

PRESERVATION AND MAINTENANCE OF THE ASTRONOMICAL SITES IN ARMENIA

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Astronomy in Armenia was popular since ancient times. There are signs of astronomical observations coming from a few thousands years ago. Two ancient observatories, Karahunge and Metzamor are especially well known. Karahunge is the Armenian twin of the Stonehenge and is even older. However, there is no proper attention from the state authorities and efforts are needed for preservation of such historical-astronomical monuments. The Byurakan Astrophysical Observatory (BAO) is the modern famous Armenian observatory founded in 1946 by the outstanding scientist Victor Ambartsumian. It was one of the world astronomical centres in 1950-s to 1970-s, and at present is the largest observatory in the Middle East area. As the ancient astronomical sites, Byurakan also needs a proper attitude from the state authorities and corresponding international organizations to preserve its values and importance for the present and future astronomical activities in the region, including its rich observational archive, telescopes, and human resources. Despite all the difficulties, the Armenian astronomers keep high international level of research and display various activities organizing international meetings and schools, preparing new young generation for the future research. The Armenian Astronomical Society (ArAS) is an affiliated member of EAS. Armenia has its Virtual Observatory project (ArVO) as well. The next Joint European and National Astronomy Meeting (JENAM-2007) will be held in Yerevan, Armenia, in August 2007. There are plans to organize astronomical tours to Armenia for making observations from various sites, including the ancient observatories. The future of astronomy in Armenia strongly depends on all of this activities and the proper attention both from state authorities and society.

Introduction

Armenia is a country of ancient civilization, rich history, unique architecture, cross-stones, manuscripts, tourism, wines and national dishes, Armenian brandy (often called cognac), and astronomy...

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 is rather active in astronomy, and the young generation is interested in this branch of science, which means that astronomy will continue to develop in the future, too. Moreover, Armenian astronomers show activity nowadays as well: one of the largest digitization projects in the world, the Digitized First Byurakan Survey (DFBS) project was conducted in 2002-2005, the Armenian Virtual Observatory (ArVO) was created in 2005, the all-European astronomical meeting (JENAM-2007) is being organized in Armenia.



Figure 1. Karahunge, the “Armenian Stonehenge”.

There are numerous signs of astronomical activities in the territory of Armenia: rock art, ancient observatories, the ancient Armenian calendar, 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.

Armenian archaeoastronomy

It is believed that the division of the sky into *constellations* was made a few thousand years ago in the Armenian Highland. According to the German astronomer and historian of science Olcott, the signs of Zodiac contain such animals that lived many thousand years ago in the territory of Armenia and around. It is very probable that ancient people named the constellations after animals living in their countries rather than known from elsewhere.

Studies of the *Armenian rock art* present in the territory of modern Armenia (historic Armenia was ten times larger, having 300,000 square km area) 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. These pictures and drawings are being studied by a number of historians, archaeologists, and astronomers. However, there is not enough governmental attitudes to organize large-scale studies or at least try to catalog and preserve these ancient treasures.

According to investigations by H.S. Badalian (1970), B.E. Tumanian (1985), and G.H. Broutian (1997), the *Armenian calendar* was one of the most ancient in the world, may be even the most ancient one. Armenians used Lunar, then Lunar-Solar 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 (Armenian “Haik”) 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. It is remarkable that the Mkhitarians from Venice are the oldest publishers of the Armenian and world calendars (since 1775).

The most fascinating historical astronomical building is *Karahunge* (the “Armenian Stonehenge”, Fig. 1; the name derives from *kar* “stone” and may mean “singing stones”; and the other famous name is Zorats Kar). It is a megalithic assemblage, 200 km from Yerevan, and 3 km from town Sisian; at an altitude of 1,770 m. The northern latitude is 39° 34’, and eastern longitude is 46° 01’. It is an assemblage of many stones put in a circle and a few arms starting from it. As many other such buildings, Karahunge was thought to be a religious assemblage. However, only in the middle of 1980th, Karahunge was first interpreted as an archaeoastronomical monument and was studied by Prof. E.S. Parsamian (1999) and Prof. P.M. Herouni (1998). Estimations give from 7700 to 4000 years for the age of Karahunge.

There are 222 stones with a total extent exceeding 250 metres, including 84 with holes (with 4-5 cm diameters). Dozens of astronomical stone instruments with accuracy of 30 arcsec may be found. 40 stones form the central ellipse with 45x36 m sizes, having a ruined stone-cluster in the centre. There is a 8m wide 8-stone road to N-E. Some stones were used to find the directions to definite stars. By some estimations (observations of definite stars), the observatory was used during 7700-2200 B.C., for about 5500 years. According to many authors (ex. Bochkarev & Bochkarev 2005), a comparison of the present state of the monument with its situation a hundred years ago reveals a considerable degradation. Thus, the monument needs an urgent protection. The monument is unique of its kind at least in the Trans-Caucasian region and could be even the oldest known observatory in the world. If the estimated age of Karahunge is confirmed by archaeological methods, it clearly should be included in the UNESCO World Heritage list of the most important cultural memorials of our planet.

Metzamor is the other ancient observatory in Armenia. Metzamor was an ancient town near river Metzamor, 35 km from Yerevan, in Arnavir province. There was a settlement since V millenium B.C. It was first interpreted as an archaeoastronomical monument in the middle of the 1960s by Prof. E.S. Parsamian (1985a). There is an observatory out of the fortress. The most probably estimation of the age is 4600 years. As Karahunge, Metzamor also needs a better study and proper attitude both from the Armenian government and world archaeoastronomical community.

Among the other archaeoastronomical sites in Armenia, the *Angelakot* dolmens may be named (Parsamian 1985b). As Karahubge, this site is also in Sisian region, 13 km from the town of Sisian. The dolmens are from Neolithic and Bronze eras. There are a few other sites in Armenia that are associated with astronomical activity of our ancient habitants.

Armenian Astronomy in the Middle Ages

One of the most remarkable scientists in the Middle Ages was *Anania Shirakatsi* (7th century), who had rather progressive astronomical ideas for those times. He was the most important scientist in Armenia, as he was a philosopher, mathematician, geographer, astronomer, chronologist, etc. He has left a few books and writings that survived up to nowadays. Many of them are kept in Matenadaran, the museum of ancient manuscripts. 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 compiled chronological tables, astronomical textbooks, etc. Anania Shirakatsi's works serve as the main source for establishing the ancient Armenian astronomical terminology, including the names of constellations and stars.

According to Prof. Pskovskiy, the *1054 supernovae* was first seen 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. This nebula has been a natural laboratory for many astrophysical investigations in various multiwavelength ranges.

Lukas 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 in St. Lazar island near Venice, a touristic site for many visitors.

Due to absence of independence for many centuries, Armenia did not have enough high level of science in the Middle Ages, however, interest in nature and admiration to heavens lived in Armenians since ancient times, and it became the basis for appraisal of the modern Armenian astronomy.



Figure 2. Two main telescopes in Byurakan: 2.6 m and 1m Schmidt.

Modern Armenian astronomy

Modern astronomy in Armenia is connected with the Byurakan Astrophysical Observatory (BAO, Mickaelian 2001a) and its founder *Victor Ambartsumian* (1908-1996), one of the most outstanding scientists of the 20th century. His works in the field of theoretical astrophysics, star formation and evolution, idea of activity of galactic nuclei are well known. Due to Ambartsumian, a new hypothesis about the star and galaxy formation and evolution was put forward and is known as “Byurakanian” approach, contrary to the classical one. According to this hypothesis, the evolution does not go from gas and dust to denser states, but vice versa. Due to activity of the dense matter, stars and nebulae (gas and dust) form. Though most of the astronomers accept the classical theory, however, Ambartsumian’s ideas strongly pushed the evolutionary understanding of the Universe. Ambartsumian was the IAU President in 1961-64, the ICSU President (1968-72), honorary member of 28 academies and societies, the President of the Armenian Academy of Sciences (1947-1993) and the Director of BAO (1946-1988). Until now, many astronomers in Byurakan work on ideas and hypotheses put forward by Ambartsumian.

Beniamin Markarian (1913-1985), another outstanding Armenian astronomer, is well known for his sky surveys and discovery of UV-excess galaxies. The First and Second Byurakan surveys, two large spectroscopic surveys were conducted by him and led to discovery of thousands of new interesting objects. *Grigor Gurzadian* is famous for his works on flare stars and planetary nebulae, as well as pioneer works in construction of the first Soviet orbital observatories. There are many other well known Armenian astronomers who worked and work in Byurakan.

However, some 80 Armenian astronomers work in other countries outside Armenia: *Yervant Terzian* and *Vahé Petrosian* are among the most well known US astronomers. Agop Terzan, Zadig Mouradian, Georges Alecian and Ralph Krikorian (*France*), Fabio Mardirossian (*Italy*), Hrant Tovmassian and Jivan Stepanian (*Mexico*), Felix Aharonian (*Germany*), and many others are known for their numerous works. Late Paris Pismis (*Mexico*), Gabriel Kojoyan (*USA*), and Tateos Aguekian (*Russia*) worked productively for many years. At present, more than 150 Armenian astronomers work in the world. 34 Armenian astronomers are IAU members and 25 are EAS members; some are members of other important international societies and organizations.

The Armenian Astronomical Society (ArAS) is a Non-Governmental Organization having its main goals to unify all Armenian astronomers all over the world, establish tight contacts between them and Armenian institutions where astronomy is active, as well as represent the Armenian astronomy at international scientific organizations. ArAS was in fact founded on June 22, 1999 in Byurakan at the meeting of 16 astronomers, its founding members. However, it was officially registered by the Ministry of Justice of Armenia two years later, on August 29, 2001. ArAS became one of the Affiliated Society Members of the European Astronomical Society (EAS) in September 2001 at the EAS Council Meeting in Munich. At present ArAS has 65 members, including those from the Byurakan Astrophysical Observatory (BAO), Yerevan State University (YSU), Yerevan Physics Institute (YerPhI), and members living and working outside Armenia. ArAS official languages are the Armenian, English and Russian. A detailed information about ArAS is given at its web page at <http://www.aras.am> (also see Mickaelian 2001b).

ArAS organizes its Annual Meetings every year in summer, in Byurakan or Yerevan, and invites all Armenian and other astronomers to take part in them and present their recent results and/or reviews on their works. ArAS has established its Annual Prize for Young Astronomers since 2004. ArAS publishes and distributes to all members its Electronic Newsletter 4 times annually. Articles concerning the Armenian astronomy, its achievements, present situation, information on forthcoming events, as well as brief scientific results of interest are being published. It publishes also abstracts of scientific papers or some short papers entirely.

At present, astronomy is active in a number of institutions in Armenia, including:

- Byurakan Astrophysical Observatory (BAO): instability phenomena in the Universe; surveys, search and study of new objects, etc.;
- Yerevan State University (YSU): Departments of Astrophysics (extragalactic astronomy), Theoretical Physics (theory of neutron stars and other superdense cosmic objects) and General Physics (theory of neutron stars, galaxy dynamics);
- Garni Space Astronomy Institute (space astronomy);
- Yerevan Physics Institute (YerPhI): Theoretical Physics Division (cosmology and gravitation) and Cosmic Ray Division (high-energy astrophysics);
- Institute of Radioastrophysical Measurements (radioastronomy).

Byurakan Astrophysical Observatory (BAO) is the main centre for astronomical research in Armenia (<http://www.bao.am>). There are about 60 scientists working on various topics of astrophysics, including Galactic and extragalactic investigations, cosmology, and theoretical astrophysics. Byurakan is situated on the slope of Mt. Aragatz, at an altitude of 1405m, 35 km from Yerevan. The main instruments are the 2.6m classical and 1m Schmidt telescopes, as well as there is 0.5m Schmidt telescope and a few other 40-60 cm size telescopes. 2.6m telescope (equipped with ByuFOSC and SCORPIO focal reducers, and VAGR multi-pupil spectrograph) carries most of the scientific tasks that are currently active in Byurakan, as well as it participates in a number of international projects in collaboration with French, German, Russian, Chinese, and other astronomers. 1m Schmidt telescope is one of the famous world telescopes. It was the instrument that carried out two Byurakan surveys, FBS (First Byurakan Survey, also known as Markarian survey) and SBS (Second Byurakan Survey).

Surveys and search for new objects are the traditional field for the Armenian astronomers: Markarian, Arakelian and Kazarian galaxies, Shahbazian groups are known to all astronomers. This tradition is being continued: searches for blue stellar objects and late-type stars; Herbig-Haro objects, H-alpha stars and stellar jets; optical identifications of IR, radio and X-ray sources, are among the main subjects of BAO's present activities. Other fields of investigations are: observational cosmology, theory of compact cosmic objects, and astrophysical applications of mathematical physics.

The Byurakan astronomers collaborate with scientists of France, Germany, Italy, UK, Spain, Russia, USA, Mexico, Japan, China, India, and other countries. Though the funding of science in Armenia is at very low level (the mean salary is equivalent to USD 20),

however the Byurakan astronomers work actively due to the international collaboration and grants, and a number of valuable contributions in science. A number of important international meetings have been organized in Byurakan, including 5 IAU Symposia and Colloquia, the First International Symposium on Communications with Extraterrestrial Intelligence (CETI) in 1971, ESO-Byurakan School in 1987, and many others.

The Armenian astronomers, as well as the whole astronomical community through Internet will have the *Digitized First Byurakan Survey (DFBS)* very soon. This project is being carried out by the Byurakan Astrophysical Observatory (Armenia) in collaboration with the Cornell University (USA) and Università di Roma “La Sapienza” (Italy). *The First Byurakan Survey (FBS)* is the largest spectroscopic survey covering 17,008 sq. degrees at high galactic latitudes ($|\text{b}| > 15$). FBS has 1139 fields (4x4 deg. each). Some 20,000,000 spectra are present in the whole survey covering a range 3400-6900Å thus giving important information especially on the nature of all these objects. The FBS was conducted originally for search for *galaxies with UV-excess (UVX)*: 1500 such galaxies have been discovered, later called Markarian galaxies. At present the survey is fully digitized and is being maintained on its webpage and on DVDs. Finally, the DFBS catalog and database with positional, photometric and spectral information on some 20,000,000 objects will be accessible.

A few new research projects based on the DFBS have been put forward such as searches for faint Markarian galaxies, new bright QSOs and Seyferts, new white dwarfs and cataclysmic variables, faint carbon stars, optical identifications of radio, IR, and X-ray sources, etc. The DFBS became a basis for the *Armenian Virtual Observatory (ArVO)* and a significant contribution to the International Astrophysical Virtual Observatories, especially for its unique spectral information.

Astronomical Education in Armenia

As astronomy is very popular in Armenia, the school astronomical education is being carried out since many decades. A number of astronomical textbooks were published in Armenian, written by the Byurakan astronomers. The University students also have textbooks in Armenian, as well as they use the Russian and English books for many courses that are taught at the University.

Since early years of the establishment, the Armenian high-level pupils participate in International Astronomical Olympiads, and the Armenian team is one of the most successful among all (there were more than ten winners). Armenian students also participate in many summer and winter schools and bring their contribution there. In the Yerevan State University (YSU), there is a Chair of Astrophysics at the Department (Faculty) of Physics. BAO and YSU lecturers teach some dozen subjects of modern astrophysics. The graduates (3-4 per year) work at BAO or YSU.

A number of astronomical summer schools were organized in Armenia (Byurakan Summer Schools in 1995, 2005 (for YSU students), 2006 (international one). The next international school is expected in 2008 and will be devoted to the 100th anniversary of Prof. Ambartsumian. An International School for Young Astronomers (ISYA) is planned for 2010 (an application is submitted to the IAU Commission #46).

Current and potential role of the Byurakan Observatory and Armenian astronomy in the Middle East area and the world

The Byurakan Observatory is not only a research institution. For most of the Armenians, it is associated with a cultural centre that can represent our nation. It is really a unique centre in the whole Middle East region. Byurakan is one of the largest observatories, and there work scientists that can teach and develop astronomy for the countries, which recently started to organize a high-level in science. In addition, Byurakan is a national science centre, probably the most famous research institute in Armenia. A project for adoption of a status of National Science Centre for Byurakan was put forward for the Armenian government. In short, the Byurakan Observatory is and may serve as:

- Research institution. Its importance for astronomy is still high, and the new international projects prove its future potential role as well;
- National science centre. As stated, Byurakan is accepted as the most important scientific centre in Armenia;
- Regional astronomical centre. Byurakan may serve as a research centre for many astronomers in the Middle East area;
- National and regional educational centre. Byurakan experts may teach and train students and young scientists to astronomical knowledge and help in their first steps in professional science;
- Unique architectural assemblage. The buildings and towers are built in a unique Armenian architectural style, all from rose tuf stone;
- Ambartsumian's museum. The museum was organized in the house of one of the outstanding astronomers of the 20th century, Prof. V.A. Ambartsumian;
- Botanical garden with rare species. After the Yerevan Botanical Garden, Byurakan Observatories garden has the largest collection of trees and various other plants;
- Armenian favourite sightseeing. Byurakan is one of the favourite places for tourism. Moreover, there are a lot of other sightseeing around Byurakan, and easily accessible from the Observatory;
- Ecological park. Given that the territory of the Byurakan Observatory is so important from many aspects, one should care about its many-sided preservation. There are plans to declare the Byurakan territory as ecological park.

We believe that the Armenian astronomical sites, especially Karahunge (which may be the most ancient observatory in the world) and the Byurakan Observatory (which is rather important for maintenance and development of astronomy in the Middle East area), must officially receive a proper attention from world organizations, particularly, they may be adopted as world astronomical heritage sites by UNESCO.

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