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ASTERISMS IDENTIFICATION USING ASTROMETRIC DATA

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RESUMEN

Se estudian las regiones de los objetos Collinder 399, Upgren 1 y Melotte 227 clasificados como asterismos en la literatura reciente. Se utilizan las posiciones y movimientos propios obtenidos del catálogo astrométrico UCAC2 y de su suplemento de estrellas brillantes, y se aplica el método de Vasilevskis-Sanders modificado por la distribución espacial para confirmar la naturaleza de estos grupos de estrellas.

ABSTRACT

We studied the regions of Collinder 399, Upgren 1 and Melotte 227 classified as asterisms in the published literature. Stellar positions and proper motions from the UCAC2 and the UCAC2 Brigth Star Supplement astrometric catalogues were used. The Vasilevskis-Sanders method, modified by the stellar density, was applied to confirm the nature of these star groups.

Key Words: astrometry — open clusters and associations: general — stars: kinematics

1. INTRODUCTION

Mainly during the late 19th century and the first decades of the 20th, asterisms have been described as loose concentrations of stars containing some bright ones, and several have been classified as open clusters. Membership studies based on photometry and relative proper motions and determinations of the age and distance began in the 1960's and showed the doubtful open cluster's nature.

The accurate proper motions and parallaxes of the Hipparcos catalogue allows us to distinguish between real open clusters and chance alignments of stars (Baumgardt 1998). Asterisms are, then, those groups of stars at greatly different distances, of different types and with different space motions.

Using position and proper motion data from a more accurate astrometric catalogue containing fainter stars, we explore a different application of the Vasilevskis-Sanders's method in order to detect groups of stars not physically related in regions of star condensations, which can be distinguished from a more thinly populated background.

The Second U.S. Naval Observatory CCD Astrograph Catalogue (UCAC2) is a highly accurate astrometric catalogue of 48330571 stars in the $8 < R < 16$ magnitude range covering the sky from $-90°$ to $+40°$ in declination and going up to $+52°$ in some areas (Zacharias et al. 2004). Positions and proper motions are on the ICRS and given at the epoch J2000.0. The precision of the positions is 15–70 mas, depending on magnitude, with estimated errors of 10 mas and below. Proper motion errors are about 1–3 mas yr^{-1} for stars to 12th magnitude, and about 4–7 mas yr^{-1} for fainter stars up to to 16th magnitude. The UCAC2 Bright Star Supplement (UCAC2 BSS) is used with the UCAC2 catalogue to fill in the missing brigth stars and to complete the sky coverage. UCAC2 BSS contains 430000 stars and all astrometric data were extracted from either the Hipparcos or the Tycho-2 catalogues (Urban et al. 2004).

2. THE METHOD

2.1. *Data set*

The central coordinates and the apparent diameter of the asterisms studied were taken from the list of removed clusters of the Catalog of Optically Visible Open Clusters and Candidates (Dias et al. 2002, 2006). We extracted stellar positions and proper motions from UCAC2 and UCAC2 BSS in a region of approximately twice the object's diameter.

2.2. *The model adopted for data analysis*

It is common to analyse stellar proper motion for membership determination. The proper motion distribution model is the result of overlapping an elliptical bivariate normal frequency distribution Φ_{fi} and a circular one Φ_{ci} for field and cluster stars, respectively (Vasilevskis et al. 1958):

$$\Phi_i(\mu_{xi}, \mu_{yi}) = \Phi_{ci}(\mu_{xi}, \mu_{yi}) + \Phi_{fi}(\mu_{xi}, \mu_{yi}) , \quad (1)$$

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where μ_{xi}, μ_{yi} are the ith star proper motions in $\alpha \cos\delta$ and δ.

Under this assumption, membership probabilities may be overestimated for stars far from the centre of the region and underestimated for stars near it. In order to eliminate this problem, an exponential function is introduced in Φ_{ci} to describe the radial stellar density for cluster stars (Jones & Walker 1988), and another constant function in Φ_{fi}, for field stars.

The radial stellar density profile is obtained for stars belonging to both elliptical and circular distributions, from star counts in concentric rings, with steps in radius depending on the object angular size, divided by their respective areas. The new function has the form:

$$\rho_i(r) = \rho_0 \exp(-r_i/r_0) + f_0 \,, \tag{2}$$

where ρ_0 is the central cluster stellar density, r_0 is the characteristic radius, f_0 is the field stellar density and r_i the stellar distance from the cluster's centre. These parameters are obtained by fitting the function (2) to the profile.

Finally, the modified elliptical and circular distributions are described by:

$$\Phi_{ci}(\mu_{xi}, \mu_{yi}) = \frac{\rho_0 e^{-r_i/r_0}}{2\pi\sigma^2} \times \exp\left[-\frac{(\mu_{xi}-\mu_{xc})^2 + (\mu_{yi}-\mu_{yc})^2}{2\sigma^2}\right]; \tag{3}$$

$$\Phi_{fi}(\mu_{xi}, \mu_{yi}) = \frac{f_0}{2\pi\sigma_x\sigma_y} \times \exp\left[-\frac{(\mu_{xi}-\mu_{x0})^2}{2\sigma_x^2} - \frac{(\mu_{yi}-\mu_{y0})^2}{2\sigma_y^2}\right]; \tag{4}$$

where σ_x, σ_y are the elliptical dispersions, σ is the circular dispersion, μ_{xc}, μ_{yc} the cluster mean proper motion and μ_{x0}, μ_{y0} the field stars mean proper motion.

These seven parameters can be found by applying the maximum likelihood principle (Sanders 1971) and the model will be enterely described.

The dynamical membership probability for the ith star is:

$$\Phi_i(\mu_{xi}, \mu_{yi}) = \frac{\Phi_{ci}(\mu_{xi}, \mu_{yi})}{\Phi_i(\mu_{xi}, \mu_{yi})} \,. \tag{5}$$

3. RESULTS

3.1. *Collinder 399*

Collinder 399 is located in Vulpecula (α_{2000} = 19h 25m 24s, $\delta_{2000} = 20°11'$). It is a concentration

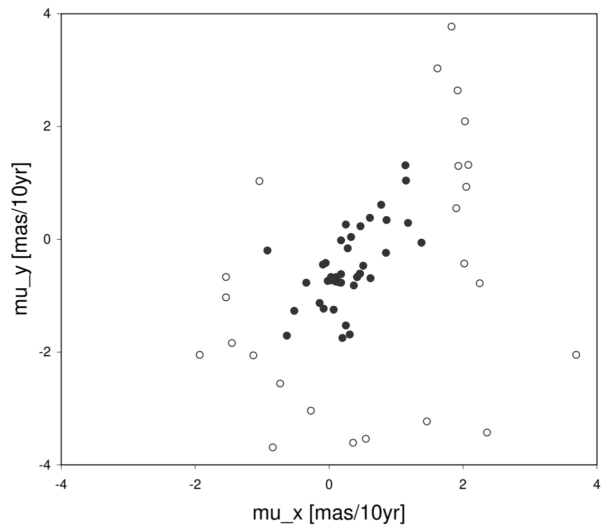

Fig. 1. VPD in the region of Collinder 399. White circles represent the components of proper motion of all the stars in the region and black circles the ones of stars belonging to the elliptical distribution.

of brigth stars located in a one square degree field. An extensive membership study of the region was done by Hall and van Landingham (1970) based on a variety of criteria. They concluded that only six stars were members of the cluster and found that the density of fainter stars was not enhanced in the cluster area. Baumgardt (1998) studied the object using parallaxes and proper motions from the Hipparcos and ACT catalogues and concluded that it was an asterism, a chance aligment of bright stars with very different motions and distances. Dias et al. (2002) investigated the region applying the statistical method of Sanders (1971) to the Tycho2 proper motions. They obtained values for the cluster and for the field stars mean proper motions. Nevertheless, they argued that Collinder 399 was an asterism based on Baumgardt's analysis.

In a radius of 80 arcmin we have carried out a radial stellar density analysis similar to that of Hall and van Landinghan's, considering all stellar magnitudes in the data. For magnitudes fainter than 10th, we also found values lower than expected in a region between 18 and 48 arcmin from the centre. We have then taken the catalogue data brighter than 10th mag and ended up with a sample containing only 81 stars.

Figure 1 shows the vector point distribution (VPD). Only 41 stars turned out to belong to the elliptical distribution. The radial density function was described by the following parameters: ρ_0 =

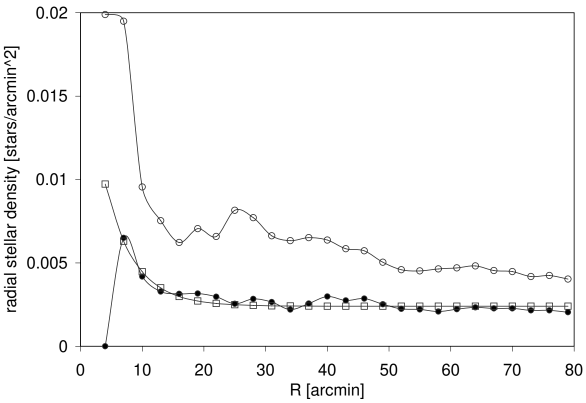

Fig. 2. Stellar density profiles in the region of Collinder 399 as a function of radius. The plots represent the stellar radial density profiles of all the region (white circles), of the stars whose proper motions belong to the ellipse (black circles), and the function $\rho_i(r)$ (white squares).

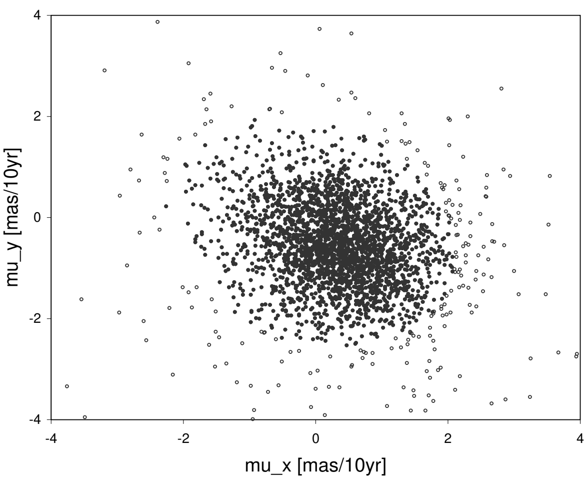

Fig. 3. VPD in the region of Melotte 227. White circles represent the components of proper motion of all the stars in the region and black circles the ones of stars belonging to the elliptical distribution.

0.017 ± 0.004 stars arcmin^{-2}, $r_0 = 4.751 \pm 0.720$ arcmin and $f_0 = 0.002 \pm 0.000$ stars arcmin^{-2}, as can be seen in Figure 2.

When the method of maximum likelihood was applied to equations (3) and (4), the model found the mean proper motion for field stars (Table 1) and did not identify open cluster members. We conclude that Collinder 399 is an asterism.

3.2. *Melotte 227*

Melotte 227 is a loose group of stars around the HD 192074 star (α_{2000} = 20h 17m 19s, $\delta_{2000} = -79°02'$). Parallaxes and proper motions of the possible members from Hipparcos were analysed by Baumgardt (1998) and showed no clustering.

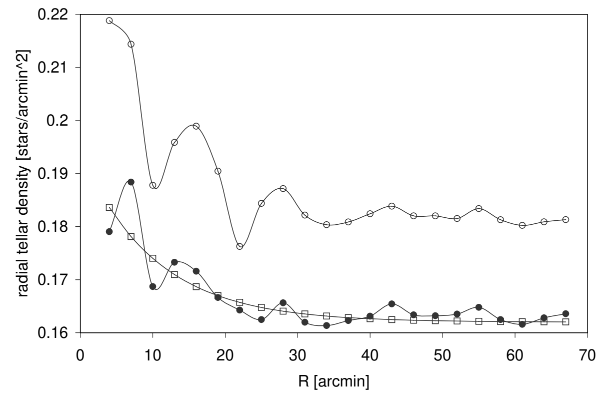

Fig. 4. Stellar density profiles in the region of Melotte 227 as a function of radius. The plots represent the stellar radial density profiles of all the region (white circles), of the stars whose proper motions belong to the ellipse (black circles), and the function $\rho_i(r)$ (white squares).

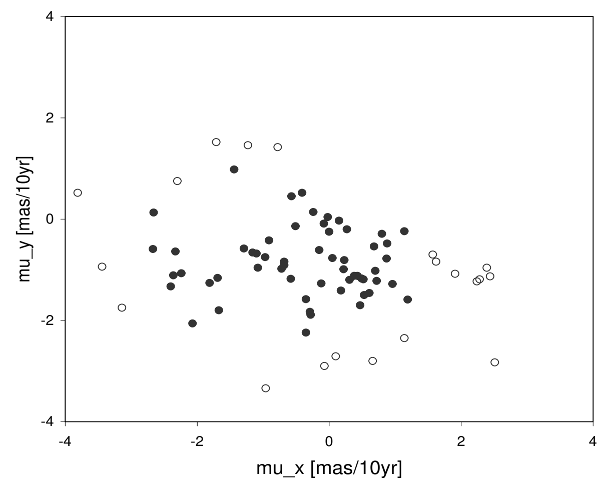

Fig. 5. VPD in the region of Upgren 1. White circles represent the components of proper motion of all the region stars and black circles the ones of stars belonging to the elliptical distribution.

We studied a region 70 arcmin wide from the centre including all magnitudes. Figure 3 shows the VPD. The proper motions of 2522 stars form an ellipse in a region of 2792 stars. The function $\rho(r)$ could be adjusted to the radial stellar density profile (as shown in Figure 4) with the following parameters: $\rho_0 = 0.031 \pm 0.006$ stars arcmin^{-2}, $r_0 = 10.221 \pm 2.890$ arcmin and $f_0 = 0.162 \pm 0.001$ stars arcmin^{-2}.

The method of maximum likelihood was applied to equations (3) and (4) and no open cluster mem-

TABLE 1

MEAN PROPER MOTION IN [MAS/YR] FOR FIELD STARS OF COLLINDER 399, MELOTTE 227 AND UPGREN 1

Object	μ_{xf}	σ_{xf}	μ_{yf}	σ_{yf}
Collinder 399	3.15 ± 0.49	4.54 ± 0.71	-4.63 ± 0.72	6.68 ± 1.04
Melotte 227	3.21 ± 0.06	8.54 ± 0.17	-5.22 ± 0.10	6.75 ± 0.13
Upgren 1	-3.65 ± 0.48	9.94 ± 1.32	-8.72 ± 1.15	6.63 ± 0.88

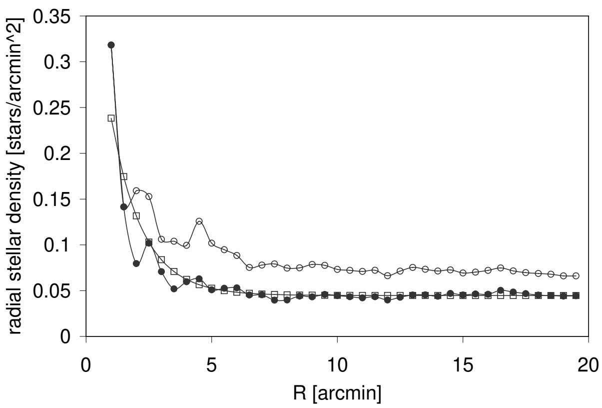

Fig. 6. Stellar density profiles in the region of Upgren 1 as a function of radius. The plots represent the stellar radial density profiles of all the region (white circles), of the stars whose proper motions belong to the ellipse (black circles) and the function $\rho_i(r)$ (white squares)

bers were found. We confirm that Melotte 227 is an asterism. The mean proper motion for field stars is presented in Table 1.

3.3. *Upgren 1*

Upgren 1 is located in Canes Venatici (α_{2000} = 12h 35m 0s, $\delta_{2000} = 36°18'$). It is a group of seven stars scattered over an area of 0.1 square degrees. Baumgardt (1998) analysed parallaxes and proper motions of the suspected seven members (from the-Hipparcos and ACT catalogues) and he concluded that Upgren 1 is not a cluster.

We analysed astrometric data in a region with a radius of 20 arcmin from the centre and included all magnitudes trying to detect a stellar concentration. Even though the region is not very populated, an ellipse containing proper motions of 57 stars could be obtained in the VPD (Figure 5) from the 83 stars in the region. Afterwards, an exponential function could be adjusted to the radial stellar density profile; its parameters are: $\rho_0 = 0.431 \pm 0.170$ stars arcmin^{-2}, $r_0 = 1.250 \pm 0.140$ arcmin and $f_0 = 0.045 \pm 0.002$ stars arcmin^{-2}, as can be seen in Figure 6. As result of applying the method of maximum likelihood to equations (3) and (4), no open cluster members were found. We conclude that Upgren 1 is an asterism. The mean proper motion for field stars is presented in Table 1.

4. CONCLUSIONS

A different application of Vasilevskis-Sander's method was explored to catalogue doubtful open clusters as asterisms, taking advantage of the accurate kinematic data of 2956 stars extracted from the UCAC2 and UCAC2 BSS catalogues. The model employed can detect fictitious stellar over-densities in space due to a visual effect using astrometric data (positions and proper motions). We confirm that Collinder 399, Melotte 227 and Upgren 1 are asterisms.

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REFERENCES

Baumgardt, H. 1998, A&A, 340, 402
Dias, W., et al. 2002, A&A, 389, 871
Dias, W., et al. 2006, A&A, 446, 949
Hall, D., & Vanlandingham, F. 1970, PASP, 82, 640
Jones, B. F., & Walker, M. F. 1988, AJ, 95, 1755
Sanders, W. L. 1971, A&A, 14, 226
Urban, S., et al. 2004, VizieR On-line Data Catalogue I/294
Vasilevskis, S., et al. 1958, AJ, 63, 387
Zacharias, N., et al. 2004, AJ, 127, 3043