Preface

This book presents the results of the CORONAS-F experiments on observation of solar activity and its manifestations in near-Earth space carried out from July 2001 to December 2005.

The study of the Sun and solar–terrestrial coupling is of fundamental importance to the astrophysics and, in general, to the human life on the Earth. The Sun is a typical star like many others in the Universe. However, when studying the Sun, we do not observe it as a distant point object, but we can investigate the solar atmosphere and solar phenomena in detail. Quite a number of fundamental scientific problems of heliophysics and solar–terrestrial physics still remain unsolved. The disturbances in the near-Earth space associated with solar activity (so-called space weather) cause an ever growing impact on various aspects of the human life. The observation of solar phenomena and their terrestrial effects, as well as the long- and short-term forecast of these effects have become important elements in securing the human activity on the Earth and in space. In the context of the future programs of flight to the Moon and Mars, the significance of investigations in this field increases, in particular, as concerns the radiation safety of astronauts on interplanetary routes.

The chapter "CORONAS-F Project: The Study of Solar Activity and Its Effects on the Earth" contains a brief description of the CORONAS-F mission, general characteristics of the scientific payload, and the main observation results.

The solar activity originates in the solar interior, which is only accessible to the methods of neutrino astronomy and helioseismology. The chapter "Brightness Fluctuations and Global Oscillations of the Sun (DIFOS Experiment)" describes the DIFOS helioseismic measurements of the solar global oscillations. These results were obtained in spite of the difficulty of high-precision near-Earth observations associated with the reflected light from the Earth's atmosphere.

Active regions in the Sun and the related dynamics of the magnetic field in the outer solar atmosphere (from the photosphere to the corona) generate the variety of active events, such as solar flares, coronal mass ejections, and accompanying phenomena (dimmings, coronal holes, shock waves). These phenomena were detected and observed on the solar disk in the course of the SPIRIT experiment, whose results are presented in the chapter "Study of Active Phenomena in the

Solar Corona in the 8–350 Å Range by Imaging Spectroscopy Methods (SPIRIT Experiment).” The corona heating is one of the unsolved fundamental problems of the solar and stellar physics. The SPIRIT X-ray telescope was used to detect and investigate one of the corona heating mechanisms—extended hot plasma features with the temperature up to 20 million degrees.

The major manifestations of solar activity—solar flares—are of considerable interest as a mechanism of particle acceleration and transformation of magnetic energy to the energy of plasma. This is the most powerful explosive process in the Solar System. It is based on the reconnection of the magnetic field in the highly conductive solar plasma. High-resolution, broadband (from optical to gamma) instruments onboard the CORONAS-F mission recorded flare emissions in the continuous spectrum, in the ion lines of solar plasma and in the gamma-range nuclear lines. These observations enabled the study of atomic and nuclear processes in solar flares and the particle acceleration processes, as well as an extensive diagnostics of the flare-generated plasma and nonthermal processes in flares. The results of these investigations are described in the following chapters: “Study of Active Phenomena in the Solar Corona in the 8–350 Å Range by Imaging Spectroscopy Methods (SPIRIT Experiment)” (SPIRIT experiment comprising the SRT-K X-ray telescope and RES-K X-ray spectroheliograph); “Experiment with the SPR-N Instrument Onboard the CORONAS-F Satellite: Polarization, Temporal and Spectral Characteristics of the Hard X-Ray of the Solar Flares” (SPR-N solar spectropolarimeter); “Observations of Doppler Shifts of X-Ray Lines in Solar Flare Spectra Based on DIOGENESS Spectrometer Data” (DIOGENESS spectrophotometer); “Investigations of Physical Processes in Solar Flare Plasma on the Basis of RESIK Spectrometer Observations” (RESIK X-ray spectrometer); “The Study of the Cosmic Gamma-Emission Nonstationary Fluxes Characteristics by the AVS-F Apparatus Data” (experiment with the AVS-F time-amplitude spectrometer); “Variability of Extreme Ultraviolet Fluxes at Various Timescales as Measured Onboard the CORONAS-F Space Mission (SUFR-SP-K and WUSS-L Experiments)” (experiments with the SUFR-Sp-K solar UV radiometer and VUSS-L solar UV spectrophotometer); “Scientific Set of Instruments ≪Solar Cosmic Rays≫,” “Protons Acceleration in Solar Flares: The Results of the Analysis of Gamma-Emission and Neutrons Recorded by the SONG Instrument Onboard the CORONAS-F Satellite,” “Dynamics of the Relativistic Electrons Flux of the Earth Outer Radiation Belt Based on the MKL Instrument,” “Dynamics of the Earth Radiation Belts During the Strong Magnetic Storms,” and “Solar Protons in the Earth’s Magnetosphere According to Riometric and Satellite Data During the Magnetic Storms of October 2003” (SCR experiments comprising the SONG spectrometer of solar neutrons and gamma rays, the cosmic ray monitor MKL, and the SKI-3 cosmic radiation spectrometer); “Spectrometer IRIS: Investigation of the Time Structure and Energy Spectra of X-Ray Emission from Solar Flares” (IRIS flare spectrometer); “Study of Solar Flares and Gamma-Ray Bursts in the Helicon Experiment” (HELICON gamma-ray spectrometer); and “RPS-1 Experiment” (RPS-1 X-ray spectrometer).

A series of outstanding events (powerful flares and ejections) occurred in the Sun in the epoch of maximum and in the declining phase of cycle 23. Simultaneous observations of these events on the solar disk and in near-Earth space with the CORONAS-F instruments contributed to better understanding of the solar–terrestrial coupling, e.g., the dynamics of the Earth radiation belts, deformation and restructuring of the magnetosphere, and penetration of high-energy particles. The results of these studies are presented in the chapter "Dynamics of the Earth Radiation Belts During the Strong Magnetic Storms."

The chapter "The Impact of Solar Activity on the Earth Upper Atmosphere as Inferred from the CORONAS-F Scientific Experiments" is devoted to the study of the Earth upper atmosphere using the SPIRIT X-ray measurements, which were taken as the satellite was entering and leaving the shadow. These observations provided us with new information on the altitude distribution of the atmospheric parameters and with the data necessary to construct an up-to-date model atmosphere of the Earth.

Regular precipitations of energetic particles from the Earth magnetosphere to the upper atmosphere determine the radiation background in the near-Earth space. The maps of such precipitations and their variations obtained with the aid of the AVS-F and RPS-1 instruments are provided, respectively, in the chapters "The Study of the Cosmic Gamma-Emission Nonstationary Fluxes Characteristics by the AVS-F Apparatus Data" and "RPS-1 Experiment."

The solar UV radiation exerts a direct influence on the Earth atmosphere and ionosphere determining their energy balance, ionization conditions, and disturbance. The results of measuring the solar UV flux with the SUFR-Sp-K and VUSS-L instruments and its variations depending on the level of solar activity are described in the chapter "Variability of Extreme Ultraviolet Fluxes at Various Timescales as Measured Onboard the CORONAS-F Space Mission (SUFR-SP-K and WUSS-L Experiments)." Along with the observations of solar flares, the chapter "Study of Solar Flares and Gamma-Ray Bursts in the Helicon Experiment" describes also the observations of gamma-bursts with the HELICON gamma spectrometer, including the unique event of 27 December 2004—an exceptionally powerful gamma-burst from a gamma repeater reflected from the Moon.

The topics concerning the control of the CORONAS-F scientific payload, collection, preliminary processing, and archiving of the scientific information are briefly dealt with in the chapters "On-Board and Ground-Based Complexes for Operating the Science Payload of the CORONAS-F Space Mission"; "CORONAS-F: Infrastructure and Organization of the Information Exchange"; and "Organization of a Unified Data Archive and Accessories for Processing Solar Images."

Throughout the book, the Universal Time (UT) is used when indicating the recorded events and analyzing the data obtained.

This book summarizes the results of a long work and broad cooperation of the scientific institutions involved in the CORONAS-F Project. It will make the data obtained accessible to the world scientific community and will demonstrate their significance in the general context of the present-day progress in space research and the future solar missions. This book is intended for the scientists working in the field of heliophysics and solar–terrestrial physics. It will be also useful to astrophysicists, students, and postgraduates of the corresponding specialties.

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The English version of the book will acquaint the broad readership with the results of the CORONAS-F mission supplemented with data that became available after the publication of the original version. It will also help in relating the data obtained during the satellite operation period to the particular phases of the activity cycle, which may be important in the post-mission complex analysis of the solar and solar–terrestrial phenomena. The English edition, though a bit overdue, will meet these requirements to the best advantage.

Troitsk, Moscow, Russia V.D. Kuznetsov

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