Contribution ID: **16** Type: **Overview**

Studies of heliospheric modulation of cosmic rays at ShICRA SB RAS and prospects of their further development

Wednesday, 9 June 2021 14:40 (25 minutes)

The ShICRA SB RAS has been conducting theoretical and experimental studies of cosmic rays and their modulation in the heliosphere for over 60 years. The results of experimental studies of variations in the cosmic ray intensity include the creation of original methods for the primary processing of the registration data of neutron monitors and muon telescopes, in particular, the methods of crossed telescopes, receiving vectors, and global survey, which are currently used to solve various fundamental and applied problems. In 1964, an analysis of the data obtained at the Yakutsk spectrograph was used to explain the nature of the observed daily variation in the cosmic ray intensity. A significant contribution to the theoretical study of cosmic rays was the discovery of the regular (diffusion) acceleration mechanism in 1977. Based on this mechanism, a theory of cosmic ray acceleration in the solar corona in linear and quasilinear versions was developed, the observation of storm particles at the interplanetary shock fronts was explained, and the acceleration at the Earth's bow shock was described. Thus, this mechanism explains the origin of cosmic rays in the heliosphere in a wide energy range from 10ˆ3 to 10ˆ10 eV. Using the global survey method to predict geomagnetic storms in real-time, the Institute maintains continuous ground-based monitoring of cosmic rays. We study the tensor anisotropy of cosmic rays, the north-south asymmetry of the heliosphere, and the behavior of the energy spectrum of cosmic ray decrease in large-scale disturbances of the solar wind. A great achievement was creating a basic model of heliospheric modulation of cosmic rays, which correctly describes the 11-year variations in the intensity of cosmic rays with energies from tens of MeV to tens of GeV observed in various experiments.

In recent years, we study cosmic ray decrease in magnetic clouds. A new mechanism for the Forbush decrease formation in magnetic clouds is proposed. The Forbush decrease occurs due to energy losses of particles in the inductive electric field of a moving cloud and their quasi-trapping in the helical magnetic field. There are no free parameters in this theory; the calculation results agree with observations.

The registration of cosmic rays will be continued on the new Yakutsk spectrograph. The analysis of its data will allow us to determine the cosmic ray anisotropy parameters, isolate the effects of the east-west asymmetry, and study the energy spectra of Forbush decreases in detail ground-level enhancements of solar cosmic rays. In future theoretical studies, it is planned to consider several topical issues of space physics, in particular, the injection of solar cosmic rays into the interplanetary space; their composition; self-consistent acceleration of charged particles, and generation of MHD turbulence in flare processes; the effect of coronal mass ejections on the space-time distribution of solar and galactic cosmic rays. As a result, this will help to understand the physical processes in the heliosphere better and, therefore, more accurately predict the space weather in the vicinity of the Earth.

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Session Classification: Cosmo- and geophysical aspects of cosmic rays

Track Classification: Cosmo- and geophysical aspects of cosmic rays