COMPARATIVE ANALYSIS OF PROPER MOTIONS OF STARS IN OPEN CLUSTERS BY USING VO TOOLS

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ABSTRACT. Astrometric catalogues such as Tycho2, Mobitel1, CSOCA, XPM, PM2000, SDSS-DR9 were used for cross identification of stars, visualization of proper motions and further data processing by using available Virtual Observatory (VO) Tools: cross-match service (CDS, Strasbourg), TopCat, Aladin. The coefficients of linear correlation for common stars as well as the standard deviations for differences of proper motions were determined for at least ten pairs of catalogues to compare the accidental errors and the systematic biases between the given data sets.

Key words: open clusters and associations: general – proper motions – virtual observatory tools

1. Introduction

Stars in open clusters of our Galaxy have been studied for more than fifty years to determine cluster membership probabilities for each star and astrophysical parameters for each cluster. Modern VO tools enable us to carry out quick and easy comparative analysis of stellar proper motions (PM) taken from different astrometric catalogues by using cross identification of stars, necessary data processing, graphic presentation of data, visualization of PM. The main aim of this work is to apply new possibilities in comparative analysis of stellar PM by using VO tools.

2. Cross Identification of Stars

There are several possible ways to carry out cross identification of stars by using VO tools such as xMatch, TopCat [5], Aladin [1]. New version of TopCat (version 4.2) released in July, 2014 contains the new CDS xMatch window, which enables us to match a loaded local table or catalogue against any VizieR or SIMBAD table.

3. Correlation of Proper Motions

Mobitel1 catalogue [3] contains astrometric data for 620 967 stars in the range of 8.0 to 17.5 for R magnitude. PM were derived from comparison of stellar positions taken from: USNO-A2.0 catalogue and CCD observations obtained with the Mobile Telescope (Mobitel) [4] in Mykolaiv in 2011-2012 years. TopCat helps us to obtain parameters of linear correlation (LC) for PM of stars in right ascension (RA) – $\mu_\alpha \cdot \cos\delta$ and declination (DE) – μ_δ for 550065 common stars. The coefficients of LC in $\mu_\alpha \cdot \cos\delta$ and μ_δ are equal to 0.9 meaning that 81% of common stars have the same direction of PM. The slopes of LC lines for $\mu_\alpha \cdot \cos\delta$ and μ_δ are 1.5 and 1.2 respectively. It means that in general the XPM catalogue [2] has larger values of PM than Mobitel1 at 1.5 times in $\mu_\alpha \cdot \cos\delta$ and at 1.2 times in μ_δ. Aladin enables us to visualize PM of common stars for Mobitel1 and XPM catalogues and to check direction and value of PM for any of them (Fig. 1).

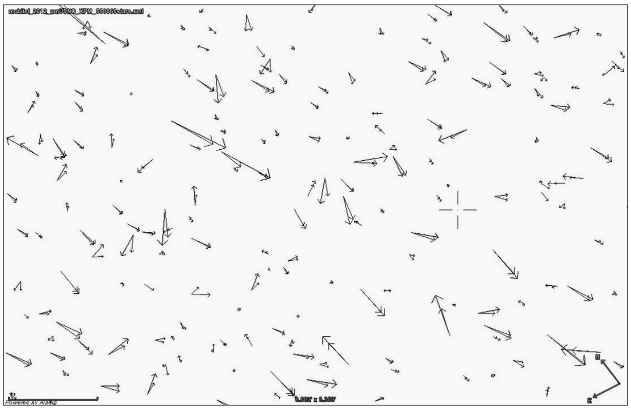

Figure 1: Visualization of PM for common stars

4. Differences of Proper Motions

TopCat facilitates us to compute and check differences of PM versus stellar magnitude, RA, and DE using its interactive possibilities. The synthetic column window easily enables us to compute the differences of stellar PM as well as to calculate any other value defined by any algebraic expression based on the values of other columns in the same row. The differences in the sense of Mobitel1 minus XPM were deliberately computed between absolute values of PM to show the systematic bias for the slope of LC lines in $\mu_\alpha \cdot \cos\delta$ and μ_δ (Fig. 2).

The so-called magnitude equation as the harmful function between PM (or positions) and stellar magnitudes may be caused by systematic errors such as: optical aberrations and guiding errors in combination with the nonlinear response of the photographic emulsion, charge transfer inefficiency (CTI) of the charge-coupled devices (CCD), image displacement due to curvature of star trails and drift rate variations during CCD observation in drift-scan mode with a stationary telescope, displacement of star image due to atmospheric differential refraction.

We have to check this function as the potential source of systematic bias. TopCat helps us to calculate the mean differences in $\mu\alpha \bullet \cos\delta$ – filled circles and $\mu\delta$ – empty squares (Fig. 3) and to graph them versus R magnitude.

The standard deviations are presented as the error bars for both mean differences: μα •cosδ and μδ.

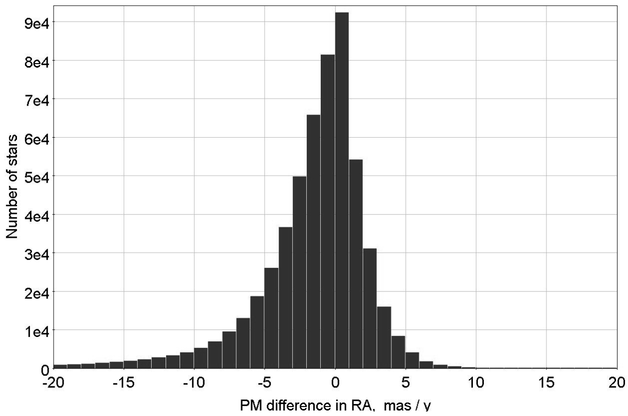

Figure 2: Differences of $\mu_\alpha{\cdot}\cos\delta$ vs number of stars

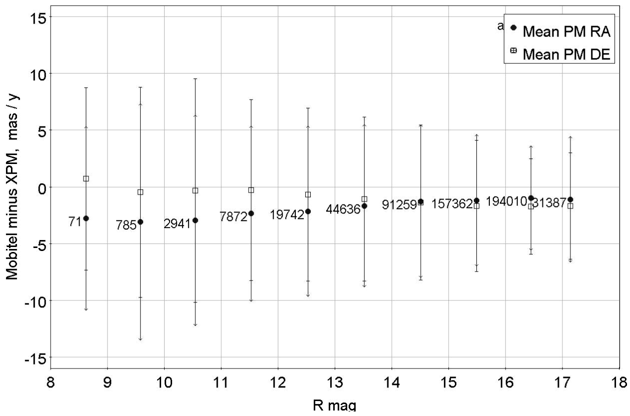

Figure 3: Mean differences in $\mu_\alpha{\cdot}\cos\delta$ and μ_δ vs R mag

Numbers of stars used for calculations of the mean differences are given on the left side from the mean values. The Mobitel1 catalogue was obtained using observations with CCD and photo plates. The XPM catalogue was obtained using observations with photo plates. Images of stars obtained with the CCD may be distorted in RA because of the CTI. At the same time, images of faint stars are less distorted due to smaller number of photons registered by the CCD. That is why the mean differences in $\mu_\alpha{\cdot}\cos\delta$ have a systematic trend with decreasing values for faint stars (Fig. 3). TopCat also enables us to calculate the mean differences between values of PM in $\mu_\alpha{\cdot}\cos\delta$ and μ_δ and to graph them as a function of declination (Fig. 4). The mean differences in the range of declinations from -5° to +30° are the smallest ones. Large differences in the range below -15° may be caused by atmospheric differential refraction and street light pollution in Mykolaiv. Large differences in the range above +33° may be caused by image displacements due to curvature of star trails and variations between apparent angular velocity of star and velocity of charge transfer during CCD observation. The velocity of charge transfer is constant for all columns of CCD pixels, and the apparent angular velocity of star is dependent on declination. Therefore, all stars within CCD frame were observed with the same velocity of charge transfer although the real angular velocities of stars are varied in declination. TopCat facilitates us to calculate the mean differences in $\mu_\alpha{\cdot}\cos\delta$ – filled circles and μ_δ – empty squares and to graph them as a function of declination (Fig. 4). The standard deviations are presented as the error bars for both mean differences: $\mu_\alpha{\cdot}\cos\delta$ and μ_δ (Fig. 4).

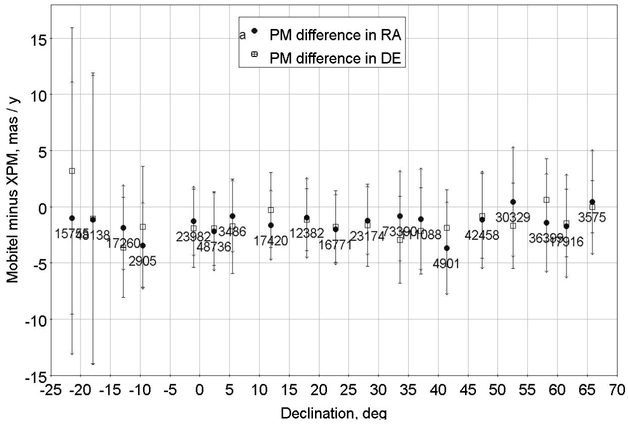

Figure 4: Mean differences in $\mu_\alpha{\cdot}\cos\delta$ and μ_δ vs DE

Numbers of stars used for calculations of the mean differences for each of 5° zone in declination are given below of the filled circles.

Conclusions

The main aim of this work was to apply new possibilities in comparative analysis of stellar PM by using VO tools. We have shown some results of comparative analysis for two astrometric catalogues. We also carried out comparative analysis for at least ten pairs of other catalogues, and the detailed results are not given in this paper due to the lack of place. Such catalogues as CSOCA and PM2000 have strong correlation with Tycho2 catalogue, because they were reduced in the system of the ICRS. The coefficients of LC in $\mu_\alpha{\cdot}\cos\delta$ and μ_δ are equal to 0.99, and the standard deviations for differences of PM are 0.8 mas/a for CSOCA and 2.4 mas/a for PM2000. The Mobitel1 and XPM catalogues have not such a strong correlation with the Tycho2 catalogue.

The work is conducted in frame of the UkrVO [6–9].

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