Digitising Astronomical Plates of the Heidelberg Königstuhl Archives

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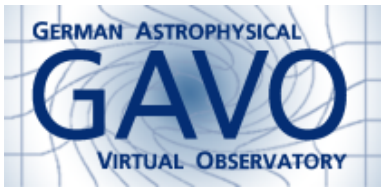
Zentrum für Astronomie Heidelberg

Sofia, Bulgaria – October 3, 2013



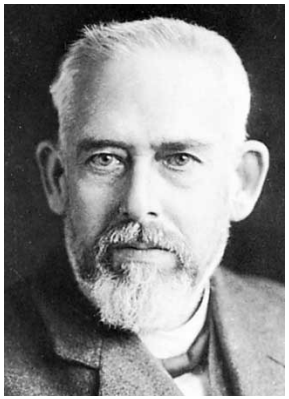
Outline

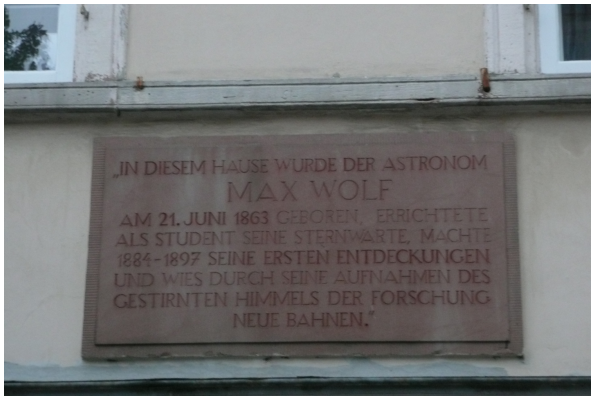
The Heidelberg Königstuhl Archives

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

Astrophotography in Heidelberg



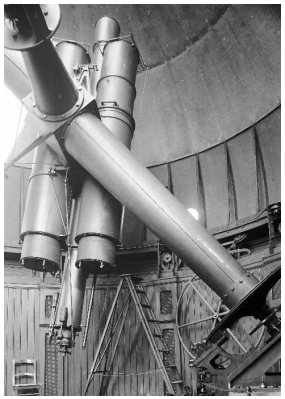


- Max Wolf (1863-1932): German astronomer and pioneer of galactic astrophotography
  - 1880: erection of a private observatory in his parent's house
  - 1890: first person who made a photography of the North America Nebula
  - 1891: first astronomer who found a minor planet ("(323) Brucia") using astrophotographical methods
  - main working field: cataloguing of astronomical nebulae
  - discovery of 246 minor planets during his scientific career

Astrophotography in Heidelberg

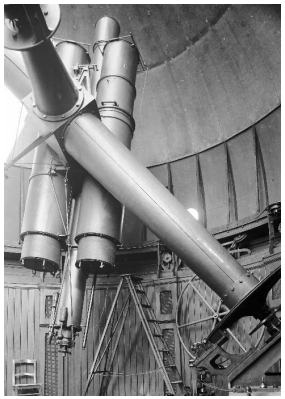
- 1898: inauguration of the "Landessternwarte Königstuhl" (Königstuhl is a hill located above the city of Heidelberg)
  - 1902: Wolf was appointed the head of the new observatory
- 1967: foundation of the Max Planck Institute for Astronomy (MPIA) on Königstuhl
- over the years, the archives of the Landessternwarte Königstuhl and the MPIA grew up to about 20,000 photographic plates

The Heidelberg Königstuhl Archives



- 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)

The Heidelberg Königstuhl Archives



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- 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

The Heidelberg Königstuhl Archives

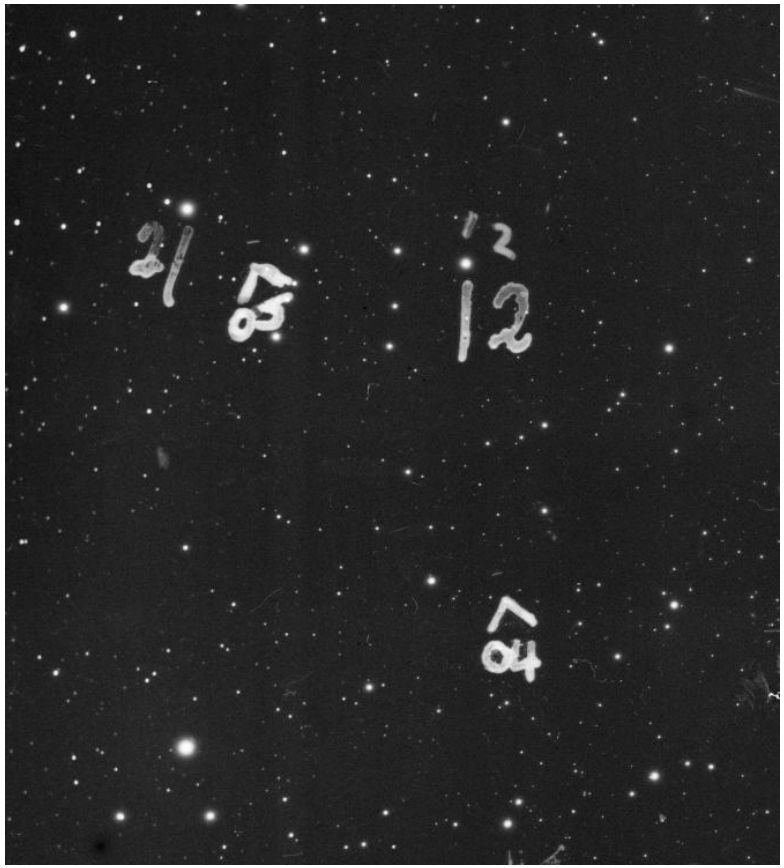
- some instrument/plate characteristics for different plate groups:

Telescope	**Focal Length/cm**	**Aperture Ratio**	**Plate Size**
Königstuhl Bruce	200	$f/5$	24(30) cm x 30 cm
Calar Alto Schmidt	240	$f/3$	24 cm x 24 cm
Königstuhl Waltz	281.5	$f/3.9$	9(13) cm x 12(18) cm
Heidelberg Wolf	90	$f/6$	9(13) cm x 12(18) cm

Photographies of Nebulae

- historical photography of the North America Nebula ("NGC 7000") in the constellation Cygnus

Photographies of Minor Planets



- 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

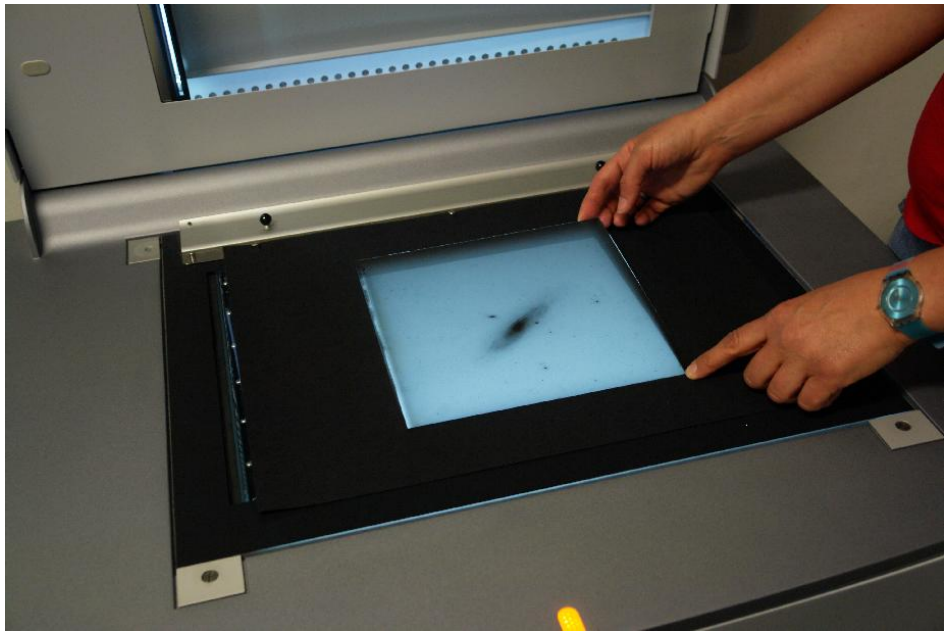
Digitising Photographic Plates

Scan Project

- 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)

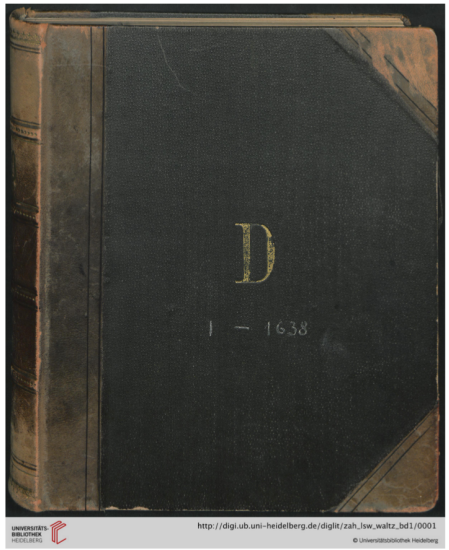
  - making the collection accessible to the interested public

Scanning Photographic Plates



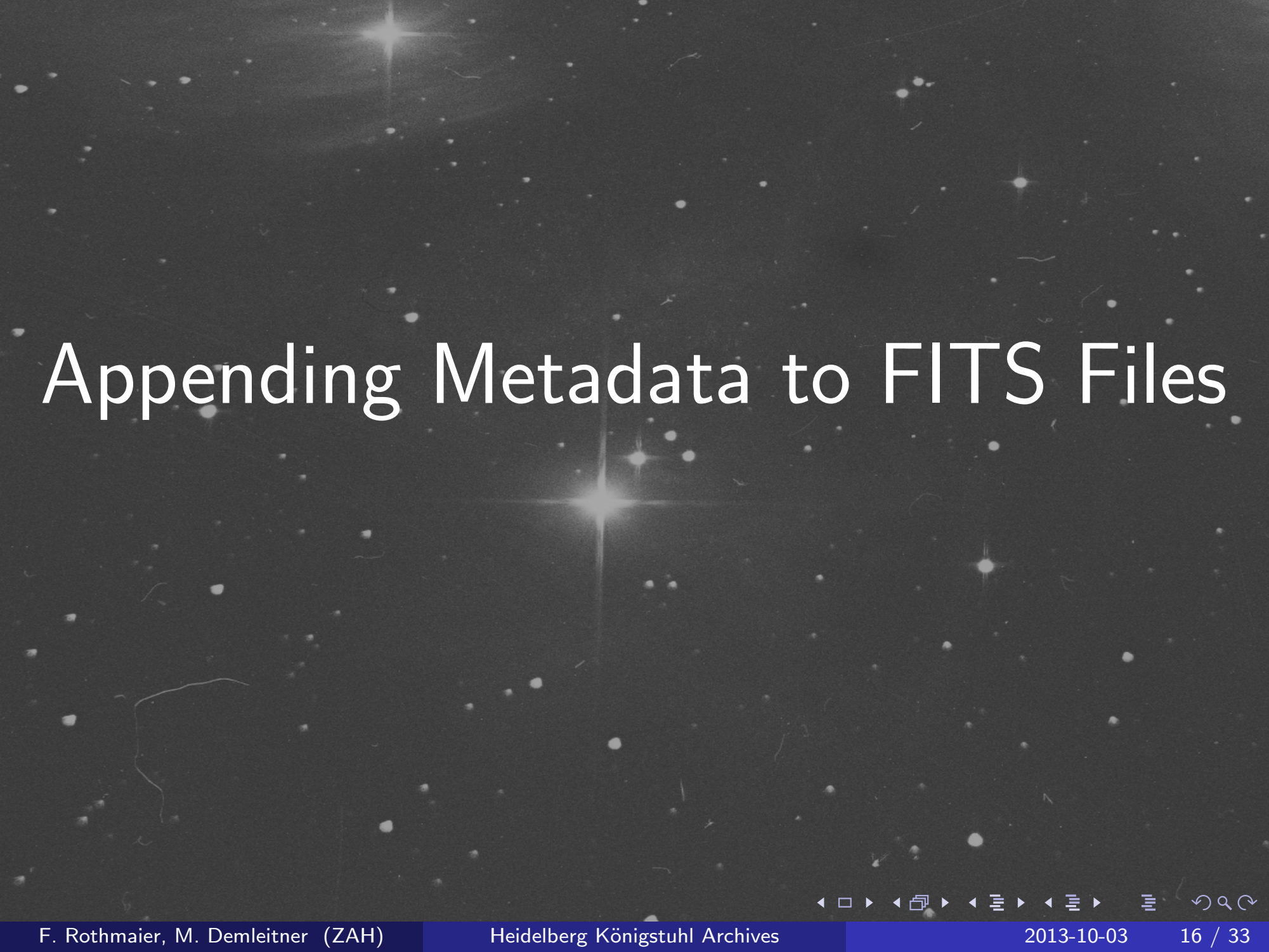
- Nexscan F4100 professional scanner of the "Heidelberg Druckmaschinen AG"
  - 315 mm x 457 mm scan area which is masked down to the various plate sizes
  - 3 x 8000 pixel CCD array for colour (RGB) and B/W work
  - 5080 dpi optical resolution

Scanning the Logs



	1906		R 44							
D 21	Nov 24	Sams	$13^{42}0 - 14^{12}0$	$+22^{5}$	I aber aller mass.			Sp II	20	mit 6" pointiert	Orionnebel

- URL: `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

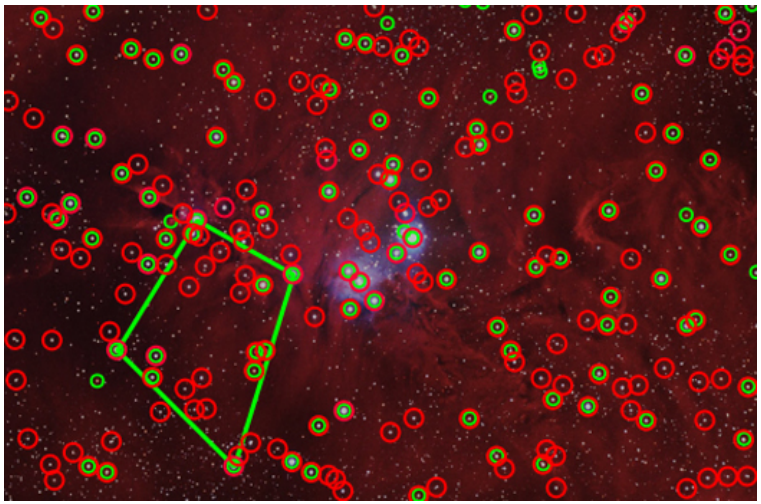
- our headers should include:
  - the observation data (observer, observation time, exposure, ...) extracted from the logs
  - plate-specific metadata: information about the telescope, instrument or the emulsion/filter combination
  - astrometrical information

↪ astrometrical calibration needed for our data files

Astrometrical Calibration

- 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/`

Astrometrical Calibration



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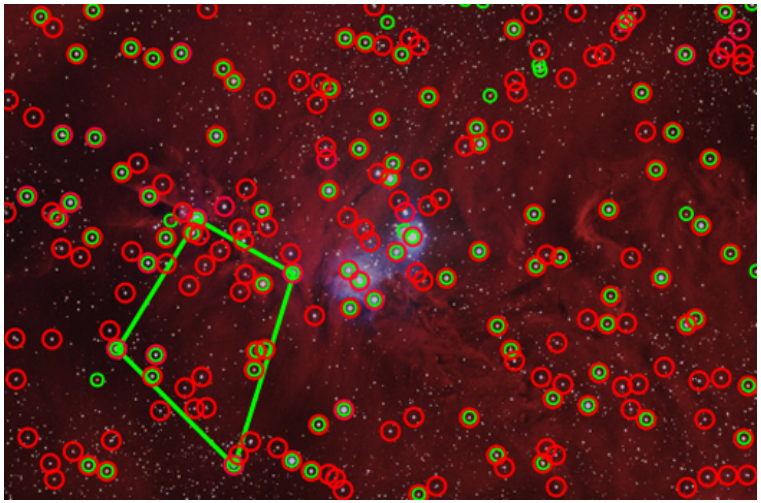
- basic idea of "Astrometry.net":
  - download of so-called "index files" that contain "skymarks", i.e. quads of celestial objects
  - for each image, the software first tries to detect stars (green circles in the figure) and second looks for sets of four objects (green lines)

Astrometrical Calibration



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- 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

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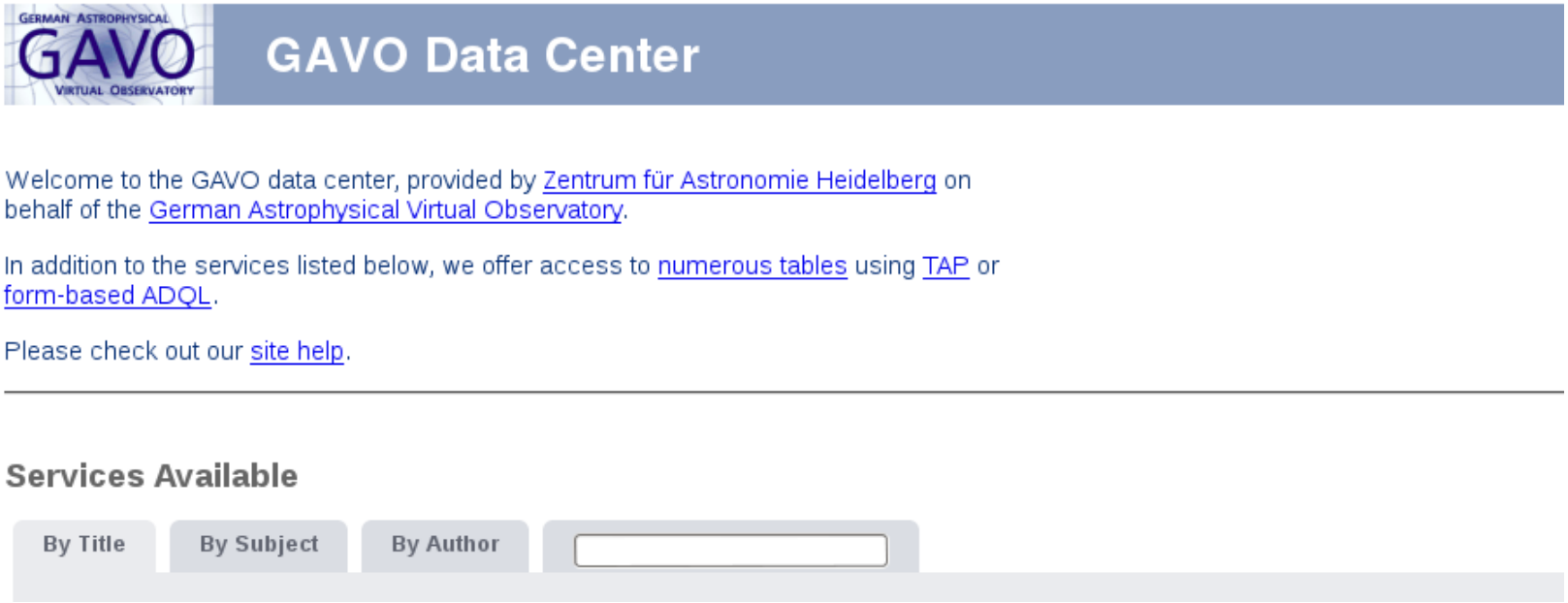
- "ObsCore Data Model"
  - simple data model used to describe observation data
  - includes a set of elements, e.g. the name of the object observed and a URL that allows for downloading the data

The GAVO Data Centre



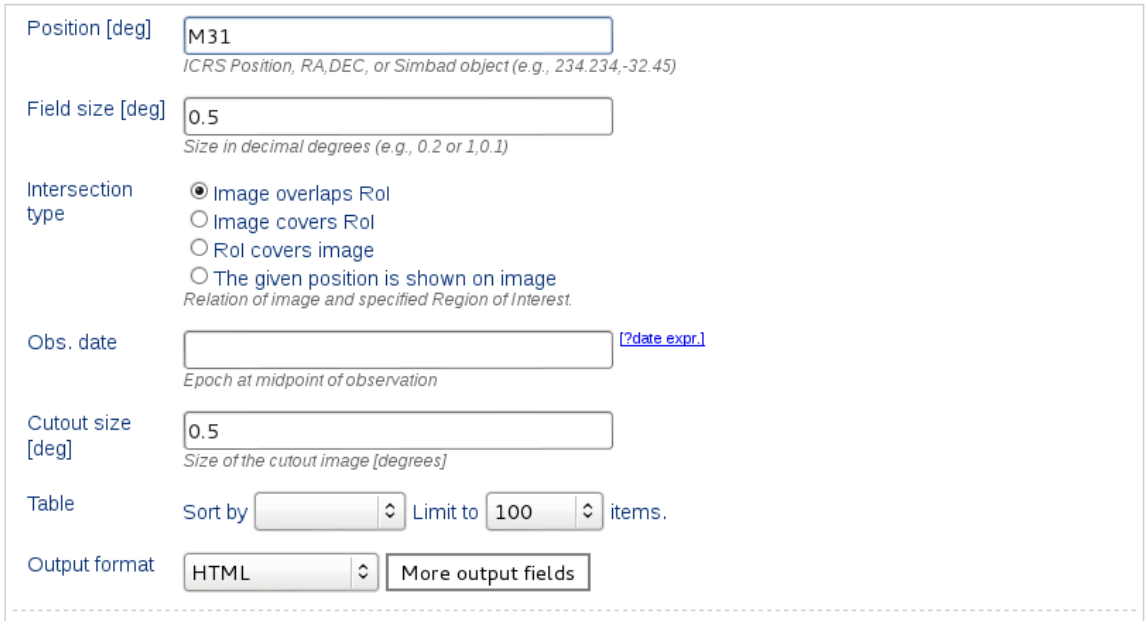
- accessible and searchable at `http://dc.g-vo.org`
- about 15 terabytes of astronomical data comprising
  - catalogues that can be accessed by different standardised protocols
  - spectra
  - digitised photo plates

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

Finding Objects by Position (SIAP)

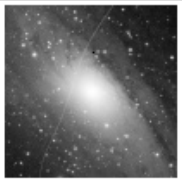
- URL: `http://dc.zah.uni-heidelberg.de/lswscans/res/positions/q/form`



- 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)

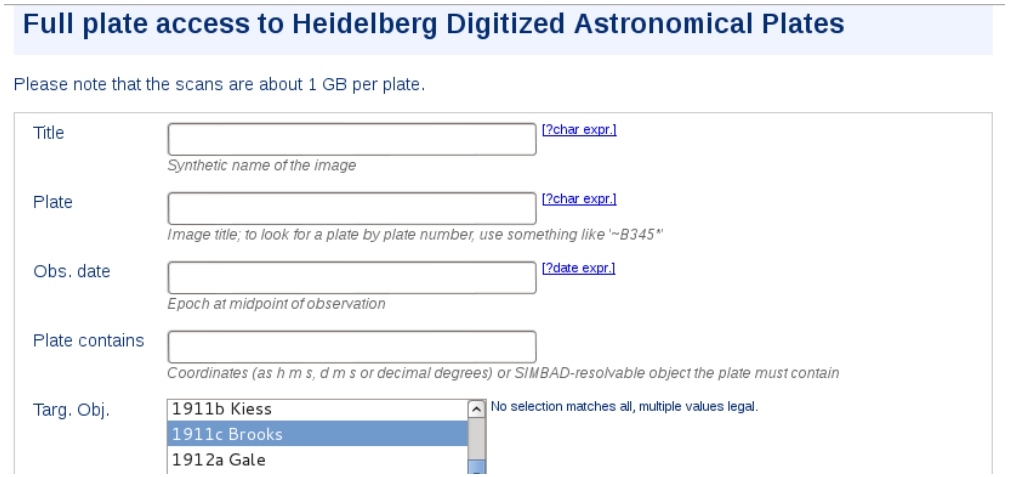
- if the database query matches at least one plate, a result list is returned

Title	Obs. date	Full Plate	Product key	Aladin	Ctr. RA [deg]	Ctr. Dec [deg]
B1384a 1905-12-26 M31	1905-12-26T20:57:44Z	[Plate Row]		[Open Applet]	10.68	41.27
B1385b 1905-12-26 M31	1905-12-26T20:57:55Z	[Plate Row]		[Open Applet]	10.68	41.27

- 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



- our users may
  - type a plate number into the search form or
  - select a target obejct

Finding Non-Stationary Objects (ObsCore)

Title	Targ. Obj.	Ctr. RA [deg]	Ctr. Dec [deg]	Obs. date	Exp. time [s]	File size [byte]	Product key	Scaled 1/4	Scaled 1/16	Observer	More
D896 1911-09-20 1911c Brooks	1911c Brooks	238.38	53.98	1911-09-20T19:26:35Z	600.0	132.8MiB		[Scaled 25%]	[Scaled 6.25%]	M.Wolf	More

- 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

Summary

- 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,

http://www.ub.uni-heidelberg.de/helios/digi/landessternwarte.html.

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

Astrometry.net, http://astrometry.net/.