# DEVELOPMENT OF ARMENIAN-GEORGIAN VIRTUAL OBSERVATORY


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## ABSTRACT

The Armenian-Georgian Virtual Observatory (ArGVO) project is the first initiative in the world to create a regional VO infrastructure based on national VO projects and regional Grid. The Byurakan and Abastumani Astrophysical Observatories are scientific partners since 1946, after establishment of the Byurakan observatory . The Armenian VO project (ArVO) is being developed since 2005 and is a part of the International Virtual Observatory Alliance (IVOA). It is based on the Digitized First Byurakan Survey (DFBS, the digitized version of famous Markarian survey) and other Armenian archival data. Similarly, the Georgian VO will be created to serve as a research environment to utilize the digitized Georgian plate archives. Therefore, one of the main goals for creation of the regional VO is the digitization of large amounts of plates preserved at the plate stacks of these two observatories. The total amount of plates is more than 100,000 units. Observational programs of high importance have been selected and some 3000 plates will be digitized during the next two years; the priority is being defined by the usefulness of the material for future science projects, like search for new objects, optical identifications of radio, IR, and X-ray sources, study of variability and proper motions, etc. Having the digitized material in VO standards, a VO database through the regional Grid infrastructure will be active. This partnership is being carried out in the framework of the ISTC project A-1606 *"Development of Armenian-Georgian Grid Infrastructure and Applications in the Fields of High Energy Physics, Astrophysics and Quantum Physics"*.



## Keywords

*Virtual Observatory, digitization, Armenian-Georgian Grid Infrastructure.*


## 1. INTRODUCTION

The Astrophysical Virtual Observatories (AVOs) have been created in a number of countries using their available databases and current observing material coming from both ground-based and space telescopes as a collection of interoperating data archives and software tools to form a research environment in which complex research programs can be conducted. At present the *International Virtual Observatories Alliance* (IVOA, http://www.ivoa.net) unifies 17 national VO projects and serves for coordination of the homogeneity and interoperability of existing astronomical data (images, spectra, catalogs, literature, etc.). Among all these data, a spectroscopic database for a large number of objects was missing until 2005. The *Armenian Virtual Observatory* (ArVO, http://www.aras.am/Arvo/arvo.htm) was created to utilize the *Digitized First Byurakan Survey* (DFBS, http://www.aras.am/Dfbs/dfbs.html, *Mickaelian et al. 2007*) as an appropriate spectroscopic database having low-dispersion spectra of some 20,000,000 objects, the largest number in the world databases. ArVO is a project of the *Byurakan Astrophysical Observatory* (BAO) aimed at construction of a modern system for data archiving, extraction, acquisition, reduction, use and publication. One of the ArVO's main tasks is to create and utilize a global Spectroscopic Virtual Observatory, which will combine data from DFBS and other low-dispersion spectroscopic databases to provide the first understanding on the nature of any object brighter $B=18^m$. Beside the DFBS, ArVO is being complemented by the Digitized Second Byurakan Survey (SBS) database, the Byurakan photographic archive, and the Byurakan Observatory 2.6m telescope observations. Since the beginning of 2009 such digitization projects have been conducted at the *Georgian National Astrophysical Observatory* (GeNAO) as well and the Georgian VO project has been started. Data from both observatories will be put in a common environment and users will be able to carry out research based on VO standards and software using the Byurakan/Abastumani and world databases. All this will be accomplished in the Armenian-Georgian regional Grid infrastructure in collaboration with the *Armenian Institute of Informatics and Automation Problems* (IIAP) and *Georgian Research and Educational Networking Association* (GRENA). Many new science projects will be available and may be carried out with high efficiency having the VO environment. The low-dispersion spectra are useful for search for new objects of given types by modeling their spectra (bright QSOs, new Markarian galaxies, planetary nebulae, cataclysmic variables, white dwarfs, carbon stars, etc.). In addition, these spectra help identifying new radio, IR, or X-ray sources when used along with other available photometric data (*Mickaelian et al. 2009*). The large amount of photometric data is useful for variability studies and revealing new variables in the observed fields. New high proper motion stars can also be discovered by a comparison of many observations having large separation in years.

## 2. IMPORTANCE OF ASTRONOMICAL PLATE ARCHIVES AND THEIR DIGITIZATION.

Photographic plates were the primary data recording medium in astronomical observatories, spanning over a century. There are a number of fundamental scientific reasons for needing access to astronomy's past observations. Basically, all astronomical objects are changing, but often only very slowly. Detecting and understanding these changes offers insight into the nature of the objects. Some questions can only be answered by studying historical data (*De Cuyper et al. 2001*). The preservation of past records is therefore vital to Astronomy. User-friendly digital archives are an essential research tool to complement modern observations.

The world's collection of photographic images is already nominally in the public domain, but as a universal resource it is seriously under-exploited. The main reasons are: (a) lack of information in digital form about the plates, and (b) lack of digital versions of the observations. The astronomical community itself must be responsible for creating a user-friendly on-line database of calibrated digital images from this resource. The creation of such a database requires a well-organized effort and substantial, but not exorbitantly high, resources.

A danger exists today for the safety of these plates, estimated at over 2 million (http://draco.skyarchive.org). Observatories and universities are space limited and some seek a safe home for the legacy left by so many astronomers (http://www.pari.edu). In a few observatories photo plates are preserved in convenient place, where they are located by a certain order in special stacks. Such stacks in fact represents a **plate library**. As a rule, in such a case they provide space, infrastructure, and Internet access. The goal is to make the archive a resource harnessed by present and generations of astronomers. The previous lack of a systematic process for preserving astronomical photographs is leading to these irreplaceable observations being discarded.

The *International Astronomical Union* (IAU, http://www.iau.org) passed a resolution in 2001 that observatories should make efforts to preserve plates, but most institutions find it hard to justify an investment of staff time or space for keeping them when they are not easily accessible in digital format. Studies of historic photographic material have often produced compelling, often definitive, data to assist the interpretation of astrophysical phenomena. The use of the older photographic material seems to be growing. (e.g. *Herczeg & Sutton 1975*; *Kroll et al. 2002*; *PDPP 2005*). This can probably be attributed to a rising awareness of the potential of plate archives. Easier availability of these observations would surely increase their use.

A few examples of research, based on archived plate collections (*Cline et al. 2004*):

- Gamma Ray Bursts Historical Data,
- Long-term Star Variability,
- Re-analysis of old observations of currently interesting objects (For example: Near-Earth Asteroids, BL Lac Objects, Novae and etc.).

## 3. PLATE STACKS OF THE BYURAKAN ASTROPHYSICAL OBSERVATORY (BAO)

Several observational modes (photographic, photoelectric, polarimetric) have been used at the BAO; most of observations have been carried out using photography, both for direct images (on photographic plates) and spectra (prism spectra on photographic plates and slit spectra on photographic films). Altogether, some 30,000 plates and 5,000 spectra on photographic films are available.

- **2.6m telescope.** Observations have been carried out since 1976 and the telescope worked using photographic modes until 1991. This is one of the largest telescopes in the region and was one of the largest ones in the world during its first years of operation. The telescope has provided thousands of direct plates in frame of variability and morphological studies of Markarian galaxies, thousands of film spectra of Markarian galaxies, FBS and SBS objects, quasars, flare stars, etc. The size of the plates is 16×16 cm and the field of view with the corrector is 45′.
- **1m Schmidt telescope.** Observations have been carried out since 1961 and the telescope worked using photographic modes until 1991. This is one of the 8 largest Schmidt telescopes in the world, and probably one of the most efficient ones. The main products are the *First Byurakan Survey* or FBS (the famous Markarian survey) with its 2000 low-dispersion plates, the *Second Byurakan Survey* or SBS with its 500 sensitized low-dispersion plates having deeper limit, thousands of direct observations for search for flare stars in star

clusters and associations, detailed colorimetry of central regions of nearby bright galaxies, monitoring of extragalactic Supernovae, etc. The size of the plates is 16×16 cm and the field of view is 4°×4°. The scale is 96.8 ″/mm. Three objective prisms (1.5°, 3°, and 4°) have been used giving 1800, 900, and 285 Å/mm at Hγ, respectively.

- **53cm Schmidt telescope.** Observations have been carried out since 1954. Direct photographic observations have been carried out. The field of view is 25 $deg^2$ (5°×5°), and the scale is 114.6 ″/mm. First studies on this telescope were the detailed colorimetric observations of galaxies. A survey of relatively nearby galaxies to determine the degree of compactness of their nuclei was carried out too, as well as search for flare stars in star clusters and associations in 1970s and 1980s. These plates may be useful for photometric studies.
- **Other small telescopes.** There are a number of smaller telescopes used during 1940s-1990s in photographic modes: 20cm Schmidt telescope, 40cm and 50cm Cassegrain telescope. Observations of non-stable red giants and supergiants, investigation of flare stars and long-period variables have been carried out, as well as photometric studies of galaxies (20cm Schmidt).

## 4. PLATE STACKS OF THE GEORGIAN NATIONAL ASTROPHYSICAL OBSERVATORY (GENAO)

Plate stacks of the Georgian National Astrophysical Observatory (or the Abastumani Observatory) contains more than 70,000 photo plates and films. This collection of astronomical negatives is very important and interesting for astronomical community because it represents observational programs containing high quality homogeneous observational material which was often used by astronomers (see e.g. *Blaauw et al. 1976*). The short description of this collection according the telescopes is following:

- **40 cm Zeiss Refractor.** Observations are being carried out since 1937. There are direct photographs of stellar fields of multiple systems of the "Trapezium" type, comets, the Moon, the planets, asteroids and nebulae, the spectrograms of celestial objects taken with the objective prisms. For a long time, up to 1963, two 20 cm cameras were used with the 40 cm refractor and provided a field of 10°×13° on 18×24 cm plates. In total, more than 7000 negatives were obtained. Later on electropolarimetric and photometric observations were carrying out using this telescope. Lunar Polarimetric Atlas (*Dzapiashvili & Korol 1982*) was compiled and published. The authors were awarded the Bredikhin Prize.
- **44 cm Schmidt Telescope – Schmidt Camera.** The telescope was mounted in 1940. It has a spherical 44.4 cm mirror and correcting Schmidt lens 36 cm in diameter. 25,000 photo films were obtained until 1985. Supernovae, comets, galaxies etc. were observed using this telescope.
- **70 cm Meniscus Telescope**. A radius of the field of view is 4°50′ and the size of the plates is 9×12 cm, also 18×18 cm. Observations began on September 12, 1955. 20,517 plates were obtained. Different sky survey programs were fulfilled. Galaxies, binary stars, Novae, Supernovae, etc. were objects of observations. As direct images, so stellar spectra using the 2°, 4°, and 8° objective prisms were obtained with dispersions of 1200 A/mm, 666 A/mm, and 166 A/mm at Hγ, respectively. Stellar catalogues were compiled (see e.g. *Bartaia 1979*; *Natsvlishvili 1991, Chargeishvili, 1988; Chargeishvili, 1994, Chargeishvili, 2003*).
- **40 cm Zeiss Double Astrograph.** Operates since 1979. Astrometric investigations were fulfilled. More than 3000 negatives were obtained. Size of the plates is 18×24 cm and 30×30 cm.

Plate stacks of the observatory includes also images obtained using **solar telescopes**. Rich observational material gathered by participants of expeditions for total solar eclipses. These special expeditions have been dispatched starting from 1936. From 1957 systematic observations of ozone and nightglow of high layers of Earth atmosphere have been made.

## 5. THE IMPORTANCE OF PLATE STACKS' DIGITIZATION

Comets, asteroids, Novae, Supernovae, planetary nebulae, different type variable stars were discovered and observed in our observatory. Catalogues were published (www.observatory.iliauni.edu.ge). Plate stacks was always a subject of special concern. Photo plates were located on the shelves according perfect order. The temperature regime and humidity were always under control. The situation is changed a bit at present. To manage the temperature and humidity stability is rather difficult, there were cases when the humidity increased and the special additional actions became necessary. Consequently, it is highly desirable to begin the process of digitization as soon as possible for the following reasons:

1. The safety of total observational material which is result of effort of many generations of astronomers of the Abastumani observatory.
2. Nowadays astronomical data processing is available only in digital format.
3. Our negatives were used only for specific purposes in the frameworks of the corresponding observational programs. Their re-analysis will serve as a bases for many new investigations.
4. The negatives gathered during 60 years period and preserved in our stacks represent historical data of many interesting astronomical objects. This fact is rather significant if remind that astronomers observed the sky photographically during 100 years approximately.
5. Our collection is more than 2.5 % of the total number of negatives existing worldwide.

## 6. PRESENT SITUATION

The group of so called *Georgian Virtual Observatory* (GVO) was established in summer 2008. The goal of this group is to care on digitization of the plate archive of Abastumani observatory and on establishment of GVO, which will make it possible to become a member of the IVOA. Since November 2008 our observatory participates in the international project of ISTC A-1606, *"Development of Armenian-Georgian Grid Infrastructure and Applications in the Fields of High Energy Physics, Astrophysics and Quantum Physics"*. Two A4 format scanners are ordered in the framework of this project and digitization of 2000 plates is planned. The database of these plates is compiled. These are the plates containing area of Galaxy anti-center, Kapteyn area, Pleiades and Orion Aggregates, also observational material of some interesting objects obtained using the meniscus telescope. Implementation of the Virtual Observatory standards and data search from the digitized plates on especially interesting objects (asteroids, variable stars, AGN, QSOs, etc.) will be done during the project fulfillment. The digitized material will be published on the GVO webpage and it will be available for any astronomer. It is very important that some members of GVO group obtained the significant number of Abastumani Observatory stacks' plates themselves during 1972-1993. We hope to digitize about 300 plates before the end of August 2009.

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