THE ERRORS OF ABSOLUTE PHOTOGRAPHIC PROPER MOTIONS OF STARS RELATIVE TO GALAXIES

A. A. KISELEV

Pulkovo Observatory, U.S.S.R.

In Photographic Astrometry the absolute proper motions of stars are determined relative to galaxies by the direct (I) or indirect (II) methods. In the direct method the plate constants are determined directly from galaxies, used as the reference stars with a Zero proper motion. In the indirect method the proper motions are first found relative to the totality of reference stars S_r $(r=1, 2, \dots r_0)$, then the obtained relative proper motions are reduced to absolute values by means of galaxies G_g $(g=1, 2, \dots g_0)$, the correction, identical for all the stars, being derived by formula (I).

$$\Delta\mu_s = \mu_s - \mu_s' = -\frac{1}{g_0}\sum_{g=1}^{g_0} \mu_g' \tag{1}$$

In the classical case (reduction by the linear formulas) method I provides a geometrically strict solution. The mean error of the absolute proper motion of a star S_s as derived by method I is determined by formula (2)

$$E^2_{\mu s\,(\mathrm{I})} = \frac{E^2_{\Delta xS}}{\tau^2} + \frac{E^2_{\Delta xG}}{\tau^2}\sum_{g=1}^{g_0} D^2_{gs}, \tag{2}$$

where $E_{\Delta xS}$ and $E_{\Delta xG}$ are the mean errors of measurements of one difference of coordinates for the stars and galaxies on the plates of the first and second epochs, D_{gs} – conditional weights (Schlesinger's dependences) of the galaxies relative to the stars S_s, and τ – the difference of epochs.

Method II does not provide the strict geometrical solution of the problem, however, with respect to accidental errors, it can result in more precise solution, as well as in less precise one. The mean error of the absolute proper motion of a star, as derived by method II, is determined by formula (3)

$$E^2_{\mu s\,(\mathrm{II})} = \frac{E^2_{\Delta xS}}{\tau^2} + \frac{E^2_{\Delta xG}}{\tau^2}\frac{1}{g_0} + \left(\sigma_R^2 + \frac{E^2_{\Delta xR}}{\tau^2}\right)\left(\sum_{r=1}^{r_0} D^2_{rs*} - \frac{1}{r_0}\right). \tag{3}$$

Here $E_{\Delta xR}$ – a mean error of measurements of the coordinates difference for the reference stars, σ_R – a dispersion of relative proper motions of the reference stars, used in determination of the initial relative proper motions, D_{rs*} – conditional weights of reference stars relative to a fictitious object placed at the point with the coordinates $x_s^* y_s^*$, complying with the condition (4)

$$x_s^* - \bar{x}_R = x_s - \bar{x}_G; \qquad y_s^* - \bar{y}_R = y_s - \bar{y}_G. \tag{4}$$

Gliese, Murray, and Tucker, 'New Problems in Astrometry', 207–208. All Rights Reserved.

$x_s y_s$ – are the coordinates of the star under determination $\bar{x}_R \bar{y}_R$ and $\bar{x}_G \bar{y}_G$ – the coordinates of the gravity centers of the systems of reference stars and galaxies.

A comparison of formulas (2) and (3) leads to the following conclusions:

(1) The error $E_{\mu s}$ in method II depends considerably on the dispersion of the proper motions of reference stars. This influence became apparent when difference of epochs is large. At a small number of galaxies (of the order of 5) and the epochs difference of 30 yr Method II provides more accurate absolute proper motions than Method I in case if there will be used 40–50 reference stars with $\sigma_R \leqslant 0\overset{''}{.}015$ per year.

(2) The error $E_{\mu s}$ in both the methods increases as the object removes from the gravity center of the galaxies, however in Method I this effect is due to the errors of measurements of galaxies, whereas in Method II to the errors of measurements of reference stars and the dispersion of their proper motions. For one object in the gravity center of the galaxies both methods give coinciding results.

(3) The errors $E_{\mu s}$ both in Method I and II can be essentially different for different stars under determination (due to the influence of configuration). This effect is to be taken into account in a comparison of photographical and meridian proper motions.

Reference

Kiselev, A. A. and Yagudin, L. I.: 1973, *Trudy 19th Astrometr. Konf.*, in press.