Astrophotography: Do photographic plates still have a place in professional astronomy?

Introduction

The photographic plate has played a major role in the professional astronomy field for almost a century. There can't be two different opinions about that. However, the advent of the more efficient CCD around two decades ago, provoked the definitive abandon of the plate technique by practically all the professional observatories.

The reign of the photographic plate left behind literally millions of plates, surviving testimonies of the golden age of the first celestial automated surveys. The preservation of the plates legacy implies to the astronomical international community the investment of not minor resources, both economical and logistical. Is that effort worth while? Do archival plates are still useful?

This essay analyses the different subjects related to astronomical photographic plates, from its development to the current state of affairs. Finally, a personal opinion about the future validity of archival plates will be stated.

Astronomical photographic plates

Astronomical observations have been performed since the dawn of the civilization, becoming something quite natural to record their results. But the corresponding drawings, written descriptions or even measurements, no matter how careful astronomers were, invariably contained inaccuracies and subjectivities. The milestone that once and forever changed the potential value of the recorded observational results was the capability to obtain and store objective images -the *astronomical photograph*.

Although the technique of capturing images had been invented as earlier as 1826 [**1**], it was not until many years of improvements that *photographic dry-plates* could finally began to be seriously and methodically applied in astronomy. By 1882 the *Harvard College Observatory* commenced the first photographic sky survey, thus starting a process that was profusely imitated by many observatories all over the world, once the last century began [**2**].

The plates used in astronomy were flat pieces of glass, with a photosensitive emulsion deposited on its active face. They were physically quite large[1] due to the large focal planes of the major telescopes specifically designed for photography [**3**].

Plates had both pros and cons. Among the first were the intrinsic properties of the glass support, being flat and rigid -assuring an excellent dimensional invariability over time- with high stability to changes in environmental conditions. The drawbacks were basically due to the distortions that

[1] Most of the plates were about 20 x 25 cm, although the greatest ones were as large as 55 x 55 cm.

the emulsion could introduce, not to mention the fragility of the plates. The fundamental problems of the emulsion came from its *non-linear response to the incident light*[2] -topping the precision of derived measurements-, and from its *low efficiency* [**3**].

A partial solution for the aforementioned problems, widely used after 1950, arose from the development of a new technique that allowed the use of *spectrographic emulsions*, that is, emulsions that did react with high sensitivity, although only in narrow bands of the spectrum. Their direct consequence was the development of the *color index*, derived from the immediate comparison between images taken with red-sensitive and blue-sensitive plates [**3**].

The last major improvement of the emulsion was the *hypersensitising technique* (usually known just as *"hypering"*), which greatly reduced the exposure time, as the hypered plates were not only much more sensitive, but shown a very linear reaction as well. Unfortunately, the storage of those plates, both before and during exposure, required very restrictive conditions[3] [**4**].

Taking advantage of no other rival technique, photographic plates were the conclusive proof of nearly all the objective facts that astronomers discovered from 1880 up to the launching of the first balloons and rockets –leaving aside *radioastronomy*. Moreover, gradually improved by the mentioned advances, plates continued to contribute in professional astronomical research for many more years, spanning almost a hundred years of plain validity.

The current situation of archival plates

The systematic daily harvest of individual images and spectrograms carried on photographic plates during one hundred years have yielded an estimated current worldwide scattered collection of about *2 million images and 1 million spectrograms*[4], each one *technically unique*, actually weighting many hundreds tons [**2**].

Storing and preserving historic plates is not a trivial issue[5]. Properly storage entails, first of all, an accurate file classification, followed by enough locative space, easily accessed, with permanent control over the environmental conditions.

Although estimations from *Eastman Kodak Co*.[6] foresee that plates can ideally survive up to 350 years [**5**], in practice many plates have been already damaged or lost (earthquakes, fires, excess of humidity, chemical attacks, etc.), or even been destroyed on purpose. Surprisingly enough, some major observatories[7] did not routinely request investigators to return their plates, even though no longer needed [**7**].

All those difficulties, mixed up with the generalized euphoria after the excellent performance of the new CCD technology, explained the overall careless situation of archival plates around 1990. Recognizing the importance of the rescue of the plates, the *International Astronomical Union* (IAU) came into scene encouraging a census of all the plates dispersed worldwide. At present, an

[2] This problem is technically known as the *"low-intensity reciprocity failure"*.
[3] Usually a special hermetic chamber filled with nitrogen.
[4] Only the *Harvard College Observatory* stores 500,000 plates, being the largest single collection.
[5] As early as 1890 *Prof. Pickering* pointed out how serious were *"the difficulties of merely storing the plates taken at Harvard, owing to the great weight of the accumulation and the necessity of protecting it from fire"* [**6**].
[6] The firm that manufactured practically all the astronomical plates.
[7] Like ESO and Kitt Peak.

online catalog aimed to include all the stored wide-field photographic plates[8] is being done by the *Wide-Field Plate Database* team based in Bulgaria [**2**].

The ultimate solution to assure the permanent conservation of the valuable information stored in each single plate, whether image or spectrogram, is *to digitalize all of them*. This titanic endeavour is also currently being performed, although its conclusion will demand at least the next ten years.

Modern observational techniques of professional astronomy

From the dawn of times until well inside last century, astronomers placed at different locations in the earthly theatre could only peer the celestial drama through a narrow opening in the stage curtains. Certainly, astronomer audience was missing an important portion of the performed *full-electromagnetic-spectrum* play, without even knowing about its existence.

Curtains first slightly moved around 1932, when *radioastronomy* was born, showing an unexpected new sector of the universal stage. However, the Earth's atmosphere prevented curtains from practically any further opening, as Figure 1 shows. Only when the earliest detectors in different wavebands were sent to space, the obstacle for the stage opening could be overcome.

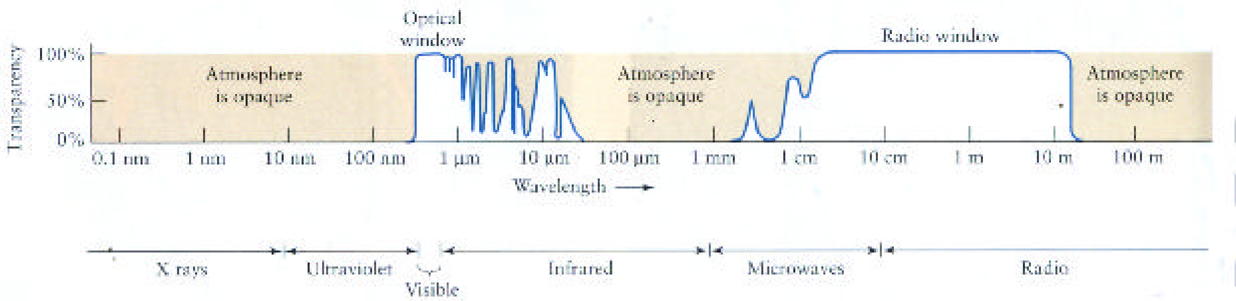

Figure 1
The Transparency of the Earth's Atmosphere

The curtains continued widening until wide open, towards the end of last century. At last, astronomers audience was allowed to enjoy the full universal radiation play in all its glory. Astronomy was revolutionized, *becoming a full multi wavelength discipline.*

Nowadays astronomers survey the Universe collecting astronomical data *from all possible wavelengths*, from the most energetic radiations -*gamma rays*- down to the lesser ones -*long-wave radio emissions*-. Exchanging data obtained from the full electromagnetic spectrum has been a routine task in modern astronomy.

Without considering all current active programs, Figure 2 depicts the new projects that NASA alone is going to support in the next ten years. Other major international astronomical research agencies have also complementary projects.

[8] The archive can be accessed at www.skyarchive.org.

The collected information by any modern detector -each time more accurate and sensitive- becomes *immediately stored in different digital files*. This avoids any possibility of accidental damage or loss, and at the same time allows the online authorized access from any place.

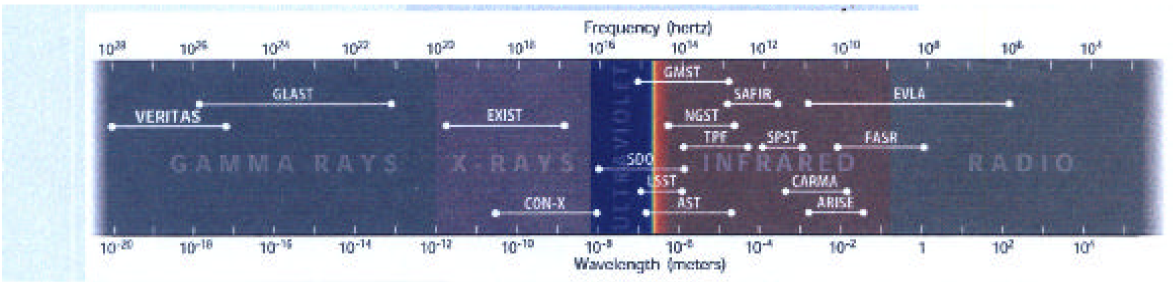

Figure 2
NASA's new multi wavelength projects to carry on in the short-coming future

Regarding visible wavelengths, the modern detector (although not only restricted to that band) is the CCD (*charge-coupled device*). Invented around 1970, it meant the beginning of the agony of the "old" photographic plate technique. Despite plates do have far greater image areas than CCDs, the latter show many other advantages: they are *much more sensitive through a wide dynamic range*, show *much linear response*, are dimensionally very stable, and last, but not least, their digital output can be directly stored into a computer [**9**].

Areas where photo plates have currently shown useful applicability

Astronomical photographic plates cover almost a century of objective heavens history. Although a blink in the Universe's life, astronomers simply can not afford to ignore such an invaluable source of information. As limited as they are, archival plates are the only "*time-domain*" astronomical data, both reliable and available.

Historic plates are been given a new lease of life through being transformed into digital data by means of state-of-the-art scanners. This has allowed computers to literally trawl through "*huge and invaluable data archives that are by far not yet fully exploited*" [**10**].

From remeasuring archival plates with new equipment, but especially *from comparing digitalized historical plates with data arisen from modern and sophisticated detectors at different wavelengths*, astronomers have managed to discover many new facts. Here are presented some of those recent successful studies, were archival plates have been "*instrumental, and in some instances essential, to disentangle astronomical information*" [**11**].

- An improvement in the absolute ephemeris of Pluto (*Standish*, 1996); the morphology of the jet of R Aquarii (*Hollis et al*., 1999); the cessation of the eclipses in SS Lacertae (*Torres & Stefanik*, 2000); the mass of Procyon (*Girard et al*., 2000); the long-term variability of red dwarf stars (*Bondar*, 1995); transient optical phenomena of gamma-ray bursts (*Shaeffer*, 1990; *Hudec et al*., 1994); optical analyses of X-ray stars, revealing the existence of active and inactive states (*Hudec & Wenzel*, 1976; *Simon, Hudec & Kroll*, 2000) [**11**].

- The confirmation of the discovery of *Quaoar* -the largest *Kuiper belt* object- and its quite circular orbit (*Brown & Trujillo*, 2002), being the largest object discovered in the Solar System for the last seventy years. Although the detection of *Quaoar* arose from a new digital image, its immediate confirmation and accurate orbital parameters came from archived images, showing an orbit "*thought to be quite circular for a solar system body, as its precise location on the old plates is highly predictable*" [**12**].

- This year's announcement of the discovery of the nearest known brown dwarf, designated *Epsilon Indi B*, less than 12 light-years far away. The discovery came up from *"a systematic computerized search for high-proper-motion objects which appear on red photographic sky plates, but not on the equivalent blue plates"* [**10**].

- The confirmation that the HIPPARCOS proper motions could be extended to stars with magnitude down to 14th magnitude. The research by *Geffert et al*. (1995) was based on kinematical studies of an open cluster with unprecedented high accuracy, applying a new multithreshold technique to very old photographic plates (the "*Carte du Ciel*" project from 1887), obtaining accuracies from 100 to 200 milliarcseconds [**13**].

Will photographic plates conserve their current validity in the future?

The digitalization of archival plates has not been finished yet. The fulfilment of this duty implies the scanning of the 100% of the plate population, *with the required quality*[9], that is, assuring that not a single "bit" of the original information gets lost in the digitalization process. The final result will be a huge digital database[10], worldwide accessible. Considering its full potentiality, the cost of this objective results minimal compared to any survey space program.

The digitalization process not only preserves the present information on historic plates, but also repairs some of their deterioration. In a similar way as current available technology allows to eliminate nearly all the imperfections of old audio records (mostly *hiss* and *clicks*), archival plates are been "rejuvenated" by means of the elimination of any detectable noise.

Moreover, continuous improvement in software research[11] permit to assure that the data obtained from plates *can even be improved*. For instance, the usual *lack of image depth of digitalized plates* -that arises when digitalized plates are compared to data from modern detectors- has been already partially defeated by stacking processes [**16**].

User-friendly digital files containing archival data has become an essential research tool to complement modern observations, and this one-way move is growing as more digitalized plates enlarge the files. The validity of the centenarian information stored in archival plates, far from expiring sometime in the future, will remain endlessly valuable.

[9] The scanning should reach the resolution imposed by the "sampling theorem", assuring that the introduced noise by the scanner process remains constrained under the original resolution of the scanned plates [**14**].
[10] It has been calculated that the proper digitalization of each single plate would demand about 100 megabytes of digital memory [**15**].
[11] Ten years ago, an "ancient" time regarding computer science evolution, NASA and Caltech developed a *"software system to comprehensively catalogue and analize the estimated half a billion sky objects in the set of over 3,000 digitized photographic plates produced by the 2nd Palomar Observatory Sky Survey, a photographic survey of the northern sky"* [17].

A completely different matter are *the historic plates themselves*. In my own opinion, once all of the plates will have been digitalized at the required standards, and the extracted information been absolutely safeguarded, their expensive preservation would be worthless. Just a minimal quantity of physical plates should be retained as surviving relics of the times when they played a leading role in Astronomy's history.

Conclusion

Despite the incessant flooding of reliable and accurate multi wavelength data, obtained by the-state-of-the-art technology, archival plates still conserve its usefulness for serious astronomical research. Far from decaying, the caught information has no future time limitations, once every single plate become properly digitalized. Having reached that objective, physical plates could be discarded.

Meanwhile, we must preserve them. Paraphrasing the ecologist adage, we all should be well aware that the astronomical historic plates information that prior generations gathered is a mankind property that actually doesn't belong to us, *we just have borrowed it from the new generations to come.*

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Figures

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