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# *uvby-β* photometry for 67 stars in the region of α-Persei

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**Summary.** — *uvby-β* photometric data are presented for 67 stars in the region of α-Persei and their relationship to the cluster is analyzed. These data allowed us to confirm at least 16 new members of the α-Persei open cluster.

**Key words:** photometry — open clusters — α-Persei.

## 1. Introduction.

Around the supergiant α-Persei, covering an apparent area of about 5° × 5° and at 166 pc distance, a group of BAFG stars known as the α-Persei open cluster can be found (its IAU official nomenclature is C0318+484).

This cluster had been studied in the past by several authors. Heckmann *et al.* (1956) published a reference list of probable members by analyzing their proper motions, and they extended previous works until a limit magnitude of 12.0. Mitchell (1960) and Crawford and Barnes (1974) studied photometrically the members in the *UBV* system (Johnson, 1964) and *uvby-β* system (Strömgren, 1966 ; Crawford and Mander, 1966), respectively. Fresneau (1980) re-calculated proper motions by Palomar Schmidt astrometric observations, obtaining mean errors smaller than $0.004''\text{year}^{-1}$. These data allowed him to re-analyze the individual probabilities of membership, to suggest new probable members and to reject stars identified as members by previous authors. In a more recent paper, Stauffer *et al.* (1985) extended the proper motions survey to at least 16.5 mag., studying the low-mass members of the clusters.

In this study, we present *uvby-β* photometry for 67 stars in the neighborhood of α-Persei whose relationship to the cluster is not well established : these are new suggested members, or stars rejected as members by proper motion criterion, but accepted as members by photometric criterion (Fresneau, 1980 ; Mitchell, 1960). No previous *uvby-β* data for these stars exist.

## 2. Observations and results.

The observations were made at Calar Alto (Almeria, Spain) in two runs (October 1987, November 1988) with the 1.52m telescope of the Observatorio Astronómico Nacional which is equipped with a one channel photometer with a dry-ice cooled RCA 31034 photomultiplier and with the conventional *UBV* Johnson and *uvby-β* Strömgren-Crawford filters.

We carried out 2 or 3 observations of 48 stars proposed as new members, and 19 stars identified as members by Heckmann *et al.* (1956) and classified as non-members by Fresneau (1980).

10 standard stars were taken from among those confirmed as members in the studies of Heckmann *et al.* (1956) and Fresneau (1980) and observed photometrically by Mitchell (1960) and Crawford and Barnes (1974).

The observations and data reduction were performed using standard procedures and the reddening correction was made as described by Crawford & Barnes (1974).

Table I shows *V-uvby-β* data obtained for the 67 stars in this work, the first column being the identification number in Heckmann *et al.* (1956). The mean error of one observation is ± 0.01, ± 0.003, ± 0.005, ± 0.002 and ±0.002 in *V*, *β*, *(b-y)*, $m_1$, $c_1$ respectively. The values were plotted in a colour-magnitude diagram (Fig. 1) by crosses. Photometric data for other members of the cluster (Crawford and Barnes, 1974) were represented in the same

diagram as dots.

Previous *uvby-β* photometry for the 67 stars is not available, so we could not compare them. An external error of $V$ magnitude was computed by comparing our values and those obtained by Mitchell (1960) and Stauffer *et al.* (1985). Stars HL271 and HL656 show large discrepancies between our values and those published by Mitchell (1960), and no big differences exist when comparing them with those of Stauffer *et al.* (1985). The first one (HL271) is a star with an optical companion and our value corresponds to the brighter star. Probably the value of Mitchell corresponds to the joint photometry of both components. A difference for the star HL656 was also found by Stauffer *et al.* (1985) and our value lies with the last one. Excluding these two stars, the mean difference $< \Delta V >$ according to our values minus others are :

| | | | | |
|---|---|---|---|---|
| Mitchell (1960) | $< \Delta V > = -0.002$ | $\sigma = 0.031$ | $N = 20$ |
| Stauffer *et al.* (1985) | $< \Delta V > = -0.036$ | $\sigma = 0.018$ | $N = 10$ |

being $\sigma$ the standard deviation and $N$ the number of stars in common. Our values are close to those of Mitchell as we expected because we used stars observed by him as our standard stars. On the other hand, the difference with Stauffer *et al.* (1985) is explained by the shift found by these authors with Mitchell's data.

### 3. Discussion.

In order to establish the photometric relationship to the cluster we have considered three criteria for each star : the reddening correction, the position on the colour-magnitude diagram, and the $V_o$-$M_v$ distance modulus value.

Even though the reddening correction is variable over the field, we assume that stars that are expected to be members should not have individual reddening corrections differing from the cluster average (0.072 mag). Crawford and Barnes (1974) found a reddening range between 0.030 and 0.160 mag.

The main sequence band has a natural width of 0.75 mag from the lower envelope defined by the single stars to the upper one defined by the binaries. Thus a star can be considered as member if it falls within that band. The existing uncertainty is strictly related to the observational errors on the magnitudes or colours. Stars falling above the single star locus, but within the 0.75 mag band, may be interpreted either as non-members or as binaries. Proper motions and radial velocities may be useful to check these stars for binarity, since photometry is not enough.

Finally, we considered a star as member by the distance modulus criterion if its $V_o$-$M_v$ is compatible with the distance to the cluster.

According to criteria related above, we separated two groups of stars. The first one includes members and possible members of the cluster. We call members those stars satisfying the three criteria. Possible members are stars whose relationship to the cluster cannot be proved in our analysis. Some of them would be members if they were binaries. The second group corresponds to non-members of the cluster.

Table II shows the obtained values of $\beta$, $E(b\text{-}y)$, $(b\text{-}y)_o$, $V_o$, $V_o$-$M_v$ for members and possible members, and table III shows the same for non-members. Possible members are indicated by "PM" in the last column on table II.

In figure 2 the main sequence for the cluster can be seen. Dots represent values found by Crawford and Barnes (1974), and our values are plotted by plus signs (members) and triangles (possible members). Non-members are not plotted to assure clarity. The ZAMS for the single stars and the upper envelope for the binaries is also plotted.

### 4. Conclusions.

The present paper presents original measurements of Strömgren photometry for 67 stars suitable to confirm (or not) cluster members already suggested by proper motion criteria. We have identified 16 stars as members of the $\alpha$-Persei open cluster, 39 have been discarded and 12 remain as possible members. The number of members would increase if the binarity of some possible members could be tested.

Comparing the photometric criteria with the astrometric one (based on proper motions) we found that 81 % of our members and 67 % of our possible members have a probability larger than 0.75 of being members in the Fresneau (1980) analysis, and 59 % of our non-members have a probability smaller than 0.75. These limits would indicate the risks associated with the use of astrometric observations without precise photometry.

Finally, we notice that 12 of the 30 stars with apparent $V$-magnitude smaller than 10.5 mag analyzed here are confirmed as members of the cluster, while only 4 of the 37 stars fainter than 10.5 mag are confirmed as such. In other words principally the membership of bright stars is confirmed.

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TABLE I. — *V-uvby-β photometry of 67 stars in the neighbourhood of α-Persei. HL : = Heckmann's list number.*

| HL | β | b-y | $m_1$ | $c_1$ | V | HL | β | b-y | $m_1$ | $c_1$ | V |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | 2.729 | .433 | .146 | .638 | 11.26 | 876 | 2.656 | .374 | .153 | .462 | 9.49 |
| 61 | 2.772 | .204 | .177 | .971 | 8.49 | 932 | 2.849 | .340 | .128 | .945 | 11.62 |
| 104 | 2.712 | .251 | .160 | .664 | 8.58 | 936 | 2.691 | .412 | .135 | .542 | 11.36 |
| 106 | 2.683 | .418 | .125 | .530 | 10.66 | 945 | 2.642 | .401 | .143 | .379 | 11.14 |
| 174 | 2.567 | .547 | .296 | .330 | 11.54 | 960 | 2.634 | .711 | .122 | .331 | 11.11 |
| 200 | 2.672 | .398 | .145 | .473 | 11.25 | 972 | 2.660 | .387 | .148 | .386 | 10.21 |
| 225 | 2.737 | .390 | .137 | .780 | 9.02 | 988 | 2.662 | .372 | .157 | .483 | 9.80 |
| 271 | 2.657 | .383 | .150 | .359 | 10.70 | 992 | 2.684 | .475 | .124 | .412 | 10.80 |
| 283 | 2.554 | .950 | .306 | .163 | 8.48 | 1045 | 2.690 | .364 | .145 | .497 | 9.90 |
| 289 | 2.586 | .699 | .302 | .449 | 10.13 | 1051 | 2.779 | .550 | .084 | .816 | 11.73 |
| 290 | 2.655 | .422 | .161 | .369 | 10.71 | 1056 | 2.900 | .065 | .195 | 1.073 | 8.19 |
| 330 | 2.571 | .898 | .212 | .209 | 9.86 | 1074 | 2.884 | .272 | .166 | .923 | 11.33 |
| 334 | 2.645 | .376 | .150 | .389 | 10.31 | 1084 | 2.862 | .155 | .174 | .902 | 8.82 |
| 379 | 2.875 | .113 | .156 | 1.100 | 8.02 | 1086 | 2.628 | .461 | .166 | .279 | 11.32 |
| 389 | 2.618 | .427 | .176 | .317 | 11.13 | 1101 | 2.572 | .478 | .167 | .248 | 11.21 |
| 407 | 2.793 | .423 | .148 | .717 | 11.16 | 1104 | 2.920 | .173 | .146 | 1.005 | 10.52 |
| 493 | 2.667 | .373 | .129 | .522 | 11.05 | 1110 | 2.566 | .484 | .210 | .189 | 11.61 |
| 537 | 2.575 | .664 | .278 | .368 | 10.09 | 1151 | 2.734 | .408 | .140 | .495 | 11.52 |
| 545 | 2.768 | .396 | .144 | .793 | 11.88 | 1160 | 2.661 | .366 | .149 | .401 | 10.12 |
| 551 | 2.643 | .430 | .157 | .357 | 11.16 | 1180 | 2.663 | .349 | .156 | .411 | 10.05 |
| 554 | 2.884 | .116 | .176 | 1.044 | 8.69 | 1181 | 2.621 | .393 | .182 | .259 | 10.52 |
| 573 | 2.691 | .354 | .144 | .564 | 9.44 | 1183 | 2.834 | .235 | .173 | 1.004 | 10.20 |
| 597 | 2.659 | .515 | .157 | .386 | 11.47 | 1185 | 2.593 | .480 | .181 | .240 | 11.19 |
| 623 | 2.569 | .769 | .268 | .228 | 12.73 | 1196 | 2.694 | .436 | .154 | .444 | 11.31 |
| 628 | 2.722 | .466 | .123 | .739 | 11.15 | 1208 | 2.667 | .397 | .156 | .400 | 10.90 |
| 633 | 2.652 | .401 | .157 | .450 | 10.22 | 1224 | 2.580 | .741 | .230 | .246 | 9.47 |
| 648 | 2.698 | .394 | .057 | .754 | 12.17 | 1240 | 2.766 | .415 | .049 | .641 | 10.98 |
| 656 | 2.826 | .408 | .048 | 1.122 | 11.81 | 1256 | 2.852 | .225 | .181 | .883 | 11.15 |
| 707 | 2.612 | .472 | .178 | .404 | 10.01 | 1260 | 2.854 | .159 | .192 | .984 | 8.58 |
| 732 | 2.645 | .361 | .155 | .387 | 10.17 | 1308 | 2.852 | .281 | .144 | 1.166 | 9.86 |
| 741 | 2.564 | .793 | .261 | .209 | 8.96 | 1315 | 2.859 | .291 | .155 | .941 | 11.31 |
| 771 | 2.628 | .460 | .151 | .366 | 11.11 | 1349 | 2.701 | .310 | .154 | .602 | 9.43 |
| 836 | 2.685 | .369 | .163 | .477 | 9.14 | 1364 | 2.563 | .782 | .254 | .233 | 10.37 |
| 865 | 2.804 | .508 | .094 | .882 | 10.73 | | | | | | |

TABLE II. — *Reddening corrected values for members and possible members. HL : = Heckmann's list number ; E(b-y) : = reddening correction ; $V_o$-$M_v$ : = distance modulus ; PM : = possible cluster member.*

| HL | β | E(b-y) | (b-y)o | Vo | Vo-Mv | remarks |
|---|---|---|---|---|---|---|
| 61 | 2.772 | .056 | .148 | 8.25 | 5.4 | PM |
| 104 | 2.712 | .029 | .222 | 8.46 | 5.3 | PM |
| 174 | 2.567 | .072 | .475 | 11.23 | 6.1 | |
| 290 | 2.655 | .105 | .317 | 10.26 | 6.5 | PM |
| 334 | 2.645 | .060 | .316 | 10.05 | 6.2 | |
| 379 | 2.875 | .065 | .048 | 7.74 | 5.4 | PM |
| 389 | 2.618 | .072 | .355 | 10.82 | 6.4 | PM |
| 554 | 2.884 | .066 | .050 | 8.40 | 6.1 | |
| 573 | 2.691 | .103 | .251 | 9.00 | 5.6 | PM |
| 597 | 2.659 | .072 | .443 | 11.15 | 7.4 | PM |
| 633 | 2.652 | .087 | .314 | 9.83 | 6.0 | |
| 732 | 2.645 | .049 | .312 | 9.97 | 6.1 | |
| 771 | 2.628 | .07? | .388 | 10.80 | 6.6 | PM |
| 876 | 2.656 | .074 | .300 | 9.17 | 5.4 | PM |
| 972 | 2.660 | .084 | .303 | 9.84 | 6.1 | |
| 988 | 2.662 | .080 | .292 | 9.46 | 5.8 | |
| 1045 | 2.690 | .104 | .260 | 9.45 | 6.0 | |
| 1056 | 2.900 | .072 | -.007 | 7.88 | 7.2 | PM |
| 1084 | 2.862 | .074 | .081 | 8.50 | 6.1 | |
| 1086 | 2.628 | .072 | .389 | 11.00 | 6.8 | PM |
| 1101 | 2.572 | .072 | .406 | 10.89 | 5.9 | |
| 1110 | 2.566 | .072 | .412 | 11.30 | 5.5 | PM |
| 1160 | 2.661 | .068 | .298 | 9.83 | 6.1 | |
| 1180 | 2.663 | .054 | .295 | 9.82 | 6.1 | |
| 1181 | 2.621 | .072 | .321 | 10.21 | 5.9 | |
| 1185 | 2.593 | .079 | .401 | 10.85 | 6.2 | |
| 1260 | 2.854 | .078 | .081 | 8.24 | 5.8 | |
| 1349 | 2.701 | .071 | .239 | 9.12 | 5.8 | |

TABLE III. — *Reddening corrected values for non-members. HL : = Heckmann's list number ; E(b-y) : = reddening correction ; $V_o$-$M_v$ : = distance modulus.*

| HL | β | E(b-y) | (b-y)o | Vo | Vo-Mv |
|---|---|---|---|---|---|
| 17 | 2.729 | .212 | .221 | 10.35 | 7.3 |
| 106 | 2.683 | .156 | .262 | 9.99 | 6.5 |
| 200 | 2.672 | .116 | .282 | 10.74 | 7.2 |
| 225 | 2.737 | .192 | .198 | 8.19 | 5.3 |
| 271 | 2.657 | .075 | .308 | 10.38 | 6.6 |
| 283 | 2.554 | .072 | .878 | 8.17 | 3.0 |
| 289 | 2.586 | .072 | .627 | 9.82 | 4.3 |
| 330 | 2.571 | .072 | .826 | 9.55 | 4.4 |
| 407 | 2.793 | .260 | .163 | 10.04 | 7.3 |
| 493 | 2.667 | .098 | .275 | 10.63 | 7.0 |
| 537 | 2.575 | .072 | .592 | 9.78 | 4.7 |
| 545 | 2.768 | .226 | .170 | 10.90 | 8.1 |
| 551 | 2.643 | .099 | .331 | 10.73 | 6.8 |
| 623 | 2.569 | .072 | .697 | 12.42 | 7.2 |
| 628 | 2.722 | .250 | .216 | 10.07 | 7.0 |
| 648 | 2.698 | .173 | .221 | 11.43 | 8.1 |
| 656 | 2.826 | .320 | .088 | 10.44 | 7.8 |
| 707 | 2.612 | .072 | .400 | 9.70 | 5.2 |
| 741 | 2.564 | .072 | .721 | 8.65 | 3.4 |
| 836 | 2.685 | .100 | .269 | 8.71 | 5.3 |
| 865 | 2.804 | .370 | .138 | 9.14 | 6.4 |
| 932 | 2.849 | .249 | .091 | 10.55 | 8.1 |
| 936 | 2.691 | .156 | .256 | 10.69 | 7.3 |
| 945 | 2.642 | .081 | .320 | 10.79 | 6.8 |
| 960 | 2.634 | .072 | .639 | 10.80 | 6.8 |
| 992 | 2.684 | .072 | .403 | 10.49 | 7.0 |
| 1051 | 2.779 | .386 | .164 | 10.07 | 7.3 |
| 1074 | 2.884 | .205 | .067 | 10.45 | 8.2 |
| 1104 | 2.920 | .072 | .101 | 10.21 | 8.9 |
| 1151 | 2.734 | .180 | .228 | 10.75 | 7.8 |
| 1183 | 2.834 | .139 | .096 | 9.60 | 7.0 |
| 1196 | 2.694 | .167 | .269 | 10.59 | 7.2 |
| 1208 | 2.667 | .100 | .297 | 10.46 | 6.8 |
| 1224 | 2.580 | .072 | .669 | 9.16 | 3.9 |
| 1240 | 2.766 | .233 | .182 | 9.98 | 7.2 |
| 1256 | 2.852 | .131 | .094 | 10.59 | 8.1 |
| 1308 | 2.852 | .213 | .068 | 8.94 | 6.5 |
| 1315 | 2.859 | .207 | .084 | 10.42 | 8.0 |
| 1364 | 2.563 | .072 | .710 | 10.06 | 4.6 |

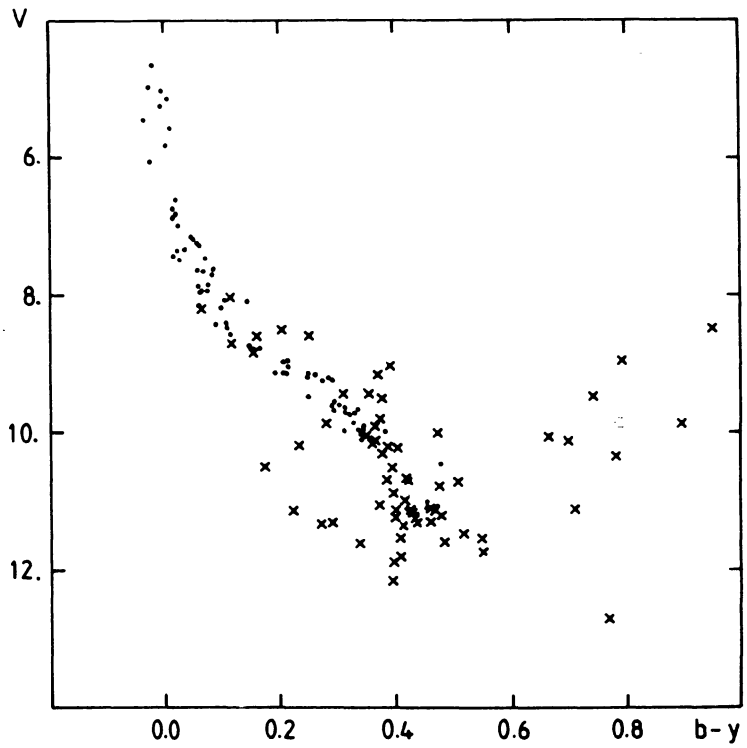


FIGURE 1. — Colour magnitude diagram. The crosses (×) represent our values for the observed stars and dots (•) are previous photometric data for other members of the cluster.

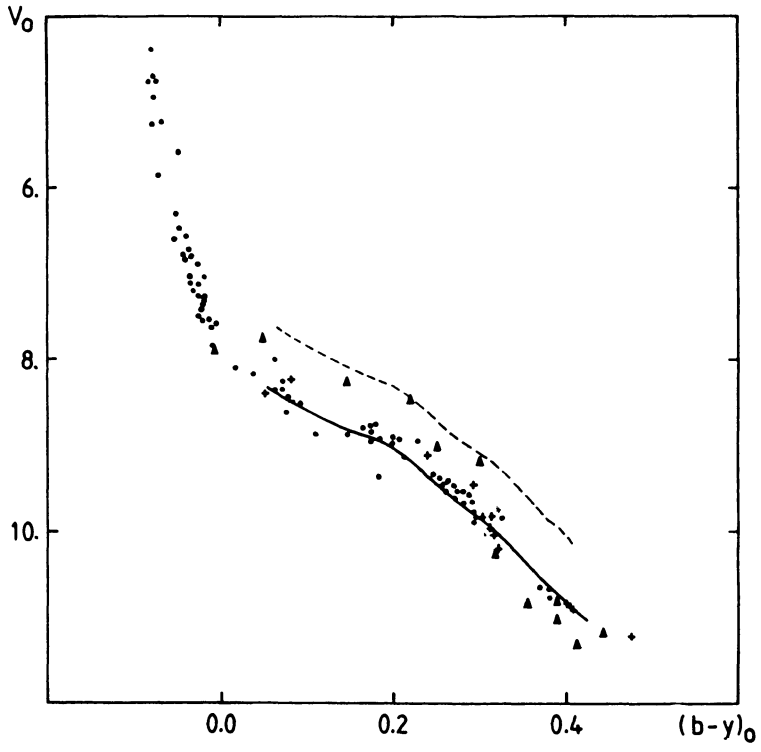


FIGURE 2. — Colour magnitude diagram corrected for interstellar reddening. The plus signs (+) represent our members, the triangles ( ) represent our possible members. Previous photometry of other members is plotted by dots (•). The solid line corresponds to the ZAMS and the dashed one is the upper envelope defined by the binaries.