Education and Heritage in the era of Big Data in Astronomy
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Armenian Astronomical Heritage and Big Data

Gor A. Mikayelyan, Sona. V. Farmanyan and Areg M. Mickaelian

NAS RA Byurakan Astrophysical Observatory (BAO),
Byurakan 0213, Aragatzotn Province, Armenia
email: gormick@mail.ru

Abstract. Astronomy in Armenia was popular since ancient times and Armenia is rich in its astronomical heritage, such as ancient and medieval Armenian calendars, records of astronomical events by ancient Armenians, the astronomical heritage of the Armenian medieval great thinker Anania Shirakatsi, etc. Armenian astronomical archives have accumulated vast number of photographic plates, films and other careers of observational data. The Digitized Markarian Survey or the First Byurakan Survey, is the most important low-dispersion spectroscopic database. It is one of the rare science items included in UNESCO "Memory of the World" Documentary Heritage list. The Byurakan Astrophysical Observatory (BAO) Plate Archive Project (2015–2021) will result in digitization and storage of some 37,000 astronomical plates and films and in creation of an Electronic Database for further research projects. Based on these data and archives and development of their interoperability, the Armenian Virtual Observatory was created and joined the International Virtual Observatory Alliance.

Keywords. Archaeoastronomy, FBS, DFBS, Plate Archive

1. Introduction

Armenia is one of the cradles of ancient science, and astronomical knowledge was developed in ancient Armenia as well. Contrary to its small territory and relatively small population, Armenia was and is rather active in astronomy. Astronomy in Armenia was popular since ancient times: there are signs of astronomical observations coming from a few thousand years ago. Among the astronomical activities that have left their traces in the territory of Armenia are: the rock art, ruins of ancient observatories, the ancient Armenian calendar, astronomical terms and names used in Armenian language since II millennia B.C., sky maps from Middle Ages, and most important, one of the largest modern observatories in the region, the Byurakan Astrophysical Observatory (BAO) with its 2.6m and 1m Schmidt telescopes.

The Byurakan Astrophysical Observatory (BAO) Plate Archive consists of 37,500 photographic plates and films, obtained with the 2.6 m telescope, the 1 m and 0.5 m Schmidt telescopes, and other smaller telescopes during 1947–1991. Its most important part, the famous Markarian Survey (or the First Byurakan Survey, FBS) 2000 plates were digitized in 2002–2007 and the Digitized FBS (DFBS) was created. New science projects have been conducted based on this low-dispersion spectroscopic survey data. In 2015, we started a project to digitize the whole BAO Plate Archive and its scientific products. It is aimed at digitization, extraction and analysis of archival data and building an electronic database and interactive sky map. The Armenian Virtual Observatory (ArVO) database will contain all new data. ArVO will provide all standards and tools for efficient usage of the scientific output and its integration in international databases.

2. Armenian Archaeoastronomy

Studies of the Armenian rock art present in the territory of modern Armenia show that the Armenians were interested in heavenly bodies and phenomena. The Earth, the Sun, the Moon, planets, comets, Milky Way, stars, constellations are reflected in these pictures drawn on rocks in mountains around Lake Sevan and elsewhere in Armenia.

According to investigations by Badalian, Tumanian and Broutian, the Armenian calendar was one of the most ancient in the world. Armenians used Lunar, then Lunisolar calendar, and since mid the 1st millennium B.C. they changed to Solar calendar, which contained 365 days (12 months by 30 days and an additional month of 5 days). The new year began in Navasard (corresponding to August 11), when the grape harvest was underway and the constellation Orion became visible in the night sky. Together with the months, all days of any month also had proper names. The year 2492 B.C. was adopted as the beginning. The Armenian Great Calendar was introduced in VI century, and the difference with the Julian one was re-calculated (Mickaelian 2014a, Farmanyan & Mickaelian 2015, Mickaelian & Farmanyan 2016). It is remarkable that the Mkhitarians from Venice are the oldest regular publishers of the Armenian and world calendars (since 1775).

3. Armenian Astronomy in the Middle Ages

One of the most remarkable scientists in the Middle Ages was Anania Shirakatsi (612–685), who had rather progressive astronomical ideas for those times. He has left a few books and writings that survived up to nowadays. Anania Shirakatsi knew about the spherical shape of the Earth. He accepted also that the Milky Way consisted of numerous faint stars, could correctly interpret Lunar and Solar eclipses, and had a number of other progressive astronomical knowledge for that time. Anania Shirakatsi's works serve as the main source for establishing the ancient Armenian astronomical terminology, including the names of constellations and stars (Harutyunian & Mickaelian 2014, Mickaelian & Mikayelyan 2014, Farmanyan & Mickaelian 2017).

According to Prof. Pskovskiy, the 1054 Supernova was first seen and recorded in Armenia in May 1054 (and only later in summer in China). Interestingly, its remnant, the famous Crab nebula has been studied in detail in the Byurakan Astrophysical Observatory and was one of its famous objects of investigation.

Ghukas Vanandetsi and Mkhitar Sebastatsi lived and worked in Europe in 17th-18th centuries and are known for their detailed charts of the heavens. Lukas Vanandetsi made astronomical instruments, published the first sky chart with Armenian names of constellations in Amsterdam at the beginning of 18th century. Mkhitar Sebastatsi was the person who founded the Armenian Catholic Church community in St. Lazar island near Venice, a touristic site for many visitors (Mickaelian 2014a, Mickaelian & Farmanyan 2016).

4. Modern Armenian Astronomy

The modern astronomy in Armenia begins with the foundation of the Byurakan Astrophysical Observatory (BAO). It is one of the most important astronomical centers in Eastern Europe and Middle East region, both by its scientific instruments and achievements. The Observatory was founded in 1946 on the initiative of Viktor Ambartsumian. The main scientific instruments at BAO are: 2.6m telescope, 1m and 0.5m Schmidt telescopes (Mickaelian 2016).

Being one of the largest telescopes in European, Asian and African region, the Byurakan 2.6m telescope allows to make detailed spectral, photometric and other investigations of interesting faint objects. The 2.6m telescope was installed in 1975 and is in

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operation since 1976. It is a classical Cassegrain system telescope. During 1976–1991, the primary observations have been carried out on the morphological study of Markarian galaxies, investigation of star clusters, groups and clusters of galaxies. The observed 5000 slit spectra on this telescope are of stellar objects of the First Byurakan Survey, T Tau and flare stars, objects of the Second Byurakan Survey. During the observations of 1996–2007, new interesting results have been obtained. Faint objects in a 1° field are being observed to find high-redshift primordial galaxies. Hundreds of IRAS and SBS galaxies, as well as many non-stable stars and young stellar objects have been studied spectroscopically. A systematic search for emission-line objects is being carried out with the 2.6m telescope, too.

The BAO 1m Schmidt telescope is one of the largest Schmidt-type telescopes in the world and one of the most efficient astronomical telescopes in general. The telescope was installed in 1960 in the main territory of the Byurakan Observatory. One of the 1m Schmidt telescope's advantages was the presence of its three objective prisms (1.5°, 3°, and 4°), which made possible wide-field spectroscopic observations with various dispersions. The objective prisms can rotate in the position angle that allows obtaining spectra of any orientation.

The First Byurakan Survey (FBS) is the most famous work done with this telescope. More than 2000 photographic plates were obtained. 1500 objects were selected, which are known at present as Markarian galaxies (Mickaelian 2014b). The survey involved the largest ever astronomical study of the nearby universe and is considered one of the most important achievements of the 20th century astrophysics. In 2011 The First Byurakan Survey has been included in UNESCO's "Memory of the World" International Register (Mickaelian *et al.* 2019a).

5. The Digitized First Byurakan Survey

The Digitized First Byurakan Survey (Mickaelian *et al.* 2007a, Massaro *et al.* 2008) is the digitized version of the First Byurakan Survey. It is the largest spectroscopic database in the world, providing low-dispersion spectra for 20 million objects. DFBS is a joint project of the Byurakan Astrophysical Observatory (BAO), Cornell University (USA) and Universita di Roma "La Sapienza" (Italy). The DFBS has been created in 2002–2003 as a result of digitization and reduction of 1874 FBS plates.

High-accuracy astrometric solution has been made for each plate. At present all plates have astrometric solution. The typical rms accuracy is 1 arcsec. Dedicated software allows quick access to any field by given position and extraction of the needed spectra, their calibration, classification and study (Nesci *et al.* 2007, Mickaelian *et al.* 2007b). The DFBS is free for the astronomical community. DFBS is the largest Armenian astronomical database and one of the largest in the world.

6. Byurakan Astrophysical Observatory Plate Archive

Byurakan Astrophysical Observatory (BAO) Plate Archive is one of the largest astronomical archives and is considered to be BAO main observational treasure. Taking into account decades hard work of Armenian astronomers and the work of BAO telescopes, as well as the results of their activities, we can say that BAO Plate Archive is one of our national scientific values. Due to Viktor Ambartsumian's brilliant ideas and the mentioned observational work, the Armenian Government has recognized BAO as National value. Today BAO archive holds about 37,000 astronomical plates, films or other carriers of observational data (Mickaelian 2014c, Mickaelian *et al.* 2019b).

The digitization project is aimed at compilation, accounting, digitization of BAO observational archive photographic plates and films, as well as their incorporation in

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databases with modern standards and methods, providing access for all observational material and development of new scientific programs based on this material (Mickaelian *et al.* 2016, Mickaelian *et al.* 2017). The electronic archive will be a part of the Armenian Virtual Observatory (ArVO) and hence, will be incorporated in the International Virtual Observatory Alliance (IVOA).

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