RECOVERY OF THE ASTROGRAPHIC CATALOGUE

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ABSTRACT. An almost fully automatic scheme has been developed which produces final positions in the system determined by the reference catalogue, cross identifications, and approximate magnitudes in a standard system. A plate-overlap method is used which permits inclusion of higher order terms either plate by plate or common to a subset of plates. Magnitude dependent errors are also included. The system has already been applied to more than 500 plates, most of them of the Paris zone, with smaller sets of the Oxford, Potsdam, and Helsingfors zones. The Paris zone yields consistent higher order and magnitude terms over the entire set analyzed so far.

1. Introduction.

Numerous efforts have been made to determine either plate constants of stellar positions for portions of the Astroghaphic Catalaogue. For instance Gunther and Kox (1970,1971,1972) have calculated final plate constants for all zones north of 32 N. Lacroute (1981) determined stellar positions for all stars of the AC between declinations 25 N. and 2 S.. Others have made use of the AC coordinates as first epoch for proper motion determinations in small and isolated areas. So far no effort has been made to derive positions in a homogeneous system for the entire AC. This, naturally, has not been possible because of the lack of an adequate reference system.

In principle, the FK5 may be considered to be an adequate reference system, even if it may not be absolutely free of systematic errors. Naturally, it does not permit a plate by plate solution for the constants of the AC plates due to the low star density. It can be used, though, if a large enough mosaic of plates is assembled. The HIPPARCOS system will be far more suitable but is not yet available. Even so, the HIPPARCOS system will be only marginally suitable for single plate solutions. On the average one may count on about ten HIPPARCOS stars per plate, but in cases it may be as little as five. Thus even here an overlap scheme is desirable.

Apart from a decision on the reference system the most convenient size of a plate mosaic or "block" has to be decided upon. This is mainly a question of the error propagation from one plate to the

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neighboring plates, but also a problem of computer capacity and computer time. While it seems attractive to assemble the entire AC in one single block, thus avoiding closing errors, this is neither possible due to computer limitations nor is it necessary because of the limited error propagation. On the other hand, it is not advisable to divide the AC into its original zones. The reduction method must permit the assembling of blocks with plates coming from different telescopes.

It is the purpose of this paper to develop and test a method and its respective computer programs which can conveniently and automatically handle the material as it is presented in the AC and produce final positions with their mean errors as well as approximate magnitudes for all objects it contains.

2. The identification of stars.

Due to the overlap scheme used in the AC each star should appear on at least two different plates. It may appear on as many as five plates. The first problem to be solved is to identify stars common to two or more plates and/or common to the reference catalogue. Provisional positions can be used for that purpose, calculated with the help of plate constants found in the literature or obtained from a semiautomatic process which identifies the reference stars on the plates. Given then a maxumum difference or tolerance in Right Ascension and Declination common objects can be identified, and their coordinates can be grouped together. The tolerance just mentioned merits some thought. If taken too small, a considerable number of identities may be lost, thus reducing unnecessarily the total number of plate-plate or plate-catalogue links. On the other hand, if the tolerance is chosen too large, false identities may be established. The tolerance can also be used to eliminate stars of large proper motion in the case of overlapping plates with a large epoch difference. Table 1 gives for a sample field the total number of plate-plate links found as function of the tolerance employed. We may mention here that for the section of the Paris zone we have analyzed so far the number of links with neighboring plates varied from about one hundred to well over one thousand five hundred while proceeding from the Galactic Pole to the Milky Way.

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TABLE I
Dependence of the total number of platel-plate links for a sample field on the selection tolerance.

Tolerance	Total number of links
3".0	17077
2".0	17013
1".5	16874
1".0	15930
0".75	14258
0".5	10496

3. The plate constants.

Linear plate constants are calculated for each individual plate. Higher order and magnitude dependent terms can be introduced in different ways. They may be considered to be independent from plate to plate. Some or all of these terms may also be considered to be common to a given subset of plates, for instance all those belonging to the same zone, or they may be common to the entire block. Likewise it is possible to remove the higher order terms, if determined previously, from the measured coordinates before these enter the block, and calculate the latter in linear terms only. Naturally, the first proposition leads to the maximum of unknowns to be determined, while the last proposition leads to the minimum of unknowns, with their respective consequences concerning computer time.

4. The epoch differences.

Most of the zones of the AC have been completed within about one decade and thus pose no major epoch problem. However, occasionally one finds plates taken more than twenty years after the main bulk. Naturally, for every plate-reference catalogue link the reference position is calculated for the epoch of the respective plate. This is not possible for the plate-plate links. For such cases the option exists to calculate the coefficients only on the basis of the comparison with the reference system. This, naturally, may lead to the necessity of eliminating some of the higher order terms. Along the border area of different zones with very different mean epochs the situation is not quite as serious since the higher order terms of the border plates may be assumed to be common to other plates deeper within the respective zones.

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5. Magnitudes and magnitude limits.

The photometric information contained in the AC is, for obvious reasons, rather inhomogeneous. Some catalogues give magnitudes, others record image diameters, etc...With the help of the photometric data in the reference catalogue this information can readily be transformed into magnitudes on an international system. An analysis of the total star count as a function of the magnitude also allows the determination, plate by plate, of a limiting magnitude, or more precisely of the apparent magnitude at which incompleteness begins to be important. This information will be used in the section on error search.

6. Results.

So far we have analyzed a total of 368 plates of the Paris zone, 80 plates of the Oxford I zone, 42 plates of the Helsingfors zone and a few plates of the Potsdam zone. Part of the machine readable coordinates of the AC was made available by Chr. de Vegt of the Hamburg Observatory, the remainder was keypunched by CIDA personnel. The Paris zone was divided into three sections, and each section analyzed independently. They all yield significant and consistent higher order and magnitude dependent terms. For Oxford we found no magnitude term and only small higher order terms. The Helsingfors zone shows an important magnitude term. More detailed information will be given in a separate paper which is in preparation.

7. Error search.

An error search has to be made before proceeding to calculate final average positions for the stars in a given field. Due to the plate overlap scheme all stars in the interior of the field should have at least two measured images. Thus solitary stars require some analysis, since their reality may be doubted. The following reasons have to be considered:

1.- Keypunching error which can be eliminated by checking against the original listing.

2.- Wrong data were recorded when measuring the plate. Such errors can be determinated only by a reinspection of the original plate.

3.- The star is beyond the limiting magnitude of the adjacent plates. These cases can readily be determined with the help of the limiting magnitudes for each plate, as discussed in the section on photometry.

4.- The star is variable and was out of reach during the exposure of the adjacent plates. This interpretation becomes unlikely when the respective overlapping plates were taken during the same night.

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5.- The star was unintentionally skipped on the overlapping plate. Inspection of the plates would resolve these cases.

6.- A plate defect was measured as a star.

On the whole, a stellar image on a plate is confirmed as such only if a second image of the same object is present on a second plate, not necessarily of the AC series. Thus any object with two or more images in the AC may be considered to be real, and likewise any object confirmed by an independent second source. For the remaining solitary images a criterion can be derived which reflects the probability of its reality.

8. Position and proper motion catalogue.

Presently we have available a catalogue of confirmed positions for about 40000 stars. This number is steadily increasing as keypunching progresses. For stars in common with the AGK catalogue proper motions have been derived also. The latter, on the average, have a mean error of 2.6 milliarcsecond per year in both components.

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Discussion:

HUGHES I understand that your proper motions are accurate to about a quarter of an arcsecond per century.

STOCK Yes.

HUGHES I think that is a remarkable result.

EICHHORN Did you find a large coma effect in the Helsingfors zone?

STOCK Definitely so.

FRESNEAU Dieckvoss combined AC+AGK2+AGK3 positions to derive p.m. with an estimated error of 0.1"/ century. Please comment on your 0.026" century quoted accuracy.

STOCK Our formal error, averaged over <u>all</u> AGK stars, is 0".260/century (I mentioned 2.6 mas/year).

LACROUTE J'ai fait la résolution complète des zones francaises du catalogue photographique avec les références de l'AGK2-AGK3, études des positions et magnitude estimation des incertitudes sur la base accords internes et des erreurs systématiques dues aux positions sur les plaques. Les recouvrements pour contrôle n'ont pas été fait. Tout est publie au Centre de Données Stellaires de Strasbourg.

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