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STARS WITH HIGH PROPER MOTIONS IN THE MODERN CATALOGS OF THE CDS DATABASE

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ABSTRACT. Stars with high proper motions, for the most part, are objects located in the solar neighborhood within 100 parsecs. These stars are important targets for a wide range of astrophysical problems, but the accuracy of the results depends on the completeness of the star samples. The uniform distribution over the celestial sphere is also important for kinematic studies. There are two catalogs of the fast stars in northern hemisphere, while only scattered lists of such stars are available for southern hemisphere. This paper presents the results of analysis of samples of stars with proper motions exceeding 150 mas/year from the modern catalogs of astronomical database CDS (PPMXL, SPM4, UCAC4, XPM, APOP, LSPM, Tycho2, URAT1 and WISE). Results of pairwise mutual cross-identification of the samples have shown that modern astrometric catalogs contain a significant number of false identifications of stars with large proper motions, and the total number of common stars in the resulting samples is extremely small and is not more than 20% on average.

Keywords: astronomical database, astronomical catalogs, stars: high proper motions stars

1. Introduction

Currently there are only a few ad hoc catalogs with the high proper motions (HPM) submitted in Strasburg database.

The most complete catalogs of stars with proper motions are the LSPM catalog based on the results of DSS scans from Palomar Sky Surveys (POSSI and POSSII) (Lepine et al., 2005) and compiled catalog **HPM-v2** maintained by the Main Astronomical Observatory of the National Academy of Sciences of Ukraine (Ivanov, 2008).

Both catalogs contain only stars in the Northern Hemisphere. The LSPM catalog contains 61 977 stars up to 21^{m} with proper motions of more than 150 mas/yr . The catalog is 98% full for the stars up to 19^{m}. The **HPM-v2 catalog** is created on the **FONAK 1.0** (Kislyuk et al., 1999) proper motions and 770 other available astronomical catalogs and sources. The catalog contains information about 618 238 stars with proper motions more than 40 mas/yr up to 16^{m}. The limiting magnitude up to 17^{m} for stars belong to double or multiple system.

The **NLTT** Catalogue (Luyten, 1980) and **Revised NLTT Catalog** (Salim, 2003) are catalogs that cover whole celestial sphere. **NLTT** Catalogue contains 58 845 stars with proper motions more than 200 mas/yr. **Revised NLTT Catalog** include 36 085 stars over whole sky, but these catalogs are not complete and their stars are unevenly distributed over the sky (see Figure 1).

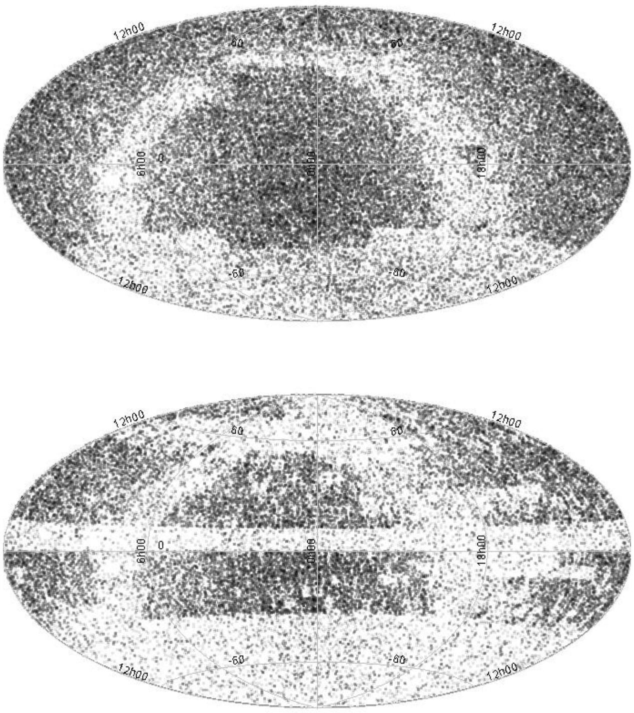

Figure 1: Distribution stars of the **NLTT** (up) и **Revised NLTT** (down) over celestial (Aitoff projection, equatorial coordinate system)

Over the last twenty years some large catalogs with stars proper motions become available for studies. Table 1 is given the catalog list that can be used for search and selection data with high proper motions stars. The list of catalogs in table 1 includes also catalog ALLWISE (Cutri et al., 2013). In this catalog, there are no proper motions. We used “d2M” field (distance separating the positions of the WISE source and associated 2MASS PSC (Cutri et al., 2003) source) for selection HPM stars. Since the mean observational epoch of WISE survey is 2010.55, only stars in range from 1.5″ to 3.0″ were chosen. The value 3.0 is declared as a maximal value which is used for cross-identification between 2MASS and ALLWISE data.

Table 1. Input catalogs.

Catalog, year	Limit Mag	Number of stars	Declination
LSPM, 2005	V 19.0	61 977	+0° — +90°
HPM-v2, 2008	V 16	618 238	–2.5° — +90°
APOP, 2015	R 20.8	100 774 150	–90° — +90°*
Tycho2, 2000	V 11.5	2 539 913	–90° — +90°
PPMXL, 2010	V 20	910 469 430	–90° — +90°
SPM4, 2011	V 17.5	103 319 647	–90° — –20°
UCAC4, 2012	R 16	113 780 093	–90° — +90°
URAT1, 2015	R 18.5	228 276 482	–24.8°— +90°
XPM, 2011	B 19	313 610 083	–90° — +90°
ALLWISE, 2013	W 17.1	747 634 026	–90° — +90°

* - Except for ±20° from Galactic Ecquator

2.Processing and Results

At the first stage samples of stars with proper motions more 150 mas/yr were selected from HPM-v2 catalog. Then cross-identification between HPM-v2 and LSPM catalogs in common declination zone were made. The size of search window was 1″. The number of common stars was only 17 435. The distribution of HPM stars from **HPM-v2** (41 550 stars), **LSPM** (61 515 stars) and their common stars over celestial sphere are given in Figure 2. As can you see, if the initial samples have demonstrated conspicuous concentration of stars in the plane of the galactic equator then the distribution of the common stars is rather uniformly. Possible reasons for this fact are the difficulties in cross-identifying of the fields with high density of stars and large errors of the star proper motions in this region.

Table 2. Number of high proper motion stars.

Catalog	Number of stars with PM ≥150мсд/год		
	All	0≤δ≤90	-90≤δ<0
LSPM	61 977	61 977	0
Hpm-v2	41 550*	40 034	1 516
APOP	21 499	5 894	15 605
Tycho2	16 673	8 202	8 471
PPMXL	75 628 403	24 416 790	51 211 613
PPMXL*	5 679 268	1 869 585	3 809 683
SPM4	212 685	—	212 685
UCAC4	968 245	59 319	908 926
URAT1	690 982	547 135	143 847
WISE	11 902 471	4 263 856	7 638 615
XPM	4 272 089	144	4 271 945

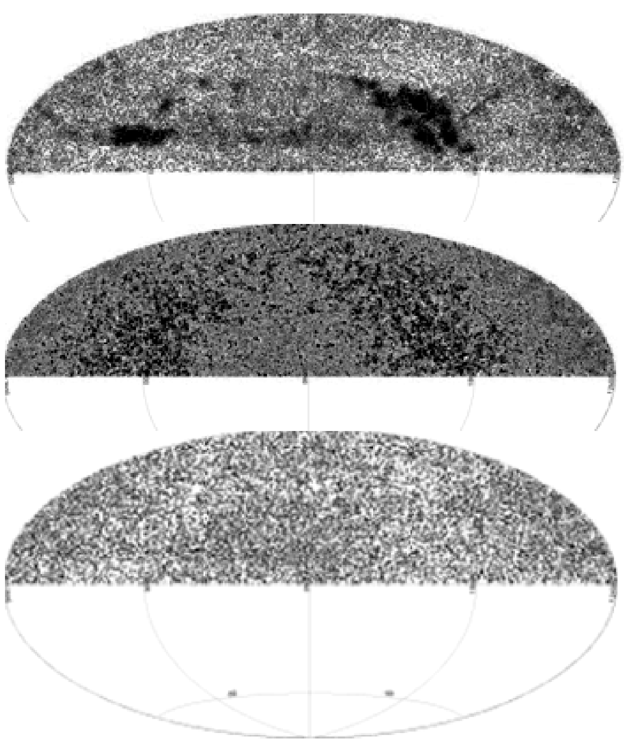

Figure 2: The distribution of HPM stars from **HPM-v2** (1), **LSPM** (2) and their common stars over celestial sphere (Aitoff projection, equatorial coordinate system).

At the next stage the samples with HPM stars were selected from the modern astrometric catalogs listed in the table1. The table 2 contains the results of this selection separately for Northern and Southern hemisphere. As can be seen, the number of Southern HPM stars is several times higher than the number of Northern HPM stars in PPMXL (Roser, 2010), UCAC4 (Zacharias et al., 2012), URAT1 (Zacharias et al., 2015) catalogs.

For ALLWISE data the number of entries with "d2M" more 1.5″ amounted to almost 12 million, and the number of HPM stars for Southern hemisphere here is also twice more than Northern one.

The HPM stars in XPM catalog (Fedorov et al., 2011) are almost lacking in the Northern hemisphere. Catalog XPM also contains incredibly large number of stars with high proper motions in Southern hemisphere.

The total number of HPM PPMXL stars exceeds 75 million. Roser et al. pointed to vast majority of PPMXL stars with high proper motion must be fakes. There are two lines corresponded PPMXL data in table 2. The second line (PPMXL*) gives the number of HPM stars with 2MASS flag identification. The obtained number of the Southern HPM stars is comparable with value obtained for XPM catalog for this region. The possible explanation of this fact could be the same underlying surveys, but the distribution of HPM stars from PPMXL catalog (see figure 3) have shown the plate structure unlike a similar distribution for XPM catalog.

Probably, the most part of the Southern UCAC4 HPM stars are also fakes.

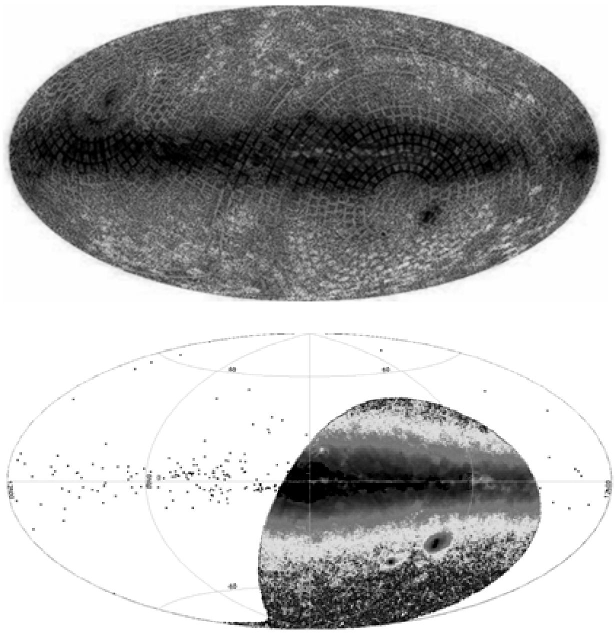

Figure 3: The distribution of HPM stars from **PPMXL** (up) and **XPM** (down) over celestial sphere (Aitoff projection, galactic coordinate system).

The pairwise mutual cross-identification of the selected HPM samples were performed. The results of search common HPM stars between different catalogs are given in table 3. The cross-identification was made with search radius of 1″. The obtained number of common stars for all pairs is very small and not exceeds 5% of the total volume of compared samples.

Table 3. The results of the pairwise mutual cross-identifications between different catalogs.

Cross-matched Catalogs	**Common stars**		
	All	**North**	**South**
PPMXL-WISE	99 440	45 705	53 735
SPM4-WISE	13 539	-	13 539
UCAC4-WISE	44 585	24 968	19 617
URAT1-WISE	72 081	61 422	10 659
XPM-WISE	27 701	-	27 701
PPMXL-XPM	238 691	115	238 576
XPM-UCAC4	10 573	7	10 566
SPM4-UCAC4	17 910	-	17 910
URAT1-UCAC4	24 106	21 493	2 613

The cross-identification between **LSPM** catalog and some catalogs from table 1 was performed for samples of Northern declination zone. These results are given in table 4.

Taking into account the limiting magnitudes of the given catalogs, should be assumed that the URAT1 catalog is not complete with respect to the HPM stars in the Northern hemisphere.

Table 4. The cross-matching results with LSPM catalog.

Catalog	All	Common with LSPM
UCAC4	59 319	32 990
URAT1	547 135	36 777
HPM-v2	41 550	17 461
PPMXL*	1 869 585	51 054

3. Conclusions

The samples of stars with proper motions more 150 mas/year were chosen from some modern catalogs CDS database. The number of common HPM stars obtained from results of mutual pairwise cross-identifications between different catalogs is not more than 5 % of total volume of compared samples.

There are three main reasons complicated the studies of high proper motion stars:

1) actual proper motions accuracy in Galactic plane is much worse than declared accuracy of individual catalogs;

2) there are no whole celestial sphere catalogs with high accuracy astrometric positions for stars fainter than $16\text{-}17^{mag}$;

3) the different limiting magnitudes and photometric bands create certain complexities by doing catalogs cross-matching.

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