A&A manuscript no.
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05(05.01.1;10.15.2 NGC 1662)

ASTRONOMY
AND
ASTROPHYSICS
30.10.2018

Proper motion and membership determination in the young open cluster NGC1662

W. S. Dias, R. Boczko, J. I. B. Camargo, R. Teixeira and P. Benevides-Soares

Universidade de São Paulo, Dept. de Astronomia, CP 3386, São Paulo 01060-970, Brazil
email: wilton@iagusp.usp.br

Received ; accepted 13.03.2000

Abstract. Relative proper motions and cluster membership probabilities of 30 stars within an area of 14′ of diameter centered in the open cluster NGC1662 ($\alpha = 04^{\rm h}48^{\rm m}$, $\delta = +10^{\rm o}56'$) are determined by combining positions of stars observed by the Valinhos CCD meridian circle with those from other astrometric catalogues.

Our basic source for first epoch of stars brighter than B=13 magnitudes is the AC2000 Catalogue, which provides a time baseline of about 90 years, whereas the USNO–A2.0 Catalogue is used for fainter stars, providing a time baseline of about 40 years in this region.

Average accuracies in proper motion of 2 mas/yr and 7 mas/yr are achieved, respectively, when the AC2000 or the USNO–A2.0 is used.

Membership determination is obtained by applying the Zhao & He (1990) method. The cluster proper motion was found to be (-3.2 ± 0.6) mas/yr in right ascension and (-1.6 ± 0.6) mas/yr in declination.

Key words: astrometry – open cluster: NGC 1662

1. Introduction

Open clusters are of special interest since their investigation may lead to a deeper insight in kinematics and star formation in the Galaxy, as well as contribute to the understanding of the Galactic structure. Some hundreds of such clusters are known and recent contributions indicate an increasing interest in proper motion determination.

In fact, the knowledge of the tangential component of the movement plays an important role when membership criteria through astrometrical techniques are concerned, since a common trend is the only characteristic to be searched for. Moreover, in some few cases, the proper motions are accurate enough to allow a study of the internal velocity dispersion, providing additional data on the cluster dynamics.

NGC1662 ($\alpha = 04^{\rm h}48^{\rm m}27^{\rm s}$, $\delta = +10^{\rm o}56'13''$, J2000.0) is a well known open cluster. It is situated in the direction of the anticenter ($l = 188^{\rm o}$) and relatively distant from the Galactic plane ($b = 20,5^{\rm o}$), corresponding to Z=140 pc for a distance of 378 pc (Hassan 1972). This distance to the plane may seem surprising for such a young cluster (logt=8.11 years) (Hassan 1972) and suggests that the formation mechanism could have been the collision of a high velocity cloud with the gas of the Galactic plane (Lépine & Duvert 1994).

Many of its properties are available in the literature such as angular diameter (12′) (Lyngå 1981); metallicity (−0.232) and colour excess (0.34) (Cameron 1985). Notwithstanding its large content of bright stars (V≤13.0 mags), no kinematic study was found for this cluster.

In this paper, we present the results of an analysis of membership obtained through proper motions. The velocity of the centroid of the cluster is also obtained in the process.

A detailed description of the employed techniques, of the observational material, and an account of the involved astrometric catalogues, is provided along with an analysis of the final results.

2. Observational data

Since 1996, an observational program for open clusters using the Valinhos CCD meridian circle (hereinafter VMC) (Viateau et al. 1999) is under way, with the aim of proper motion determination.

In this work, only observations performed during the year 1996 were used. The observational procedure is entirely differential, and data reduction was made with respect to HIPPARCOS system as materialized by TYCHO catalogue (ESA 1997). Reference stars within the limits of the cluster were deleted from our reference positions

Send offprint requests to: W. S. Dias

file, so that members and candidates could have the same treatment during the reduction process.

Table 1. Astrometric characteristics of Valinhos observational data in the strip centered in NGC1662

Number of stars	400
Strip lenght and width	40^{m} and $14'$
Mean precision in right ascension	$0''.08$
Mean precision in declination	$0''.09$
Mean epoch of observations	1996.6
Limiting magnitude	15
Reference system	HIPPARCOS
Equinox	J2000.0
Reference catalogue	Tycho

The resulting data is, therefore, a catalogue of positions for stars brighter than V=15.0 mags.

The main astrometric characteristics of VMC observational data for the cluster field are given in Table 1 (Viateau et al. 1999).

The large range of right ascension was necessary to assure the observation of enough reference stars.

It should be pointed out that our sample is not complete, in the sense of the cluster membership, for stars with magnitude V>15. In fact, the star density of USNO-A2.0 (Monet et al. 1998) corresponds to more than 10 times the number of detectable stars by VMC, which is a strong indication that many of the cluster members may have not been considered in this study.

The observed star numbers in the region of the cluster are listed in Table 3. The first column contains Tycho numbers, when applicable. Columns two and three give the J2000 star equatorial coordinates at mean epoch of observation, 1996.6. Column four lists the visual magnitudes.

The data and a complete cross identification are available on request.

3. First epoch catalogues

Individual proper motions were determined by combining current epoch observations, as obtained from the VMC, with those provided by previous astrometric catalogues (see Table 2).

Our main sources for faint (V>13 magnitudes) and bright (V≤13 magnitudes) stars were the USNO–A2.0 and the AC2000 (Urban et al. 1998a) catalogues, respectively. In addition to them, TAC (Zacharias et al. 1999), TYCHO, PPM (Röser and Bastian 1991, Bastian 1991) and SAO (SAO 1966) catalogues were used so that proper motions could be enhanced for bright stars. Since the last two catalogues are given in the FK5 system, some procedure to change their positions to HIPPARCOS system was necessary to compute the proper motion.

In view of the small extent of the observed field, the reference system transfer was accomplished simply by averaging the differences of the common PPM/SAO and HIPPARCOS stars.

4. Proper Motions

The first step in proper motion determination is the identification of the object in view in the available catalogues.

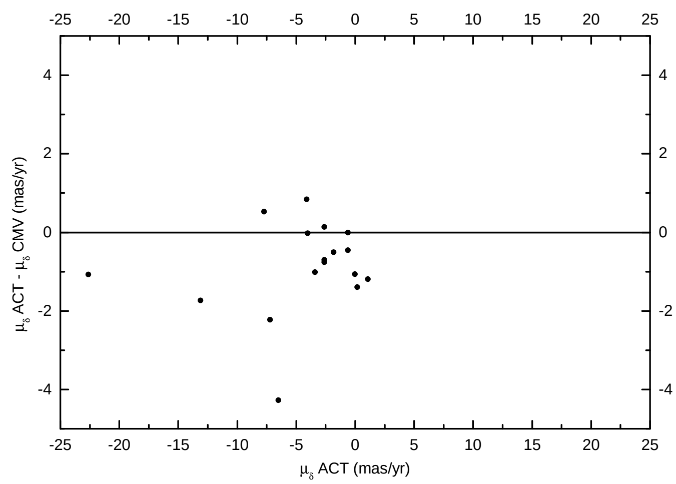

Fig. 1. Comparision of proper motions with ACT catalog in μ_δ

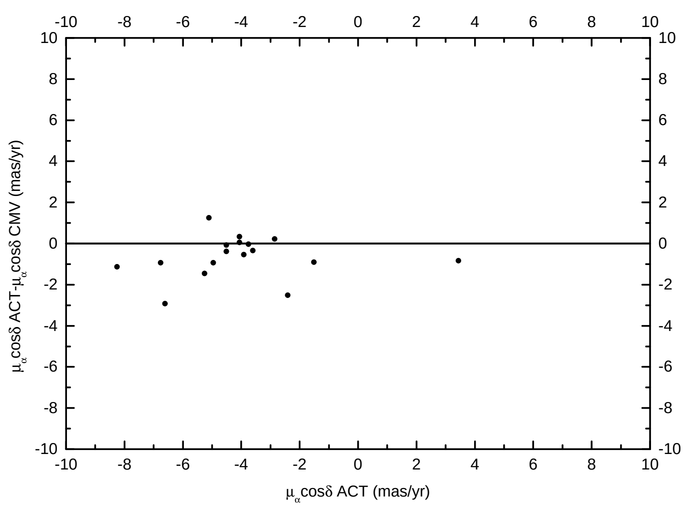

Fig. 2. Comparision of proper motions with ACT catalog in $\mu_\alpha \cos\delta$

Table 2. Catalogues's characteristics in the zone of the cluster NGC1662. For each catalogue, column 2 gives the positional standard error, column 3 gives the reference system, column 4 gives the number of stars within the zone, column 5 gives the mean epoch of observation and column 6 gives the magnitude limit.

Catalog	Mean Precision	System	n stars	Mean Epoch 1900.+	Magnitude Upper Limit
USNO–A2.0	$0''.25$	Hipparcos	8122	55	B and R $\leq$ 20
TAC	$0''.09$	Hipparcos	62	81	B $\leq$ 12
AC2000	$0''.30$	Hipparcos	348	07	B $\leq$ 13
Tycho	$0''.03$	Hipparcos	18	91	V $\leq$ 13
PPM North	$0''.30$	FK5	31	31	V $\leq$ 11
SAO	$0''.17$	FK5	29	40	V $\leq$ 9.5

Table 3. Positions and proper motions of stars in the region of the cluster NGC 1662. The coordinates are given for equinox J2000.0 and mean epoch of observation 1996.6. σ denotes the standard deviation. P is the estimated membership probability. In the last column are given the catalogues used to determine the proper motions of the stars: A=AC2000; P=PPM; S=SAO, T=TAC; U=USNO; Ty=Tycho. The numbers with '*' represent the sequence number in the appropriate zone of the USNO catalogue.

Tycho id.	α (J2000) hh mm ss	δ (J2000) ^{o} $'$ $''$	mag V	σ_α (mas)	σ_δ (mas)	μ_α (mas/yr)	μ_δ (mas/yr)	$\sigma_{\mu\alpha}$ (mas/yr)	$\sigma_{\mu\delta}$ (mas/yr)	P	
687 469 1	4 48 00.572	10 57 10.57	10.23	74	63	-4.5	-2.5	0.8	0.6	0.99	ATTy
3081 *	4 48 01.140	10 52 26.63	13.90	206	289	8.1	-16.9	8.9	10.2	0.66	U
3084 *	4 48 02.478	10 57 09.34	14.58	34	295	2.2	-9.8	7.4	10.3	0.58	U
230047	4 48 04.947	10 59 21.19	11.92	73	101	-0.3	0.9	1.2	1.4	0.60	A
687 472 1	4 48 15.119	11 00 33.75	11.41	49	58	-4.0	-0.6	0.6	0.8	0.99	ATy
687 277 1	4 48 15.987	11 01 04.43	09.11	69	62	0.1	4.8	0.9	1.1	0.00	APTTy
3088 *	4 48 21.615	10 54 19.72	14.32	87	90	-2.2	-9.8	7.6	7.7	0.63	U
230095	4 48 22.936	10 53 13.96	11.78	83	145	-2.1	-2.4	1.1	1.7	0.91	A
687 583 1	4 48 24.937	10 55 09.04	09.58	40	101	0.7	-0.1	0.8	0.5	0.02	APSTTy
687 61 1	4 48 26.386	11 00 42.60	10.94	24	51	-3.7	-1.2	0.9	1.0	0.98	ATTy
230104	4 48 27.311	10 55 14.43	11.28	132	31	5.1	-5.5	1.6	0.5	0.00	A
687 580 1	4 48 27.842	10 55 08.31	09.91	22	75	-1.7	0.8	0.9	0.8	0.76	APTy
687 481 1	4 48 27.872	10 55 45.60	10.54	14	60	0.3	-1.2	0.9	0.7	0.27	APTTy
230109	4 48 29.051	11 00 11.64	11.72	35	66	-2.8	-2.3	1.3	1.3	0.95	A
687 496 1	4 48 29.505	10 55 48.14	08.42	56	60	9.9	-0.7	1.3	1.1	0.00	PSTTy
3239 *	4 48 30.727	10 59 02.00	14.40	174	369	-4.0	-13.0	8.5	11.6	0.64	U
687 739 1	4 48 32.079	10 57 58.96	08.71	38	70	4.4	1.1	1.2	1.2	0.00	PSTTy
687 556 1	4 48 34.488	10 56 43.98	09.03	32	77	-2.0	-1.1	0.6	0.6	0.96	APSTTy
3260 *	4 48 35.437	11 00 16.72	13.89	154	269	-5.5	-14.7	8.2	9.9	0.71	U
467995	4 48 37.533	10 55 33.52	12.68	70	285	-1.4	-4.3	3.7	4.8	0.66	A
3283 *	4 48 39.896	10 53 33.32	14.86	21	355	7.7	-12.0	7.4	11.4	0.62	U
687 405 1	4 48 41.391	10 52 02.21	09.41	55	69	-3.6	-2.8	0.3	0.5	0.99	APTTy
687 664 1	4 48 42.208	10 59 33.27	10.84	50	36	-4.2	-1.2	0.4	0.5	0.99	ATTy
230145	4 48 43.306	10 50 31.87	12.56	53	87	-3.8	-3.1	1.5	1.4	0.96	A
687 555 1	4 48 44.426	10 53 21.32	09.47	60	26	0.8	-4.0	0.8	0.7	0.01	APTTy
3330 *	4 48 50.033	10 57 33.92	14.28	351	221	-7.7	-9.1	11.3	9.1	0.67	U
3359 *	4 48 56.021	10 55 47.40	14.90	240	95	2.9	-8.6	9.4	7.7	0.52	U
3373 *	4 48 58.183	10 54 33.25	14.39	11	237	4.8	-7.3	7.3	9.4	0.53	U
687 1284 1	4 49 00.580	10 50 33.04	11.75	75	47	-3.3	6.0	3.7	3.4	0.77	ATy

Next, we carried out a standard linear weighted least squares solution for the proper motion, with the weights taken from each individual catalogue documentation.

4.1. Comparison with ACT proper motions

To check the quality of our proper motions, we determined the mean square differences for 17 common objects with ACT catalogue (Urban et al. 1998b) obtaining 1.4 mas/yr and 2.1 mas/yr in μ_δ and $\mu_\alpha \cos\delta$.

In spite of the near equality between our proper motions and those of ACT (Figs. 1 and 2), we must refrain from making definitive conclusions, since the first epoch for both catalogues is the same, so that strong correlation between both sets is likely.

5. Membership Determination

Usually, the most accurate way to distinguish cluster members from field stars is based on kinematic data, specially on proper motions obtained with long time interval between measured positions (van Leeuwen 1985).

To determine the membership probabilities of each observed star we adopted the Vasilevskis & Rach (1957) method to provide initial values of the parameters to be used in Sanders (1971), Uribe & Brieva (1994) and Zhao & He (1990) methods.

According to the method suggested by Zhao et al. (1982), proper motions different from the mean by more than four times the standard deviation were discarded.

As expected, the results obtained by all methods were very similar. We consider that the finest results were those obtained by means of the Zhao & He method, since heterogeneity can be accommodated to the data accuracy.

In Table 4 we can see the distribution parameters determined by the Zhao & He (1990) method. The meaning of the symbols in Table 4 are as follows: N_c is the cluster stellar contents; N_f is the number of field stars; (μ_{xc},μ_{yc}) are the cluster proper motions in x and y; (μ_{xf},μ_{yf}) are the mean proper motions of field stars in x and y; (σ_{xf},σ_{yf}) are the dispersions in x and y of the field stars proper motions; σ_c is the dispersion of cluster stars proper motions and θ is the orientation angle of the minor axis of elliptical field stars proper motions distribution.

With the frequency function parameters we could determine the individual probability of the membership of each star in the cluster, as suggested by Zhao & He (1990).

In Table 3 we give the kinematic parameters of stars observed by the VMC in the cluster field.

6. Conclusions

The determination of proper motions by means of combining present epoch observations with ancient positions, is a simply obtainable and valuable source of information on stellar kinematics.

Table 4. Parameters obtained from Zhao and He method to NGC 1662.

N_c	μ_{xc} (mas/yr)	μ_{yc} (mas/yr)	σ_c	
20	-3.2	-1.6	0.6	
N_f	μ_{xf} (mas/yr)	μ_{yf} (mas/yr)	σ_{xf}	σ_{yf}
10	2.4	-1.2	3.8	4.0
θ				
72.4°				

In this paper we have combined our meridian circle observations with the ninety years old AC2000 positions and other data to asserting the membership of 30 stars in the NGC1662 neighbourhood. The results are that 20 of these stars have high membership probabilities. We have obtained the overall cluster proper motion, namely, $\mu_l = -3.6$ mas/yr and $\mu_b = 0.6$ mas/yr, in galactic coordinates.

Acknowledgements. We would like to thank Dr. J. Lépine, Dr. N. Zacharias and Dr. S. Urban for their suggestions and we are specially grateful to Mr. W. Monteiro for his collaboration in the observations at Valinhos, as well as all those who contributed to this work. W. S. Dias is supported by CNPq.

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