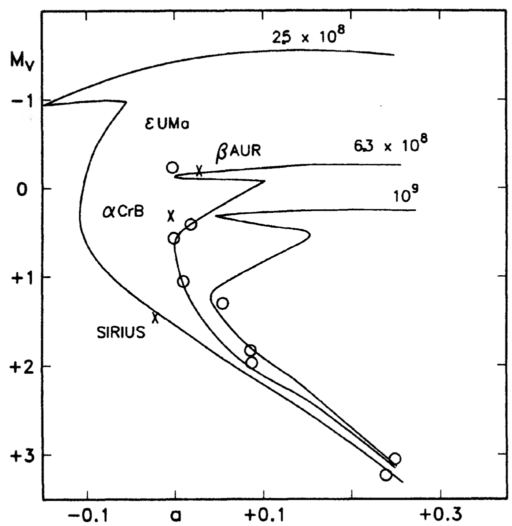


FIG. 4. The dipper stars (clear circles) and three nearby, supercluster members (labeled crosses) in the ($M_v$, $a$) plane. The isochrones are from the overshoot models of Maeder & Meynet (1991).

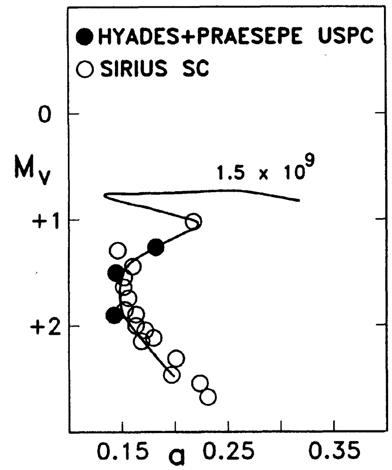


FIG. 6. The USPC (δSct) variables in the Hyades and Praesepe cluster (clear circles) and the oldest stars in the Sirius supercluster in Fig. 5 (closed circles).

tween the two superclusters and this translates into $\Delta$[Fe/H]$\sim$0.18 dex (Eggen 1989), agreeing well with the results from the spectroscopic study. The values of $C_m$ in Fig. 7(d) show a difference in CN strength between the two superclusters. The red giants in the Sirius supercluster have CN strengths decidedly weaker than in the Hyades stars of about the same age.

The apparent consistency of metallicity for all the main-sequence stars (Fig. 3) precludes the possibility of detecting age differences on the basis of metallicity. However, chromospheric activity may permit a basis for age separation. Soderblom & Clements (1987) published values of the chromospheric emission in the Mg II ($h$ and $k$), log $R_{hk}$, for nine members of the Sirius supercluster in Tables 2 and 4 and for ten certain members of the Hyades cluster. These stars are listed in Table 9, together with the bolometric luminosity, log $L_{\mathrm{BOL}}$ and are represented in Fig. 8 by closed circles (Sirius supercluster) or crosses (Hyades cluster). The stars in both aggregates form three groups, indicated by straight lines in the figure, and are remarkably consistent. The data for the Sun, ⊙, are based on observations published by Ayres *et al.* (1981). The distribution of stars in Fig. 8 is certainly not a matter of age alone because the members of neither aggregate are as old as the Sun. However, there is some reason to regard the four stars with little or no chromospheric emission (log $R_{hk}\sim -5$ dex) as reflecting some more local phenomenon. One of these stars, HR 3886, is a close visual binary with a companion 0.8 mag fainter but HR 1983, HR 7451, and VB 7 in the Hyades cluster are not known to be double. HR 1983 does have a common proper motion companion, HR 1982, and if the stars are of the same age, the

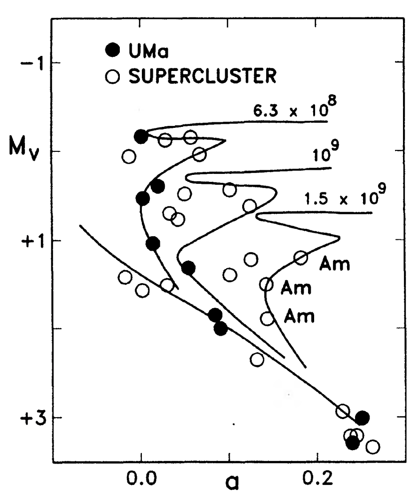


FIG. 5. Same as Fig. 4 but with all early type, supercluster members.

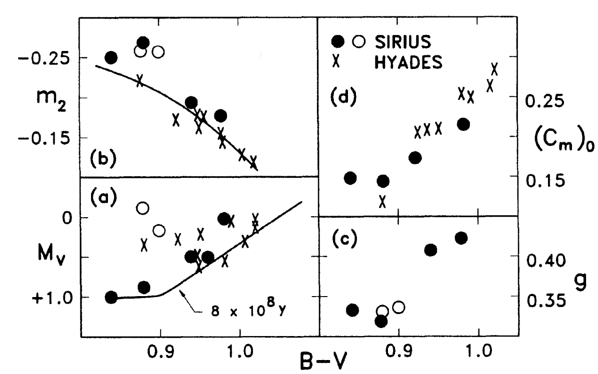


FIG. 7. The red giants of the Sirius supercluster (clear and closed circles) and the youngest red giants of the Hyades supercluster (crosses) in the (a) ($M_v$, $B-V$), (b) ($B-V$, $m_2$), and (d) ($B-V$, $C_m$) planes. Figure 7(c) contains the Sirius supercluster members in the ($B-V$, $g$) plane.

TABLE 7. USPC ($\delta$ Sct) variables in the Hyades and Praesepe clusters (Eggen 1992).

| HR (HD) | Name | $M_V$ | $a_o$ | HR (HD) | Name | $M_V$ | $a_o$ |
|---|---|---|---|---|---|---|---|
| (73729) | BQ Cnc | $+2\overset{\mathrm{m}}{.}65$ | $0\overset{\mathrm{m}}{.}232$ | 1356 | V696 Tau | +2.0 | $0\overset{\mathrm{m}}{.}158$ |
| 1368 | V775 Tau | +2.55 | 0.225 | (73345) | CY Cnc | +1.8 | 0.156 |
| 1351 | V438 Tau | +2.5 | 0.197 | 1547 | V480 Tau | +1.7 | 0.158 |
| (73746) | BV Cnc | +2.3 | 0.207 | (74028) | BX Cnc | +1.6 | 0.155 |
| (73450 | BS Cnc | +2.15 | 0.171 | (74050) | BY Cnc | +1.55 | 0.153 |
| (73798) | BW Cnc | +2.1 | 0.172 | (73763) | BN Cnc | +1.45 | 0.162 |
| 1388 | $\kappa$ Tau | +2.15 | 0.178 | (73576) | BU Cnc | +1.3 | 0.143 |
| (73178) | BC Cnc | +1.9 | 0.164 | 1392 | $\upsilon$ Tau | +1.07 | 0.213 |

TABLE 8. Red giants in the Sirius supercluster.

| HR | $(B-V)_o$ | $M_V$ | $m_2$ | g | $(Cm)_o$ | $\Delta$[Fe/H] Note |
|---|---|---|---|---|---|---|
| 1195 | $0\overset{\mathrm{m}}{.}94$ | $+0\overset{\mathrm{m}}{.}5$ | $-0\overset{\mathrm{m}}{.}189$ | $0\overset{\mathrm{m}}{.}406$ | $0\overset{\mathrm{m}}{.}171$ | — |
| 3512 | 0.84 | +1.0 | −0.247 | 0.335 | 0.145 | — |
| 4514 | 0.98 | +0.05 | −0.175 | 0.421 | 0.214 | 0.07 |
| 6292 | 0.90 | +0.2 | −0.252 | 0.337 | — | — |
| 8039 | 0.88 | −0.1 | −0.254 | 0.332 | 0.136 | 0.19 |
| 8252 | 0.88 | +0.9 | −0.265 | 0.321 | 0.140 | 0.27<br>0.18 |

[Fe/H] Hyades − [Fe/H] Star. (McWilliam 1991).

The Hyades metallicity is based on HR 1346 ($\gamma$ Tau), 1373 ($\delta$ Tau), 1409 ($\epsilon$ Tau) and 1411 ($\theta$ Tau).

TABLE 9. Chromospheric emission strength.

| HR (HD) | log $R_{hk}$ | log $L_{Bol}$ | VB (VA) | log $R_{hk}$ | log $L_{Bol}$ |
|---|---|---|---|---|---|
| | Sirius SC | | | Hyades Cluster | |
| 1321 | -4.14 | 33.5 | 7 | -4.78 | 33.25 |
| 1322 | -4.21 | 33.7 | 22 | -4.09 | 33.6 |
| 1982 | -4.24 | 32.95 | 25 | -4.36 | 33.05 |
| 1983 | -5.00 | 33.8 | 40 | -4.29 | 33.95 |
| 3998 | -5.00 | 34.0 | (226) | -42.7 | 32.6 |
| (109011) | -4.38 | 33.1 | | | |
| (115043) | -4.10 | 33.6 | 50 | -4.26 | 33.7 |
| 4867 | -4.24 | 33.95 | 57 | -4.30 | 34.2 |
| 5634 | -4.53 | 33.9 | 77 | -4.31 | 34.0 |
| 5867B | -4.17 | 32.95 | 96 | -4.14 | 33.5 |
| 7451 | -5.03 | 33.7 | 117 | -4.29 | 33.1 |

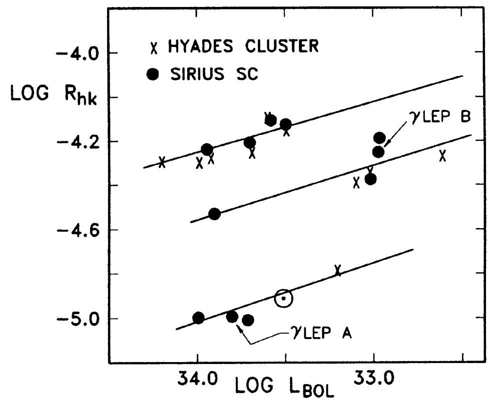


FIG. 8. Hyades cluster (crosses) and Sirius supercluster (closed circles) members in the ($\log R_{hk}$, $\log L_{\rm BOL}$) plane.

value of $\log R_{hk}=-5.00$ dex for HR 1893 signals some anomaly in the index or in the presence of substantial underlying absorption.

If we assume that the weak emission in the four stars with $\log R_{hk}$ near $-5$ dex results from some anomaly, the other two groups of objects could represent two epochs of star formation. A previous discussion (Eggen 1990a) suggested that

$$\Delta \log R_{hk}=0.3\Delta \log t.$$

The difference of 0.28 dex between the mean values of $\log R_{hk}$ in these two groups would be consistent with the total age spread of $2.5\times10^{8}$–$1.5\times10^{9}$ yr in Fig. 5. However, a considerable increase in data and extension of theoretical study are needed before the chromospheric activity can be accepted as confirmation of multiple epochs in the formation of aggregate members.

Two of the youngest stars in the supercluster are HR 2491 ($\alpha$ CMa) and HR 3615 ($\alpha$ Vol). Both stars are double with HR 2491 having a white dwarf companion in a 50 yr orbit and HR 3615 is an equal component, spectroscopic binary. Both objects have been classified, at times, as metallic line A stars. In view of the possibility that the present state of the system of HR 3615 may represent a stage in the evolution of HR 2491 (Eggen & Iben 1988), a spectroscopic investigation of the former appears warranted.

The space distribution of the supercluster members is shown in Fig. 9 where the crosses represent the UMa stars. The UMa stars give a mean position of $(X, Y, Z)=(7.5, 9.6, 21.2)\pm(2.5, 1.6, 1.6)$ pc. The individual proper motions and the total space velocity of the supercluster leads to $(U, V, W)=(-14.9, +1.3, -11.2)\pm(0.2, 0.2, 0.1)$ km/s for the UMa stars in FK5.

The values of P.V. in Tables 2 and 4, and $\Delta M_v$ in Tables 3 and 5 for the UMa stars and all of the supercluster members are

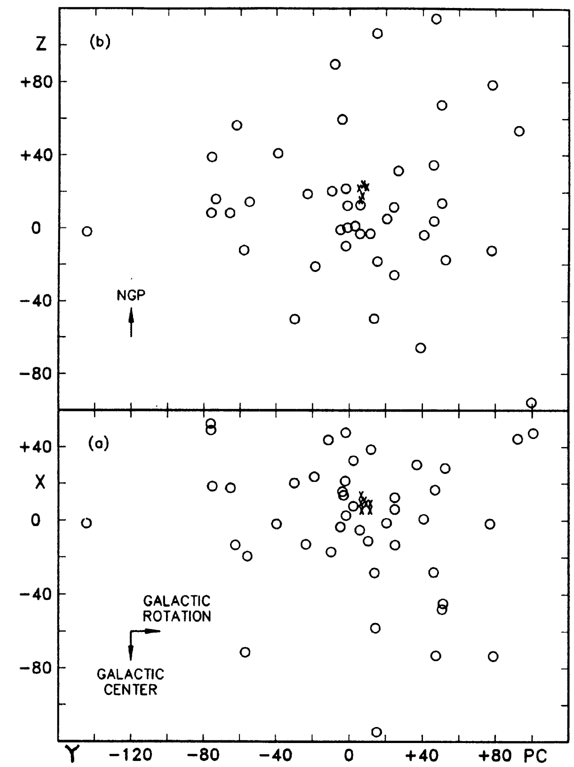


FIG. 9. The distribution of the dipper stars (crosses) and other members (clear circles) in the (a) $Y$, $X$ and (b) $Y$, $Z$ planes.

| | P.V. | $\Delta M_v$ Obs-Clus |
|---|---|---|
| Supercluster | $-0.03\pm1.1$ ($\sigma$) km/s | $+0.01\pm0.19$ ($\sigma$) mag |
| UMa | $+0.18\pm0.3$ ($\sigma$) | $-0.07\pm0.20$ ($\sigma$) |

The radial velocity data for the UMa stars is very weak with all of the stars having variable velocity from orbital motion or very broad spectral lines and even the systemic velocities from orbits of known spectroscopic binaries are poorly determined. For example, HR 4905 ($\epsilon$ UMa) is probably a spectrum variable and velocity amplitudes of about 20 km/s have been found for Fe, Cr, and Ti lines (Woszczyk & Jasinski 1980), whereas the hydrogen lines appear to give a constant velocity near $-11$ km/s (Abt & Snowden 1973), agreeing reasonably well with $-13$ km/s predicted from the supercluster parameters. The wide, common proper motion pair HR 5054/5 consists of two binary systems. The derivations of the systemic velocity for the equal component, spectroscopic binary HR 5054 range from $-5$ to $-13$ km/s (e.g., DeStrobel 1951) whereas the single spectrum binary HR 5055 is thought to be possibly a triple system and short period pulsating star (e.g., Wallace & Beardsley 1964; Gutmann 1968). Estimates of the systemic velocity of HR 5055 range from $-9$ to $-15$ km/s. HR 5062 (80 UMa) is also a broad lined star and the measured radial velocity ranges from $-23.6$ km/s from 11 Allegheny plates to $-17.6$ km/s form KPNO plates, compared with $-11.9$ km/s predicted from the supercluster

TABLE 10. Comparison of cluster and trigonometric parallax.

| HR (HD) | π Clus | π Trig | Clus/ Trig | HR (HD) | π Clus | π Trig | Clus/ Trig |
|---|---|---|---|---|---|---|---|
| 2491 | 0.3873 | 0.378 | 1.025 | 4554 | 0.0406 | 0.028 | 1.450 |
| 1983 | 0.1259 | 0.128 | 0.984 | 4931 | 0.0402 | 0.034 | 1.182 |
| 5634 | 0.0640 | 0.064 | 1.000 | 4905 | 0.0398 | (0.009) | -- |
| (41593) | 0.0652 | 0.066 | 0.987 | 5793 | 0.0386 | 0.045 | 0.857 |
| 7451 | 0.0483 | 0.037 | 1.306 | (115043) | 0.0391 | 0.050 | 0.782 |
| 531 | 0.0457 | 0.046 | 0.994 | 4867 | 0.0391 | 0.041 | 0.954 |
| 4295 | 0.0450 | 0.053 | 0.849 | 5062 | 0.0387 | 0.045 | 0.860 |
| 4141 | 0.0428 | 0.036 | 1.190 | 5973 | 0.0385 | 0.050 | 0.771 |
| (10901) | 0.0417 | -- | -- | 7312 | 0.0368 | 0.049 | 0.751 |
| 4660 | 0.0411 | 0.061 | 0.674 | 1666 | 0.0347 | 0.050 | 0.693 |
| 5054/5 | 0.0407 | 0.047 | 0.866 | 4803 | 0.0308 | 0.037 | 0.831 |
| | | | | | | mean | 0.95 |
| | | | | | | σ | ±0.20 |

TABLE 11. Stars in M39.

| No. | $(B_2-V)_o$ | d | $M_V$ | $V_o$ | Mod. |
|---|---|---|---|---|---|
| 45 | -0.003 | 1.206 | +1.94 | 8.97 | 7.03 |
| 137 | -0.004 | 1.206 | +2.34 | 9.30 | 6.96 |
| 20 | -0.043 | 1.302 | +2.06 | 9.42 | 7.36 |
| 144 | -0.037 | 1.261 | +2.30 | 9.48 | 7.18 |
| 143 | -0.023 | 1.268 | +2.11 | 9.53 | 7.42 |
| 112 | -0.041 | 1.251 | +2.42 | 9.62 | 7.20 |
| 22 | -0.044 | 1.262 | +2.37 | 9.62 | 7.25 |
| 8 | 0.029 | 1.178 | +2.37 | 9.86 | 7.44 |
| 16 | 0.051 | 1.111 | +2.75 | 10.10 | 7.35 |
| 140 | 0.060 | 1.106 | +2.04 | 10.11 | 7.37 |
| 10 | 0.143 | 0.944 | +3.25 | 10.24 | 6.99 |
| 47 | 0.191 | 0.942 | +2.81 | 10.28 | 7.47 |
| 171 | 0.131 | 0.931 | +3.45 | 10.54 | 7.09 |
| 40 | 0.120 | 1.348 | +3.46 | 10.54 | 7.09 |
| 11 | 0.253 | 0.759 | +3.74 | 10.85 | 7.11 |
| 183 | 0.227 | 0.780 | +3.82 | 11.12 | 7.30 |
| 6 | 0.183 | 0.793 | +4.18 | 11.18 | 7.00 |
| 174 | 0.264 | 0.743 | +3.81 | 11.46 | 7.65 |
| | | | | | 7.25 |
| | | | | | ±0.20 |
| 185 | 0.029 | 1.119 | +2.20 | 10.34 | 8.14 |
| 112 | 0.049 | 1.325 | +2.05 | 10.82 | 8.77 |
| 15 | -0.007 | 1.252 | +2.07 | 10.92 | 8.85 |
| 172 | 0.197 | 0.908 | +2.97 | 10.98 | 8.01 |
| 48 | 0.019 | 1.171 | +2.39 | 11.08 | 8.69 |
| 151 | 0.324 | 0.640 | +4.46 | 11.19 | 6.73 |

motion. The uncertain, mean difference, observed − predicted, in the radial velocities is $+0.3\pm1.7$ km/s for the UMa stars and $+0.65\pm1.7$ km/sec for the remaining objects, not known to have variable velocity. A very small decrease in $V_{\rm TOT}$ may be indicated but more observations of the apparently variable velocity stars are needed.

The supercluster parallaxes for the 23 stars in Table 10 exceed 0.030 arcsec and are compared with the available mean trigonometric values, from the unpublished Yale Parallax Catalogue (quoted by Hoffleit 1982, 1984), giving a mean value of "Clus" $\pi$/"Trig" $\pi=0.95\pm0.20$.

### 5. NGC 7092 (M 39)

The possibility that the sparse cluster M 39 belongs to the supercluster was discussed in Eggen (1983). Two cluster stars have proper motion determinations of H quality and 17 other stars are in PPM, giving similar results:

| $\mu_\alpha$ | $\mu_\delta$ | |
|---|---|---|
| −0.0010 arcsec | −0.018 arcsec | 2 stars, H quality |
| −0.0009 | −0.018 | 17 stars, PPM. |
| ±0.0004 | ±0.004 ($\sigma$) | |

Anthony-Twarog (1984) finds $E(b-y)=0.025$ mag and a modulus of 7.23 mag from four colors and H$\beta$ photometry of the brightest stars. Geneva photometry (Rufener 1988) is available for the twenty four stars listed in Table 11, where the values of $V$ and $(B2-V1)$ are corrected for a reddening of $E(b-y)=0.025$ mag; the stars are identified by Rufener. The reddening free index $d=[U-B1]-1.430[B1-B2]$ is used to derive the luminosities (Hauck 1973). The first 18 stars in Table 10 lead to a modulus of $7.25\pm0.20(\sigma)$ mag; one star, No. 22, is a double lined spectroscopic binary. The six stars at the end of the table are nonmembers, except possibly No. 151, which may be an undetected, equal component binary. The agreement of the modulus obtained from the Geneva photometry for the A to G type members, with that obtained from Strömgren photometry is remarkable.

Loyd Evans & Meadows (1964) determined the radial velocity for 12 cluster members in a controlled study where the zero point of the velocities was established by the dipper stars. They found a mean velocity of $+0.9\pm3.1$ km/s on the Lick Observatory system. Trumpler (1928) found −14 km/s on an unspecified radial velocity system, and Abt & Sanders (1973) found a mean cluster velocity of −7.8 km/sec from 15 stars, 6 of which are spectroscopic binaries.

The mean proper motion predicts a modulus of 6.55 mag and a radial velocity of +0.9 km/s, as a supercluster member. The velocity agrees with the Loyd Evans and Meadows result but the proper motion would need to be one-third smaller to match the photometric modulus. Obviously more observations of the apparent motions of this cluster are needed before supercluster membership can be considered.

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