

Status and Prospects of UHECRs Studying by Orbiting Telescopes

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Despite the long-term operation of large ground installations, the problem of sources of ultra-high-energy cosmic rays (UHECRs) is still far from its solution. An important step towards solving the problem may be the use of a new technique for registering extensive air showers (EAS) in the atmosphere of Earth, namely measuring a fluorescent track from orbit. This observation method allows one to achieve a large exposure and to record events throughout the celestial sphere with one device.

A program for registering UHECRs from Earth's orbit is being implemented in a series of projects. The first of them, the TUS detector, was launched aboard the Lomonosov satellite in 2016. During the operation of the detector, the spatiotemporal structure of the UV glow of the atmosphere was studied, and information was obtained on transient flashes that trigger the detector. A number of UV tracks similar to those expected from EAS were recorded in the nocturnal atmosphere.

The next step should be a full-scale telescope with a larger optical system and a field of view, which allows recording dozens of events per year beyond the GZK cut-off. Such a project, named KLYPVE-EUSO is being developed by the JEM-EUSO collaboration for installation on board the International Space Station. Variants of the lens and mirror telescopes are considered.

During the preparation of the K-EUSO project a number of pathfinders are being developed: balloon experiments EUSO-Balloon and EUSO-SPB1, fluorescence detector at the Telescope Array site. The UV Atmosphere (Mini-EUSO) experiment is operating onboard the Russian Segment of the ISS since October, 2019.

A more advanced experiment POEMMA (Probe of Extreme Multi-Messenger Astrophysics) is planned to be implemented after K-EUSO. It is aimed at detecting both UHECRs and high-energy (above 20 PeV) neutrinos. POEMMA is a system of two telescopes on separate spacecrafts that provide a stereoscopic image of the EAS track and registration of the direct Cherenkov radiation from ascending showers of energetic neutrinos. Currently EUSO-SPB2 project with Cherenkov and fluorescence cameras is in preparation for a launch in Spring 2023 in the path of K-EUSO and POEMMA missions. SINP MSU develops a digital data processing system for the fluorescent telescope photodetecting modules.

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