RevMexAA (Serie de Conferencias), **34**, 6–9 (2008)

PHOTOGRAPHIC ASTRONOMY, A VALUABLE BUT NEGLECTED FIRST EPOCH MATERIAL

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RESUMEN

Las observaciones fotográficas desaparecieron con la llegada del CCD, pero no así su legado, constituyendo los primeros registros de campo extenso, muy importantes para la elaboración de los movimientos propios estelares. La existencia de colecciones de placas con aporte astrométrico todavía inédito y la aparición de tecnología sencilla y barata que facilita el proceso de digitalización, es una llamada a los observatorios tradicionales a mostrar el material todavía no aprovechado, para facilitar su reducción por aquellos que se sientan motivados a ello.

ABSTRACT

Nowadays, CCDs are the primary imaging technology in astronomy, but not long ago there were photographic plates. Truly, the photographic era has left to us an important heritage of sky imaging, that spans about two centuries in time. Plates are the oldest records of wide fields on the sky, which makes them tremendously valuable for the measurement of stellar proper motions, that is, for photographic astrometry. The existence of plate collections with potentially great scientific value but not yet reduced, and the possibility of using simple and inexpensive technology to digitize them, offer an unprecedented opportunity to take advantage of this first-epoch material, now literally in storage.

Key Words: astrometry — catalogs — stars: kinematics — techniques: miscellaneous

1. GENERAL IDEAS AND PROPOSAL

Photographic observations were the standard tool for positional astrometry in the last two centuries. They have allowed us to keep the oldest records of the sky that can still be used today for scientific purposes. Obviously, when CCD technology arrived, standards were changed. Clear advantages of the new electronic detector could be summarized by its having a high quantum efficiency, images directly stored in digital format and a photometric linear response. These advantages overcome the small field of view of the useful CCD area.

Still, photographic material covers a time interval that is currently about ten times longer than what CCDs have done; it also provides us with an imaging record of the sky from which we can extract as much information as possible, making use of currently available technology. This is indeed one of the main contributions of photographic astrometry, the possibility of obtaining valuable information, even a long time after the images were taken. It is also one of the reasons that inspired the design of what are considered the most important and complete astronomical international projects, the Astrographic Catalog and the Carte du Ciel.

Most of the old observatories of the world have in their historical patrimony important plate collections covering the sky at different epochs through the 19th and 20th centuries. In the Ibero-American region, we can highlight the collections of the Carte du Ciel plates from the Córdoba zone (Argentina), the Tacubaya zone (México) and the San Fernando zone (Spain) (Figure 1), also most of the 7000 plates stored in La Plata Observatory (Argentina), plates from INAOE and IA-UNAM (México) and plates at the Santiago de Chile National Observatory (Chile).

Old-epoch plates contribute to the measurement of stellar proper motions in an important way. Their larger positional and photometric errors, as compared to CCD, are compensated by the long interval of epochs they span. Proper motion precisions attainable with the use of old plate catalogues can in fact be close to those of the Hipparcos and Tycho-2 catalogs.

As in any astrometric reduction, either on a plate or on a CCD, the first step is to determine the most precise position of the stars present in the field. In old times, a visual determination process was carried out on the plates for such purpose, and this became the largest source of errors, to which we have to

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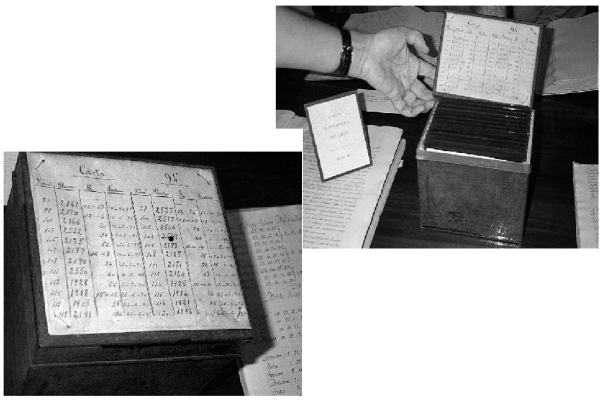

Fig. 1. Carte du Ciel plates from the San Fernando zone. These plates have been carefully preserved at the Real Observatorio de la Armada de San Fernando (Spain). Plates shown in this figure date from 1895.

add those introduced by the optical distortion of the telescope. In the best cases, 3 to 5 microns of typical error were achieved in the visual process; however, using a microdensitometer PDS machine, errors can be reduced to less than 1 micron. A PDS machine is ideal for measuring the stellar positions (Figure 2), but their very small number, immobility and problems to transport plates to and from the PDS location, have been important handicaps to start the plate reduction, especially on large collections. These are the reasons why many plates are still unprocessed.

An alternative solution to a PDS machine scan is the use of a transportable, maneuverable and inexpensive flatbed commercial scanner. Vicente, Abad, & Garzón (2007) showed that although the scanner is not the best-performing device, quick and precise enough results can be obtained from it (Figure 3). It was shown that systematic errors are large, but their being systematic means that they can be diagnosed and corrected for. In their case, errors of a few hundred microns were reduced to merely 3 to 4 microns, values that are similar to those obtained from other non-PDS machines currently used in astrometry. These machines, besides being slightly less precise than a PDS, have also the inconvenience of transportation mentioned in the previous paragraph. Therefore the flatbed commercial scanner is a much better option, especially when facing the loss of the scientific value of the plates.

This ADeLA contribution is an appeal to work on those unused photographic collections, now. A simple and inexpensive technology is offering us the opportunity to make the most out of this plate material.

Fig. 2. PDS microdensitometer is the ideal instrument for digitize plates.

2. WHY NOW?

There are currently a few all-sky astrometric catalogues available to the astronomical comunity. The Hipparcos Catalogue (Perryman et al. 1997) is the best optical realization of the International Celestial Reference Frame, but it only has stars brighter than V=12. The Tycho-2 Catalogue (Høg et al. 2000) contains an almost complete set of 2.5 million stars brighter than V=11.5. It is a compiled catalog based on the Hipparcos space mission and early-epoch ground based catalogs, like the AC2000 (Urban et al. 2003), itself a product of the Astrographic Catalog reduction. There is also the UCAC2 Catalog (Zacharias et al. 2004), which covers the sky south of $\delta = 45°$, and has a magnitude limit of R=16. The newer version, UCAC3, expected to be released by late 2008, will have full-sky coverage and its proper motions should be free of systematic errors (Zacharias 2008). There are also other ground-based catalogs, which are deeper but have lower proper motion accuracy. For a comprehensive overview of the currently available proper motion catalogs, see Girard (2008).

For the future, there is GAIA. The ESA astrometric space mission will take a giant step, switching astrometry from the milli- to the micro-arcsecond

Fig. 3. A commercial flatbed scanner has been used as alternative for a digital reproduction of plates. Carte du Ciel San Fernando plates have been digitized with excellent results.

regime. This, of course, will not happen before 2020. In the meantime –a whole decade– there are ongoing deep astrometric projects, all of them based on CCD observations, but none of them include plates in their material. A reason to start considering the use of the old plate collections now, is because they offer us the possibility of attaining milli-arcsecond accuracy down to V=16 mag, today. This gives us the chance to expand our knowledge of the Galaxy kinematics by a substantial amount, far more than what Hipparcos or Tycho-2 have allowed. An example of ongoing work in this sense is Rapaport et al. (2006), who reduced the Bordeaux zone of the Cart du Ciel. Similar efforts are being made to complete the San Fernando zone.

3. WHICH PLATES AND HOW?

Obviously, it is not possible to take advantage of all unused plates. Emulsion degradation, bad storage conditions and irrelevant scientific contribution are some of the reasons to consider in order to avoid non-profitable goals. But deep old projects covering large areas, as the Carte du Ciel zones, or areas observed regularly enough (like in variability studies), could contribute importantly to kinematical studies of the Galaxy. Those interested in searching old epoch material should say what they are looking for. Those having old plates should say what they have. This paper is in fact, a call for both sides.

The elaboration of a complete database of plates is hard, and its completeness inevitably will vary from place to place. A correct description of the actual state of an old plate is too difficult to evaluate and to transmit. Nonetheless, a sorted database including coordinates of the plate centers, epoch, filter, exposure time, name of the object or area, and a jpg image of the plate obtained by a digital commercial camera, could open the doors of the plate collections to the astronomical community. The current availability of Internet, and web resources like the Virtual Observatory, can also be extremely helpful in this sense.

Once the plate collections and their contents are known, there comes the digitization process. The use of a scanner for the plate reduction produces positional accuracies comparable to those obtained by other astrometric machines, and it can even get close to what a PDS microdensitometer can achieve. Acceptable accuracy, repetitivity and mobility are great advantages for their use. Truly, a PDS machine is the best option in terms of precision, but in every other sense, a scanner becomes an excellent option.

4. WHO WILL DO IT?

Although astrometry right now is not exactly the most popular field in astronomy, fortunately several astrometrists can still be found in Latin-American institutions, besides US and Europe. The Cordoba Observatory, the ROA Institute, the CIDA Foundation, the Bordeaux Observatory, the Valinhos Observatory, the University of Chile and Yale University, are some of those with the capability of addressing the process of plate reduction. Yale University, Cordoba Observatory and Bordeaux Obsevatory (and in the nearby future CIDA Foundation) have access to an original or a modified PDS machine. The availability of scanners and of the proper software to be used in the measuring process gives an important boost to the contribution of photographic astrometry to astronomy.

In particular, the CIDA Foundation offers its knowlegde and willingness to collaborate in this way, to people who need to use old plates not yet reduced. This is the moment to remember that these plate collections are there, before time and obliviousness causes them to lose their scientific value.

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