Sonneberg Observatory PHotographic Image Archive

Current state and activities

Peter Kroll[1,2], Sergej Schumacher[2], Norbert Polko[1], Frank Mattei[1], Thomas Berthold[1], Georg Luthardt[1], Jörg Sänger[1], Angelika Wicklein[1]

[1]Sonneberg Observatory and 4π Systeme GmbH, [2] Coburg University of Applied Sciences and Arts

Abstract

Sonneberg Observatory harbours approx. 275,000 astronomical glass plates and films taken with different instruments and at different sites between 1923 and 2010. More than 85% (237,000 plates) have been digitized in the last years forming **SOPHIA – S**onneberg **O**bservatory **PH**otographic **I**mage **A**rchive with 25 TB of raw image data. Currently effort is taken to find WCS solutions for all digitized plates of the Sky Patrol as these form a homogeneous sub collection (about 150,000 plates) of more or less equal scale (825"/mm), limiting magnitude (14.5^m in pg (blue); 13.5^m in pv (yellow/red)), emulsions and time coverage (1954 – 2010).

Introduction

Sonneberg Observatory's plate archive consists of about 275,000 plates of sizes 6×6 cm^2 up to 30×30 cm^2, most of them 13×13 cm^2. They were taken with different instruments, mostly Tessars (55/250 mm, about 150,000 plates), Astrographs (400/1950 mm, 400/1600 mm, 25,000), Schmidt (500/700/1720 mm, 8,500) and others between 1923 and 2010. Depending on focal length and plate size the field of view runs from $3°$ through $30°$. Fourteen Tessar instruments, forming the so-called "Sky Patrol" and equipped with broad-band filters, cover the complete visible sky above Sonneberg from North Pole down to $-33°$ declination with limiting magnitude 14.5^m in pg (photographic = blue) and 13.5^m in pv (photovisual = yellow/red), while the astrographs and Schmidt camera cover about 80 selected, mostly non-overlapping fields of $10° \times 10°$ across the sky forming the "Field Patrol". A complete list of instruments and fields is given in Bräuer & Fuhrmann, 1999 [1].

The hand-written log books of the different instruments have been key-punched in the 1980ies with the then emerging first personal computers to be stored in a dBase database. Over years, almost 90% of the log books were transferred in this way, the remaining 10% are still to be entered, but are more complicated due to non-standard notations and use of different filters and emulsions, also in combination with spectral exposures.

First tests to scan plates in bulk started 1991 with a projection line scanner. However, the speed was rather slow, just 5000 plates in three years. Afterwards some tests with different scanner equipment have been conducted, but the sheer number of plates prohibited the use of a single high-end but expensive and slowly super scanner. With the progress of digitization techniques around year 2000 and the availability of fast transparency scanners of sufficient quality the situation changed. In the context of the acquisition of Sonneberg Observatory by 4π Systeme GmbH in 2004, the company started bulk digitization of the plate collection beginning with the uniform Sky Patrol plates representing about 75% of the collection.

Bulk scanning and storage

The bulk scanning started in 2004 with four *HP Scanjet 7400C* with illumination unit. With an output of 50,000 plates per year, almost all Sky Patrol plates could be digitized until 2007. For larger plates the scanner *Microtek ScanMaker 9800 XL* was used from 2008 on. The two scanner types (see Fig. 1) were operated by `VueScan 6.2` software with 16 bit output and a scan resolution of 20 μm. The latter value was a kind of compromise between duration of scanning one plate (10 to 30 minutes) and just **not** resolving the grains in the photographic emulsion which is in the order of 15 to 20 μm (see study [2] of Spasovic et al.).

Figure 1: HP Scanjet 7400C and Microtek ScanMaker 9800 XL.

The current total number of scanned plates sums up to 237,430, which is about 85% of all plates. There are 211,751 scans of small plates (Sky Patrol) and 25,679 scans of big plates (Field Patrol with astrographs).

From 2004 on all scan data were stored on DVDs which was the a reasonably priced solution for storing large amounts of data. To enhance storage reliability each scan file was stored on two DVD of different manufacturers. In addition, the raw image scan files of TIF format were compressed using `gzip -9` leading to a compression of about 80%...90%. Summing up all scan files the total amount of raw data is about 25 TB.

By drifting down of prices and in order to improve access the content of all DVDs have been copied to hard disks in the course of 2018. In the meantime there is a storage system of 24 TB for Sky Patrol plates as these data are currently increasingly used.

Current scientific goals

Obviously, the ultimate goal of digitising astronomical plate archives such as that of Sonneberg Observatory is to analyse the complete spectrum of scientific data that can be extracted. This is, however, a complex task needed to be split in realistic portions. A first step is the investigation of the most homogeneous part of the archive which is represented by the about 150,000 Sky Patrol plates covering the whole sky visible at Sonneberg running from the end of 1950ies to 2010.

Motivated by Nikolaus Vogt of Valparaiso/Chile we have started a search for rare outbursts of WZ-Sge stars, i.e. dwarf novae with very long super cycles of more than 10,000 days. During the last couple of years several new stars of this type have been discovered but the outburst history of the stars is widely unknown.

Owing to the fact that faint stellar imprints very near to the plate limit can easily get lost by automatic means, we have decided to inspect all plates of the star's location by naked eye. However the process of loading the full image, finding the star's environment and looking for a – possibly faint – outburst is very time consuming and tediously. The situation can be improved by automatic extraction of a relatively small snippet just showing the star's position and some surrounding stars. This, however, requires a good WCS solution of the whole plate.

WCS solutions for Sky Patrol plates

To achieve a WCS solution we have made use of the `solve-field` application, which is part of the `astrometry.net` software package. After some first trials it turned out that it will not be easy to find parameters to yield a good WCS solution. Typical and frequent problems with the plates were stray light, poor development, and overexposure (see figure 2).

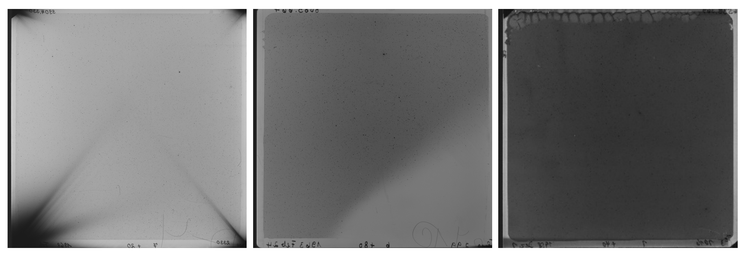

Figure 2: Examples of problematic plates. From left to right: stray light while handling plate before development, poor development, overexposed due to fog or moon light.

Also, the problem of star detection near the heavy distorted edges and corners of the plates had to be solved. Typical for the Sky Patrol plates is the astigmatism of the Tessar optics. Fig. 3 shows a detailed part of the center and of one edge of a plate.

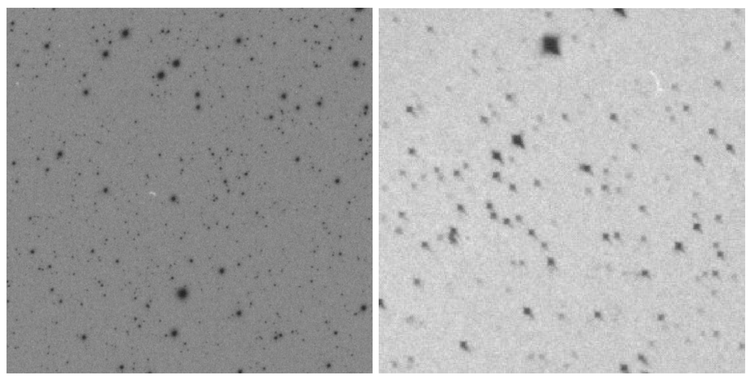

Figure 3: Typical detailed image of center of a plate (left) and a region next to a corner (right) showing the characteristic crosses of astigmatism.

The algorithm of star detection has also problems with very nearby stars as shown in figure 4.

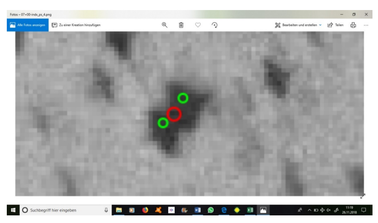

Figure 4: Two nearby stars erroneously identified as one single star.

After getting initial help from the Marburg group (see [2]) S.S. has studied a broad spectrum of parameters to get WCS solution on more than 90% of the plates of one field within acceptable computing time (1 min for one plate).

Finally, the best results have been achieved with the follwing set of parameters:

```
solve-field --overwrite --invert --cpulimit
3600 --ra 15 --dec 40 --radius 30
--scale-low 3 --scale-high 30 --scale-units
"dw" --downsample 3 --plot-scale 0.25
--odds-to-solve 1E200 --odds-to-reject
1E-30 --code-tolerance 0.002 --pixel-error
1 --tweak-order 4 --dir plate_solved
--new-fits plate_wcs.fits plate.tif >>
plate_solved.txt
```

Figures 5 and 6 show one example of detected (marked red) stars for a typical good plate (field 7^h $+20°$) and the position of catalogue stars based on the WCS solution (marked green).

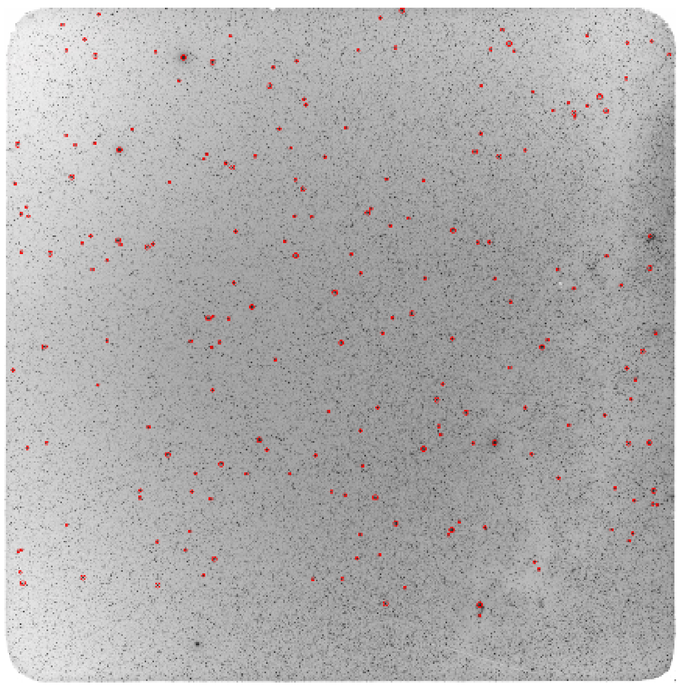

Figure 5: Stars detected by `solve-field`.

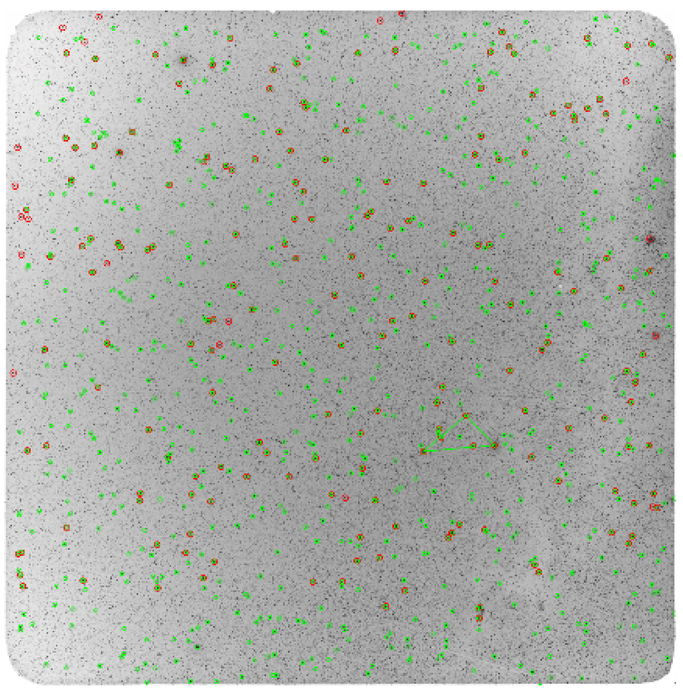

Figure 6: Stars detected by `solve-field` (red) and assigned to a star catalog (green).

Outlook

Starting with the fields which have recently been used for testing `solve-field` parameters all plates of those fields are going to be processed. Afterwards, the process will be carried out field by field. As there are 120 different fields of Sky Patrol, each in two colors, and between about 500 and 2500 plates per field, this process will take some time.

The next step will then be to build up a database of all detected objects with their position, magnitude and other attributes.

The digitisation of the remaining 15% (about 40,000 plates) of the collection is going to be launched as soon as a new scanner could be procured, accompanied by key-punching the remaining (but complicated) log books.

References

[1] T. Bräuer, B. Fuhrmann: The Sonneberg Plate Archive, in P. Kroll et al.: Treasure-hunting in astronomical plate archives, 1999.

[2] M Spasovic, C Dersch, C Lange, D Jovanovic, A Schrimpf: Sonneberg Sky Patrol Archive – Photometric Analysis, in P. Skala: Proceedings of Astroplate 2016, p. 67, Prague 2019

Contact

`pk@4pisysteme.de`