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REDUCTION OF MERIDIAN OBSERVATIONS BY THE OVERLAP METHOD

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RESUMEN. Se presentan algunos resultados y un modo sencillo de reducir observaciones de meridiano por el método de traslape.

ABSTRACT. In this paper we present some results and a simple way of reducing meridian observations by the overlap method.

Key words: ASTROMETRY

I. INTRODUCTION

Meridian observations are usually grouped in series which are reduced separately. The coordinate axis are fixed by reference stars, which define the system to which program stars are reduced.

In this work we study the possibility of reducing all observations at once in a single least squares problem having as unknowns not only the instrumental parameters (constant for each series) but also the positions of all stars (reference and program stars). In this case all observations will contribute equally for the definition of the instrumental system. This process takes into account the fact that the positions of the stars which are common to various series are constant, in exactly the same way as in the reduction of photographic plates by the overlap technique (Eichhorn, 1960).

We present here a relatively simple way of dealing with the least squares system, which is both of huge dimensions and singular. We give also some results of this technique applied to two years of observations carried out with the photoelectric meridian circle of the Bordeaux Observatory (Requième and Mazurier, 1986).

II. REDUCTION

Consider the reduction in right ascension as an example. We make use of Bessel's equation, which involves three unknown constants, say m_k, n_k and c_k, for each series. In the conventional method we consider first the fundamental stars, whose coordinates are supposed to be free from error, and solve for the besselian constants by least squares:

$$m_k + N_k tg\delta_i + c_k sec\delta_i = (\alpha_i - TS_{ik}) + r_{ik} , \quad (1)$$

where α_i and δ_i are the catalogue coordinates reduced to the date, TS_{ik} is the observed sideral time of transit and r_{ik} is the residual of the least squares solution. The right ascension of the program stars is obtained with the help of m_k, n_k and c_k:

$$\alpha_i = TS_{ik} + m_k + n_k tg\delta_i + c_k sec\delta_i \quad . \quad (2)$$

The final result for the program stars is the average of α_i as determined by (2). For the fundamental stars the average of their residuals is interpreted as a correction to the adopted right ascension.

In the overlap method we introduce the right ascension correction $\Delta\alpha_i$ as an additional unknown and solve by least squares the set of all equations of observation:

$$m_k + n_k \mathrm{tg}\delta_i + c_k \sec\delta_i - \Delta\alpha_i = \alpha_i - TS_{ik} + r_{ik} \quad , \qquad (3)$$

for the unknowns m_k, n_k and c_k, where k ranges over all series, and $\Delta\alpha_i$, where i ranges over all stars, reference and program. System (3) can be conveniently solved iteratively in spite of it being singular, according to a general result that will be published elsewhere. The singularity is a consequence of the essential impossibility of fixing an origin for the unknowns and must be removed by adjoining to (3) a set of three independent conditions. For these we have selected the following:

$$\Sigma\Delta\alpha = \Sigma\Delta\alpha\sin\delta = \Sigma\Delta\alpha\cos\delta = 0 \ , \qquad (4)$$

the sums ranging over the reference stars only, so that the final results will share with the reference latalogue the same equinox and part of the $\Delta\alpha\delta$ errors.

III. SOME RESULTS

In the following we make a comparison of the positions obtained by the two methods. The observational data consist of 40000 observations of 5000 stars. In the case of overlap reduction the coordinates were obtained after three iterations (section II).

The systematic differences between the two methods, for both coordinates, are displayed in Fig. 1 and 2, as functions of the right ascension and declination, respectively. These curves in fact reflect the differences between an instrumental semi-absolute reference system (overlap) and the system defined by the reference catalogue in the observed zone (conventional).

The most remarkable feature in these diagrams are the undulations that can be seen in the curves dependent on the right ascension. The source of this perturbation can be the instrumental system, the reference system or both. However independent results (Morrison et al, 1987; Boczko, 1989) suggest that this disturbance comes from the reference catalogue FK5.

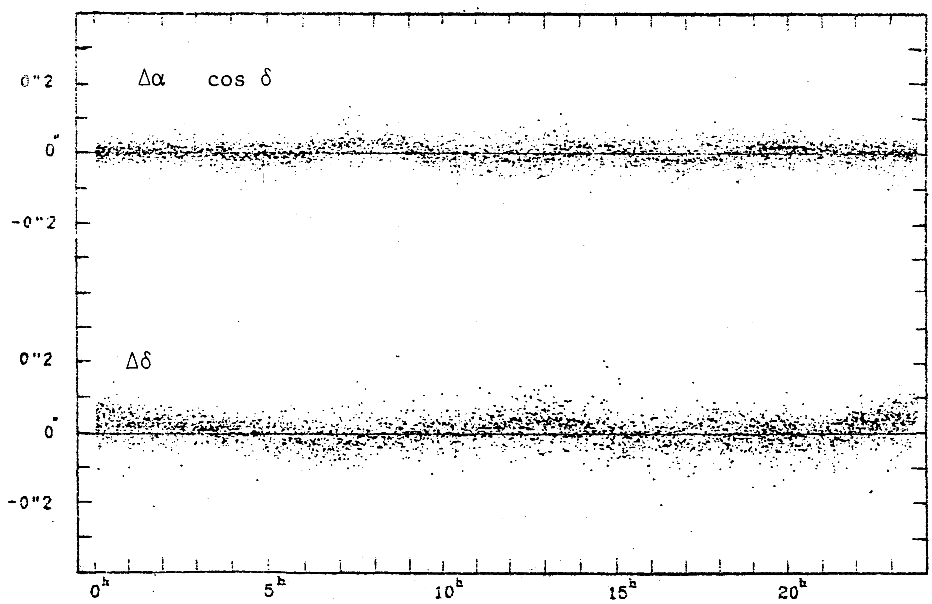

Fig. 1. Systematic differences overlap - conventional (FK5 system) reduction techniques, as function of right ascension.

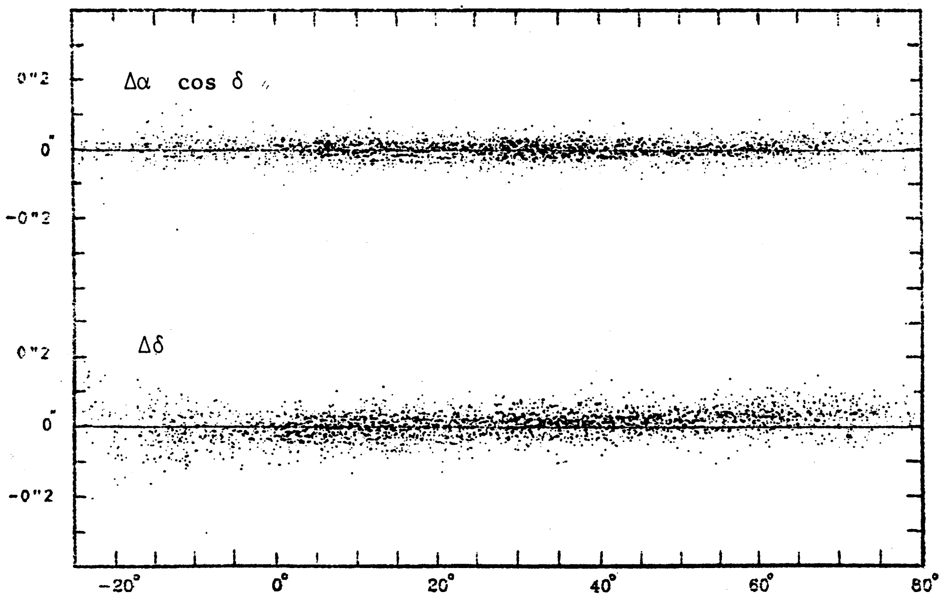

Fig. 2. Same as Fig. 1, as function of declination.

IV. CONCLUSIONS

We have shown that the overlap techniques for the reduction of astrographic plates can be applied to meridian circle data, with little increase of computational effort over the conventional procedure. The results have a semi-absolute character, since all the observations contribute on the same basis and the adjustment is global. As a consequence we have been able to disclose systematic errors in the FK5 dependent on the right ascension.

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