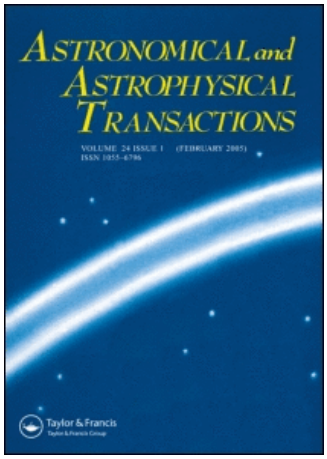

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Analysis of USNO-B1 proper motions of stars in open-cluster fields

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USNO-B1 proper motions for stars in the fields of NGC 457 and χ and h Per open clusters are analyzed and compared to the the proper motions based on plate material taken with normal astrographs. USNO-B1 proper motions in central regions of clusters are found to have large errors due mostly to numerous misidentifications in crowded fields. At the same time, USNO-B1 proper motions for the rest of cluster stars proved to compare fairly well to those inferred in classical astrometric studies. Standard deviations of the proper-motion differences between USNO-B1 and cluster proper-motion studies are found to be on the order of 3.4–4.2 mas yr^{-1}.

Keywords: astrometry; proper motions; open clusters

1. Introduction

In recent years, many authors (see, e.g., [1]) began to use USNO (United States Naval Observatory) catalogs extensively to study open clusters. Following the three consecutive releases USNO-A0, USNO-A1, and USNO-A2, an essentially new version of the catalog, USNO-B1, has been published [2]. It contains the data for a total of 1 045 913 669 objects (stars and galaxies) based on the measurements of 3 668 832 040 individual images on 7435 Schmidt plates taken during the last 50 years. The catalog contains right ascensions and declinations (accurate to 200 mas), proper motions, and magnitude estimates. The latter, unfortunately, have low accuracy and contain various random errors and biases [3]. Comparison of USNO data with other astrometric catalogs in order to identify particular errors and other inaccuracies is undoubtedly a task of great importance. Below we perform thorough analyses and comparisons to estimate the errors of USNO-B1 proper motions, their nature, and some specifics of their use for the studies of the kinematics of open-cluster stars.

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2. Analysis

We begin with the analysis of USNO-B1 proper motions. The latter were determined using digitized images of several photographic sky surveys. Moreover, USNO-B1 is based on the measurements of plates taken with Schmidt telescopes, which are by no means purely astrometric instruments. In the classical technique, stellar proper motions are to be determined from the first and second-epoch plates taken on the same long-focus astrograph, preferrably, at the same hour angles and greatest possible epoch difference. All this makes it necessary to compare stellar proper motions based on observations made with normal astrographs with the USNO-B1 proper motions in order to assess the accuracy of the results obtained. Note that the reliability of the proper motions inferred from the differences of stellar positions on the first- and second-epoch plates also depends on correct identification of stars in these sources. Unfortunately, automatic identification in crowded fields is not always confident, as pointed out by the authors of USNO-B1. Despite the identification problems just mentioned, USNO catalogs are widely used to study open clusters. In view of these problems, Kharchenko *et al.* [1] performed extensive analysis of open clusters based on ASCC-2.5 and USNO-A2.0 catalogs: they determined the proper motions in wide fields of open clusters and identified probable members for 401 clusters (and for the first time for 181 clusters).

Let us now compare USNO-B1 with other known astrometric catalogs. In this paper, we report the results of the comparison of proper motions of stars based on observations made with homogeneous astrometric telescopes (identical normal astrographs in Pulkovo and Tashkent) with the corresponding USNO-B1 proper motions using the field of the open cluster NGC 457 as an example. To this end, we cross identified the catalogs of Lavdovsky [4] and Latypov [5], and USNO-B1 catalog in order to assess the errors of the proper motions listed in these catalogs.

Lavdovsky [4] determined the proper motions for 905 stars based on two pairs of plates taken with Pulkovo normal astrograph with an epoch difference of 46 years. The standard error of the proper motions listed in this catalog is equal to 3.5 mas yr^{-1}. The proper motions of 659 stars determined by Latypov [5] are based on the plates of NGC 457 taken with Tashkent normal astrograph. Latypov [5] used four plate pairs with an epoch difference of 42.26 years. The standard error of a single proper-motion determination was equal to $\pm$ 2.4 mas yr^{-1}. The third catalog, as mentioned above, is based on the measurements of digitized stellar images on Schmidt plates with the epoch difference on a par with those of the first two catalogs (up to 50 years). Cross identification yielded 344 common confidently identified stars in the catalogs of Lavdovsky [4] and Latypov [5] and 87 common stars in the catalogs of Lavdovsky [4] and USNO-B1 (with known proper motions). This allowed us to compare the proper motions of these stars listed in three catalogs and list the results in table 1.

The results of our comparison show that the proper motions of some USNO-B1 stars in the central regions of open clusters differ substantially from the results of Lavdovsky [4] and Latypov [5]. Stars with large (500 to 1000 mas yr^{-1} and higher) proper motions in this region proved to be misidentified in the USNO-B1 catalog in most of the cases (e.g., star No. 1482-60558 with $\mu_x = -646$ mas yr^{-1} and $\mu_y = 482$ mas yr^{-1}). With high proper motion stars excluded and proper motions reduced to a single system, the results of the three determinations agree well with each other.

Thus we estimated the standard errors of proper-motion differences between the three catalogs:

$$\sigma_{Lavdovsky-Latypov} = \pm 3.2\, mas\ yr^{-1},$$

$$\sigma_{Lavdovsky-USNO-B1} = \pm 4.1\, mas\ yr^{-1},$$

$$\sigma_{Latypov-USNO-B1} = \pm 4.2\, mas\ yr^{-1}.$$

Table 1. Numbers and proper motions (in mas yr^{-1}) of selected stars in the NGC 457 open cluster according to the catalogs of Latypov (1972), Lavdovsky (1961), and USNO. Stars misidentified in the USNO-B1 catalog are shown in bold type.

			Latypov		Lavdovsky		USNO-B1	
$N_{Latypov}$	$N_{Lavdovsky}$	$N_{USNO-B1}$	μ_x	μ_y	μ_x	μ_y	μ_x	μ_y
41	96	1480-0055210	31	−6	30	−8	36	−8
53	120	1481-0056905	55	−23	63	−19	58	−24
200	**264**	**1481-0058244**	**−5**	**−6**	**1**	**0**	**58**	**174**
205	268	1483-0056542	−10	−10	−15	−5	−12	−12
209	**275**	**1481-0058294**	**2**	**1**	**3**	**5**	**88**	**−24**
212	273	1480-0056875	1	−3	1	6	6	−4
225	287	1483-0056625	−13	6	−8	5	−6	0
264	**345**	**1483-0056870**	**−4**	**−4**	**−2**	**−1**	**−180**	**330**
265	**349**	**1483-0056895**	**−3**	**−3**	**5**	**−1**	**−206**	**16**
315	**412**	**1483-0057151**	**−2**	**1**	**−4**	**3**	**−86**	**398**
320	400	1482-0060297	−1	−1	−1	10	−6	−6
321	415	1482-0060333	−5	−4	−4	−9	−2	−6
322	**416**	**1482-0060324**	**−4**	**−1**	**0**	**−2**	**108**	**−150**
325	**423**	**1481-0058859**	**4**	**−3**	**7**	**0**	**24**	**−16**
334	**437**	**1482-0060396**	**−8**	**−1**	**2**	**−1**	**−238**	**342**
335	**439**	**1482-0060425**	**1**	**−8**	**−1**	**−2**	**−222**	**106**
337	436	1483-0057248	10	−5	5	−2	4	4
345	**420**	**1482-0060340**	**−3**	**2**	**6**	**−1**	**22**	**−24**
364	**465**	**1483-0057361**	**2**	**−3**	**−8**	**−2**	**72**	**−44**
376	**476**	**1482-0060558**	**4**	**−1**	**1**	**−2**	**−646**	**482**
395	501	1484-0048443	−8	−7	−6	−3	−10	−8
407	512	1481-0059168	8	−4	7	−7	10	12
420	526	1482-0060713	92	−6	91	−6	92	4
422	529	1486-0043205	4	−3	3	−1	−4	−2
440	555	1482-0060826	−40	−50	−33	−42	−32	−52
446	560	1483-0057799	−1	1	−3	3	−4	−4
448	565	1480-0057995	0	−3	9	0	10	2
455	577	1484-0048780	−9	−1	−9	−7	−6	−14
473	608	1483-0058116	14	9	15	11	12	10

To verify these conclusions, we also made similar comparisons in the field of χ and h Per. Our sources of initial data for comparing with USNO-B1 were the catalog [4] based on three pairs of plates taken with Pulkovo normal astrograph with an epoch difference of 53.90 years and a catalog error of $\sigma = \pm 2.0$ mas yr^{-1} and the catalog of Muminov [6] based on three pairs of plates taken with Tashkent normal astrograph with an epoch difference of 80 years ($\sigma = \pm 1.9$ mas yr^{-1}). The field considered is more crowded than the NGC 457 field, making identification much more difficult. Many bona fide cluster members in the central regions of χ and h Per proved to have large proper motions in USNO-B1 catalog. With such misidentified stars excluded, we determined the following standard errors based on more than 500 remaining common stars:

$$\sigma_{Lavdovsky-Muminov} = \pm 2.5\, mas\ yr^{-1},$$
$$\sigma_{Lavdovsky-USNO-B1} = \pm 3.8\, mas\ yr^{-1},$$
$$\sigma_{Muminov-USNO-B1} = \pm 3.4\, mas\ yr^{-1}.$$

3. Conclusions

As is evident from the above, the comparison errors of the proper motions taken with single-type normal astrographs are significantly lower than normal astrograph minus USNO-B1

comparison errors. Thus our analysis of USNO-B1 data for three open clusters leads us to conclude that:

– Beyond the central parts of open clusters USNO-B1 proper motions agree well with the proper motions based on normal-astrograph catalogs and can be successfully used to study open star clusters.
– USNO-B1 proper motions of some of the stars in the central regions of open star clusters are evidently overestimated and cannot be used, in particular, because of problems with stellar identification.
– For stars in central regions of open clusters the proper motions based on normal-astrograph observations should be preferred.

Note that a somewhat different comparison between USNO-B1 and Pulkovo catalogs [7] was made in selected fields almost free of crowded regions by the laboratory of astrometry and Galactic astronomy of the Main Astronomical Observatory of the Russian Academy of Sciences. (See http://www.gao.spb.ru/personal/lfoa/LAZA/WIN/page_31.html), which also revealed various systematic errors.

Our future plans include scanning the plates taken with the Tashkent normal astrograph and double Zeiss astrograph in order to create a library of digitized images in the declination zones from -2 to $+20$ degrees and in some sky areas up to the North Pole. This project will complement USNO-B1 data and, in particular, allow a number of open clusters to be studied, many of them for the first time.

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