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Digitization and electronic distribution of the astronomical plate archives of Italian Astronomical observatories

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Abstract. We give some technical details on the digitization of the astronomical plate archives going on in some Italian Astronomical Observatories with commercial scanners and report on some preliminary tests on the scientific use of the digitized plates.

Key words. astronomical data bases: miscellaneous – catalogues

1. Introduction

In the last years, the use of internet-accessible astronomical data archives allows to put on everybody's desktop a great deal of astronomical data. This is particolarly true for the space-based astronomical instruments: the data of every High Energy mission, or of the Hubble Space Telescope, for instance, are now public one year after the observation, allowing the use of an ever-growing data set by the astronomical community also for purposes quite different from those motivating the original observation proposals.

This is still not true for the old data from ground based telescopes, because the original data were taken on photographic plates rather than with the modern digital electronic detectors. The only way to make the wealth of historical observations present in the plate archives available to the worldwide astronomical community is

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to digitize and store in electronic form these old plates and put them in computers connected to the internet network. As a matter of fact, an observation "does not exist" if it is not available on the Web.

We decided therefore to undertake a major effort to demostrate the practical possibility, using state-of-the-art desktop computers and commercial scanners, to digitize and put on the Web in a few years a sample of the astronomical plate archives of the Italian Observatories (including the Specola Vaticana), checking that the electronic form contains essentially the same astrophysical information as the original plates.

The astronomical Institutions presently involved in the project can be derived from the authors list of this paper.

Parallel to this national project, the Roma group started a similar project in the Summer of 2001 together with the Byurakan Astrophysical Observatory to digitize the plates of the First Byurakan Survey (the Markarian Survey): the state of the project can be followed on a dedicated WEB page (http://astro1.phys.unroma1.it/DFBS/). Some 230 plates have already been scanned (April 2003) and can be made available on request.

2. Technical scanning details

After an accurate search on the market among scanners working in transparency mode, and some trials, we selected the EPSON 1640 XL scanner for our work, with a plate holder of A3 size and an optical resolution of 1600 dpi (about 16 micron), density range 3.6, 14 bit resolution. It is connected to a PC with a Firewire link and allows to scan a 20x20 cm plate in few minutes. This model is used at Asiago, Padova and Specola Vaticana. The smaller (A4 size) model EPSON 1680 Pro, with the same resolution, is sufficient for plates up to 20x20 cm and is used at Catania and Byurakan.

The Torino group has started to make trial scans of their plates with a Microtex Artixscan 1100 (1000 dpi density 3.9, 14 bit resolution).

The automatic normalization of the commercial scanners does not work properly for astronomical plates, because it is taylored for normal photography: the software however allows to set manually the data number for the darkest and brightest areas of the image. After several trials we decided to scan each plate setting the lower limit on the overexposed stars, and the higher limit on the unexposed plate border (the plate fog level), caring that in no case the data go outside the allowed numerical range. The setting scanning parameters is a fundamental step to preserve the photometric information contained on the plate and requires about the same time as the scanning itself. In practice the overexposed plate areas must have counts around 100 and the plate fog around 15000. We use a special program written by Stefano Mottola (Berlin, DLR) to control the scanner (running under Windows) and to write the output image directly in FITS format (16 bit) on the hard disk, with a standard header containing the basic data of the plate: the header is presently written by hand, but we are studying the possibility to retrieve automatically these data from an electronic log-book.

3. Astrometric accuracy

We made first of all some tests of the geometric reproducibilty of the scans. A first test was simply to repeat the scan of a plate leaving it on the same position on the plateholder and blink the images: no difference could be seen at the pixel level of accuracy on a full 20x20 cm plate. A second test was made computing the astrometric solution, using standard IRAF tasks, of several objective prims plates of the Byurakan Survey (16x16 cm), assuming the red head of the spectra as a star position. All the stars ($\sim$ 1000) of the Tycho2 catalogue present on each plate were used: the rms deviations of the fit in both directions were again of the order of 1 pixel. The free parameters of the transformation are the plate center, the scales in both directions and the rotation angle of the plate with respect to the RA DEC grid (rxyscale in IRAF notation). A third test was made on small areas (16x16 mm) of some Asiago direct Schmidt plates, with a scale of 1.57 arcsec/pixel, using a number of GSC-2 stars to compute a local plate solution, finding an rms deviation of just 0.33 arcsec.

4. Photometric accuracy

A major difference between the chemical emulsions and the modern electronic detectors is its non linear response to the signal. Most of the old astronomical plates were not photometrically calibrated, due to intrinsic technical difficulties or simply because much of the photometric work was made by eye comparison with a reference sequence contained in the field.

To test the photometric accuracy we transformed the transparency raw data into intensity, simply assuming that

I=(V-B)/(T-B)

where I is the intensity, V is the average value of the unexposed plate, B is the value of the darkest pixel and T is the DN of a given pixel. Such assumption implies that the photographic contrast parameter (usually referred to as γ) is equal to 1.0.

Photometry was then performed with IRAF/APPHOT for a number of plates. We report in Fig. 2 the result for about 50 stars in the field of M17, and in Fig. 3 for about 200 stars in the field of 3C345. The rms deviation from the best fit line is 0.14 mag and the slope is 0.85, close to the ideal value of 1.0

A better accuracy may surely be obtained with a more refined determination of the Density-Intensity relation, possible if proper densitometric spots are available for a given plate. Auto-calibration procedures for plates without densitometric spots have also been realized in the past (see e.g. Agnelli et al.1979) but generally work for focal lenghts larger than those of the Schmidt telescopes.

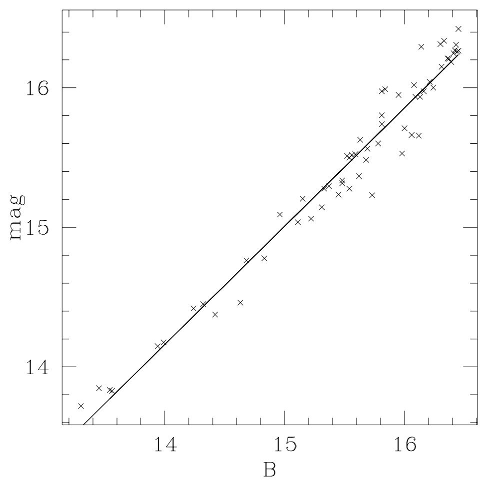

Fig. 1. Instrumental magnitudes of a GSC-2 photometric sequence in the field of M17 *vs* their photoelectric B values, from a plate of the Catania 40/61/121 Schmidt telescope.

5. Distribution policy

The enormous data amount produced in the framework of this project poses a series of problems. Not only plate images should be properly archived to avoid data loss by the natural degradation of photographic support, but it is also our aim to allow a fast and simple access to them. While it is possible to immagine to store the FITS files produced on a set of DVDs it is not so simple to allow such an archive to be easily accessed. Nowaday, prices of mass storage devices (hard disks) are fastly decresing and units of even 200GB can be considered as the high-end PCs standard. It must be noticed that the price per megabyte of such devices is of the same order of the one of DVDs. While this does not imply that we are planning to produce only a magnetic archive (DVDs will be used in any case), it means that our main storage device will be based on hard disks.

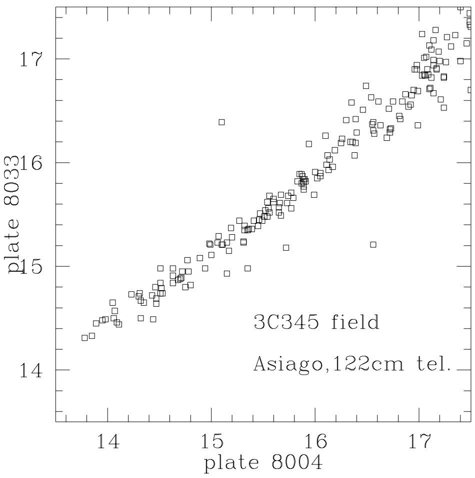

Fig. 2. Instrumental magnitudes of stars in the field of 3C345 from two digitized plates of the Asiago 122 cm f/5 Newton telescope, showing the good reproducibility of the data.

Maintaining data on hard disks allows an easy access through usual WEB user interfaces but creates also a problem concerning reliability. Since magnetic supports are not as secure as optical ones, some protection system should be adopted. Our solution has been to purchase a Network Attached Storage unit (NAS) that supplies the required data protection level by redundancy (RAID5) as well as support for multiple disks and network connections.

A NAS unit is essentially a PC running a network enabled Operating System that mounts a certain number of hot swappable disks. The initial configuration takes place through a WEB interface and the data access is granted by the most popular TCP protocols (FTP, NFS, Samba, etc.). There are now available cheap units (for instance using ATA disk interface instead of SCSI one) that allow to build a complete system with more than 0.5 TB of storage space for less that 3000 Euro. We are actually testing an X-tore XT unit at Campo Imperatore Observatory with 4 disks of 200 GB each for a total of 540 GB of data available (with RAID5 redundancy) and no hot spare installed. We plan to implement a similar device at the Asigo Observatory linking the WEB interface of the plates archive to this device using the FTP protocol. From the user point of view it will be identical to the case where images are directly stored on the web server.

Our current plan is that each Observatory will keep its digitized plate archive at home on one (or more) dedicated NAS unit, allowing the data access through the internet to the astronomical community.

The log books of the plates of the Observatories participating to the project are being put into electronic form. Those relative to the Asiago Observatory are now complete and available on the Observatory website (http://www.pd.astro.it/). Those of the Specola Vaticana are under way while those of Torino and Catania are in the starting phase.

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