SOLAR SYSTEM

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BALDONE OBSERVATORY IN THE CIRCLES OF TIME

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ABSTRACT. 1957 – The first laboratory building, known as the White House, was built near Baldone on the Riekstu hill, in the territory of the next Observatory. 01.01.1958 – The Astronomy Sector was separated from the Institute of Physics and commenced independent activity as the Laboratory of Astrophysics at the Latvian Academy of Sciences (LAS). In 1967, with the decision of the Presidium of the Latvian SSR LAS the Laboratory of Astrophysics was transformed into the Radioastrophysic Observatory at LAS. Under the leadership of the first director, Janis Ikaunieks, an instrumental observation base develops – a 1.2m Schmidt telescope was installed in 1966 for optical observations. The project of the variable base radio interferometer after the death of J. Ikaunieks was unrealized. To continue astronomical observations in radio range, in 1972 10m radio telescope RT-10 was purchased.

Non-stationary processes and spectral research of carbon stars are associated with the study in optic range develops following the plan of J.Ikaunieks. After the establishment of the UL Institute of Astronomy in 1997, the field of research in the optical range is supplemented by the research direction of small objects of the solar system. However, the area of radio astronomy has stopped due to lack of funding.

The scientific potential of the Baldone Observatory remains significant. It should be mentioned that the 22,000 Schmidt telescope astroplate archive obtained in 1967-2005, will be digitized entirely this year. After digital image processing, coordinates and brightness for about of 330,000,000 objects will be obtained. The database will contain details of star movement, brightness variability (both long-term and short-term) and details of known, unknown asteroids and comets.

In 2008, monitoring of asteroids in the Solar System is started in Observatory. Up till now 77 new asteroids have been discovered in the Solar System and 11 of them have been named.

Research on carbon stars is still continuing successfully. The number of carbon stars currently discovered has reached 400. A methodology has been created for estimating the temperature and distance to the carbon stars. Work is currently underway to improve this method.

Observatory is continuing its work on popularizing astronomy. Number of visitors per year has risen from 1000 in 90s to almost four thousand in 2018.

Keywords: Baldone Observatory-history-carbon stars-photographic archive – asteroids

АНОТАЦІЯ. 1957 – перша лабораторна будівля, відома як Білий дім, була побудована поблизу Балдона на пагорбі Ріксту, на території майбутньої обсерваторії. 01.01.1958 – Астрономічний сектор відокремився від Інституту фізики і розпочав незалежну діяльність як Лабораторія астрофізики Латвійської академії наук (ЛАН). У 1967 р. Рішенням Президії Латвійської РСР ЛАН Лабораторію астрофізики було перетворено на Радіоастрофізичну обсерваторію при ЛАН. Під керівництвом першого проректора Яніса Ікаунієкса розвивається інструментальна база спостереження – в 1966 році для оптичних спостережень був встановлений 1.2-метровий телескоп Шмідта. Проект радіоінтерферометра змінної бази після смерті Я. Ікаунієкса не був реалізований. Для продовження астрономічних спостережень у радіодіапазоні, у 1972 р. було встановлено 10-метровий радіотелескоп РТ-10.

Нестаціонарні процеси та спектральні дослідження вуглецевих зірок, пов'язані з вивченням в області оптичного діапазону, продовжили розвиток за планом Дж. Ікаунієкса. Після створення UL Інституту астрономії у 1997 році сфера досліджень в оптичному діапазоні доповнюється напрямком досліджень малих об'єктів Сонячної системи. Однак напрямок радіоастрономії зупинилася через брак фінансування.

Науковий потенціал обсерваторії Балдона значно відновлюється. Слід зазначити, що 22 000 архівів астропластин Шмідта, отримані в 1967-2005 роках, цього року будуть повністю оцифровані. Після цифрової обробки зображень будуть отримані координати та блиск приблизно для 330 000 000 об'єктів. База даних буде містити деталі руху зірки, зміни блиску (як довгострокової, так і короткострокової) та деталі відомих і невідомих астероїдів та комет.

У 2008 році в обсерваторії розпочато моніторинг астероїдів у Сонячній системі. Дотепер у Сонячній системі було виявлено 77 нових астероїдів, 11 з них отримали назву.

Дослідження вуглецевих зірок досі успішно тривають. В даний час кількість виявлених вуглецевих зірок досягла 400. Створена методологія для оцінки температури та відстані до вуглецевих зірок. Зараз ведуться роботи з удосконалення цього методу.

Обсерваторія продовжує роботу над популяризацією астрономії. Кількість відвідувачів за рік зросла з 1000 у 90-х майже до чотирьох тисяч у 2018 році.

Ключові слова: Балдонська обсерваторія – історія, вуглецеві зорі – фотографічний архів – астероїди

1. Historical review

The Astrophysics Observatory of the Institute of Astronomy of the University of Latvia in Baldone Riekstu hill began its activities in 1958. The Astronomy Sector was separated from the Institute of Physics and commences independent activity as the Laboratory of Astrophysics at the Latvian Academy of Sciences (LAS). A year ago, the first laboratory building was built in the territory of the next observatory, 5 km from Baldone town near Riekstu hill, the so-called "White House". The founder and first director of the Observatory was Janis Ikaunieks (1912-1969). He planned to develop two directions of research: to create a large base radio interferometer and research late-type stars in the optic. In 1959, an agreement was signed with Carl Ceiss factory of East Germany (GDR) on the construction of a Schmidt telescope to ensure the performance of optical observations.

In 1962, by coordinating the astronomical plans of the Baltic republics, it is planned that the Astrophysics Laboratory of LAS would become a radio astronomy center in the Baltics region. The name of the Astrophysics Laboratory was changed in 1967 with the LAS decision to Radioastrophysical Observatory at the LAS. At this moment in time, the project of a two-kilometre long rig for multi-antenna for variable base radio interferometer has been completed. This project does not succeed because of the premature death of Janis Ikaunieks. The further development of the area of radio interferometry, 30 m rotating radio antennas were built in Roņu Island and the cities of Engure and Salacgriva also was also discontinued . An interesting deviation – similar plan was realized many years after in Mullard radio observatory in England. Thanks to the efforts of Arturs Balklavs (1933-2005), the next long-term director of the Observatory, the direction of radio astronomy studies remains with the 10 m radio antenna purchased in 1972, at 755, 610 and 326 MHz.

The development of optical astronomy went in line with Janis Ikauniek's idea. On the first days of January 1965, the 1.2 m large field (19 square meters field of view) Schmidt system telescope with an input aperture of 0.8 m has arrived to the Observatory. It is the twelfth largest Schmidt telescope in the world to date (Figure 2).

The construction of pavilion for telescope was carried out with the help of Latvian specialists only and was completed in June 1966. The pavilion and the dome of the telescope were designed by the Latvian Design and Cons truction Bureau of the Latvian SSR LAS. Construction work was led by the repair and construction department of LAS. The dome was made by the Riga Ship Repair Plant and assembled by a specialized assembly plant. These organizations met for the first time with such a special object, therefore there were many difficulties in their work (Figure 3). The first observations with Baldone Schmidt telescope were made in December 1966. The test results have shown, that it is a very high-quality instrument.

After gaining political independence in 1991, the process of reorganization in all sectors of the economy and science began in Latvia. As a result of science reform, the institutes of LAS were integrated into universities. The LAS Radioastrophysical Observatory together with Astronomical Observatory of the University of Latvia (UL) formed independent Institute of Astronomy at the UL in 1997. Previously the sharp decline of finance amount for science leads to the abandonment of the radio astronomical research at the Baldone Observatory. Research of carbon stars and nova continues in the newly established UL Institute. Following the recommendation of the Red Giant Working Group of the International Astronomical Union, an updated version of the Galactic Carbon Star Catalogue was prepared and published by the institute astronomers, in 2001. The average amount of visits to the catalogue home page is close to 100,000 per year.

Figure 1: 10 m Baldone Observatory radio telescope RT-10.

Figure 2: Baldone Schmidt telescope

Figure 3: Baldone Schmidt telescope pavilion

2. Research in Baldone Observatory

The properties of carbon (C) stars are still successfully studied in the optical range. Over 300 new carbon stars have been discovered on the objective prism photographs taken with the Baldone Schmidt telescope. A green-yellow survey was made with the resolution about 500 or 1000 at H-gamma. The region of the sky covered by the survey: 4.5 degrees wide zones centered on the galactic latitudes +7 and -7 degrees between longitudes 68 and 200 degrees on the equatorial zone at longitudes 84-96 degrees and 172-180 degrees on several other separate fields with five degrees diameter. Some infrared plates were made on the Kodak plates 1N with resolution 500 near the A band of Earth atmosphere. The region of the sky covered: 4.5 degrees wide zone centered on the galactic latitude +7 degrees between longitudes 128 and 140 degrees, region between latitudes +9.5 and -9.5 degrees and longitudes between 80 and 96 degrees. In the last ten years occasional prism observations were made with CCDs: CCD ST – 10XME and STX-16803. More than 50 new carbon stars were discovered in Cygnus, Perseus and Cassiopeia regions (Eglitis & Sokolova, 2018). Non-stationary processes are being studied not only in the newly discovered C stars, but also in 70 flaming stars which were discovered in Andromeda Galaxy. Spectrophotometric studies of C stars reveal that gradients [757 -- 685] shows the correlation with Teff taken from Bergeat et al. (2001). It reveals a possibility to classify carbon stars by temperature indices and to detect effective temperatures of stars with accuracy ± 350 K. Investigations of C stars in LMC by Mauron (2008) give possibilities to create a method to evaluate absolute magnitude of late carbon stars using (J – K)o color indices. The calculation of distances was made by the equation:

$$Mk - mk + 5\lg r + Ak + 10 = 0, \text{ where r is in kpc.}$$

Now our methodology is testing using GAIA parallax measurements.

On the subject of carbon stars General Catalogue of Cool Carbon Stars (CGCS) (Alksnis et al., 2001) and four monographs were prepared, two of which were reissued in the US.

In 2005/2006 years, the Baldone Astrophysics Observatory has exhausted the astroplates reserves, as manufacturers have already abandoned astronomical photo plate production. The transition period to new light receivers is successfully used for the recoating with aluminium of the main mirror of Baldone Schmidt's telescope in Germany, and from 2007 the telescope continues to observe with a small 3.2 megapixel CCD camera that uses only 0.4% of the telescope's field of view. As the telescope opportunities change, research topics are also changing. Although the theme of traditional carbon star research has been retained, in 2008 monitoring of the asteroids in the solar system had started. Despite the very small sky coverage, the new direction of research brings positive results thanks to the uniquely high telescope light sensitivity. The 21mag threshold is reached by the telescope in the red part of the spectrum with an 8-minute exposure which allows the recording of 50m bodies in the Main Asteroid Belt (i.e., at distances 330 to 480 million km). In the next 7 years, 49 new asteroids are being discovered. 11 of them were named.

Table 1. Asteroids discovered at the Baldone Astrophysical Observatory.

Number	Name	Year of designa-tion	Discovering year	Diam (km)
274084	Baldone	2011	2008	1.5
284984	Ikaunieks	2012	2010	1.5
294664	Trakai	2012	2008	3.5
321324	Vytautas	2012	2009	3
330836	Orius	2013	2009	35
343157	Mindaugas	2013	2009	3.5
392142	Solheim	2014	2009	3
332530	Canders	2015	2008	2
353646	Blumbahs	2015	2008	1.5
428694	Saule	2016	2008	0.6
457743	Balklavs	2016	2009	1

In 2010, three UL institutes – Atomic Physics and Spectroscopy, Astronomy, Geodesy and Geoinformatics – establish the Association FOTONIKA-LV. A year later, the Association in the fierce competition earns FP7 3.7 million EUR REGPOT project FOTONIKA-LV, which has a positive push for research growth in all three institutes. In 2012–2013, several master theses and three doctoral theses have been taught in astrophysics. Using FOTONIKA-LV project funds, high-precision scanners are being purchased, which lay the foundations for the Baldone Schmidt telescope's more than 22,000 (direct) and 2,300 (spectral) astronomical plates archive digitization. The scanning process of direct plates in this year is in the final stages. After completing the next step – digital image processing with special programs developed by the National Academy of Sciences of Ukraine at the Main Astronomical Observatory (Andruk et al., 2014, Andruk et al., 2016a, b), a large astronomical database will be obtained. The evaluation shows that around 330,000,000 stars will have accurate equatorial coordinates and brightness. It will be an exclusive database for refining the visible movement of stars, for variability of brightness studies, for asteroids and comets, both known and new research. As shown by the processing of digital images of some of the astroplates obtained in the ecliptic region, they contain dozens of asteroid images up to 17 B (blue spectrum range) many of which were discovered decades later than the photographic observations in Baldone observatory. This result points to a real opportunity to discover new unknown asteroids and comets near Earth. Publication of data of U – ultraviolet observation is also important, as the number of publications in the Astronomical Data System of Strasbourg with U magnitudes are close to hundred, while articles with the visual and near infrared measurements are tens of times more.

2016 – 2017 years were filled with intensive work on optimizing the optical system of Schmidt telescope. As a result of the optical system calculations, the Institute of Astronomy managed to develop an additional lens to be placed in the optical system of the Schmidt telescope to make the convex compatible Schmidt telescope focal plane with the flat bed plane of CCD. There are now two 16.8 megapixel cameras STX-16803 in the focus of the telescope. Each CCD

Figure 4: Two CCD cameras are located in the focal plane of the Schmidt telescope.

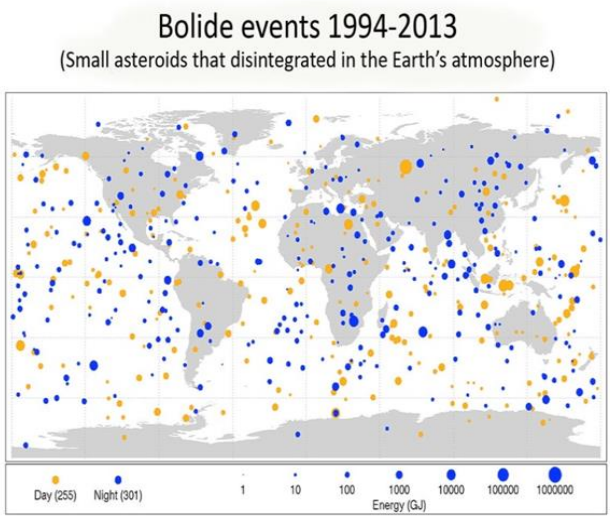

Figure 5: Largest blue (night) and yellow (day) circles match the energy of the Chelyabinsk event. (https://www.nasa.gov/jpl/bolide-events-1994-2013/).

is covering one degree of sky (see Figure 4). As a result, the effectiveness of Baldone Schmidt telescope increased 25 times. This benefit was confirmed by the first observations with an improved optical system in the August-September 2017, when 21 new asteroids were discovered in a short period of time. Up to now 77 new asteroids were discovered in Observatory. The direction of research is important to protect the Earth from the fall of asteroids and to mine the minerals on them in future. Events such as the fall of Chelyabinsk's meteorite seem rare. However, as shown by NASA's published radar map of bolides fall, similar events on Earth are on average every five years (Figure 5) and only because of the uneven population distribution on Earth it is not as often observed.

The new capabilities of telescope allow for intensification not only of classical carbon star research, but also expand research field: to study the physical properties of comets and asteroids, and to start investigations in the field of relativistic particle. The co-operation with radio astronomers allowed winning the Latvian Science Council's basic and applied research project "Complex Solar System Small Body Research".

The popularity of the Baldone Astrophysical Observatory is growing in the world, thanks to work on digitizing the archives of astronomical photographic plates, preparing many scientific publications, participating in international conferences and creating a Planetarium in the dome of the Schmidt Telescope. The number of popular science lecture visitors has increased from 1000 in 2012 to almost 4000 in 2018. Baldone Astrophysical Observatory has been invited as a member in three international projects related to the popularization of natural sciences (Scientist Night, Night 2018-2019," Youth attraction to astronomy (projects Est-Lat Interreg SpaceTem and Online Observatory)).

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