

ASTROMETRIC CATALOGS: BE CAREFUL!

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RESUMEN

En este trabajo hemos iniciado una investigación sobre los movimientos propios en los principales –y extensos– catálogos astrométricos. Esta investigación consiste en la comparación de los movimientos propios de tres catálogos con los obtenidos exclusivamente mediante observaciones CCD con el círculo meridiano hechas en el Observatorio Abrahão de Moraes, Valinhos (Brasil) durante 15 años. La motivación para este trabajo es el uso –cómodo pero peligroso– de los movimientos propios de los más importantes catálogos, que globalmente son muy buenos, pero que localmente no lo son. Nuestro propósito es llamar la atención sobre la necesidad de usar estos catálogos con cuidado, sobre todo para los movimientos propios de las estrellas débiles.

ABSTRACT

In this work we have started an investigation of the proper motions given by some of the main and huge astrometric catalogs. This investigation consists in the comparison between proper motions from these catalogs and those determined exclusively with CCD meridian circle observations done at the Abrahão de Moraes - Valinhos Observatory (Brazil) over 15 years. The motivation for this work is the comfortable but dangerous utilization of proper motions from some of these very important catalogs that globally can be very good but locally not so good. Our goal is just to alert for the need of a more careful utilization of these proper motions, mainly those of faint stars.

Key Words: astrometry — catalogs — proper motions

1. INTRODUCTION

It is not difficult to see that as a consequence of the applied technology (CCD) in astrometric observations a big jump in precision and an even bigger jump in the number of stars present in the recent published astrometric catalogs resulted. Today, astrometric catalogs containing tens and hundreds of millions of stars become more and more common. So, rightly and understandably, the trend is to use more and more the proper motions from these catalogs instead of measuring the proper motions as was done in the not-so-far past.

We cannot forget that this “new” reality leads to a completely automatic process of data reduction and that punctual investigations are almost impossible; in general we work with means of data that can hide problems and mistakes. So, in summary, we cannot ignore that even for those very good catalogs we can find bad or even wrong proper motions mainly for the faint stars which, in general, are measured with a poor number of epochs and/or a short timebase.

Here, using a very homogeneous set of proper motions determined exclusively with CCD meridian observations realized at the Abrahão de Moraes Observatory, Valinhos, Brazil (Viateau et al. 1999; Teixeira et al. 2000, 2011) we have analyzed the proper motions from some of the most important and dense astrometric catalogs PPMXL (Roeser et al. 2010), UCAC4 (Zacharias 2011) and SPM4 (Girard et al. 2011) in the region of 12 low extinction windows in the galactic bulge direction.

The goal is not to criticize, not even to judge these works that are certainly very good and important. Our goal is simply to draw the attention of the potential user community to the fact that even being globally very good and very precise, locally the proper motions can be bad or even wrong. These comparisons are not yet finished and in the future, we hope to develop a more detailed and deeper analysis.

This work was started when we were evaluating the external quality of a recently published astrometric catalog (GBVOC) in the direction of the galactic bulge (Teixeira et al. 2011). In this paper one can find a more detailed description of the instrument, data treatment and internal and external precision.

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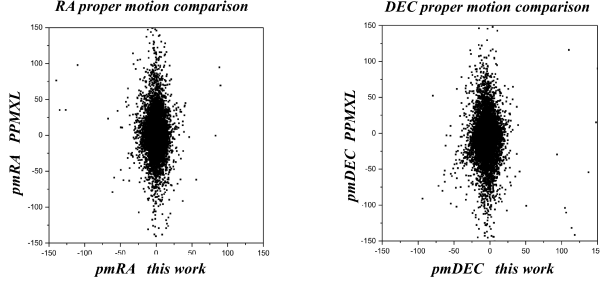


Fig. 1. Proper motion comparison with PPMXL catalog.

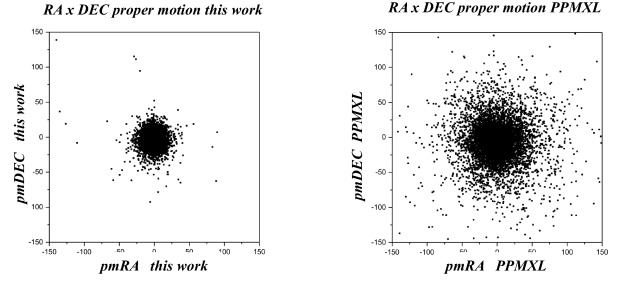


Fig. 2. Proper motion comparison with PPMXL catalog.

2. PROPER MOTIONS FROM VALINHOS OBSERVATORY

The observations for the proper motions measurements were performed only with the CCD meridian circle (Viateau et al. 1999; Teixeira et al. 2000) installed at the Abrahão de Moraes Observatory ($\phi = -23^{\circ}00'06''$, $\lambda = +46^{\circ}58'03''$) over 15 years, from 1996 to 2010 (Teixeira et al. 2011).

Unfortunately, in the observational period some technical problems (from 2000 to 2005) prevented the observations in all years of this period. So, we could observe only during nine years, which means that a maximum of nine distinct epochs were used to calculate the proper motions.

The proper motions were measured only for those stars with twenty observations or more, observed in at least six different years and at least three times each year. Moreover, we selected only the stars with a timebase equal to ten years or more. This filtering ensures a good compromise between the number of observations, the observational epochs, and the timebase, giving excellent precision on positions and proper motions. The target stars are spread in 12 regions of 5 min in right ascension by 14' in declination around each low-extinction window of the galactic bulge (Blanco 1988; Blanco & Terndrup 1989; Dominici et al. 1999) whose sizes are estimated to be $20' \times 20'$. We used the Tycho 2 catalog (Høg et al. 2000) as reference for our reductions.

We provide homogeneous and precise proper motions for about 12000 stars with a mean internal precision of 4.0 mas yr^{-1} , which is compatible with the best astrometric catalogs. This precision depends on magnitudes and degrades for faint objects. In the best interval ($9 < V < 14.0$) on average the internal errors in our proper motions are smaller than 2 mas yr^{-1} . The quality of our proper motions associated to the tight control of the whole process of astrometric reduction transforms this artisanal work into an important tool to investigate possible inconsistencies in other astrometric catalogs.

3. ANALYSIS

In the following figures we show the comparison of our proper motions with those of PPMXL (Röser et al. 2010), UCAC4 (Zacharias 2011) and SPM4 (Girard et al. 2011). In each case we were very strict in the cross-identification to minimize the mistakes.

Typically, the expected pattern in this kind of comparison would be a distribution of points along the diagonal with a greater dispersion around the center where most of the distant, faint stars lie. But this is not the case as we can see in Figure 1, where we show the proper motion comparison for about 10000 Valinhos and PPMXL common stars. The pattern with this vertical tendency is quite different from that expected.

In this figure we verify that while the Valinhos proper motions are clearly confined to a small regions, from -25 to 25 mas yr^{-1} , as expected from galactic models, the PPMXL proper motions can attain very high values, 100 mas yr^{-1} or more. The number of stars in this situation in the case of the PPMXL proper motions seems to be much too large and inconsistent with what is expected about the universe of large proper motions.

To better understand the origin of the unexpected pattern that appears in the Figure 1, we separated the sources of proper motions, and we present the Vector Point Diagram (VPD) in Figure 2, Valinhos VPD on the left and PPMXL VPD on the right. It is not difficult to note the great dispersion (great proper motions) in the PPMXL VPD in both coordinates. In summary, these figures tell us that PPMXL presents in the observed region, a great number and maybe, an improbable great number, of stars with large proper motion in both coordinates.

In Figure 3 we can see the same effect as in Figure 1 but now separating the stars brighter than $V \simeq 12$ magnitudes (red points). In this case we see easily that the great dispersion concerns essentially the fainter stars, which is another contradic-

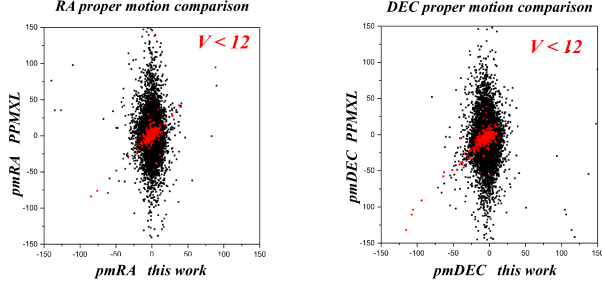


Fig. 3. Proper motion comparison with PPMXL catalog. The color figure can be viewed online.

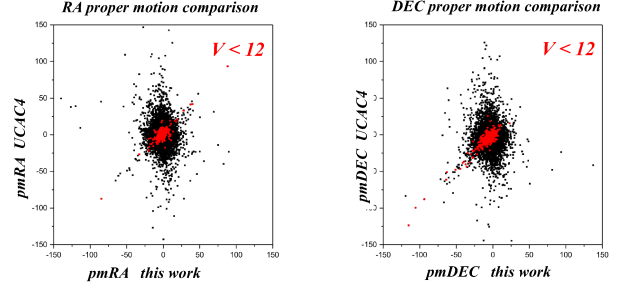


Fig. 6. Proper motion comparison with UCAC4 catalog. The color figure can be viewed online.

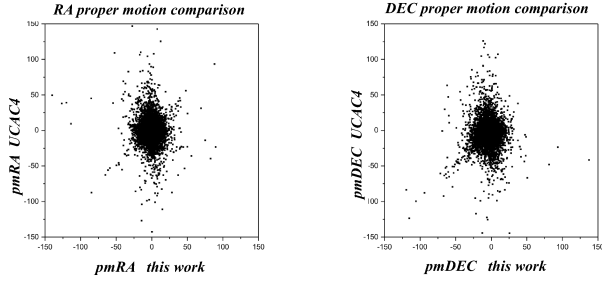


Fig. 4. Proper motion comparison with UCAC4 catalog.

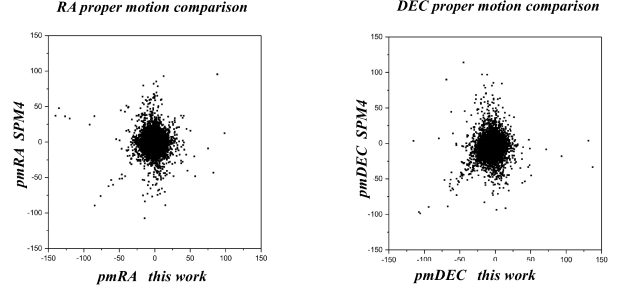


Fig. 7. Proper motion comparison with SPM4 catalog.

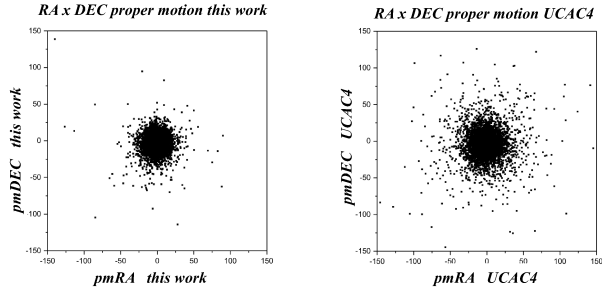


Fig. 5. Proper motion comparison with UCAC4 catalog.

tion: the largest proper motions should correspond to the brightest stars and not to the faintest.

As said, we also compare the Valinhos proper motions with those from a beta version of the UCAC4 (Figure 4). The scenario is roughly the same for the about 10000 UCAC4 stars but it seems a little better. The UCAC4 proper motions are less sparse, the vertical pattern is less pronounced.

Figure 5, where we can see the VPDs shows the large dispersion of the UCAC4 proper motions. Again, we have here a large number of stars with proper motions reaching 100 mas yr^{-1} or more but less than in the PPMXL catalog. In Figure 6 it is clear that the largest dispersion in the UCAC4 catalog also corresponds to the faintest stars ($V > 12.0$).

In other words, even though the dispersion in Figure 5 is a little smaller than in Figure 2, the scenario for UCAC4 and PPMXL is about the same. Both present an unexpected pattern (vertical tendency) for their proper motions: too many faint stars with large proper motion.

Finally, we analyzed the proper motions of about 10000 common stars from the SPM4 catalog. In this case, although the vertical pattern is present, the scenario is better as we can confirm in Figure 7. The pattern in the central region is more like a circle and the proper motion are more concentrated. Only a small number of the SPM4 stars present large proper motions suggesting an improved consistence compared to the other two catalogs. The other two figures (Figures 8 and 9) confirm this perception.

The other similar figures, Figures 8 and 9, confirm the better homogeneity of the SPM4 proper motion. Coincidentally the SPM4 has a much smaller number of stars than the others, allowing a more direct intervention in the reduction, analysis of data and results at the moment of compilation.

4. DISCUSSION

As we could see the amount of large proper motions for the faint stars in some of the most important astrometric catalogs is unexpected. Although

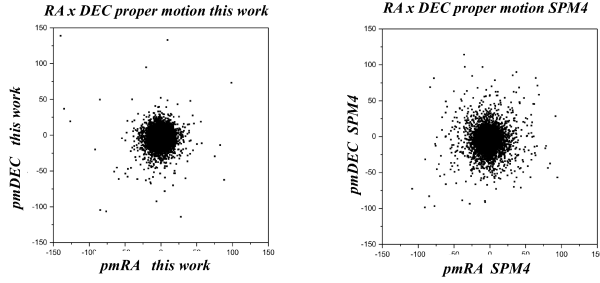


Fig. 8. Proper motion comparison with SPM4 catalog.

with different intensities, in the 3 analyzed catalogs we see a distribution of the points along the vertical completely unexpected (Figures 1, 4 and 7). This suggests that the proper motions for the faint stars could be very imprecise or even wrong. In any case, this verified tendency alerts us that they could be not reliable.

In these catalogs the majority of the faint stars had the proper motions measured only with 2 points (2 epochs) and with a timebase not large enough. In fact, the reality is even worse when we take into account that the limiting magnitude of the Valinhos stars and so of these comparisons is essentially $V \simeq 15$, rarely attained 15.5 or 16.0 (Teixeira et al. 2011). As these catalogs contain stars much fainter than those used in this analysis we think that the situation is even worse.

Despite the care of the authors in their assessments and analyzes and the care of the users it is certain that the detection of these inconsistencies is very difficult, or even impossible when dealing with millions of stars. In these cases in general the tests are performed on averaged values of proper motions

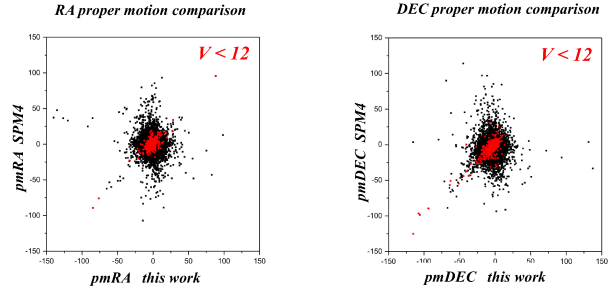


Fig. 9. Proper motion comparison with SPM4 catalog. The color figure can be viewed online

or on differences in proper motions and the patterns disappear. What we could see was possible only because we could compare point by point.

Surely these catalogs are very good and very important and our intention was not at all to criticize, only to show that we need to be careful using proper motions from the huge astrometric catalogs (mainly for the faint stars), and that there is still some place for artisanal works like ours in the astrometric works.

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