Astronomy in Georgia

B.B. Chargeishvili *

Evgeni Kharadze Georgian National Astrophysical Observatory, Abastumani, Georgia

Abstract

We provide a brief history of Georgian astronomy and discuss its current state. The discussion also covers the scientific facilities of Georgia's leading astrophysical institute, the Evgeni Kharadze Georgian National Astrophysical Observatory, as well as current scientific projects and specialists involved in them. It also includes educational activities on astronomy in Georgia.

Keywords: *History, Telescopes, Scientists, Projects, Outreach*

1. History

Here we consider the state of astronomy in Georgia. To summarize the history, note that while comprehensive knowledge of contemporary astronomy can be found in old Georgian texts and literary monuments, there is no documented evidence of any professional astronomical activity in ancient Georgia. This must be due to the historical fact that in our history there was no more or less prolonged period of peace. The beginning of professional scientific activity in Georgia in the field of astronomy is associated with the establishment in 1932 of the first astronomical research institution, the Abastumani Astrophysical Observatory (AbAO), which is attributed to the unbelievable efforts of the renowned scientist and esteemed individual, Evgeni Kharadze. As the AbAO is Georgia's foremost institution for professional astrophysical study, we shall focus on its history and present art of state. Following the most recent reorganization in 2019, the observatory's official name has changed to Evgeni Kharadze Georgian National Astrophysical Observatory. Step by step, AbAO gained new facilities, telescopes, and other scientific instruments. The field of research interest grew and became wider. And almost fifteen years ago, we had about 10 telescopes on the mountain Kanobili, where the observatory is located, and the research field included almost all branches of contemporary astrophysics, say variable stars, nova and supernova stars, galaxies, nebulae, the study of the sun, the solar system, and the upper atmosphere, theoretical astrophysics, and cosmology. In many branches, the observatory held a leading position, such as spectral classification, polarimetric study of solar planets and the moon, and plasma astrophysics. Researchers in Abastumani created valuable stellar 2D classification catalogs (Chargeishvili et al., 2013, Kharadze et al., 2014) and lunar polarimetric atlases (Dzhapiashvili & Korol', 1982).

International scientific relations have been the concern of all generations of scientists in our observatory. Scientists from our observatory were members of the IAU and participated in the work of different commissions and divisions. Scientists from foreign countries such as Germany, Bulgaria, Hungary, Ukraine, and Russia visited AbAO to get acquainted with and master the advanced results of Georgian scientists in various fields of astrophysics such as spectral classification, plasma astrophysics, and others. Our scientists have developed very productive relationships with such foreign research institutions as Space Research Institute, Moscow, Russia (Zeleny & Taktakishvili, 1987); The Special Astrophysical Observatory, Karachay-Cherkessia, Russia (Bartaya et al., 1994); Pushkov Institute of Terrestrial Magnetism, Ionosphere and Radio Wave Propagation, Moscow, Russia (Kulidzhanishvili et al., 1985); Keldysh Institute of Applied Mathematics, Moscow, Russia (Molotov et al., 2008); Space Research Institute, Sofia, Bulgaria (Chagelishvili et al., 1991); Toyama University, Toyama, Japan (Chargeishvili et al., 1993, Zaqarashvili et al., 1996, Zhao et al., 1993a,b); Katholic University of Leuven, Leuven, Belgium (Bagashvili et al., 2017, Mdzinarishvili et al., 2020, Shergelashvili & Poedts, 2005, Shergelashvili et al., 2005); Space Research Institute, Graz, Austria (Srivastava et al., 2010, Zaqarashvili et al., 2010); Astrophysical Observatory of Turin, Torin, Italy (Bodo

*bidzina@aidio.net

doi: https://doi.org/10.52526/25792776-24.71.2-340

et al., 2005, 2007, Tevzadze et al., 2010); Kepler Astronomical Center, Pedagogical University, Zielona Góra, Poland (Gil et al., 2002, Melikidze et al., 2000); Carnegie Mellon University, Pittsburgh, Pennsylvania, USA (Kahniashvili et al., 2009, 2010). Our observatory scientists have participated in many international scientific conferences and workshops. In 1986, AbAO was the initiator of such an important workshop as the Joint Varena-Abastumani Workshop on Plasma Astrophysics, which later found its continuation as the Varena-Abastumani-ESA-Nagoya Workshop on Plasma Astrophysics. In 2014, the observatory hosted an international symposium on the topic "our mysterious sun: magnetic coupling between solar interior and atmosphere" with participation from world-renowned scientists. The annual Georgian-Armenian, Burakan-Abastumani astronomy colloquiums, created in 1974 by close friends and observatory founders Evgeny Khaaradze and Viktor Ambartsumyan, are a great example of deep scientific ties and human international friendship.

The transition from photographic plates to CCD matrices in astronomy came at a difficult political and economic time for Georgia, and the observatory could not keep up with technological developments and equip its instruments with advanced technologies. It led to the cancellation of some scientific projects because several instruments became inoperative. Unfortunately, for the past 50 years, we have had no possibility of adding any serious scientific instruments. The last time, only several telescopes were operating. Among them are the Meniscus 70-cm telescope, the AZT 14 telescope, the double astrograph, and the Big Coronagraph. Although practical astronomy had such difficulties, many of our astronomers became involved in projects analyzing abundant satellite data, and the branch of data analysis became leading mostly in solar physics. Today, our theoretical astrophysicists have come closer to data analysis. This should increase the potential for future observational projects. And it was very timely that the observatory got an opportunity from the government to replace our old, non-functioning 1.25-meter AZT 11 with a new, Austrian-made robotic 1.5-meter telescope equipped with a modern spectrographic interface. The installation of this telescope and the new dome has just been completed and is currently undergoing testing and debugging.

To conclude the history of the Observatory, it is important to honor the memory of the deceased scientists who set the standards of the Observatory both in the field of science and human relations, including E. Kharadze, Sh. Vashakidze, R. Bartaia, V. Dzapiashvili, J. Lominadze, A. Pataraia, R. Kiladze, E. Tsikarishvili and many others.

2. Present state

The population of Georgia is 3.7 million. Accordingly, there are few organizations involved in astrophysical research. The largest organization is our 'Evgenii Kharadze Georgian National Observatory' (Abastumani Astrophysical Observatory). There is the 'Center for Theoretical Astrophysics of the Institute of Theoretical Physics' at Ilia State University (with 7 scientists), which is engaged in research in the field of astrophysics, and a person at Ivane Javakhishvili Tbilisi University, who also works in this field. The majority of specialists working in the field of astrophysics in Georgia come from AbAO. Our scientific staff counts 54 people, and their annual scientific productivity expressed in publications is about 80 publications. Among them, articles are 60, and refereed articles in highly ranked international journals are 40.

2.1. Scientific projects

Here we briefly outline the state-funded scientific projects conducted at the AbAO. Our scientific stuff is organized in three scientific departments. They are 'Galaxies and Stars', 'Sun and Solar System', and 'Theoretical Physics and Cosmology'. The field of study which ongoing state-founded scientific projects cover is traditionally wide and includes galaxies, stars, asteroids, the sun, pulsars, shear flows in astrophysical plasma, and cosmology. The projects are distributed among the departments as follows:
'Galaxies and stars'
1. A study of variable stars and other transients
2. Study of active hearts of galaxies at high energies
3. Search for GW optical matches within the GRANDMA collaboration.
4. Study of selected active galaxies through monitoring
5. Study of the physical characteristics of galaxies at different stages of evolution
6. A study of structure growth with the three-point function of galaxies
7. Search and study of periodic processes and transit events in stars of different spectral groups by photometric and spectroscopic methods

doi: https://doi.org/10.52526/25792776-24.71.2-340

'Sun and the solar system'

8. Study of dangerous asteroids approaching Earth in the Abastumani observatory
9. Solar Atmosphere/Magnetoseismology of the Solar Interior and Space Weather
10. Modeling and observations of solar and space weather processes
11. Study of physical processes in the chromosphere.
12. Magnetospheric heating and pair formation caused by magnetocentrifugal effects in pulsars and other compact objects.

'Theoretical Physics and Cosmology'

13. Testing non-standard cosmological models by studying the physics of gravitational waves, primordial magnetic fields, hidden energy, and neutrinos.
14. Formation of turbulence and coherent structures/flows in astrophysical flat and disk shear flows.
15. Dynamics of astrophysical flat and disk shear flows - non-ideal magnetohydrodynamic effects.

As one can see, our scientific projects count 15. Among them, the projects using actual observations of our telescopes are only 5. We hope that the new telescope will increase interest in our projects in native observational data from Abastumani. Even more new projects will appear concerning the ASA 15 telescope abilities.

In addition to state-founded scientific projects, the observatory hosts research projects funded by the National Science Foundation.

2.2. Scientific facilities

Abastumani Astrophysical Observatory is located in two different places. The main staff of our observatory works at the Tbilisi Office in the center of Tbilisi. The observatory is 250 km from Tbilisi and is built on the nice mountain Kanobili. On the mountain, we have about 10 astronomers and about 40 supporting personnel.

The most busy is the Meniscus 70 cm diameter telescope. The Maksutov System Meniscus Telescope was installed in 1955. This wide-field telescope is designed to observe the various objects in the night sky and to perform a lot of photometric or spectroscopy measurements. The telescope is equipped with Different Refractive Index Prisms (1, 2, 4, 8, degrees) located in front of the objective, which allows, if necessary, to perform the spectral classification of stars and the detection of the objects in special class.

Another operating telescope is AZT-14, Reflector with Parabolic Mirror. AZT-14, was installed in 1968. Cassegrain system. Objective diameter: 48 cm. The telescope is used for photometric study of variable stars.

One more telescope that is operable but is not loaded with many projects is 40-cm Wide Field Double Astrograph. It was installed in 1978. It consists of two identical refractors. Objective diameter: 40 cm. This telescope was used successfully for many years to perform astronomy observations of the solar system, observations of various types of stars in our galaxy, and extragalactic purposes.

The next science-used solar telescope that is only left among others that became non-actual and inoperable is the Solar Coronagraph. The Solar, Large Non-Eclipse Coronagraph, was installed in 1977. Objective diameter: 53 cm. The telescope is used for high-dispersion observations of the physical and dynamic characteristics of the Sun's outer atmosphere and for studying the "fine" structure of the chromosphere and the Corona.

The Schmidt-Cassegrain System telescope with automatic control was installed in 2018. The correction plate's diameter is 36 cm. It is mainly used for the polarimetric and photometric study of celestial bodies.

The chromospheric and photospheric telescopes were installed in 1957. Both of these telescopes (two tubes) were mounted on the same Parallax Unit, and therefore they have a common remote control and the clock mechanism. The chromospheric telescope is a refractor with an objective diameter of 6 cm. The telescope—narrow spectral band interference—polarizing filter, allows to get the 1.7-cm-diameter image of the sun (in the center of H alpha line) with the chromatic features such as prominences, filaments, and eruptions. The Photospheric Telescope is a refractor with an objective diameter of 13 cm. The telescope provides a 7.8-cm-diameter image of the sun (in the white band) with photosphere features such as granules, sunspots, and solar flares. Observational data collected by this telescope are valuable even today because of their long-term, more than three activity cycles, and uniformity. Today, observations made with this telescope are not scientifically valid, but we want to use it for educational purposes.

The final but most important one is our flagman, the Telescope ASA AZ1500 f6.

doi: https://doi.org/10.52526/25792776-24.71.2-340

- Optical design: Ritchey-Chrétien RC
- Main mirror aperture: 1,500 mm
- Dome internal diameter: 12.0 m
- Dome outer diameter: 12.5 m
- Shutter width: 3.0 meters

Telescope equipped with CCD Camera Andor iKon-XL 230 BV. Pixel number: 4096 x 4108. Pixel size: 15 microns. CCD type: Monochrome

Telescope equipped with Shelyak Whoppshel Spectrograph Spectrograph type: Echelle

- Spectral resolution: R = 30,000 and 15,000 (average at spectral range)
- Spectral range: 400 – 750 nm

2.3. Digitization of the glass and film library

Several attempts were made in previous years to digitize the vast observational data collected at our observatory over the course of more than 50 years. These initiatives were made by small groups of our astronomers with financial assistance from various grants. They helped answer specific local scientific challenges but did little to help with the larger task of digitizing the entire collection. After the reorganization of the observatory, we established the "Department of Technical Support and Development of Scientific Infrastructure," which includes a special team of six personnel concerned with systemizing and digitizing the observatory's glass and film collections. The glass library of the Abastumni Astrophysical Observatory contains around 70,000 photographic plates and films. Materials are mainly collected using the following instruments:

The 40-cm reflector has been making observations since 1937. Direct images of the moon, planets, asteroids, comets, and spectra of "trapezium"-type systems and clusters were obtained. In total, there are around 6500 images. Until 1963, two 20-cm cameras were utilized with the 40-cm telescope. Later, polarimetric and photometric measurements were made using this telescope. The 44 cm Schmidt camera was built in 1940. Before 1985, 25,000 photographic plates had been received. This telescope was used to observe supernovae, comets, galaxies, and other celestial objects. The 70-cm meniscus telescope has been in operation since 1955. We have received 20,500 photographic plates. Several sky review program observations have been made. Direct images of galaxies, binary stars, supernovae, and other objects are obtained. The telescope operated with preobjective prisms. The telescope's unique spectral material was used to perform two-dimensional spectral classification in certain parts of the sky. The 40-cm double astrograph has been operational since 1979. Astrometric measurements are made. Three thousand negatives were taken. For many years, several instruments have been observing the sun. There is also a rich, unique observational material of solar eclipses from the 1936 expeditions. Since 1957, atmospheric physicists have observed ozone and nighttime high-level lighting. There is an abundance of content to digitize.

So far, the digitization team has digitized astronomical logbooks from all stellar telescopes. 1600 spectroheliograph tapes and over 16,000 Schmidt's anaberration camera films have been scanned. The scanning of the spectral material on the 70-cm meniscus telescope has begun. The scanned materials are currently saved as ".tif" files. In the near future, it will be integrated into ".fits" files with suitable headers that preserve logbook details. A search engine program has been developed. Finally, we will publish it on our website for public consumption, as most observatories do.

2.4. Popularization of science in Georgia

From the very beginning of our observatory, all young astronomers were involved in guiding visitors on Mount Kanobili. At that time, we received visitors free of charge, and the guides did not receive a salary for this. Nowadays, we have a department of "Science Outreach". Now visitors have to pay for the visit, but in many cases, when we have special requests from schools or universities, our astronomers organize free lectures and excursions. I must say that popularization of astronomy is even more important now, since there is no astronomy subject in state schools and undergraduate programs at universities. Three state universities have only master's courses in astrophysics, without providing classical basic knowledge

doi: https://doi.org/10.52526/25792776-24.71.2-340

of astronomy. In order to increase the interest of schoolchildren in astronomy, we decided to combine the educational function, and for the third year now, free interactive lectures and seminars for schoolchildren have been held weekly in the Tbilisi office. In these classes, in addition to theoretical knowledge, students learn to assemble simple telescopes from scrap materials. These materials are purchased at the expense of the observatory, and after assembly, they are given to children as gifts. Two months ago, we organized the first "Astrophysical Conference of Young Scientists," where our young scientists and schoolchildren presented their reports. Our astronomers give popular lectures in various public schools. We intend to expand the scope and cover rural areas. After the repair of the accommodation infrastructure on Mount Kanobili is completed, we are going to organize annual summer schools for schoolchildren there. It would be great if this took on an international character.

Acknowledgements

The author would like to thank the organizers of the Southwest and Central Asian 4th Regional Astronomy Workshop, in particular Dr. Areg Mikaelian, Director of the Burakan Astrophysical Observatory.

References

Bagashvili S. R., et al., 2017, Astron. Astrophys. , 603, A134

Bartaya R. A., Chargeishvili K. B., Chentsov E. L., Shkhagosheva Z. U., 1994, Bulletin of the Special Astrophysics Observatory, 38, 103

Bodo G., Chagelishvili G., Murante G., Tevzadze A., Rossi P., Ferrari A., 2005, Astron. Astrophys. , 437, 9

Bodo G., Tevzadze A., Chagelishvili G., Mignone A., Rossi P., Ferrari A., 2007, Astron. Astrophys. , 475, 51

Chagelishvili G. D., Chanishvili R. G., Lominadze D. G., Filipov L. G., Khristov T. S., 1991, Advances in Space Research, 11, 61

Chargeishvili B., Zhao J., Sakai J.-I., 1993, , 145, 297

Chargeishvili K. B., Bartaya R. A., Kharadze E. K., 2013, VizieR Online Data Catalog: Spectral Classes in Kapteyn areas 68-91 (Chargeishvili+, 2000), VizieR On-line Data Catalog: III/271. Originally published in: 2000AbaOB..75...93C; 2013yCat.3271....0C

Dzhapiashvili V. P., Korol' A. N., 1982, Polarimetric atlas of the moon.. Tbilisi Metsniereba

Gil J. A., Melikidze G. I., Mitra D., 2002, Astron. Astrophys. , 388, 235

Kahniashvili T., Maravin Y., Kosowsky A., 2009, Phys. Rev. D. , 80, 023009

Kahniashvili T., Kisslinger L., Stevens T., 2010, Phys. Rev. D. , 81, 023004

Kharadze E. K., Bartaya R. A., Chargeishvili K. B., 2014, VizieR Online Data Catalog: Spectral Classes in Kapteyn areas 92-115 (Kharadze+, 2003), VizieR On-line Data Catalog: III/275. Originally published in: 2003AbaOB..76....3K

Kulidzhanishvili V. I., Stepanov A. I., Nikolskii G. M., 1985, Abastumanskaia Astrofizicheskaia Observatoriia Byulleten, 60, 109

Mdzinarishvili T. G., Shergelashvili B. M., Japaridze D. R., Chargeishvili B. B., Kosovichev A. G., Poedts S., 2020, Advances in Space Research, 65, 1843

Melikidze G. I., Gil J. A., Pataraya A. D., 2000, Astrophys. J. , 544, 1081

Molotov I., et al., 2008, Advances in Space Research, 41, 1022

Shergelashvili B. M., Poedts S., 2005, Astron. Astrophys. , 438, 1083

Shergelashvili B. M., Zaqarashvili T. V., Poedts S., Roberts B., 2005, Astron. Astrophys. , 429, 767

Srivastava A. K., Zaqarashvili T. V., Kumar P., Khodachenko M. L., 2010, Astrophys. J. , 715, 292

Tevzadze A. G., Chagelishvili G. D., Bodo G., Rossi P., 2010, Mon. Not. R. Astron. Soc. , 401, 901

Zaqarashvili T., Chargeishvili B., Sakai J., 1996, Astrophys. Space. Sci. , 246, 107

Zaqarashvili T. V., Díaz A. J., Oliver R., Ballester J. L., 2010, Astron. Astrophys. , 516, A84

Zeleny L. M., Taktakishvili A. L., 1987, Astrophys. Space. Sci. , 134, 185

Zhao J., Chargeishvili B., Sakai J.-I., 1993a, , 146, 331

Zhao J., Chargeishvili B., Sakai J.-I., 1993b, , 147, 131

doi: https://doi.org/10.52526/25792776-24.71.2-340