

# Byurakan Astrophysical Observatory (BAO): current activities and statuses

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## Abstract

We review the current activities and statuses of the Byurakan Astrophysical Observatory (BAO), one of the most active research institutes of the Armenian National Academy of Sciences. BAO was founded by the outstanding scientist, National Hero of Armenia Viktor Ambartsumian in 1946 as an institute of the Armenian Academy of Sciences. Its main scientific research field is the instability phenomena of the Universe. It is recognized as an Armenian National Value in 2013, IAU Regional Centre in 2015, IAU Outstanding Astronomical Heritage in 2021, Registered UNESCO documentary heritage item (Markarian Survey) in 2011 and has a number of other statuses. BAO has two major instruments; 2.6m classical reflector and 1m Schmidt telescope. A number of research projects are active at BAO and its scientists are rather active at international level. Since 1998, BAO bears the name of V. A. Ambartsumian.

**Keywords:** *observatories – telescopes – observations – databases – meetings – summer/winter schools.*

## Introduction

Byurakan Astrophysical Observatory (BAO) is one of the famous and most active research institutions of the Armenian National Academy of Sciences (NAS RA), as well as one of the most important astronomical centres 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 (1908-1996), the famous Armenian scientist of the 20th century. BAO is situated at an altitude of 1405m on the southern slope of Mt. Aragatz (with highest peak at 4090 m altitude), near village Byurakan, some 30 km Northwest to Yerevan, the capital of Armenia. V.A. Ambartsumian became the first director of the observatory, and main directions of astrophysical investigations were determined by him. First studies at BAO related to the instability phenomena taking place in the Universe, and this trend became the main characteristic of the science activity in Byurakan. Scientific results came just after the foundation of BAO. In 1947 stellar systems of new type, stellar associations were discovered by V.A. Ambartsumian. It was proved that at present star-forming processes are going on in the Universe, and stars are being formed by groups. Ambartsumian put forward an idea of star-forming in stellar associations together with gas and dust. In the mid-50s V.A. Ambartsumian gave a new explanation for radiogalaxies radiation and proposed a new conception on the activity of galactic nuclei. By the time, it was accepted by all the astronomers, and at present most of the astrophysical observatories have the subject of Active Galactic Nuclei (AGN) as one of their main research areas. The discovery of stellar associations and Ambartsumian's idea about activity of galactic nuclei, as well as investigations on radiation transfer theory, based on Ambartsumian's principle of invariance, elucidated the further development of the research activities in BAO. Among the observing studies, Markarian Survey on Active (UV-Excess) Galaxies may be mentioned, carried out in 1965-1980. After the disintegration of the Soviet Union, the Byurakan astronomers underwent difficult situation in economy and science, however, in a few years a new activity began in mid-90s with some re-organizational process and new international collaborations. Due to French astronomers, the 2.6m telescope was equipped with new instrumentation and started to giving new interesting results. Later on, in 2015, the 1m Schmidt was also renovated and started observations. Due to obtained results the Byurakan Observatory is recognized by the scientific community as one of the main centres for astrophysical research. The conceptions and ideas proposed in Byurakan have found their further elaboration in many observatories, a few thousands of new objects discovered in

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Byurakan are observed worldwide by famous astrophysicists. Since 1998 the Byurakan Observatory bears the name of V.A. Ambartsumian – its founder and scientific leader for many years. It is now more than 75 years that the Byurakan Observatory is among the world astronomical centers and successfully continues its new discoveries and high-level research.

## BAO telescopes

The ZTA-2.6 telescope (installed in 1975) is the largest observational instrument of the Byurakan Astrophysical Observatory and one of the 10 biggest telescopes of Europe, Asia, Africa and Australia. It is included in the list of the largest scientific equipment of the former USSR territory. At the time of its installation, it was the 7th largest telescope in the world.



Figure 1. 2.6 m telescope of BAO.

BAO's 1m Schmidt Telescope (installed in 1960) is one of the world's 10 largest telescopes of this type and one of the most effective telescopes in general. Markarian Survey (FBS), observations of stellar clusters and associations and discoveries of thousands of flare and T Tau stars were carried out by this telescope.

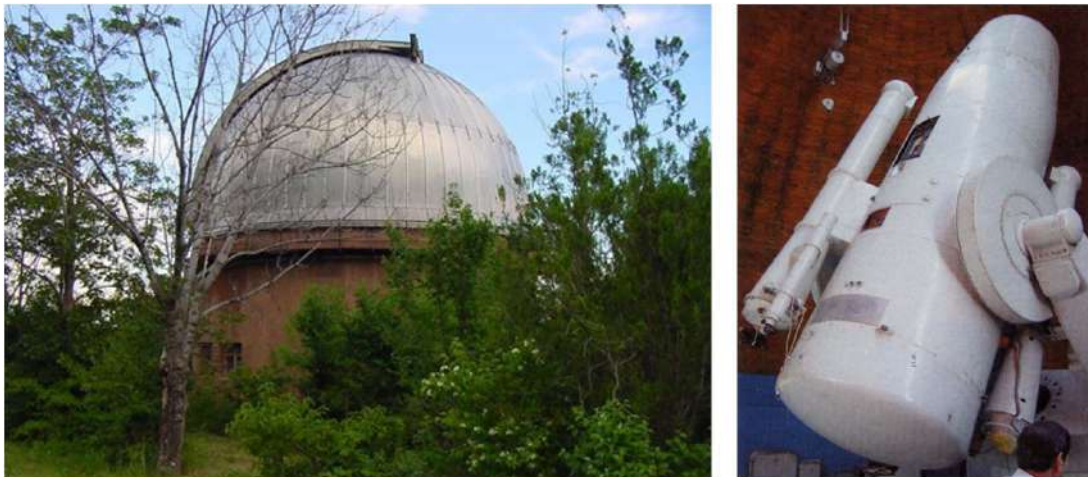


Figure 2. 1m Schmidt Telescope of BAO.

## Research Activities

BAO is one of the rarest observatories in the world where many new cosmic objects have been discovered. About 14,500 cosmic objects have Armenian names. It is famous by its surveys. Stellar Associations were discovered in 1947 by Viktor Ambartsumian in BAO. The formation of the stars in groups and the continuous processes of star formation currently occurring in the Galaxy have been proved. In the middle of 1950s,

Viktor Ambartsumian put forward the hypothesis of the activity of galactic nuclei, as a result of which a new direction of astrophysics has been developed. The main directions of research at BAO are:

- Star-Formation phenomena, Star-Formation regions, young stars and young stellar objects.
- Nebulae, their connection with stars, mechanism of formation and evolution.
- Nuclear and Star-Formation activity of galaxies, groups and clusters of galaxies.
- Theoretical studies: radiative transfer theory, interpretation of spectra.
- New directions: astrochemistry, astrobiology, High Energy Astrophysics (HEA) and others.

BAO basic program is called A-3: The role of non-stable phenomena in the evolution of cosmic objects.

### ***Research Departments***

Currently, BAO has 9 research departments covering broad aspect of astronomical/astrophysical topics, from stars to galaxies and from observations to theory. They are:

- *Astronomical Surveys*, Head: *Dr. Areg Mickaelian*
- *Non-Stable Phenomena*, Head: *Dr. Haik Harutyunian*
- *Young Stellar Objects (YSOs)*, Head: *Dr. Tigran Magakian*
- *Active Galaxies*, Head: *Dr. Ruben Andreevyan*
- *Astrochemistry, Astrobiology and Exoplanets*, Head: *Dr. Ararat Yeghikyan*
- *Theoretical Astrophysics*, Head: *Prof. Arthur Nikoghossian*
- *High Energy Astrophysics (HEA)*, Head: *Dr. Gagik Ter-Kazarian*
- *Cosmic Compact Objects and Relativistic Gravity*, Head: *Dr. Armen Sedrakian (Germany)*
- *Archaeoastronomy and Cultural Astronomy*, Head: *Dr. Hayk Malkhasyan*

In addition, *Prof. Elma Parsamian* is BAO Director's scientific advisor. BAO also has foreign scientific advisors:

- Vladimir Airapetian (GSFC, NASA, USA)
- Georges Alecian (Paris-Meudon, France)
- Tigran Arshakian (Koeln, Germany)
- Valeri Hambaryan (Jena, Germany)
- Garik Israelian (IAC, Spain)
- Michel Dennefeld (IAP, France, Project Advisor)
- Lex Kaper (Amsterdam, Netherlands, Project Advisor)

### ***Research Projects***

Along with their regular research work, BAO scientists have a number of projects, including:

- RA Science Committee Advanced Research Grant 21AG-1C044 (2021-2026): Star Forming Regions: *Origin and Evolution*, PI Elena Nikoghosyan

- RA Science Committee Advanced Research Grant 21AG-1C053 (2021-2026): *Revelation of Early Stages of Gal. Evolution by Means of Multiwavelength Study of Active Galaxies*, PI Areg Mickaelian
- RA Science Committee Thematic Grant 21T-1C031 (2021-2024): *Young Stellar Objects with Extreme Outbursting Activity*, PI Tigran Magakian
- RA Science Committee Remote Laboratories Establishment Grant 22RL-039 (2022-2027): *Search and identification of high-velocity stars by means of dynamical ejections from multiple stars and Supernova explosions*, PI Valery Hambaryan (Jena, Germany), Co-PI Satenik Ghazaryan
- Volkswagen Foundation Research Grant (2021-2023): *Equation of State and Composition of Proto-Neutron Stars and Merger Remnants with Hyperons*, PI Armen Sedrakian
- ANSEF grant PS-astroex-2597 (2022-2023): *Search and studies of luminous X-ray galaxies*, PI: Areg Mickaelian

### ***Digitized First Byurakan Survey (DFBS)***

The First Byurakan Survey (FBS) has been created by Beniamin Markarian and colleagues in BAO in 1965-1980. The survey is the largest ever astronomical spectroscopic survey of the northern sky and is considered as one of the most important achievements of the Astrophysics in 20th century. This was a new method of search for active galaxies. The first digitalization project of Armenia was carried out in BAO in 2002-2007 by Areg Mickaelian and his team, the digital version of 2000 plates of Markarian Survey (FBS) was created and reserved in the largest Armenian astronomical database. This digitized version is called DFBS, the largest low-dispersion spectroscopic database in the world (<https://www.aras.am/Dfbs/dfbs.html>).

### ***Armenian Virtual Observatory (ArVO)***

The Armenian Virtual Observatory (ArVO) was created in 2005 and is one of the 22 national VO projects of the International Virtual Observatories Alliance (IVOA). The Astrophysical Virtual Observatories (AVOs) have been created in a number of countries using their available databases and current observing material as a collection of interoperating data archives and software tools to form a research environment in which complex research programs can be conducted. Among all these data, a large spectroscopic database for all objects will be especially useful. ArVO has being created to utilize the Digitized First Byurakan Survey (DFBS) as an appropriate spectroscopic database. 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. ArVO is based on the Digitized First Byurakan Survey (DFBS). 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, as well as provide the first understanding on the nature of any object up to B=18m. In frame of the ArVO, BAO collaborates with the Institute of Information Technologies (IIT) of the Armenian National Academy of Sciences to develop software for ArVO corresponding to the IVOA standards. Beside the DFBS, ArVO is being complemented by the Digitized Second Byurakan Survey (SBS) database, the Byurakan photographic archive, and BAO 1m and 2.6m telescopes observations.

### ***Space Debris Monitoring project***

Since 2014, the Roscosmos station has been operating under contract at BAO, which monitors Space debris. The collaborator is the Astronomical Scientific Centre (Russia). A new monitoring project started at the observational base "Saravand" of BAO. This project initiated for revealing natural and artificial objects at the near-Earth Space. This is a kind of continuation of earlier observational projects implemented at the Observatory prior the collapse of Soviet Union. This time, near-Earth space monitoring is carried out at the request of the Russian agency "Roskosmos". For observations, the EOP-1 module is used, which includes small telescopes with a mirror diameter of 40cm, 25cm and 19cm.

### ***Collaborations***



BAO has always been very active in international collaborations and also collaborations with local (Armenian) scientific organizations.

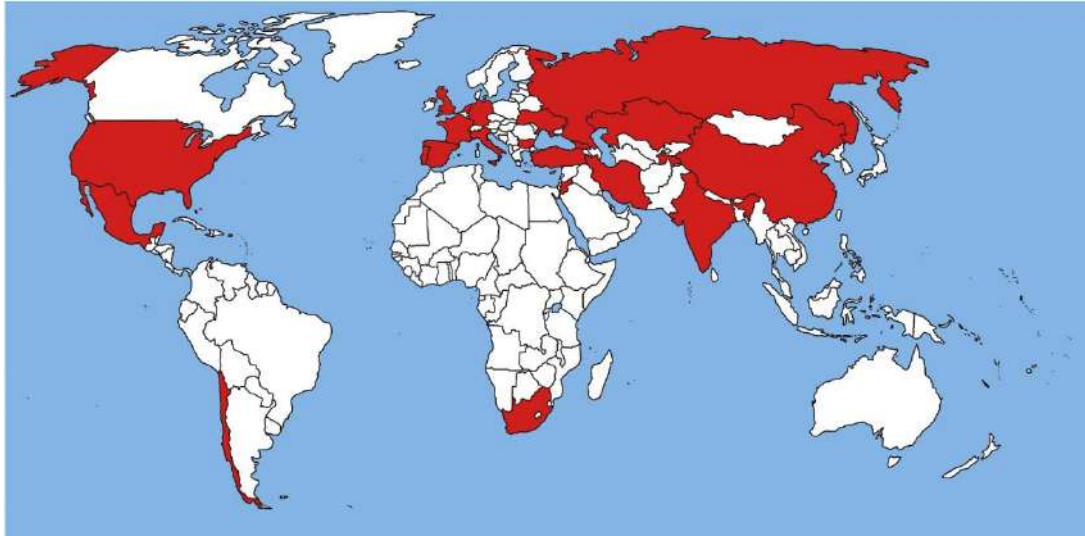


Figure 3. The world map of BAO collaborations. In total, 23 countries are involved.

## Scientific Organizational Activities

### *BAO seminars*

BAO is very active in organizing seminar. We have 4 types of seminars: Scientific, including also review seminars, Technical, Information, and Reports. During 2017-2023, 182 seminars, including 41 by foreign speakers were organized. The seminars by outstanding scientists were given by: Nobel Prize Winners John Mather (NASA/GSFC, USA), Reinhard Genzel (MPE, Germany), and Michel Mayor (Geneva Observatory, Switzerland), IAU President Ewine van Dishoeck (Leiden Observatory, Netherlands), ESO Director General Xavier Barcons (ESO, Germany), outstanding scientists Joseph Silk (IAP/JHU, France), Jill Tarter (SETI Institute, USA), Edward P.J. van den Heuvel (University of Amsterdam, Netherlands), Vahé Petrosian (Stanford University, USA), Daniel Kunt (IAP, France) and others.

### *European Annual Astronomical Meeting 2007*

One of the European Astronomical Society (EAS) Annual Meetings was organized by BAO in 2007 in Armenia (JENAM-2007, Joint European and National Astronomy Meeting). It was the largest ever scientific event in Armenia by both its significance and the number of participants. It had 14 parallel sessions and hundreds of talks and posters.

### *IAU Symposia and Colloquia*

Six IAU Symposia and an IAU Colloquium have been organized by BAO: 1966, 1986, 1989, 1998, 2001, 2016 and 2023. Due to BAO, Byurakan village appears in the list of 10 "cities", such as Paris, Rome, Vienna, Prague, Beijing, Honolulu, Rio de Janeiro, where the International Astronomical Union's (IAU) meetings took place most frequently. The Proceedings were published by Cambridge University Press (CUP) and the Astronomical Society of the Pacific (ASP) Conference Series.

### *First International Conference on CETI 1971*

The world's first international (in fact, Soviet-American) conference on the search for extraterrestrial intelligence (SETI) and communication with them (CETI) was held at BAO in 1971. Many famous scientists were present, including 3 Nobel Prize Winners. At that time the exoplanets were not yet discovered and

the scientists believed that the only way of revelation of extraterrestrials is the communication with them by sending and receiving radio signals. But the meeting encouraged many further studies in this area.

### ***UNESCO Conference 2017***

A UNESCO Regional Conference, the only such one in Armenia was organized by BAO in 2017 entitled “Astronomical Heritage of the Middle East”. It covered many aspects of Archaeoastronomy and Cultural Astronomy and was rather important for the Armenian science representing many talks and posters on various heritage items, including the Armenian calendars, the Armenian (astronomical) rock art, ancient observatories, names of constellations, medieval Armenian astronomy, Anania Shirakatsi’s heritage, etc. The Proceedings were published by the Astronomical Society of the Pacific (ASP).

### ***Meetings on Interdisciplinary and Multidisciplinary Sciences***

In 2015 and 2020, we have organized Symposia on “Astronomical Surveys and Big Data” (ASBD and ASBD-2) with the participation of astronomers and computer scientists. Many leaders and/or other representatives from the International Virtual Astronomy Alliance (IVOA) and national VO projects were present. In 2014, we organized one of the first meetings of such type “Relation of Astronomy to other Sciences, Culture and Society” (RASCS) with wide participation of astronomers, physicists, computer scientists, chemists, biologists, historians, archaeologists, philosophers, linguists, and others. A number of meetings on Archaeoastronomy and Cultural Astronomy were organized as well.

### ***Byurakan International Summer Schools (BISS)***

The Byurakan International Summer Schools (BISS) for Young Astronomers (founded in 2006) are among the World’s top-3 Astronomical Schools. In 2018, Byurakan International Summer School (BISS), which is being held once per 2 years, was announced one of the world’s best astronomical schools by the International Astronomical Union. The school is intended for young astronomers, MSc and PhD students in Astronomy. Until now, 8 summer schools have been held: 2006, 2008, 2010, 2012, 2016, 2018, 2020 and 2022. The 2010 school was combined with the IAU International School of Young Astronomers (ISYA).

## **BAO Official Statuses and Initiatives**

### ***BAO as RA National Value***

BAO was granted the status of “National Value” of the Republic of Armenia in 2013, by the decree of the RA government. BAO is one of the 3 RA National Values together with Matenadaran and Armenian Genocide Museum-Institute. Its importance as a National Value includes its research and scientific-organizational activities, national and international statuses and significance, cultural, educational and outreach activities and importance, rich botanical garden, unique architectural ensemble, and its importance as a centre for Scientific/Astro Tourism.

### ***BAO as IAU Regional Centre***



Figure 4. BAO as IAU Regional Centre

In 2015, the Byurakan Astrophysical Observatory (BAO) was appointed by the International Astronomical Union (IAU) as a host of the South West and Central Asia Regional Office. Being one of the 11 regional offices of Astronomy, it coordinates astronomy for development activities in the nearby countries. The official members are: Armenia, Georgia, Iran, Kazakhstan, Tajikistan and Turkey. The activities are performed within three Task Forces: TF1 Universities and Research (Professional Astronomy), TF2 Children and Schools (Astronomical Education) and TF3 Public Outreach.

### ***BAO UNESCO Documentary Heritage item***

In 2011, Markarian survey (the First Byurakan Survey, FBS) was included in the UNESCO “Memory of the World” documentary heritage international register. It is one of the 12 UNESCO items in Armenia and one of the rare scientific heritage items of UNESCO in the whole world. FBS contains the records of a unique astronomical survey carried out in BAO by the great Armenian astronomer Benjamin Markarian and his colleagues in 1965-1988. The survey involved the largest ever astronomical spectroscopic study of the nearby universe and is considered as one of the most important achievements of the 20th century astrophysics. It provides data on 40,000,000 low dispersion spectra for 20,000,000 objects. The records were carried out on BAO 1m Schmidt telescope. They cover the whole Northern Sky and part of the Southern Sky at high galactic latitudes and some part in the Milky Way areas. The FBS was conducted originally for search of galaxies with UV-excess (UVX). The discovery of 1515 UVX galaxies by Markarian and colleagues (later called Markarian galaxies) was the first and the most important work based on the FBS plates. It was digitized in 2002-2007 by Areg Mickaelian and his team and the Digitized First Byurakan Survey (DFBS) was created, the largest low-dispersion spectroscopic database in the world, and the first digitization project in Armenia in all spheres (<https://www.aras.am/Dfbs/dfbs.html>).



Figure 5. BAO UNESCO Documentary Heritage item

### ***BAO as IAU Outstanding Astronomical Heritage***

In 2021, BAO was included in the IAU Outstanding Astronomical Heritage (OAH) list as one of the most important world observatories. This list serves as UNESCO Heritage candidate list. BAO was among the first items that made up this list and started this initiative.



Figure 6. BAO as IAU Outstanding Astronomical Heritage

### ***Armenian Astronomical Society (ArAS)***



The Armenian Astronomical Society (ArAS) was founded in 2001 and brings together 100 astronomers from 20 countries. Operating at BAO and being a non-governmental organization (NGO), ArAS aims to develop Astronomy in Armenia, foster the collaboration between the Armenian and foreign astronomical institutions, strengthen the connection between the Armenian and foreign astronomers, contribute to the astronomy education and science popularization in Armenia. ArAS is also an affiliate member of the European Astronomical Society (EAS). ArAS has a very rich webpage, circulates electronic newsletters (ArASNews), organizes Annual Meetings and awards ArAS Annual Prizes for young astronomers (Yervant Terzian Prize).

### *Byurakan Astrophysical Observatory as a Unique Architectural Ensemble*

BAO's architectural ensemble is listed in Armenia as a unique architectural construction. It is also submitted to the IAU Outstanding Astronomical Heritage (OAH) list as a unique architectural building. The construction of the observatory's architectural complex began in 1946 under the supervision of famous architect Samvel Safarian and the latest buildings were designed and built under the supervision of another famous architect Sargis Gurzadyan. The first buildings were Viktor Ambartsumian's house (now house-museum) and the two telescope towers in front of the administrative building. The architectural ensemble of the observatory comprises of the administrative buildings and telescope towers. Buildings constructed during 1940-1950's were designed by the famous Armenian architect Samvel Safarian, while the ones constructed during 1960-1980's by Sargis Gurzadian.



Figure 7. Byurakan Astrophysical Observatory as a Unique Architectural Ensemble

### *Armenian National Hero Viktor Ambartsumian House-Museum*

Armenian National Hero Viktor Ambartsumian house-museum is situated at the Byurakan Astrophysical Observatory. Viktor Ambartsumian's house was built in 1950. It was turned into a house-museum in 1998 on the occasion of the great scientist's 90th anniversary. The house-museum presents Viktor Ambartsumian's life and activity, family photos, career path including various scientific works, diplomas, certificates and awards. In the same year (1998), BAO was named after Viktor Ambartsumian.



Figure 8. Armenian National Hero Viktor Ambartsumian House-Museum

### *BAO Pantheon as a Monument of Local Significance*

In 2021, by the decree of the Expert committee of the RA Ministry of Education, Science, Culture and Sport, Pantheon of Viktor Ambartsumian and his family members, as well as other Armenian astronomers (established in 1965) situated near the Byurakan Astrophysical Observatory (BAO), was granted the status



of a newfound monument of local significance. According to the BAO directorate decision 2021, the cemetery was renamed “Byurakan Astrophysical Observatory Pantheon”.

### ***BAO Park as an Arboretum***

According to the agreement signed between the RA Ministry of Ecology and the Byurakan Astrophysical Observatory in 2017, the Observatory’s green area was recognized as an arboretum (“dendropark”). It has some 140 types of trees and plants, as well as a variety of birds, insects and small animals.

### ***BAO as Scientific (Astro) Tourism Center***

In 2016, International Astronomical Union recognized the Byurakan Astrophysical Observatory as the initiator of astronomical tourism (Astro Tourism) in the world, while in 2015 according to the agreement signed the same year, it was recognized as Scientific tourism center of Armenia by the Armenian Institute of Tourism. BAO was recognized as an initiator of astronomical tourism in the world by IAU in 2016 and according to the 2015 agreement with the Armenian Institute of Tourism, as the center of scientific tourism of Armenia.

At the end, we give a summary table with all BAO statuses and initiatives.

BAO official statuses and initiatives.

Table 1.

Year	Statuses / Initiatives	Short	Awarded or recognized by
1946	Was founded as an Armenian Academy Research Institute	Research Institute	RA Government
1946	“Communications of BAO” journal was founded	ComBAO	BAO
1956	BAO Unique Architectural Ensemble was built	Architectural Ensemble	RA Government
1960	BAO 1m Schmidt telescope – among the world Top-10 wide-angle telescopes	BAO 1m Schmidt	
1965	“Astrofizika” (Astrophysics) journal was founded (then as an All-Union journal)	“Astrophysics”	NAS RA
1966	BAO was awarded Lenin Order	Lenin Order	USSR Government
1975	BAO 2.6m telescope – among the Top-10 telescopes in Europe, Asia, Africa and Australia	BAO 2.6m	
1977	BAO Special Council was established	BAO Special Council	NAS RA
1995	BAO Educational and Outreach programs	BAO Edu/Outreach	BAO
1998	Viktor Ambartsumian House-Museum	VA House-Museum	RA Government
2001	Armenian Astronomical Society	ArAS	EAS
2005	Armenian Virtual Observatory	ArVO	IWOA
2006	Byurakan International Summer Schools	BISS	IAU Division C
2009	BAO as initiator of the Scientific Journalism in Armenia	Scientific Journalism	
2009	BAO as initiator of the Scientific Tourism in Armenia, BAO as Astro Tourism Center	Astro Tourism Center	IAU / Armenian Inst. of Tourism
2011	UNESCO “Memory of the World” Documentary Heritage International Register	UNESCO MOW	UNESCO
2013	RA National Value	RA National Value	RA Government
2015	IAU South West and Central Asia Regional Office of Astronomy for Development	IAU SWCA ROAD	IAU
2017	BAO Protected Area – Arboretum	Arboretum	RA Government
2021	BAO Pantheon as a Monument of Local Significance	BAO Pantheon	RA Government
2021	IAU Outstanding Astronomical Heritage	IAU OAH	IAU