

LARGE PHOTOGRAPHIC CATALOGUES

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Abstract. Large photographic catalogues still have their importance in modern astrometry. Old catalogues are used to derive good-quality proper motions. Present-day catalogues may be used to extend the Hipparcos and Tycho systems to fainter magnitudes.

1. Introduction

For more than a century, photographic astrometry has been *the* method for acquiring large numbers of star positions. Soon after the introduction of dry emulsion plates, photographic techniques were introduced into astronomy. At this early stage, the largest project of international cooperation in astronomy was started, the *Astrographic Catalogue* (AC), (Congrès Astrophotographique International 1887). The aim was a complete survey of the sky down to 13th or 14th magnitude with 0."3 rms error per star position. Later on somewhat smaller surveys were carried out: AGK2 (Schorr and Kohlschütter 1951) and AGK3 (Heckmann et al. 1975) on the northern hemisphere, CPC (Jackson and Stoy 1954), CPC2 (Zacharias et al. 1992) and FOKAT-S (Bystrov et al. 1989) on the southern hemisphere. A series of zonal catalogues has been produced at the Yale Observatory. In this paper we shall demonstrate that these photographic catalogues make an important contribution for the determination of precise proper motions.

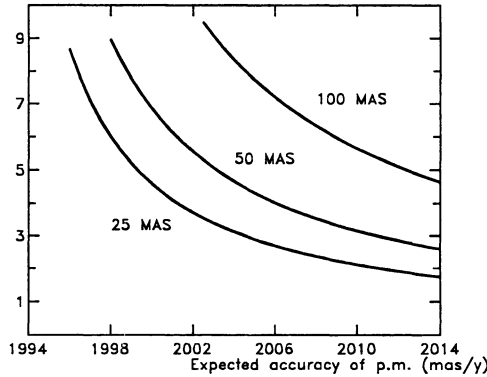


Figure 1. Expected accuracy of proper motions (mas/year), which can be achieved by combining Tycho measurements with new measurements of a given accuracy, plotted as a function of epoch. The individual curves refer to the assumed rms-errors per coordinate of these new measurements.

2. Status of astrometry today

All coordinates of celestial objects must refer to an appropriate coordinate system. This has been established in the past by the Fundamental Catalogues, the last of this series being FK5 (Fricke et al. 1988). From 1997 onwards, the Hipparcos catalogue, tied to an extragalactic reference frame, will be the reference for optical astrometry. Its coordinate system will be defined by the positions and proper motions of the 120 000 Hipparcos stars. The individual rms-errors of the Hipparcos stars will be 2 mas per coordinate in position and 2 mas/year per coordinate in proper motion. There is indication that the Hipparcos catalogue will be even more accurate.

The Tycho experiment on Hipparcos will provide us with the positions of one million stars with an accuracy of 30 mas per coordinate, but, unfortunately, the accuracy of the Tycho proper motions, 30 mas/year, will be rather poor (Høg et al. 1992).

The use of CCDs in astrometry is going to be a new tool for the acquisition of high quality positions for large numbers of stars. Van Altena (1994) describes two methods of CCD astrometry: CCDs operated in drift-scan mode are expected to obtain individual star positions with 100 mas rms-error per coordinate. If operated in the classical stare mode, 50 mas may be achieved under favourable conditions (van Altena 1994). Let us assume that the measurements can be tied to a reference system without loss of accuracy. If sky surveys of this kind should be carried out in the near future, we can ask about their impact on proper motions if the Tycho measurements are used as a first epoch. Figure 1 shows the rms-error of a proper motion per coordinate, expected from a combination of Tycho with

future observations of the 100, resp. 50 mas accuracy level. If e.g. a survey with 50 mas would be performed in 2002 the resulting proper motions would only be good to 5.5 mas/year. Were it possible to increase the accuracy to 25 mas in the future, observations from 2002 onwards would make sense. However, 100 mas and even 50 mas observations before 2010 cannot compete with old photographic catalogues for the determination of proper motions, as we will show below.

3. The role of old photographic catalogues

Old photographic catalogues usually do not reach an accuracy comparable to modern ones or CCD techniques. However, the latter still have to prove their potential, when actual data will be published. Old photographic catalogues profit from large epoch differences when combined with Tycho. In Table 1 we present the performances of selected photographic catalogues. AGK2 in the north, and CPC2 in the south yield fairly good proper motions when combined with Tycho. However, they only supply positions for roughly half of the Tycho stars. Better results are expected when combining Tycho with AC. Essentially all Tycho stars are contained in AC, and proper motions with rms-errors of 2 - 3 mas/year are expected, with the Paris and Sydney zones at the extremes (see Table 1).

TABLE 1. Accuracy of proper motions to be achieved by combining the catalogue in column 1 with the Tycho observations. The columns have the following meaning: catalogue, number of stars, decl. zone, epoch, rms-error of a catalogue position in mas (in the case of AC two measurements enter a catalogue position), expected rms-error of a proper motion in mas/year.

Catalogue	Number of stars	Declination Zone	Epoch	ε_p	ε_μ
AGK2	180 000	+90 -02	1930	180	3.0
CPC2	250 000	+00 -90	1967	100	4.3
AC-Paris	340 000	+24 +17	1897	160	1.7
AC-Sydney	380 000	-52 -65	1907	300	3.6

More than 100 years after the start of the AC project, it can now be fully exploited because all the published measures have been put into machine-readable form (Nesterov et al. 1990). The project of combining AC with Tycho is described in Röser and Høg (1993) and is called *Tycho Reference Catalogue* (TRC).

Table 2 describes the situation regarding proper motions to be expected within the next 3 years. Progress will be in number and accuracy. Large photographic catalogues contribute to the last two lines of this table. The

catalogue (GSC-AC) is described by Röser et al. (1994). Proper motions for all AC stars are determined using a systematically improved version of the *Guide Star Catalogue* (GSC) as second epoch. These catalogues of proper motions will have an impact on stellar kinematics up to a distance of one kpc, although the *sub – milliarcsecond* regime is not yet reached.

TABLE 2. Accuracy of proper motions to be expected within a few years. ε_{μ} is the rms-error of proper motion. Unit: mas/year.

Catalogue	Number of stars	ε_{μ}
Hipparcos	120 000	1.5
TRC	1 million	2-3
GSC-AC	4 million	4-6

So far we have not touched the problem of the systematic accuracy of the photographic catalogues. In the TRC project (Röser and Høg 1993) the AC has to be reduced to the Hipparcos system. This work will be carried out at Astronomisches Rechen-Institut after the Hipparcos catalogue will be available. Magnitude equations and plate distortions will be investigated and removed. GSC 1.0 is known to show serious systematic errors (Taff et al. 1990). Röser et al. (1994) describe a new method to reduce GSC 1.0 to the PPM system. The first author is presently studying magnitude dependent errors in GSC 1.0 by comparing overlapping GSC plates.

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