Digitising Astronomical Plates of the Heidelberg Königstuhl Archives

Florian Rothmaier, Markus Demleitner
with contributions by Holger Mandel and Stephanie Schwemmer

Zentrum für Astronomie Heidelberg

Sofia, Bulgaria – October 3, 2013
1. The Heidelberg Königstuhl Archives
2. How to Digitise Photographic Plates?
3. How do we Append Metadata to our FITS Files?
4. How do we publish the data?
The Heidelberg Königstuhl Archives
Why Astrophotography?

- **astrometry**: determining astrometrical quantities (positions, proper motions)

- **photometry**: measuring the intensity of an astronomical object’s electromagnetic radiation

- **spectrography**: investigating the spectra of stars and other astronomical objects

- **preservation**: archiving of data may allow for discovering unknown objects at a later time
Max Wolf (1863-1932): German astronomer and pioneer of galactic astrophotography

- 1880: erection of a private observatory in his parent’s house
- 1890: first person who made a photography of the North America Nebula
- 1891: first astronomer who found a minor planet (“(323) Brucia”) using astrophotographical methods
- main working field: cataloguing of astronomical nebulae
- discovery of 246 minor planets during his scientific career
Astrophotography in Heidelberg

- 1898: inauguration of the “Landessternwarte Königstuhl” (Königstuhl is a hill located above the city of Heidelberg)
  - 1902: Wolf was appointed the head of the new observatory
- 1967: foundation of the Max Planck Institute for Astronomy (MPIA) on Königstuhl
- over the years, the archives of the Landessternwarte Königstuhl and the MPIA grew up to about 20,000 photographic plates
about 10,000 plates of the sizes 24 cm x 30 cm or 30 cm x 30 cm taken by the Bruce double astrograph at Landessternwarte

about 600 plates of the size 24 cm x 24 cm taken by the Schmidt telescope at Calar Alto (Spain)
about 10,000 plates of the sizes 24 cm x 30 cm or 30 cm x 30 cm taken by the Bruce double astrograph at Landessternwarte

about 600 plates of the size 24 cm x 24 cm taken by the Schmidt telescope at Calar Alto (Spain)

about 4,000 smaller-sized plates from the Waltz reflector (Landessternwarte)

about 4,000 smaller-sized plates taken by Wolf’s double astrograph first in his parental house, later at Landessternwarte
some instrument/plate characteristics for different plate groups:

<table>
<thead>
<tr>
<th>Telescope</th>
<th>Focal Length/cm</th>
<th>Aperture Ratio</th>
<th>Plate Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Königstuhl Bruce</td>
<td>200</td>
<td>$f/5$</td>
<td>24(30) cm × 30 cm</td>
</tr>
<tr>
<td>Calar Alto Schmidt</td>
<td>240</td>
<td>$f/3$</td>
<td>24 cm × 24 cm</td>
</tr>
<tr>
<td>Königstuhl Waltz</td>
<td>281.5</td>
<td>$f/3.9$</td>
<td>9(13) cm × 12(18) cm</td>
</tr>
<tr>
<td>Heidelberg Wolf</td>
<td>90</td>
<td>$f/6$</td>
<td>9(13) cm × 12(18) cm</td>
</tr>
</tbody>
</table>
Photographies of Nebulae

- historical photography of the North America Nebula ("NGC 7000") in the constellation Cygnus
Photography of the minor planets “(325) Heidelberga” (label 05) and “(175) Andromache” (label 04), taken on the 27th of January 1909.
Photographies of Comets

- comet “C/1911 O1” (“Brooks”) taken on the 25th of September 1911
Digitising Photographic Plates
in 2005, funded by the Klaus-Tschira Foundation, a scan project was started with the aim of

- preserving the plate collection suffering from oxidation processes, humidity, temperature fluctuations (and dormouse attacks)

- making the collection accessible to the interested public
Scanning Photographic Plates

- **Nexscan F4100** professional scanner of the “Heidelberg Druckmaschinen AG”
  - 315 mm x 457 mm scan area which is masked down to the various plate sizes
  - 3 x 8000 pixel CCD array for colour (RGB) and B/W work
  - 5080 dpi optical resolution
### Scanning the Logs

<table>
<thead>
<tr>
<th>Day</th>
<th>Month</th>
<th>Date</th>
<th>Time</th>
<th>Temperature</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Nov</td>
<td>24</td>
<td>15:00</td>
<td>13°0 -14°0</td>
<td>+22°C</td>
</tr>
</tbody>
</table>

- **URL**: [http://www.ub.uni-heidelberg.de/helios/digi/landessternwarte.html](http://www.ub.uni-heidelberg.de/helios/digi/landessternwarte.html)
Appending Metadata to FITS Files
Further Processing of the Digitised Plates

- digitised plates are saved in the wide-spread FITS ("Flexible Image Transport System") format
  - a major feature of a FITS file is the human-readable ASCII header used to store metadata about the image

- our headers should include:
  - the observation data (observer, observation time, exposure, ...) extracted from the logs
  - plate-specific metadata: information about the telescope, instrument or the emulsion/filter combination
  - astrometrical information

astrometrical calibration needed for our data files
usage of the program “SExtractor”

- extracts objects by separating areas belonging to background and objects ($\rightarrow X, Y$)
- writes extracted objects to a catalogue
- URL: http://www.astromatic.net/software/sExtractor

usage of the calibration tool “Astrometry.net”

- seeks to return astrometric calibration metadata for an image
- URL: http://astrometry.net/
basic idea of “Astrometry.net”:  
- download of so-called “index files” that contain “skymarks”, i.e. quads of celestial objects  
- for each image, the software first tries to detect stars (green circles in the figure) and second looks for sets of four objects (green lines)
basic idea of “Astrometry.net” (continued):

- each found quad is then checked for a match in the skymark index
- when a matching skymark has been found, the tool provides a cross-check of the type ‘Where else in this image would I expect to see stars?’ (red circles)
- based on some quality criteria, the software decides whether the image has been astrometrically solved
Calibration Failures

- for about 2.5% of the digitised plates, Astrometry.net does not find positions

- in many cases, the reason for this is evident:
  - double or multiple exposures
  - photography guided on an object resulting in long trails
  - too noisy photographies
  - ...

- but in some cases, it’s unclear why the calibration fails

→ further investigation needed
Data Publication
A Few Words on the Virtual Observatory

The Virtual Observatory (VO) is about...

- specifying standards, i.e., defining how
  - data should look like ("data models")
  - two or more machines should query and exchange data ("protocols")

- archiving data:
  - storing all kinds of astronomical data (e.g., catalogues, images, spectra, ...) in data centres which can be accessed from all over the world

- developing applications that enable users
  - to retrieve data from VO-compliant databases
  - to analyse, manipulate or visualise data
Standards in the Virtual Observatory

“Simple Image Access Protocol” (SIAP):
- allows for retrieving image data out of a variety of astronomical repositories by using a uniform interface
- query is defined by choosing a rectangular sky region
- query returns a list of image candidates
“Simple Image Access Protocol” (SIAP):
- allows for retrieving image data out of a variety of astronomical repositories by using a uniform interface
- query is defined by choosing a rectangular sky region
- query returns a list of image candidates

“ObsCore Data Model”
- simple data model used to describe observation data
- includes a set of elements, e.g. the name of the object observed and a URL that allows for downloading the data
Welcome to the GAVO data center, provided by Zentrum für Astronomie Heidelberg on behalf of the German Astrophysical Virtual Observatory.

In addition to the services listed below, we offer access to numerous tables using TAP or form-based ADQL.

Please check out our site help.

Services Available

- accessible and searchable at http://dc.g-vo.org
- about 15 terabytes of astronomical data comprising
  - catalogues that can be accessed by different standardised protocols
  - spectra
  - digitised photo plates
Heidelberg Digitized Astronomical Plates

“Heidelberg Digitized Astronomical Plates” (HDAP)

- URL: http://dc.g-vo.org/hdap
- data volume: \(\sim 14\) TB
- currently 14,277 calibrated plates in the database

Services Available

By Title  By Subject  By Author  

Search: heidelberg

- Flash/Her os Spectra Web Interface
- HDAP -- Heidelberg Digitized Astronomical Plates

Authors
- Mandel, H.; Birkle, K.; Landessternwarte Heidelberg

Last Update
- 2013-04-18

Description
- Scans of plates obtained at Landessternwarte Heidelberg-Königstuhl and German-Spanish Astronomical Center (Calar Alto Observatory), Spain, 1900 through 1999.
as specified by the Simple Image Access Protocol our users

- have to give coordinates (or a resolvable object name like $M31$) and a field size
- may select a type of intersection between search and image area
Finding Objects by Position (SIAP)

- if the database query matches at least one plate, a result list is returned

<table>
<thead>
<tr>
<th>Title</th>
<th>Obs. date</th>
<th>Full Plate</th>
<th>Product key</th>
<th>Aladin</th>
<th>Ctr. RA [deg]</th>
<th>Ctr. Dec [deg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1384a 1905-12-26 M31</td>
<td>1905-12-26T20:57:44Z</td>
<td>[Plate Row]</td>
<td></td>
<td>[Open Applet]</td>
<td>10.68</td>
<td>41.27</td>
</tr>
<tr>
<td>B1385b 1905-12-26 M31</td>
<td>1905-12-26T20:57:55Z</td>
<td>[Plate Row]</td>
<td></td>
<td>[Open Applet]</td>
<td>10.68</td>
<td>41.27</td>
</tr>
</tbody>
</table>

- the list enables a user to download the FITS file and it provides plate metadata, e.g.
  - the observation date
  - the coordinate (right ascension and declination) of the center of the observation
Finding Non-Stationary Objects (ObsCore)

- ObsCore-compliant metadata allows for retrieving exposures of non-stationary objects in the database, e.g. minor planets or comets,

- http://dc.zah.uni-heidelberg.de/lswscans/res/positions/fullplates/form

### Full plate access to Heidelberg Digitized Astronomical Plates

Please note that the scans are about 1 GB per plate.

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Synthetic name of the image</td>
</tr>
<tr>
<td>Plate</td>
<td>Image title; to look for a plate by plate number, use something like ^^9345^^</td>
</tr>
<tr>
<td>Obs. date</td>
<td>Epoch at midpoint of observation</td>
</tr>
<tr>
<td>Plate contains</td>
<td>Coordinates (as h m s, d m s or decimal degrees) or SIMBAD-resolvable object the plate must contain</td>
</tr>
<tr>
<td>Targ. Obj.</td>
<td>Selection: matches all, multiple values illegal.</td>
</tr>
</tbody>
</table>

- our users may
  - type a plate number into the search form or
  - select a target object
Finding Non-Stationary Objects (ObsCore)

- a list of matching plates is returned providing
  - a FITS file of the image (also available in scaled versions)
  - information about the observation date, the observer, and the exposure time

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D896 1911-09-20 1911c Brooks</td>
<td>1911c Brooks</td>
<td>238.38</td>
<td>53.98</td>
<td>1911-09-20T19:26:35Z</td>
<td>600.0</td>
<td>132.8MiB</td>
<td><img src="image" alt="Scaled 25%" /> <img src="image" alt="Scaled 6.25%" /></td>
<td>M.Wolf</td>
<td>More</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F. Rothmaier, M. Demleitner (ZAH) Heidelberg Königstuhl Archives 2013-10-03 30 / 33
more than three quarters of the Heidelberg Königstuhl plate collection have been preserved by digitisation

observation logs for the Bruce telescope and the Waltz reflector have been scanned (logs for Wolf’s double astrograph are being scanned)

about 14,000 digitised plates stored in the GAVO Data Centre providing an astrometrical calibration
  - plates can be retrieved by using a positional search (SIA Protocol)
  - files that contain non-stationary objects are accessible thanks to the ObsCore data model

current funding ends by April 2014; at that time, the entire Königstuhl plate collection will have been digitised
Благодаря!
References

Scan Project – Digitizing Astronomical Plates of the Heidelberg Königstuhl Archives,
http://www.lsw.uni-heidelberg.de/projects/scanproject/.

Observation Logs (“Beobachtungsbücher”) of Landessternwarte Heidelberg,

GAVO Data Center, http://dc.g-vo.org/.