THE XPM CATALOGUE AS A REALISATION OF THE EXTRAGALACTIC REFERENCE SYSTEM IN OPTICAL AND NEAR INFRARED WAVELENGHS

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ABSTRACT. The analysis of the absolute proper motions of the XPM catalogue is shortly presented in this article. It is shown that coordinate axes, given by the XPM catalogue, have ambiguities of rotations relative to the LQAC quasars and ICRF2 sources less than 0.2 mas/yr. In our opinion the XPM catalogue is the independent as to proper motions realization of the ICRS system in optical and near infrared ranges of wavelengths. The XPM star proper motions were compared with those from modern catalogues UCAC-3 and PPMXL. It is concluded that the proper motions of stars in these modern catalogues have considerable random and systematic errors.

1. INTRODUCTION

The final version of the XPM catalogue compiled on the basis of 2MASS (Skrutskie et al. 2006) and USNO 2.0 (Monet D. et al. 1998) catalogues is presented. The XPM catalogue (Fedorov et al. 2009, 2010) contains positions and absolute proper motions of about 300 million objects covering the whole sky in the magnitude range $10^m < B < 22^m$ as well as the standard J, H, K, B and R magnitudes. Positions in the XPM are referred to the HCRF (Kovalevsky et al. 1997) for the 2000 epoch. The Catalogue contains proper motions over the whole sky without gaps. In the fields, which cover the zone of avoidance or which contain less than of 25 galaxies the so-called quasi absolute calibration was performed. The proper motion errors are varying from 3 to 10 mas/yr depending on a field under consideration. The zero-point of the absolute proper motion frame (the absolute calibration) was derived by using more than 1.1 million galaxies from 2MASS and USNO-A2.0. The mean formal error of absolute calibration is less than 1 mas/yr. The XPM Catalogue will be available via CDS in Strasbourg in 2010.

2. THE INVESTIGATION OF ABSOLUTE PROPER MOTIONS STARS IN THE XPM

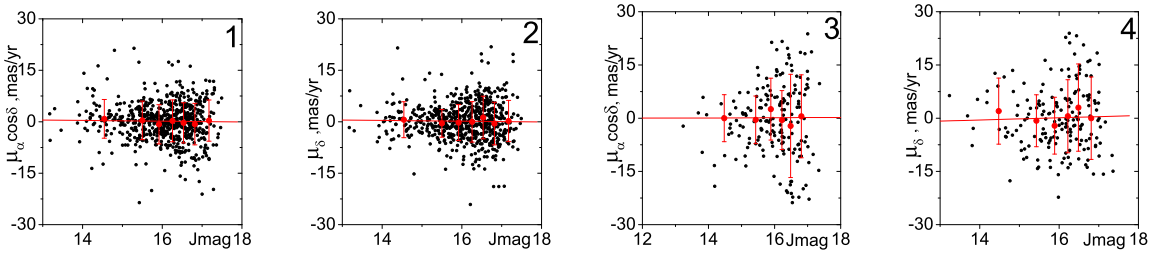

Figure 1: Scatter of individual formal proper motions of optical counterparts of ICRF2 sources as a function of magnitude J. 1, 2 - Northern hemisphere, 3, 4 - Southern hemisphere.

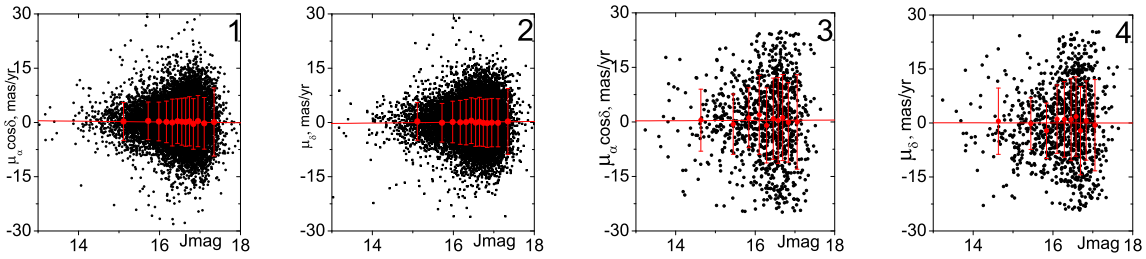

Figure 2: Scatter of individual formal proper motions of LQAC quasars as a function of magnitude J. 1, 2 - Northern hemisphere, 3, 4 - Southern hemisphere.

Below we present some results of investigations of the XPM catalogue and brief information for possible users of the Catalogue. For analysis of quality of the proper motions of the XPM stars the different tests have been made. About 1000 optical counterparts of ICRF2 (Arias et al. 2009) sources and a few tens thousands LQAC (Souchay et al. 2009) quasars were identified among the XPM catalogue objects. These objects were not used in procedure of the absolute calibration of proper motions. Therefore formal proper motions were obtained for them in the same way as for stars. So far as these objects are the extragalactic point sources we expect that their mean proper motion should be zero. The analysis was made for northern and south hemisphere separately since the initial data for them are given by different surveys. Scatters of individual formal proper motions of optical counterparts of ICRF2 sources and LQAC quasars as a function of magnitude J are shown in Fig. 1 and Fig. 2. The red solid circles and lines show the mean values and standard deviations respectively. The mean value of formal proper motions of ICRF2 sources and LQAC quasars are less than 0.2 mas/yr. The standard deviations for ICRF2 sources are estimated to be approximately from 4-8 mas/yr (north) to 6-10 mas/yr (south) and for LQAC quasars are estimated to be approximately from 3-8 mas/yr (north) to 7-12 mas/yr (south).

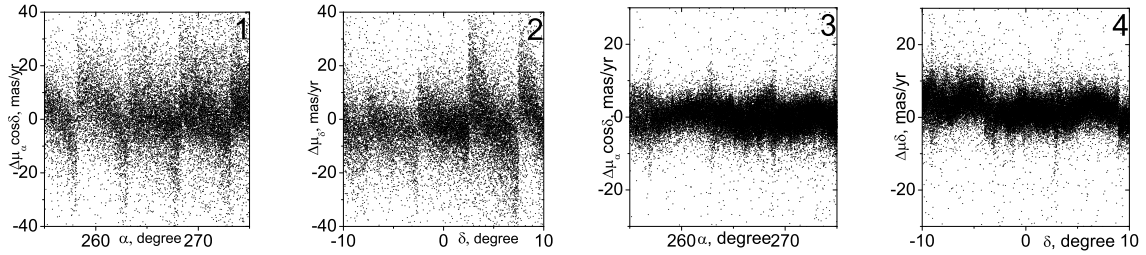

Figure 3: The individual differences of proper motions of stars (XPM - UCAC-3.0; 1, 2) and (XPM - PPMXL; 3, 4) in selected fields as a function of RA end Dec

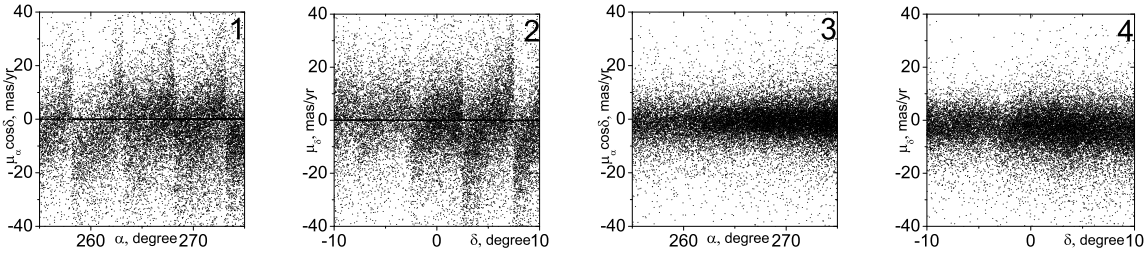

Figure 4: The proper motions of stars UCAC-3.0 (1, 2) and XPM (3, 4) in selected fields as a function of RA end Dec

Any difference of mean value of formal proper motions of extragalactic sources from zero we regard as

the residual rotation of coordinate axes given by the XPM. The dispersions of formal proper motions of extragalactic sources characterize the random errors of proper motions of point sources in corresponding magnitude range. Performed tests definitely indicate that the coordinate axes, given by the positions of XPM catalogue for fixed epoch are non-rotating with respect to distant extragalactic objects to within ± 0.20 mas/yr. Thus we can conclude that the coordinates and the derived absolute proper motions of the XPM stars materialize the ICRS (Arias et al. 1995) in optical and near infrared ranges of wavelengths.

3. COMPARISON OF XPM WITH OTHER CATALOGUES OF PROPER MOTIONS

1. The individual differences of proper motions of stars (XPM - UCAC3 and XPM - PPMXL) in the selected fields were calculated. We have found, that proper motions of the UCAC-2, UCAC-3 catalogues (Zacharias et al. 2004, 2010) are distorted by the appreciable systematic errors. Although the mean proper motions from field to field behaves quite smoothly, the breaks at the borders of fields are very large and reach a value 40 mas/yr (Fig. 3). One can see also that proper motions of the PPMXL catalogue (Roeser et al. 2010) also contain the breaks which are considerably less than in the UCAC-3 and reach about 5-10 mas/yr.

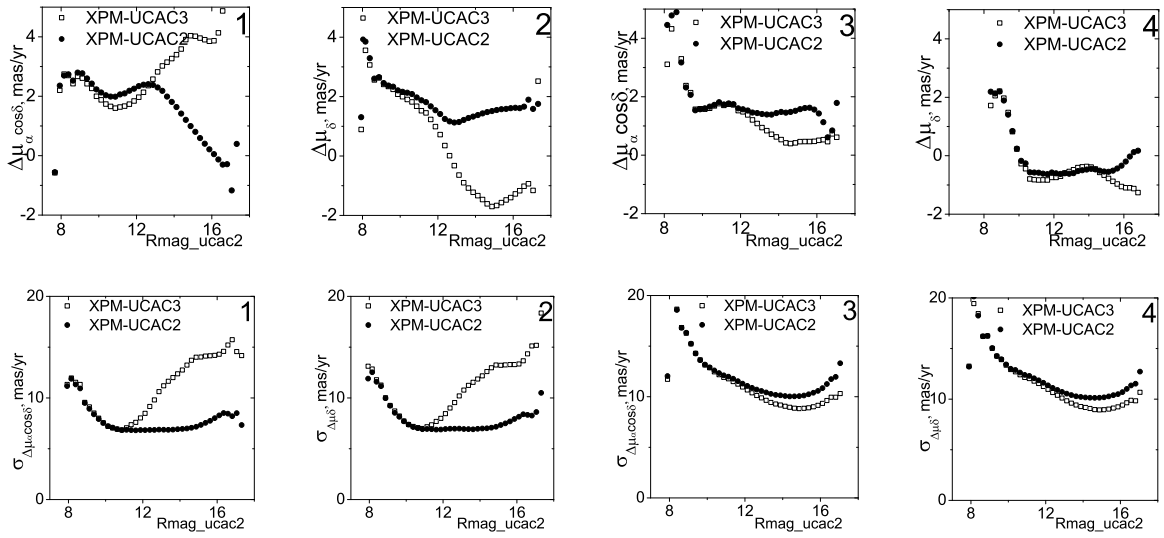

Figure 5: The systematic differences of proper motions (XPM-UCAC2) and (XPM-UCAC3) (top panel) as well as their dispersions (bottom panel), depending on the magnitude R of UCAC2. 1, 2 - Northern hemisphere, 3, 4 - Southern hemisphere

The noted facts should be taking into account in course of kinematical investigations as well as in astrometric applications. Since the majority of modern high-precision observations are executing with CCD in the fields with size about several tens arc minutes the results obtained from these observations due to breaks can be erroneous. For the comparison the UCAC-3 and the XPM proper motions as a function of the coordinates for the same fields are presented in Fig. 4. As can see the XPM proper motions have not considerable distortions.

2. The systematic differences of proper motions (XPM-UCAC2), (XPM-UCAC3) and (XPM-PPMXL) as well as their dispersions, depending on the magnitude were computed.

The systematic differences of proper motions between the UCAC-2.0, UCAC-3.0, PPMXL and the XPM catalogues are shown in Figs. 5 and 6 for the Northern and Southern hemispheres, respectively. Undoubtedly, the systematic differences of proper motion (UCAC-2.0-UCAC-3.0) for the Northern and Southern hemispheres are the most intriguing feature. It could be a result of using the early epoch the Schmidt plate data from the SuperCOSMOS project.

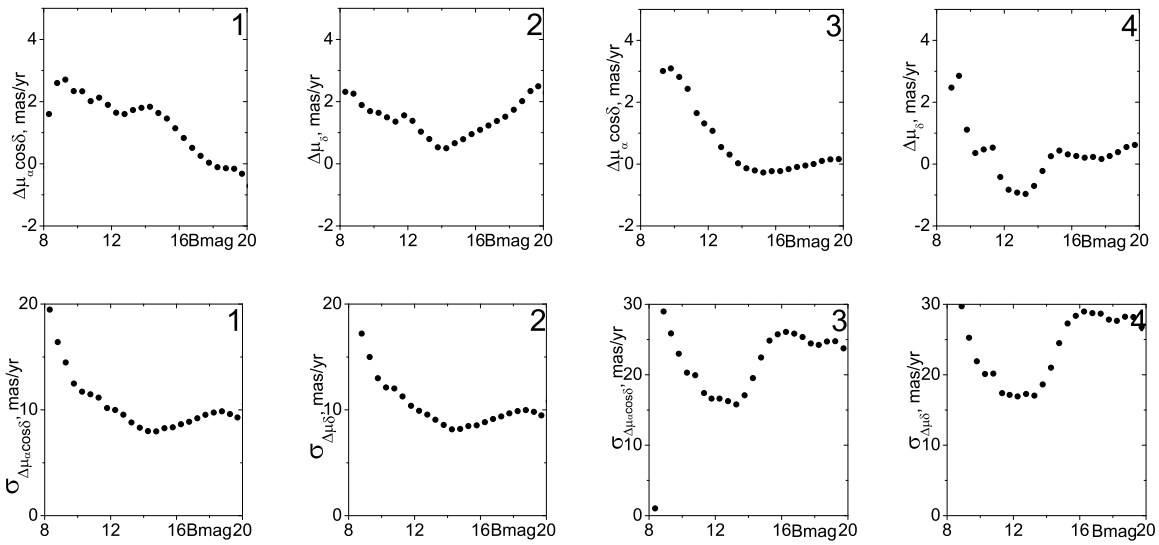

Figure 6: The systematic differences of proper motions (XPM-PPMXL) (top panel) as well as their dispersions (bottom panel), depending on the magnitude B of PPMXL. 1, 2 - Northern hemisphere, 3, 4 - Southern hemisphere.

4. SUMMARY

In our opinion the XPM catalogue is very important for astrometry as it makes possible to realize the global quasi-inertial coordinate system in the magnitude range $10^m < B < 22^m$. The coordinates and proper motions of the XPM sources are referred to the International Celestial Reference System in optical and near infrared ranges of wavelengths. The reached accuracy of determination of the residual rotation of the XPM system is about $\pm$ 0.20 mas/yr. In addition to astrometry, the data of this catalogue could be used for determining the kinematical parameters of the Galaxy, for example, in the framework of the OgorodnikovMilne model.

5. REFERENCES

Arias E. F., Charlot P., Feissel M., Lestrade J.-F., 1995, "The extragalactic reference system of the International Earth Rotation Servise, ICRS", A&A , 303, pp. 604-608.

Arias E. F. et al., 2009, "The Second Realization of the International Celestial Reference Frame by Very Long Baseline Interferometry", IERS Technical Note No. 35.

Fedorov P.N., Myznikov A.A., Akhmetov V.S., 2009, "The XPM Catalogue: absolute proper motions of 280 million stars", MNRAS , 393, pp. 133-138.

Fedorov P.N., Akhmetov V.S., Bobylev V.V. and Bajkova A.T., 2010 "An investigation of the absolute proper motions of the XPM catalogue", MNRAS , 406, 1734-1744

Kovalevsky J. et al., 1997,"The Hipparcos Catalogue as a realisation of the extragalactic reference system", A&A 323, p. 620-633

Monet, D., 1998, The 526,280,881 Objects In The USNO-A2.0 Catalog, A&AS Bulletin of the American Astronomical Society, Vol. 30, p.1427

Roeser S, M. Demleitner and Schilbach E, 2010, The PPMXL Catalog of Positions and Proper Motions on the ICRS. Combining USNO-B1.0 and the Two Micron All Sky Survey (2MASS), AJ 139 p. 2440-2447

Skrutskie M.F. et al., 2006, "The two Micron All Sky Survey (2MASS)", AJ , 131, 1163

Souchay J., et al., 2009, "The construction of the large quasar astrometric catalogue (LQAC)", A&A 494, p. 799-815

Zacharias N., et al., 2004, "The Second US Naval Observatory CCD Astrograph Catalog (UCAC2)", AJ 127 p. 3043-3059

Zacharias N., et al., 2010, "The Third US Naval Observatory CCD Astrograph Catalog (UCAC3)", AJ 139 p. 2184-2199.