SALVAGING AN ASTROMETRIC TREASURE

The European Network for the use of the Carte du Ciel

M. HIESGEN[1], P. BROSCHE[2], A. Ortiz GIL[2], J. COLIN[3],
A. FRESNEAU[1], M. GEFFERT[2], H. T. MACGILLIVRAY[5],
S. HECHT[4], E. KALLENBACH[4], M. ODENKIRCHEN[2],
C. SCHÄFFEL[4] AND H.-J. TUCHOLKE[2]
[1] *Observatoire Astronomique de Strasbourg, France*
[2] *Sternwarte der Universität Bonn, Germany*
[3] *Observatoire de Bordeaux, France*
[4] *Institut für Mikrosystemtechnik, Mechatronik und Mechanik der Technischen Universität Ilmenau*
[5] *Royal Observatory, Edinburgh*

1. Introduction

"Salvaging an astrometric treasure" is an european effort to retrieve the astrometric and photometric information contained in the early Carte du Ciel plates. Five institutes from three european countries are involved. The project was supported by the European Community.

2. The Plates of the Carte du Ciel

The "Carte du Ciel" (CdC) and "Astrographic Catalogue" (AC) projects were the very first photographic all-sky surveys. They started after the 1887 "Congrés Astrophotographique International" held in Paris. The observations were made from 1893 until 1930. While the AC plates were measured completely, the CdC plates were not up to now. They were taken to make paper charts of all stars down to B=14^m. About 7000 plates covering almost 75% of the entire sky were taken for the Carte. These plates are spread all over the world in 15 observatories.

3. A New Measuring Machine

To access these plates, a transportable measurement machine which can be sent around to digitize the plates at their storage locations was developed.

B.J. McLean et al. (eds.), New Horizons from Multi-Wavelength Sky Surveys, 415–417.

The desired positional accuracy of this machine is $< 1\,\mu$m, the maximum time to digitize a $160 \times 160\,mm^2$ plate is 30 min. Engineering studies at the Technical University of Ilmenau (Germany) have led to the construction of a prototype scanner approaching these goals. This machine uses air bearings and achieves movement of the plate holder by an integrated electrodynamic x-y-$\delta\phi$ drive without contact between object holder and base (Kallenbach 1995). The measurements with the final version will be done by a large CCD with effective size of 10–15 μm per pixel. This machine will cost less than \$100 k.

4. First Results

To develop the reduction process and to analyse the quality of the CdC, we measured nearly 100 plates of the Paris zone on different available measuring machines. We can show that stars up to B=15.5^m can be detected on the plates. This means that about 20 million stars can be used to derive proper motions with an accuracy of 2 mas/y when using present epoch surveys (Lasker *et. al.* 1996). Previuos work using the AC have shown that this accuracy is possible.

In most cases, three exposures were taken on each plate with a small shift between them. These triple images show a triangular geometry of up to 300 μm size. The presence of several exposures and its peculiar geometry leads to the merging of the three exposures when the star is relatively bright ($\sim$ B = 8^m). In addition, the plates were provided with a rectangular grid to make the finding of stars on the charts easier.

Emulsion defects, dirt and dust are also present on many of the plates. These factors make it very difficult to determine accurate astrometric and photometric data of merged stellar images and those affected by réseau lines. To detect the triple objects, we developed a new algorithm using a local-maximum-finder. The identification of the 3 exposures has to be done automatically without knowing the triangle geometry and size. The results of these processes can be seen in Figure 1.

We used a model consisting on three added bi-dimensional Gaussian curves including a saturation parameter to be fitted to these triple images. A principal component analysis of the 22 fit parameters has shown that at least 7 dimensions are necessary to represent the manifold of the parameters. In the majority of cases, we obtained an internal positional accuracy of around 0.12″. Internal magnitudes can be calibrated with an accuracy of 0.12^m. This is independent of the elongation of the images caused by optical aberrations.

Some pilot projects which have used a limited number of plates have shown the value of the CdC for galactic astrometry. Geffert *et al.* (1996)

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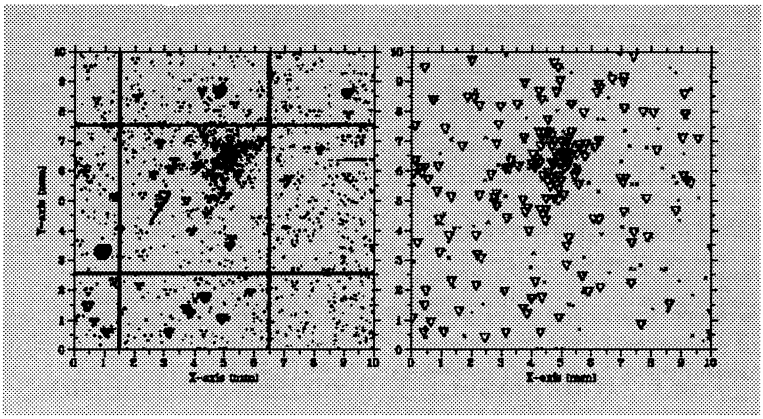

Figure 1. Part of a 1911 Carte du Ciel plate: Contour-plot of raw pixel data (left) and all thereon detected objects (right). Crosses show the single objects, triangles the detected triple images.

have used CdC plates for a proper motion study of the open cluster NGC 1647, others used these plates for astrometry of single objects (Dick *et. al.* 1993) or globular clusters (Hiesgen *et al.* 1996b). There are some more groups working with CdC plates on single targets (Lattanzi *et. al.* 1994, Jones 1996).

The most important reason of digitizing the whole CdC is be to provide equitorial coordinates and B-magnitudes around epoch 1910 for stars down to $B = 15.5^m$.

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