In Flight Measurements System of Millimetron Primary Mirror Surface

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Millimetron Space Observatory (MSO) is a mission dedicated to far infrared astronomical observation from space. The key element of MSO is its 10 m primary mirror which is cooled to cryogenic temperatures: 10 K is goal and below 20 K is specification. The primary mirror accuracy specification is 10 µm and goal is 5 µm RMS which would allow for effective observations at wavelength above 150 µm. Due to its mirror temperature, aperture size and state of art instrumentation on board, that MSO will be several orders of magnitude more sensitive than previous space missions in far infrared like Herschel Space Observatory (HSO) and it will have 3 times more spatial resolution in single dish mode than HSO.

Main mirror (see figure 1) of MSO will have to be deployed in space because solid 10 m aperture does not fit under fairing of available launching systems. Primary mirror consists of central fixed part of 3 m diameter and 24 deployable petals located around central part. Each petal contains support structure and three panels attached to it by means of mechanical actuators, in such a way that both position and curvature of each panel can be adjusted while in space. Central part of the mirror also consist of 24 identical panels supported by mechanical actuators.

Panels of primary mirror are made from carbon reinforced plastic composite material designed to have zero coefficient of thermal expansion. The panels are replicated during curing off the AstroSetal glass negatives which are polished to high accuracy, of 1..2 µm RMS. The CRFP panel design allow to achieve very low specific mirror mass of <10 kg/m^2.

The main dish is designed to deploy with accuracy of 1 mm PV. Final surface accuracy will be achieved by placing the panels around optimal paraboloid surface with common focus by means of mechanical actuators. Both piezo and step motors solutions for actuators are being considered.

One of the key technological challenges in order to achieve final surface accuracy is ability to measure surface deviations in flight conditions. In addition the surface accuracy of the panels will not allow to use visual light optical methods to measure mirror accuracy. In this contribution we will discuss three main methods considered to achieve required measurement accuracy:

- Photogrammetry, using on-board high resolution cameras and photogrammetry targets on panels. This method achieves 100 µm typical accuracy
- Laser ranging. This method will involve fiber – optics based absolute distance laser measure with accuracy of 1 µm which allows to measure positions of special targets, located on each panel in 3D space. This information will be used to place the panels at desired positions and change their curvature if needed.
- Coherent signal adjustment using signal form bright astronomical source and successive approximation approaches, staring with lower frequencies and then propagating to the higher frequencies. Astronomical receiver would be used for this purpose.

We will provide numerical estimate for efficiency of each method and its limiting accuracy at realistic MSO main dish design and available astronomical sources.

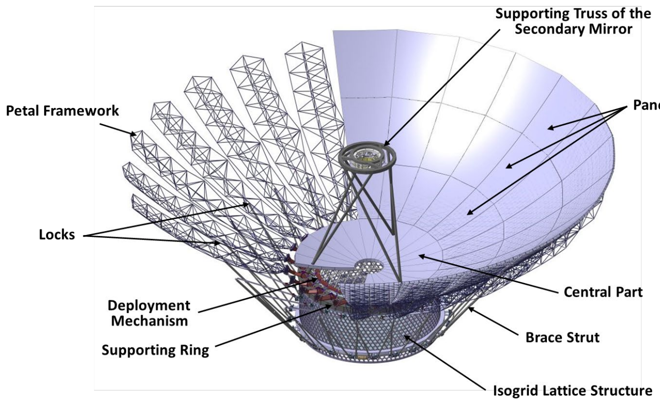

Figure 1, Construction of MSO's primary mirror

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