The Millimetron Space Observatory: Hardware Development and Breakthrough Science Objectives

Th. de Graauw*[1,2], A. Baryshev[3], S. Likhachev[1], A.S. Andrianov, E. Golubev[1], A. G. Rudnitskiy[1], A. Smirnov[1], P. André[4], M. Arkhipov[1], P. de Bernardis[5], P. Hartogh[6], D. Lis[7], D Novikov[1], I. Novikov[1] , S. Pilipenko[1], A. Punanova[8] and Y. A. Schekinov[1], on behalf of Millimetron team.

[1] Astro Space Center of P.N. Lebedev Physical Institute, 119997, Moscow, Russian Federation
[2] European Southern Observatory, 763 0355 Vitacura, Santiago de Chile, Chile
[3] Kapteyn Astronomical Institute, University of Groningen, 9747 AD, Groningen, The Netherlands
[4] Lab. d'Astrophysique (AIM/SAp), CEA, F-91191 Gif-sur-Yvette, France
[5] Sapienza University of Rome, 00185 Roma RM, Italy
[6] Max Planck Institute for Solar System Studies, 37077 Gottingen, Germany
[7] JPL/CalTech, Pasadena CA 91125, California, United States
[8] Ural Federal University, 620075 Yekaterinburg, Russian Federation

To make progress in our understanding of several key questions in astrophysics, FIR and Submm space observatories are an urgency. As a next step, after the successful mission of the Herschel Space Observatory, we are developing the Millimetron Space Observatory (MSO) that comprises a 10-m cryogenically cooled telescope, to be deployed in space. With the recent cancellation of SPICA, the MSO is the only opportunity left for a sizable FIR space mission in the foreseeable future.

The MSO will operate as a 10 m single dish, with high-resolution imaging and spectroscopy instrumentation, and as an observing station in a Space-Earth VLBI interferometer. The initial orbit will be around the L2 position of the Sun-Earth system and at a later stage it might go into a highly elliptical orbit to improve UV coverage. The MSO will be launched at ambient temperatures and in orbit, the antenna and instruments will be cooled through a combination of passive and active cooling with mechanical coolers. This brings the 10-m antenna to temperatures to below 10K, with a goal of 5K. As such MSO will open up new windows in astrophysics with unprecedented sensitivity and sub-microarcsecond angular resolution.

We will present an overview and progress in the development of the payload module, that includes the antenna and its foreseen cooling system. We will also present a summary of the key scientific objectives that are under study by international .science working groups that concern amongst others: - sub-microarcsecond imaging of the Event Horizon Telescope targets, - components of the CMB spectral distortion, compact obscured galaxy-nuclei, - detailed and high sensitivity studies of Water and other hydride molecules important to reveal the star and exoplanet formation process, and - imaging of the star forming filamentary structures by magnetic field measurements. These key scientific objectives will determine the instrumentation complement of the MSO. These will include FIR polarimetric cameras and spectrometers, a THz heterodyne instrument and dedicated mm/submm receivers for the Space-Earth interferometry.

The MSO is a Russian-led mission in collaboration with an extensive international consortium. The launch is foreseen for 2029.