Millimetron Space Observatory: progress in the development of payload module

A. Smirnov(1), E. Golubev(1), M. Arkhipov(1), E. Filina(1), V. Pyshnov(1), N. Myshonkova(1), S. Fedorchuk(1), T. Kosmovich(1), I. Vinogradov(1), A. Baryshev(1,2), Th. de Graauw(1), S. Likhachev(1) and N. Kardashev(1)

Millimetron Space Observatory (MSO) is mission addressed to creation a space cryogenic telescope with aperture about 10-m [1]. Such telescope will allow scientific community to have an astronomical instrument with enormous sensitivity and angular resolution in the submillimeter and far-infrared wavelength ranges. We plan to install at the telescope several FIR and sub-millimeter scientific instruments, which will enable high-resolution imaging and spectroscopy observations with unprecedented sensitivity. At the same time, MSO will enable observations with an extremely high angular resolution (up to 0.1×10^{-6}arcsec) as an element of a ground-space very long baseline interferometry system (S-VLBI). Thereby the observatory will contribute breakthrough capability into solution a number of cosmology and fundamental astrophysics questions about the origin and evolution of our Universe, galaxies, stars and other objects [2].

The MSO is divided into two parts: the payload module and the bus module. Due to the complexity of the payload module, most of the recent years of work are focused on it. This module includes an antenna of the telescope, scientific receivers, functional and service systems and a high-gain radio system for transmitting scientific data to Earth.

The primary mirror of the telescope will be deployable and consist from of a 3-m aperture central part surrounded by 24 deployable petals. The concept of petals deployment is based on the successfully launched and currently working Radioastron project [3]. The surface accuracy of the deployable 10-m primary mirror of Radioastron achieves about 1 mm in space conditions. The telescope of MSO would have much better surface accuracy - less than 10 μm (rms). In order to achieve this we plan to use an active surface control system based on a wave front sensing. This system will be periodically employed to correct inaccuracies in the positions of the panels caused by different factors.

A combination of a high modulus carbon fiber reinforced plastic (CFRP) and a cyanate ester resin as a binder provides a lightweight structure with low moisture absorption, high thermal stability and high stiffness. This combination has been chosen for the material of the primary mirror of telescope and many parts of it. The panels are mounted on the back support structure (Fig. 1) made from CFRP via precision cryogenic actuators.

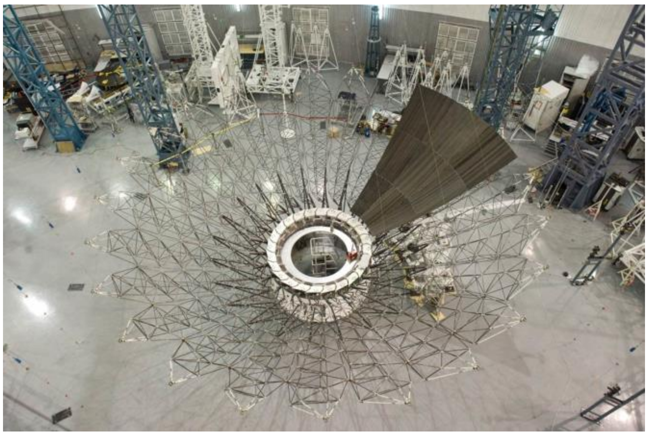

Fig. 1. Photo of the full-scale deployable mock-up of back up structure of the primary mirror with six installed panels.

To achieve the required sensitivity of the telescope in the submm/FIR we need to cool antenna down to the temperature less than 10K (goal). It may be possible to do this on-orbit only by a combination of effective radiation cooling and additional active mechanical cooling. A cold space antenna requires minimization and stability of external thermal radiation. This is one of the reasons why MSO will be placed into orbit around the second Earth-Sun Lagrange point (L2). The MSO antenna into L2 will be cooled passively to a temperature about 30 – 60K by a suite of the deployable multi-layer V-groove shields. The following steps to reduce the temperature of the antenna are based on active reducing the thermal loads applied to it. Active mechanical cooling is based on existing close cycling space mechanical coolers.

In this work, we will focus on the progress in the development of payload module.

[1] Astro Space Center of P.N. Lebedev Physical Institute, 84/32 Profsoyuznaya str., Moscow, Russia.

[2] Kapteyn Astronomical Institute, University of Groningen, Landleven 12, 9747 AD, Groningen, The Netherlands.

References

[1] Smirnov A.V. et al. "Space mission Millimetron for terahertz astronomy," *Proc. SPIE 8442, Space Telescopes and Instrumentation*: *Optical, Infrared, and Millimeter Wave,* 84424C, 2012.

[2] Kardashev N.S., et al, "Review of scientific topics for Millimetron space observatory" *Phys. Usp*., vol.57, Is. 12, pp. 1199-1228, 2014.

NOTES:

[3] Kardashev N.S., et al. ""RadioAstron"– A Telescope with a Size of 300 000 km: Main Parameters and First Observational Results," *Astronomy Reports*, 57, 153-194, 2013.

NOTES: