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RESUMEN

En este trabajo se expone el estado actual del proyecto de formación de un catálogo de posiciones y movimientos propios, basado en los dos mayores proyectos astrométricos llevados a cabo por el Real Instituto y Observatorio de la Armada (ROA), a lo largo de su dilatada historia. La participación en el doble proyecto fotográfico, Catálogo Astrográfico (AC) y Carta del Cielo (CdC) y el proyecto de automatización, traslado y puesta a punto del círculo meridiano, cuyo principal producto ha sido el catálogo HAMC2. Las placas de los proyectos AC y CdC están siendo reducidas en forma conjunta para aportar un catálogo de posición, primera época de un intervalo de tiempo que se cierra con el HAMC2. Para la reducción de las placas fotográficas de la CdC se han usado medios sencillos y novedosos, como el uso de un escaner comercial en su digitalización, estando en este momento a la espera de la reducción definitiva de 30 placas que han tenido que ser reescaneadas.

ABSTRACT

An updated summary of a future large astrometric catalogue is presented, based on the two most important astrometric projects carried out by the Real Instituto y Observatorio de la Armada de San Fernando (ROA). The goal is to make a catalogue of positions and proper motions based on ROA's Cart du Ciel (CdC) and the Astrographic Catalogue (AC) San Fernando zone plates, and the HAMC2 meridian circle catalogue. The CdC and AC plates are being reduced together to provide first-epoch positions while HAMC2 will provide second-epoch ones. New techniques have been applied, that range from using a commercial flatbed scanner to the proper reduction schemes to avoid systematics from it. Only thirty plates (out of 540) remain to be processed, due to scanning problems that are being solved.

Key Words: astrometry — catalogs — methods: data analysis — proper motions

1. INTRODUCTION

The AC and CdC projects are well known. They were considered the largest and most complete international scientific collaborations undertaken until very recently, when modern projects like GAIA were set up to revolutionize astrometry. Many references offer detailed information of AC and CdC, but it is worthy to highlight that while AC was designed with an astrometric purpose, CdC was meant only as a deeper cartography of the sky.

The ROA, formerly known as Real Observatorio de Marina de San Fernando, was one of the few observatories that reached the goal of completing both plate collections in the assigned area, with targets between declinations $-3°$ and $-9°$. The plates have been preserved thanks to the permanent care they receive, since they were declared a historical patrimony of the ROA and Spain.

Many reasons motivated the start of this project, mainly: the excellent state of the plates and their scientific potential still not exploited. But, in view of the impossibility of extracting plates from ROA and using a microdensitometer to scan them, we decided to try a commercial flatbed scanner for their digitization. It has been proved that errors are comparable or better than those obtained with the visual measurements of the AC collection.

Although the progress of this work has been slow for different reasons, we are getting closer to publishing a complete catalogue of positions.

2. THE PHOTOGRAPHIC MATERIAL

The CdC plate collection consists of 1260 $2° \times 2°$ plates, separated in RA by 8 time-minutes and declination centers at $-3°$, $-5°$, $-7°$ and $-9°$ for the triple-exposure plates, and at $-4°$, $-6°$ and $-8°$ for the single exposure ones.

One of the main issues to solve in the astrometric reduction of the plates has been the small separation between the triple exposures which form an equilateral triangle, because optical distortion (coma) from the ROA Gautier telescope blurs, distorts and merges the individual images, especially towards the edges of the plates. This restricts the reduction to the central area of the plate, with varying degrees of

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success from plate to plate, depending on the magnitud and the radial distance to the center. Thanks to the original design of the CdC project, where each star appears at least in two plates, the area covered by even plates is complete, except for the borders which overlap with other CdC zones.

Therefore and looking for an uniform catalogue, we have chosen only the plates centered on even values of declination for the final reduction. Likewise, and since plates are being reduced into the AC reference system, we have included all the visual measurements of the AC plates. In total, we have processed 1800 plates, 1260 from AC and 540 from CdC.

3. PLATE REDUCTION

A sample of the plates reduced has been given by Vicente et al. (2007), where a complete explanation of the scanner used and the processing of the data is given, regarding the correction of the non-uniform motion of the scanning device along the plate. A double digitization is performed per plate which obviously increases work by a factor of two.

As important as to find the method to detect distortions introduced by the scanner on the plates is that it could be applied in an easy and automatic form. But, that is not always possible. Some plates are problematic and it is neccessary to have on hand some alternative proccess. One of them is, for plates with a good number of overlaping stars with their equivalent AC plate, to make a new CdC digitized plate, including the X-coordinates from the direct digitized plate and the X-coordinates from their 90° tilted digitized plate for each star. Making use of the Polinomio Deslizante function (Stock & Abad 1988) it is possible to easily reduce the plate to the AC plates' system, with excellent results.

For most of the plates, distortions introduced by the scanner are detected by comparing the positions measured in one scan of the plate versus those obtained from the other, 90°-tilted, scan. Later the Polinomio Deslizante function is used to model such distortions and the corrected positions are then reduced into the AC plates' system.

To take full advantage of the substantial overlap between plates we use Stock (1981) as the initial reduction method, where the lineal component is solved by matrices, and then the non-lineal effects are solved using Abad (1993). All plates, now in a AC plates' system, are treated in this way.

4. RESULTS

This work is still ongoing, but an estimation of the final results can be seen at Vicente et al. (2010).

TABLE 1

MEAN ERRORS FOR A REPRESENTATIVE SAMPLE OF PLATES REDUCED

Mag.	RA error	Dec error	N. stars
3	0^s034	$0''28$	2
4	0^s019	$0''39$	19
5	0^s023	$0''37$	150
6	0^s022	$0''33$	617
7	0^s019	$0''29$	3059
8	0^s020	$0''29$	12458
9	0^s022	$0''32$	41983
10	0^s023	$0''34$	87861
11	0^s022	$0''33$	119731
12	0^s019	$0''27$	84382
13	0^s010	$0''15$	46983
14	0^s008	$0''12$	46297
15	0^s008	$0''11$	21560
16	0^s008	$0''12$	436
Total mean errors			
	0^s019	$0''28$	465538
Total mean error with *Hipparcos* catalogue			
	0^s023	$0''35$	5603

There is was shown that position and proper motion errors were better than those obtained with the *Hipparcos* and *Tycho* catalogues, due to the large span between epochs and the depth in magnitude of the plates.

After that, in 2009, a new complete re-reduction was started, using the CdC even-declination plates and all of the AC ones. A first set, including most of the plates, was straightforwardly reduced using Vicente et al. (2010) with the *Hipparcos* Catalogue as reference system. Results obtained can be seen in Table 1, and correspond to those stars having images in more than one plate. Plate CdC overlap is defined by that of the AC and CdC on their borders, since multiple-exposure plates were not considered in this reduction.

Figure 1 shows the distribution of (RA, Dec) residuals between the new partial CdC and AC catalogue, and *Hipparcos*. No systematic differences are visible.

Another 120 CdC plates have been more difficult to reduce.

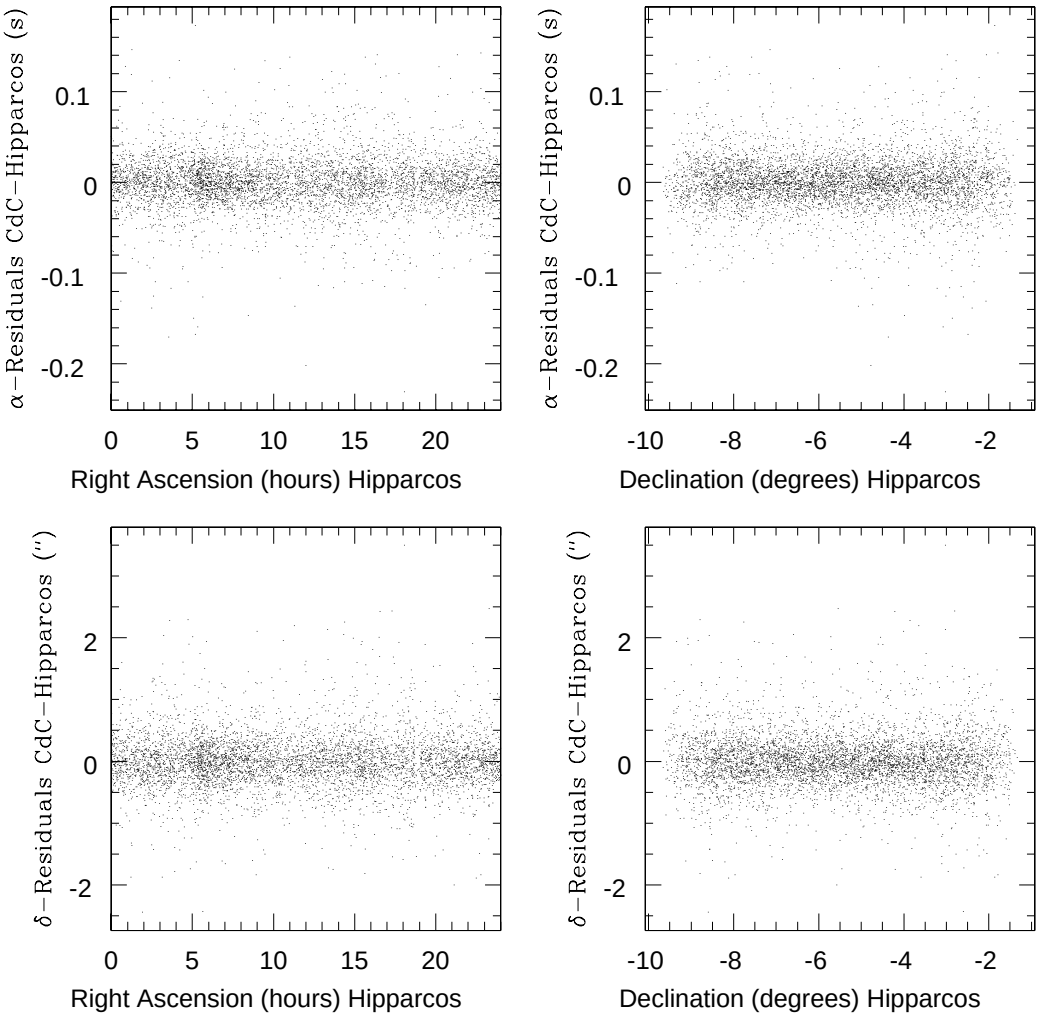

Fig. 1. Distribution of (RA,Dec) residuals between the new partial CdC and AC catalogue, and Hipparcos. No systematic differences are visible.

Most of them have been treated by building a composit plate, using the X-coordinates from direct and tilted digitization plate for each star.

Others required a manual reduction, one by one, due to: bad state of the plate, incomplete digitization that missed a portion of the plate, and some that simply yielded results inconsistent with the input data. Lastly, another 30 plates had to been re-digitized in January 2012, for reasons such as: misidentification in plate number, missing 90°-orientation scan, corrupted files. These plates are currently being reduced.

5. NEAR FUTURE

A catalogue's value resides not only in its quality, always a must, but also in its usefulness, the possiblity of the data being indeed used, for example, in the determination of proper motions.

In 2008, the Segundo Catálogo Meridiano Hispano-Argentino (HAMC2) was published. It is complete down to $V = 16.5$ magnitude and includes the San Fernando zone. The HAMC2 can be considered as ROA's most recent large astrometric enterprise.

The AC and CdC projects started what has been now a 120 years journey in astrometric large field work by ROA. In the 80's, a modernization process started with the automatization of the ROA Grubb Parsons Meridian Circle. In 1996, the now-called San Fernando Automatic Meridian Circle (CMASF), located at Observatorio Carlos U. Cesco in Argentina, made possible to make the HAMC2 cata-

logue (Muiños et al. 2008). Working with all the plate collections of the largest and more significant astrometric projects at ROA also pays homage to the great scientific history of ROA. This does not mean an end to the golden epoch for astrometry at ROA, as work continues with the automatization of the Baker-Nunn Camera (0.5 m) now installed at Observatorio de Fabra, Spain (Montojo et al. 2011). Nonetheless, it is hard to imagine that projects of such worldwide scale will be undertaken again in the coming future.

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