A Giant Step: from Milli- to Micro-arcsecond Astrometry
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The understanding of the FK5 and Hipparcos proper-motion systems†

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Abstract. Comparing proper motions of the FK5 and Hipparcos, several authors declared that the two proper-motion systems are inconsistent with the value of the precession correction obtained from VLBI and LLR observations. Based on the proper-motion data from the PPM and ACRS catalogues which are constructed on the FK5 system, the inconsistent values of the precessional correction and of the time-dependent term of equinox correction, derived from the different subsets of stellar samples, have been found. One of the reasons for those discrepancies should be mostly due to the internally biased proper-motion system of the FK5.

Keywords. astrometry, Galaxy: fundamental parameters, reference systems

1. Introduction

The Hipparcos system defines a quasi-inertial reference system on the ICRS. The pointing error of its coordinates with respect to ICRS in the mean observational epoch J1991.25 is ± 0.6 mas and the rotation error of the system is ± 0.25 mas yr^{-1} (Perryman, *et al.*1997). The FK5 system is a dynamical system and transfers to the inertial system through a precise determination of the precession constant and time-dependent term of equinox correction. From researches on VLBI and LLR it was found that the IAU 1976 precession constant was actually over-estimated, and this leads to the lunisolar precession correction of the FK5 system of $\Delta p \approx -3.0$ mas yr^{-1} (McCarthy & Captaine 2002).

From the comparison of the FK5 system and Hipparcos, one found that the speed of rotation ω, between two systems, can be expressed (ESA 1997)

$$\omega = (\omega_x, \omega_y, \omega_z) = (-0.10 \pm 0.10, 0.43 \pm 0.10, 0.88 \pm 0.10), \tag{1.1}$$

in units of mas yr^{-1}. If both the FK5 and Hipparcos systems are rigid, then the speed vector ω should theoretically reflect the precession correction of the FK5 system, or we have $\omega_x = 0$, $\omega_y = -\Delta p \sin\epsilon$, and $\omega_z = +\Delta p \cos\epsilon - (\Delta\lambda + \Delta e)$. Here $\Delta\lambda$ and Δe are the planetary precession correction and time-dependent term of equinox correction, respectively. If the measurement results $\Delta p = -2.997 \pm 0.008$ mas yr^{-1} (McCarthy & Captaine 2002) and $(\Delta\lambda + \Delta e) = -1.16 \pm 0.26$ mas yr^{-1} (derived from ACRS proper motions, Miyamoto & Sôma 1993) are substituted into the above formulae, it is quite obvious that the three components are in contradiction with the speed vector ω in Eq.(1.1). Mignard & Froeschlé (2000) and Walter & Hering (2005) attempted to resolve the contradiction of the relation between the two systems with the precession constant corrections, but there were still a lot of questionable points awaiting clarification. In my previous work, I have more systematically analyzed the systematic errors of the PPM and ACRS proper motions with respect the Hipparcos, and pointed out that there are serious problems which exist in the past ground-based systems, such as the regional error, magnitude equation

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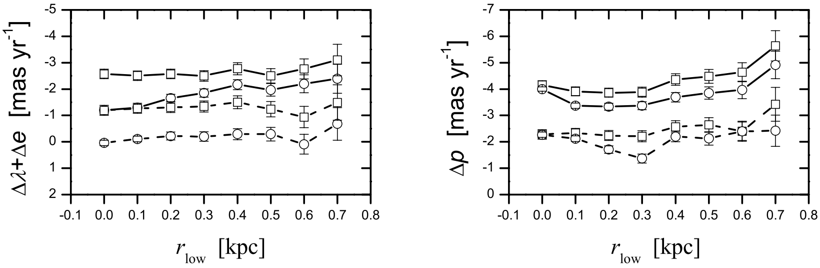

Figure 1. Precession correction and time-dependent term of equinox correction. The solid lines express results derived from PPM proper motions, while the dashed curves show those from ACRS data. Circles and squares indicate results determined from all type of stars and from K-M giants, respectively.

and color equation, etc. (Zhu 2000). In the present work we will go further to study the effects of the PPM and ACRS proper-motion systems on the determination of the precession constant correction in order to understand the FK5 and Hipparcos proper-motion Systems from another point of view.

2. Precession constant correction and discussion

For the processing, we again adopt the 3-D kinematics model, similar as Miyamoto & Sôma 1993) did. To consider problems such as arising from magnitude equations of PPM and ACRS proper motions and velocity dispersion of the nearby stars on the estimation of the parameters, we give separate results for the different subsamples in the heliocentric distance $r_{low} \leqslant r \leqslant 1.0$ kpc. Precession constant correction Δp and the correction $(\Delta\lambda + \Delta e)$ are illustrated in Figure 1, derived for all type of stars and for K-M giants, respectively.

From analysis of Δp and $(\Delta\lambda + \Delta e)$ given in Figure 1, we can cognize some features of the proper-motion systems and give a conclusive discussion as follows:

The results deduced from PPM and ACRS show obvious systematic differences, indicating an overall difference of $\sim$1.5 mas yr^{-1} between the two proper-motion systems. Thus, neither PPM nor ACRS can completely represent the FK5 system. Furthermore, there are serious regional error, magnitude equation and colour equation in the FK5 system. In a certain sense, the FK5 system is a non-rigid reference system. Thus, the FK5 and Hipparcos proper motion systems cannot be connected simply by making use of the precession correction. Only when the FK5 is an ideal rigid system and the Hipparcos system is strictly established on the ICRS system, can this sort of simple relation hold.

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