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New 30-cm Solar Telescope at National Astronomical Observatory Rozhen

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Abstract

A new solar telescope is about to be established at National Astronomical Observatory Rozhen, Bulgaria. Its construction and commissioning mark a new chapter in the development of solar observations in the region after the beginning of coronal monitoring in 2005. The new 30-cm reflector is going to be focused on chromospheric observations. Its main parameters, scientific purposes and development status are presented in the current work.

Introduction

Over the last two decades there is a serious progress regarding new possibilities and methods of solar observations and their physical interpretation. Nevertheless, the modern solar physics is still facing lots of unanswered questions. Finding the answers is directly bound to a permanent monitoring of different manifestations of solar activity. There are ground-based and space-based observations now. The space-based observatories (e. g. SOHO, STEREO, SDO, etc.) together with the modern ground-based solar telescopes make possible to take a look at the Sun in a large range of the electromagnetic spectrum – gamma rays, ultraviolet, visible and infrared light, radio waves. This allows studies of the same active processes at different layers of solar atmosphere (so called “solar tomography”). All these observations widen our understandings of the physics of the Sun.

Historically, the development of Bulgarian astronomy naturally leads to the development of solar research. We owe its historical roots to the activity of Prof. Marin Bachevarov - Dean of the Faculty of Physics and Mathematics of Sofia University, Rector of the University and a pioneer for the construction of the first modern observational astronomical instrument in Bulgaria – a 6-inch refractor. From 1899 to 1905 Prof. Bachevarov, together with a group of students, began regular observations of sunspots from the Observatory in Sofia [*Petrov N., et al.*, 2018]. Years later, in 1961, the first research expedition to observe a total solar eclipse on February 15 was organized in Bulgaria [*Dermendjiev V. N., et al.*, 1999].

In the very beginning of 1990s the foundations of modern observational solar physics were laid in Bulgaria by Prof. Vladimir Dermendzhiev, who built solar tower with 15-cm refractor for white-light observations of active processes. It was the first important step to the realization of the idea of own observational base in the Institute of Astronomy. As a result of even more efforts, a solar coronagraph was built in the solar tower of National Astronomical Observatory (NAO) Rozhen in 2005 [*Petrov N., et al.*, 2018]. The renovation and progress of solar observational infrastructure in Bulgaria continued in 2019 with laying the foundations of building the first chromospheric telescope in Bulgaria.

This paper gives a preliminary information about the project for construction of new solar telescope in Bulgaria – its future location, main characteristics, scientific purposes and development status.

Scientific purposes

Scientific purposes change over time. New objectives appear due to the development of solar physics. The telescope should, therefore, be designed so as to be adapted to new scientific challenges. Bellow, we present objectives of the new 30-cm solar telescope planned to installed in NAO Rozhen, which can be formulated in terms of requirements of modern solar and solar-terrestrial physics.

Nowadays ground-based imaging of the Sun can be used as a complement monitoring of the solar activity. Its main advantages in the era of space-borne instruments are the relatively low cost of implementation and the ability access the received data immediately.

A Hα solar observations reveal the active nature of the solar atmosphere. The interaction between the convective motions in the photosphere and the dynamics in the hot corona happen in-between in the chromosphere – a layer where the kinetic energy of the plasma gradually becomes weaker than the energy of the magnetic field and the plasma parameter β shifts from $\beta>1$ (photosphere) to $\beta\leq1$ [*Rodriguez Gomez J. M., et al.*, 2019] before reaching low-beta values in the corona and in the active region chromosphere ($\beta<<1$) [*Sakurai T.*, 2017]. The chromosphere is also a region from solar atmosphere where the temperature rises in height as it is situated right above the temperature minimum layer.

Prominences/filaments, fibrils, Ellerman bombs, flares and more are only part of the phenomena observable in Hα. One of the main scientific purposes of the new solar telescope is dedicated to make regular observations of various manifestations of solar activity. A free-access online database is going to be established and updated as soon as the daily observations begin.

A network with amplified magnetic field situated above the photospheric network is visible in the chromosphere during Hα observations. It is called chromospheric network and is outlining the supergranulation cells. A downward flow of material with typical velocity of about 1-2 km s^{-1} marks their boundaries [*Rieutord M. and Rincon F.*, 2010]. Bright streams of luminous gas about 10000 km high, called spicules originate from the chromospheric network [*Sterling A. C.*, 2000]. They are one of the smallest Quiet-Sun structures available for observations. The surface of the spicules is assumed as the actual boundary between the chromospheric and coronal material.

Telescope parameters and capabilities

The telescope is currently under construction. It is designed as Schmidt–Cassegrain reflector with diameter of the main mirror D = 305 mm and a focal length F = 3050 mm (Figure 1). It is equipped with Hinode solar guider and a flat K8 glass filter with a bandwidth 6560±500 Å that provides reflection of at least 94% of the light in non-working areas of the spectrum to prevent overheating. A system of telecentric lens and a focal reducer (0.75x – 0.4x) provides the opportunity for correction of the focal length. The effective focal length F_{eff} will vary in range 5000 to 15000 mm and, respectively, the field of view will between 2.5x2.5 arcmin and 10x10 arcmin. With this telescope, we will be able to obtain observational material from active regions in the solar chromosphere with a line-of-sight velocity resolution between 0 and 10 km s^{-1}. At the end of the tube will be placed a Hα filter (λ = 6562.8 Å) with a bandwidth ~0.3 Å and a possibility for displacement of the centre of the bandpass at ±0.5 Å by 0.1 Å step. The telescope was planned to receive its first light from the territory of NAO Rozhen in the first half of 2020, but now the deadline is indefinitely extended due to the pandemic situation.

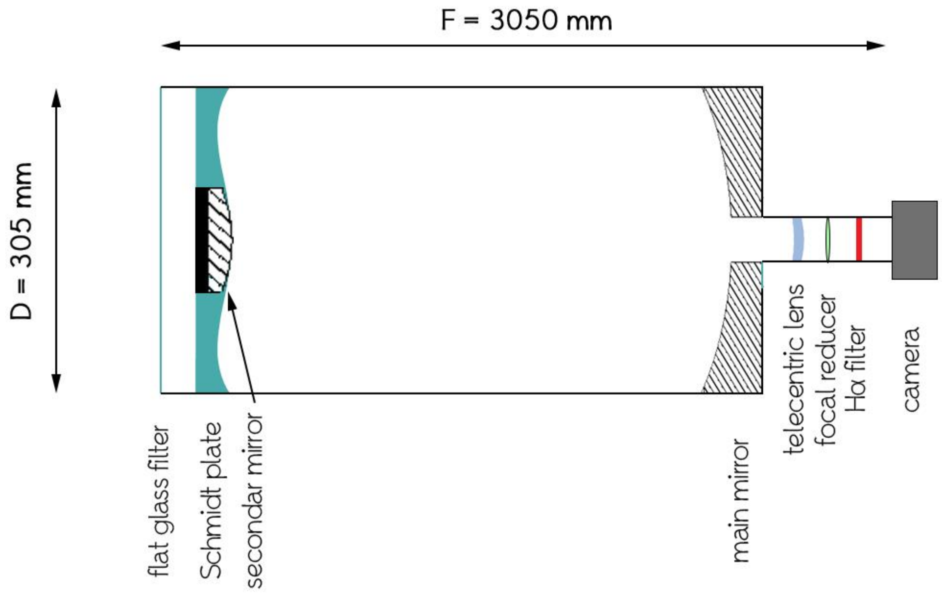

Fig. 1 Optical scheme of the Schmidt–Cassegrain telescope.

Nevertheless, the optical part of the telescope is already constructed and the first calibration test image, taken at the factory is now released (Figure 2). It is captured when to the telescope F/10 F = 3050 mm is attached a telecentric focal extender 4.3x equal to F/43 F = 13115 mm and a focal reducer 0.7x that, finally, makes F = 9180 mm. The scale of the image is 0.13"/px in unfavourable weather conditions with high seeing.

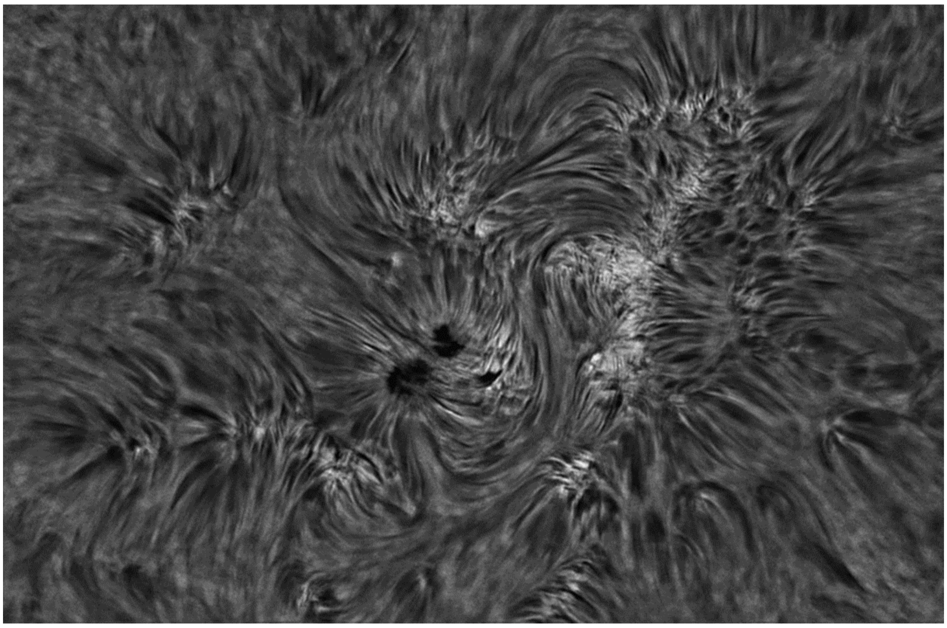

Fig. 2 A preliminary shot of the telescope, taken on 2020 August 10, showing the active region 12770.

The telescope will be equipped with a digital camera with high-performance, high-quality imaging by combining FLIR expertise with the latest in CCD and CMOS technology.

Apart from the operational software for telescope control, for the analysis of the observational data, a new software product founded on existing procedures in the IDL-based software product SolarSoftware will be developed. Precise data processing is the basis for quality scientific production, which necessitates the development of a specific algorithm that will facilitate and universalize the preliminary data analysis. Processed data will be provided through a specially designed website.

Upon its completion, the telescope will serve same tasks, both in regular solar observations and in the effective training, qualification and educational activities related to heliophysics and astronomy.

Conclusions

We present an overview of the capabilities and technical specifications of the new 30-cm solar telescope that is going to receive its first light from the territory of NAO Rozhen soon. The telescope suggests a Hα view to the structures and dynamics of solar chromosphere in precise detail. Unlike most of the Hα telescopes used today it is not going to capture full disk images of the Sun. The changeable field of view that varies between 2.5x2.5 arcmin and 10x10 arcmin will offer observations of particular separate chromospheric parts. A database with free access that is going to archive daily observations is currently under construction.

Acknowledgment

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