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TESIS experiment on EUV imaging spectroscopy of the Sun

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Abstract

TESIS is a set of solar imaging instruments in development by the Lebedev Physical Institute of the Russian Academy of Science, to be launched aboard the Russian spacecraft CORONAS-PHOTON in December 2008. The main goal of TESIS is to provide complex observations of solar active phenomena from the transition region to the inner and outer solar corona with high spatial, spectral and temporal resolution in the EUV and Soft X-ray spectral bands. TESIS includes five unique space instruments: the MgXII Imaging Spectroheliometer (MISH) with spherical bent crystal mirror, for observations of the Sun in the monochromatic MgXII 8.42 Å line; the EUV Spectoheliometer (EUSH) with grazing incidence difraction grating, for the registration of the full solar disc in monochromatic lines of the spectral band 280–330 Å; two Full-disk EUV Telescopes (FET) with multilayer mirrors covering the band 130–136 and 290–320 Å; and the Solar EUV Coronagraph (SEC), based on the Ritchey–Chretien scheme, to observe the inner and outer solar corona from 0.2 to 4 solar radii in spectral band 290–320 Å. TESIS experiment will start at the rising phase of the 24th cycle of solar activity. With the advanced capabilities of its instruments, TESIS will help better understand the physics of solar flares and high-energy phenomena and provide new data on parameters of solar plasma in the temperature range $10^5 - 10^7$ K. This paper gives a brief description of the experiment, its equipment, and its scientific objectives.

Keywords: Sun; Flares; X-rays

1. Introduction

The experiment TESIS, dedicated to EUV imaging spectroscopy of the Sun, is scheduled to start on December 15, 2008, on board the Russian spacecraft CORONAS-PHOTON, with the aim to provide complex observations of solar energetic phenomena in the transition region and lower and outer corona. The organization responsible for TESIS and its instrumental equipment is the Laboratory of X-ray Astronomy of the Sun (XRAS) of the P.N. Lebedev Physical Institute of the Russian Academy of Science (http://tesis.lebedev.ru).

XRAS began systematic studies of solar EUV radiation in 1957. The first experiment attempting to measure solar X-rays was carried out by Mandel'stam, Efremov and Lebedev aboard the second Soviet Earth satellite launched on November 3, 1957 (Mandel'Stam, 1965). Scientific apparatus on the satellite registered many signals, but none were due to solar X-rays. It became clear later that these signals were due to radiation belt particles. Apparently, these measurements were the first observations of the radiation belts. Afterward, space instruments designed by XRAS worked on board the third Soviet satellite (May 15, 1958), Cosmos-166 (June 14, 1967), Intercosmos-1 (October 14, 1969), Intercosmos-4 (October 14, 1970) and

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on other Soviet spacecrafts dedicated to the observation of the Sun.

During the last decade, XRAS carried out its space experiments in the framework of the Russian program CORONAS (Complex ORbital ObservatioNs of the Activity of the Sun) developed in cooperation with the Russian Space Agency. From 1994 to 2008, this program assumed the launch of three spacecrafts adapted for investigation of the Sun and solar-terrestrial connections.

The first satellite of the three, CORONAS-I, was successfully launched on March 2, 1994 from the cosmodrome Plesetsk in northern Russia. Scientific payload of the spacecraft included the TEREK-K multichannel telescope and the RES-K spectroheliometer operating in the EUV band 180–304 Å (SobelMan et al., 1996). In this experiment, the first systematic observations of the Sun were performed at wavelengths 132, 175 and 304 Å with spatial resolution up to 1 arcsec per cell. Monochromatic spectrograms of the Sun in the bands 8.41–8.43 and 180–209 Å, without overlapping, were also obtained for the first time. This experiment successfully revealed new aspects of solar flares in EUV emission. Unfortunately, the scientific program of the experiment ceased in July 5, 1994 because of the loss of the satellite orientation. Some of the results obtained during TEREK-K and RES-K are considered by (Zhitnik et al., 1999).

The following spacecraft of CORONAS project was CORONAS-F, launched in July 31, 2001 Oraevsky and Sobelman, 2002. On board the satellite, XRAS carried out the SPIRIT experiment to study solar flares and high-energetic phenomena during the maximum of solar activity with multichannel telescope SRT-C and spectroheliograph RES-C (Zhitnik et al., 2003a). Over 4 years of observations, from July 31, 2001 to December 6, 2005, SPIRIT obtained about 100,000 images of the full Sun at wavelengths 175 and 304 Å, more than 200,000 monochromatic images of the Sun in the MgXII 8.42 Å line, and about 10,000 spectroheliograms in the 177–207 and 285–335 Å bands. The data obtained by the experiment characterize the dynamics of solar plasmas with temperature of $10^5 - 10^7$K on a time scale from several seconds to tens of days and a spatial scale from thousands to hundreds of thousands of kilometers. Main results of the SPIRIT experiment are summarized in Zhitnik et al. (2003b, 2006).

Based on its previous space projects, XRAS has developed the current experiment, TESIS, which will take place on board the third spacecraft of CORONAS program: CORONAS-PHOTON. The experiment is directed at acquiring data on the physical parameters and spatial structure of plasma in the transition region and in the inner and outer corona with the following aims: (1) the study of mechanisms of solar wind generation and coronal heating, (2) the development of methods for space weather forecasting, (3) the study of the production and evolution of high-temperature plasmas in the corona, and (4) the analysis of processes of magnetic energy accumulation and release before and during flares. The spatial, spectral and temporal characteristics of TESIS are improved significantly compared with those of its predecessor, SPIRIT. These improvements are mostly due to last year's progress in the production of high-resolution optics based on multilayer normal-incidence mirrors.

In the present paper, we give a brief description of TESIS experiment regarding the spacecraft characteristics

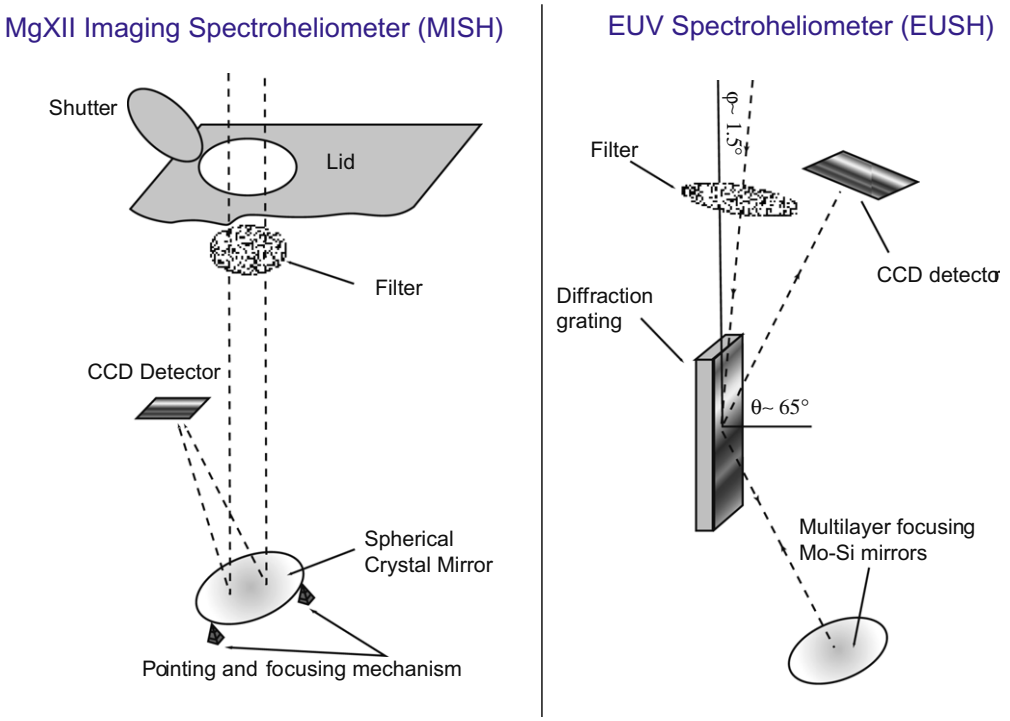

Fig. 1. TESIS scientific instruments: MgXII Imaging Spectroheliometer (left panel) and EUV Spectroheliometer (right panel).