A NEW 50 cm TELESCOPE FOR THE RUSSIAN-CUBAN OPTICAL TELESCOPE NETWORK

UN NUEVO TELESCOPIO DE 50 cm PARA LA RED DE TELESCOPIOS RUSO-CUBANA

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Since 2017, the Institute of Astronomy of the Russian Academy of Sciences (Russia) and the Institute of Geophysics and Astronomy (Cuba) have been implementing a joint international project with the aim of building a distributed global optical telescope network. The first 20 cm robotic telescope of this network has been operated since 2021 in Havana. The construction of the second 50 cm telescope has been underway since 2023 and it is expected to be finished and installed in 2025 near Kislovodsk (Russia). According to the current plan, a third 1 m telescope will be installed in 2030 at Valle de Picadura (Cuba). In the present contribution, the main parameters and scientific equipment of the 50 cm telescope are described and its role in the Russian-Cuban distributed global telescope network is discussed.

Desde 2017, el Instituto de Astronomía de a Academia de Ciencias Rusa (Rusia) y el Instituto de Geofísica y Astronomía (Cuba) han estado implementando un proyecto internacional conjunto con el objetivo de construir una red global de telescopios ópticos. El primer telescopio robótico de 20 cm de esta red opera desde 2021 en La Habana. La construcción del segundo telescopio de 50 cm has estado llevándose a cabo desde 2023 y se espera instalar en 2025 cerca de Kislovodsk (Rusia). De acuerdo con el plan actual, un tercer telescopio de 1 m será instalado en 2030 en Valle de Picadura (Cuba). En la presente contribución, se describen los principales parámetros y el equipamiento científico del telescopio de 50 cm, y se discute su papel en la red global de telescopios ruso-cubanos.

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I. INTRODUCTION

The collaboration between Russia and Cuba on astronomical research began in 2017. The Russian-Cuban working group on cooperation in science, technology and the environment was established, which included representatives of the governments and ministries of the two countries.

The Institute of Astronomy of the Russian Academy of Sciences (INASAN, Moscow, Russia) and the Institute of Geophysics and Astronomy (IGA, Havana, Cuba) have been implementing a joint international project, with the goal of building a Russian-Cuban multi-task network of optical telescopes RCO (Russian Cuban Observatory) (Fig. 1). The process of the RCO construction is divided into three stages. At the beginning of 2021, the first telescope was installed at the Institute of Geophysics and Astronomy of the Republic of Cuba in Havana [1]. It was the first result of the fruitful cooperation between three organizations – IGA, INASAN and the Institute of Applied Astronomy of the Russian Academy of Sciences (IAA RAS) [2,3].

In 2023, the second phase of implementation of the Russian-Cuban optical telescope network began with the aim of building a 50 cm telescope in Russia.

II. IMPORTANCE OF THE OPTICAL TELESCOPE NETWORK

Distributed global optical telescope networks are efficient tools for modern observational astronomy and astrophysics, since many observational tasks require long continuous observation series of the studied objects.

As an example, we can reference the detection and tracking of newly discovered asteroids [4], photometric studies of variable stars [5] and the study of optical transient events, e.g. sources of gamma-ray bursts and tidal disruption events.

If the network is made up of telescopes of different apertures with different kinds of scientific instruments, it will be possible to carry out different research tasks. At least two types of telescopes should be included in the network – wide-field survey telescopes and a middle-aperture follow-up telescopes equipped with cameras and spectrographs.

The global and universal Russian-Cuban network of optical telescopes RCO should include survey telescopes with an aperture of larger than 0.2 m and a field of view of the order of several degrees, and astrophysical telescopes with an aperture of more than 0.5 m equipped with cameras and spectrographs. As mentioned before, the first RCO wide-field of view 20 cm robotic telescope has been put into operation and works as a multipurpose astrometric and photometric instrument [2,3].

The most interesting objects will be studied in more detail with larger telescopes both in spectroscopic and photometric modes. The best way to have a guaranteed time for such follow-up observations is to have dedicated telescopes within one network. For this purpose, the 50 cm telescope is under construction in the ongoing stage 2 of the RCO network. Thereafter, in stage 3 of the RCO network construction, a 1 m telescope will be built.

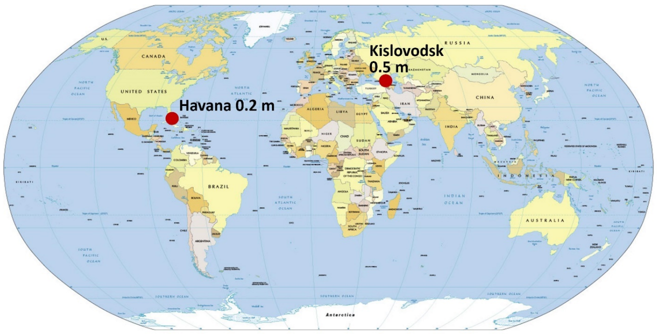

Figure 1. Russian-Cuban network of optical telescopes (RCO) illustrating the first two telescopes included.

Other telescopes from Russia and worldwide can be used for follow-up observations of the most interesting objects, e.g. INASAN's 2 m telescope at the Terskol observatory and 1 m telescope at the Simeiz observatory. According to the existing agreements, the 0.5 m telescope of the Ussuri Department of the IAA RAS and the 0.5-1.5 m telescopes of the astronomical institutes of the Academy of Sciences of the Republic of Uzbekistan and the Republic of Tajikistan will also be used for follow-up observations. The joint usage of these observation sites and telescopes within the network allows observations along an arc of 214°C (or 14.3 h) in the northern hemisphere. Taking into account the length of the observation nights (6 to 12 hours) for the above-mentioned observation sites, it is possible to carry out a practically round-the-clock monitoring program and alert observations.

III. IMPLEMENTATION OF THE RUSSIAN-CUBAN DISTRIBUTED GLOBAL OPTICAL TELESCOPE NETWORK

The process of the RCO construction is divided into three stages. In 2021, the first node – RCO optical station in Havana was built and began operation.

The second phase of implementation of the Russian-Cuban optical telescope network began in 2023 with the aim to build an observation station close to Kislovodsk (Russia) with a 50 cm multipurpose (photometry and spectroscopy) telescope. According to the schedule, this node should begin scientific operation in 2025. In the third stage, a custom 1 m wide-field telescope with spectroscopic, astrometric and photometric capabilities will be designed and built. It will be installed in Cuba at the Valle de Picadura observatory located 80 km east of Havana. This telescope should begin its operation in 2030.

IV. THE SECOND RCO STATION WITH 50 CM ROBOTIC TELESCOPE FOR SPECTROSCOPY AND PHOTOMETRY

As mentioned before, the second node of the Russian-Cuban optical telescope network will be equipped with a 50 cm telescope (Fig. 2). It is the first telescope of the network with both spectroscopic and photometric functionality. The time difference of 8 hours (120 degrees) between the Kislovodsk (central part of Russia) and Cuba allows for continuous observations of up to 16 hours. The location of the second telescope in Russia significantly boosts the functionality of the Russian-Cuban network both in terms of global coverage and observation modes.

The RCO observation station close to Kislovodsk will be equipped with (a) Astrosib RC500 0.5 m aperture telescope with switchable diagonal mirror for fast change the observation mode, (b) equipment for astrometric (positional) and photometric observations: FLI Kepler 4040 camera with Johnson-Cousins-Bessel UBVRI filters; (c) equipment for spectroscopic observations: suspended BACHES spectrograph with ZWO ASI294 MM camera and active optics; (d) Astrosib FMDD-700 direct drive mount; and (e) Astrosib ASD-4.5 dome;

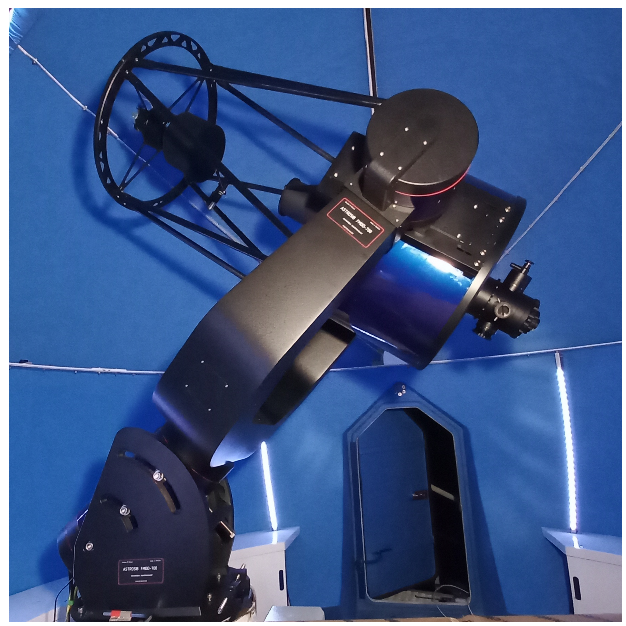

Figure 2. RC500 0.5 m aperture telescope for the second RCO station near Kislovodsk (Russia).

The RC500 is a 0.5 m aperture Ritchey-Chretien telescope produced by ASTROSIB Ltd in Russia. The optical system with a 508 mm primary mirror is housed in a carbon-fiber truss design optical tube assembly. It has a two-lens field corrector whose equivalent focal ratio is F/8 (focal length 4000 mm), and has an optical assembly mass of 68 kg. The telescope is equipped with a motorized focuser and motorized primary mirror covers.

The RC500 telescope is mounted on an Astrosib FMDD-700 equatorial fork mount equipped with direct drive motors and

26 bit absolute encoders. It is housed in a 4.5 m Astrosib ASD-4.5 all-sky dome installed on an original hyperboloid 5.4 m high pier design by INASAN.

It has two main scientific instruments – a camera and a spectrograph, which are quickly interchangeable by the telescope's folding mirror. Both modes of operation, photometry and spectroscopy, are available to the user at any time without the need to mechanically modify the telescope's setup. The time to switch between two instruments is less than 1 minute, which allows for a very flexible observational program every night.

BACHES (Basic Echelle Spektrograph) is a compact, lightweight, and inexpensive medium resolution (R~20000) Echelle spectrograph manufactured by Baader Planetarium GmbH (Germany) (Fig. 3). BACHES©head allows acquiring spectra of the object of interest as well as calibration spectra. With a 0.5 m telescope it is capable of obtaining spectra of 10 mag targets with a SNR of 20 for 30 minute exposures. The spectrograph is very compact and well suited for remote autonomous operation at a robotic observatory.

The BACHES was already procured and has been successfully used on the 1 m telescope at the INASAN Simeiz observatory for several years: it will be relocated to the new 0.5 m RCO telescope.

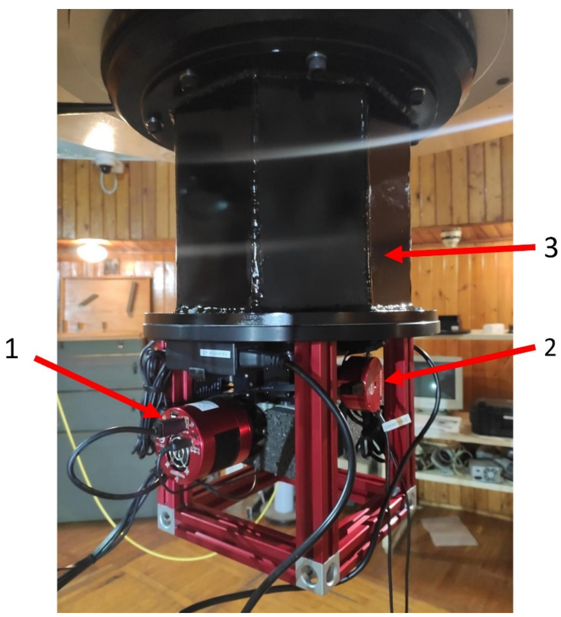

Figure 3. BACHES spectrograph on INASAN Simeiz Zeiss-1000 telescope. (1) the main spectrograph's camera, (2) guide camera and (3) telescope adaptor.

The BACHES main parameters are (a) average spectral resolution: R~20000 with slit 25x130 μm; (b) spectral range: 3920-8000 Å continuously (depending on detector size); (c) Spectrograph efficiency: ~27 % at 5040 Å, total efficiency ~11-13 %; (d) limiting magnitude: ~10 mag. visual (SNR=20, 30 min. exposure); (e) detector: low noise and extra high sensitivity cooled back-illuminated sCMOS camera ZWO ASI294MM, Sony IMX492, sensor size 19.1x13 mm; and (f) fiber feed calibration module: Thorium-Argon hollow cathode lamp and Tungsten flat-field lamp.

The spectrograph is equipped with a tip-tilt active optics Starlight SXV-AO-USB module with a ZWO ASI178MM fast guide camera. Active optics allows for long spectroscopic observations with an exposure of up to 0.5 hour and more. A simple achromatic telescope's focus extender F/8 to F/10 is used to couple the spectrograph with the telescope.

The second RCA 50 cm telescope's scientific instrument is the sCMOS camera FLI Kepler 4040. The camera's main parameters are (a) sensor: GPIXEL GSENSE4040, (b) format: 4096 x 4096 pixels; (c) pixel size: 9 μm; (d) full well Capacity: 70000 e-; (e) shutter type rolling and mechanical; (f) typical system Noise: 3.7 e-; (g) typical dark current: <0.5 e-/pixel/sec at -30°C; and (h) typical nonlinearity: <1 %.

The camera is equipped with a FLI CFW5-7 filter wheel with 7 slots for photometric filters. In the first step, 5 filters of the standard Johnson-Cousins-Bessel system UBVRI will be installed. The sixth slot of the filter wheel will be used for broad-band imaging (integral light) to achieve maximum sensitivity of the telescope. In particular, this mode is efficient to search for new objects such as asteroids, comets and space debris. The seventh slot of the filter wheel will be reserved for future scientific observation programs.

The 50 cm telescope time service uses high accuracy time signals coming from GPS and GLONASS. It provides timing for all acquired frames and coordinates information.

V. RCO STATION OPERATION

The observation site close to Kislovodsk has a set of equipment that can be operated remotely and autonomously: the weather stations, lightning detector, GPS/GLONASS receiver, all-sky camera and surveillance cameras. All the equipment of the 50 cm RCO robotic observatory has standard device drivers. The observatory is controlled by a set of special software created by INASAN. It allows the control of all devices to perform scientific observations, data storage and data processing remotely.

The RCO observation station close to Kislovodsk will operate in a fully robotic mode with remote access by INASAN and IGA staff. It will allow Cuban astronomers to conduct scientific research both in photometric and spectroscopic modes in the territory of the Russian Federation at a site with good astro-climatic conditions.

The main tasks of the IGA staff during the construction of the RCO observation station at Kislovodsk are: (a) to conduct astronomical and astro-climatic observations, (b) to process astronomical and astro-climatic data, (c) to conduct educational events and internships for Cuban scientists in the Russian Federation.

VI. CONCLUSIONS

The Russian-Cuban RCO network is set out in 3 stages: the first one includes the 20 cm telescope which has already been built in Havana (Cuba), the second stage includes the 50 cm telescope which is currently under construction close to

Kislovodsk (Russia), and in the third stage a 1 m telescope will be built at Valle de Picadura (Cuba).

In 2025, after the beginning of the 50 cm telescope operation, the Russian-Cuban network functionality will improve significantly both in terms of global coverage and observation modes, including spectroscopic observations and more precise photometric observations.

The 50 cm telescope of the second RCO observation station close to Kislovodsk will operate in a fully robotic mode. It will allow Cuban and Russian astronomers to conduct scientific research both in photometric and spectroscopic modes.

VII. ACKNOWLEDGMENTS

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