Plate archive of Nikolaev Astronomical Observatory: digitization, databases, image processing and results of current research

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Nikolaev Astronomical Observatory
Multi Channel Telescope (MCT)
former Zonal Astrograph

Zonal Astrograph (D=160 mm, Iris = 120 mm, F=2040 mm, FOV= 5° x 5°) operated from 1929 to 1999
Preview image of photoplate from database of observation. Plate made in NAO in 1976 (δ=-24°, t= 20min).

Digitization of plates at first with 600DPI and then with 1200DPI resolution has been carried out since 2007 to obtain preview images with all marks made on plates.

Digitization of plates with 1200 DPI resolution after clearing of all marks on plates has been carried out since 2009 for astrometric image reduction.
Scanners

EPSON PERFECTION V200 Photo
(2008) 3.2D max
A4, 4800DPI optical
Transparency 9"-2", 3.2D

EPSON PERFECTION V750 Pro (2011) 4.0D max
A4, 4800x9600DPI optical
Transparency 10"-8", 4.0D
All text data from the observational log books was transferred into the database management system (DBMS) written in FoxPro. Total number of plates is 8325, and 8271 of them were already scanned. DBMS allows us to carry out data handling and processing by using various menu options. The main menu consists of five parts. The first part contains various text data viewers and hour angle calculator.
Database management system of photographic observations

The second menu allows us to view and print various text data, such as list of plates with (un)modified FITS header, plate sizes vs observational programs, quality of emulsion, history of database update, statistical reports about scanned plates, list of plates with long exposures.

The third menu allows us to compile output text files for all observational programs in the format of Nikolaev archive.
Database management system of photographic observations

The fourth menu allows us to view and edit all text files in accordance with the format created by the Institute of Astronomy (Sofia, Bulgaria).

The fifth menu allows us to view any reference information about photographic plates, such as history of observations, programs and objects, observers, bibliography, quality of emulsion, log books of observations etc.
Databases of photographic observations. Distribution of photo plates by RA & DEC.
Data volume of photo plate images obtained at NAO and stored in data bank
Plate archive of the Nikolaev observatory
Number of preview images obtained in NAO

February 2014: Preview images - 99% of plate archive, 93% in FITS format. 99% of images are available in UkrVO.
First astrometric results of data processing were obtained in 2009. Images of 50 plates containing about 17000 stars were processed. The obtained accuracy was about 0."07 for both coordinates and resolution of 1200 DPI.
Catalogues of stars in fields near Galactic plane were obtained with common reduction of CCD observation and plate archive images.

Use scanner Epson V750 Pro for receiving of 2100 images of photo plate in 210 fields.

Reduction of 2100 images.
Obtained coordinates of about 20,000,000 objects.

Use telescope Mobitel KT-50 for receiving 6500 CCD frames in 172 fields.

Reduction of 6500 CCD images.
Obtained coordinates of about 9,000,000 objects.

Obtained 3 catalogues in 2013:

- Photographic catalogue for epoch 1981.6:
  903000 stars (8-16)”, accuracy: 0.”02 - 0.”07
- CCD catalogue for epoch 2012.2:
  760000 stars (9-17)”, accuracy: 0.”02 - 0.”04
- Catalogue of coordinates and proper motions:
  700000 stars (8-16)”, accuracy: 0.”02-0.”04, 0.005”/year

In 2013, using 2100 images of 210 plates distributed close to the Galactic plane and 6500 CCD images we obtained a catalogue of coordinates and proper motions for about 700000 stars. The catalogue accuracy is about 0.”04, proper motion - 0.”005/year. Also we obtained a catalogue of coordinates for more than 900000 stars from plates with accuracy about 0.”06.
MIDAS data reduction for photo plate images

Data reduction process: filtering, bright stars image restore, find stars and save X,Y coordinate and brightness. 20-30 minutes per image on Core2Duo 2.5Ghz

Part of image before (left) and after (right) filtering. Processing was carried out in a batch mode of 30-50 images.
Using high precise ruler to check V750 scanner in 2400 DPI

It has linear biases up to 10 pixels per 10000 pixels of movement, stable during few days. CCD line bending

It has periodic counterpart from 2 to 5 pixels, unevenness of the carriage

The results are used as amendments in calculating the coordinates of the objects on images. Consideration of amendments improves the result by RA of about 25-30% and by DEC of about 40-60%.
Improvement of results by statistical methods using reference stars

RA (left) and DEC (right) after first iteration

RA (left) and DEC (right) after third iteration
Catalogue accuracy

Distribution of catalogue accuracy in mas by magnitude (RA – black, DEC – white)

Distribution of number of stars in catalogue by accuracy (RA – black, DEC – white)
Development of the digital database

- Development of astronomical databases with web interface has been started since 2004, connect databases to Aladin program has been started since 2005.
- The daily average volume of the new astronomical information obtained from the CCD instruments makes from 1 GB up to 12GB, depending on the purposes and conditions of observations. For compare: size of all observation from 1996 till 1998 was near 5GB.
- The total data volume of obtained plate and CCD images was about 3 TB at the middle of 2013.
Ukrainian Virtual Observatory (UkrVO) is a member of IVOA since 2011

At the end of 2013 the contribution of the NAO to the UkrVO are:

- metadata of photo plates: 20%
- photo plate images (blue): 35%
- metadata of CCD observations: 100%
- CCD images: 100%
- catalogues: 80%
All receiving data are stored on servers in two copies, namely, working and backup. Also we made copies of observational data as archives on DVD. All obtained observations have been stored in FITS format since 1998 and for plate images since 2008.
Web services via Aladin graphical interface

ASCC, FONAC, XPM

SuperCOSMOS catalog (SSS.cat)
LEDA Hypercat

XPM Catalogue: Absolute proper motions of 280 million stars.
FON Astrographic Catalogue (FONAC, Version 2.0): 2.0 million stars
All Sky Compiled Catalogue (ASCC-2.5): 2.5 million stars
GAIAX (TGAS-1)
Database of photographic observations via Aladin

More than 34000 plates from 15 telescopes (GAO+MAO).
More than 8000 preview images (MAO): 300 or 600 dpi.
Database of CCD observations via Aladin

Database of photographic and CCD observations via browser

More than 34000 plates from 15 telescopes (GAO+MAO).
More than 8000 preview images (MAO): 300 or 600 dpi.
More than 70000 CCD frames from 3 telescopes (MAO).
Preview images for all frames.

Do you want to select only the plates with preview images?  Yes  No
Select plates with exposure more than: 10 min

Number of plates in the database: 34198
Conclusions

- We obtained preview images of all plate archive of NAO. The database is available in the UkrVO web site.
- Photographic and CCD databases are populated with new data and work via graphical interfaces of browser as well as Aladin.
- We obtained new catalogues using new CCD and old photographic observations.
Thank you for attention!