Investigation of Hot X-Ray Points (HXPs) Using Spectroheliograph Mg XII Experiment Data from CORONAS-F/SPRIT

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Abstract Observations in the Mg XII 8.42 Å line onboard the CORONAS-F satellite have revealed compact high temperature objects – hot X-ray points (HXPs) – and their major physical parameters were investigated. Time dependencies of temperature, emission measure, intensity, and electron density were measured for 169 HXPs. HXPs can be divided into two groups by their temperature variations: those with gradually decreasing temperature and those with rapidly decreasing temperature. HXP plasma temperatures lie in the range of 5 – 40 MK, the emission measure is \(10^{45} – 10^{48}\) cm\(^{-3}\), and the electron density is above \(10^{10}\) cm\(^{-3}\), which exceeds the electron density in the quiet Sun \((10^8 – 10^9\) cm\(^{-3}\)). HXP lifetimes vary between 5 – 100 minutes, significantly longer than the conductive cooling time. This means that throughout a HXP’s lifetime, the energy release process continues, which helps to maintain its high temperature. A HXP’s thermal energy is not greater than \(10^{28}\) erg, and the total energy which is released in HXPs does not exceed \(10^{30}\) erg. HXPs differ in their physical properties from other flare-like microevents, such as microflares, X-ray bright points, and nanoflares.

Keywords Corona, active · Flares, microflares and nanoflares · Spectral line, broadening

1. Introduction

The process of plasma heating in the solar corona to temperatures beyond 5 MK occurs due to intense energy release. The study of these processes is important for understanding the reason for energy release, measuring the physical conditions in which these processes take place, and for compiling a comprehensive picture of events occurring in the solar corona. Images of hot plasmas have been obtained from X-ray tele-

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scopes such as the Yohkoh/SXT (Tsuneta et al., 1991; Ogawara et al., 1991), the RHESSI (Lin et al., 2002), the XRT/Hinode (Kosugi et al., 2007; Golub et al., 2007), and the spectroheliograph Mg xii/SPRIT (Zhitnik et al., 2003a). These images showed that hot plasma is not present everywhere in the solar corona, but just in compact areas. High-temperature events of the solar corona are flares, hot loops, microflares (Lin et al., 1984; Benz and Grigis, 2002), active-region transient brightenings (ARTB: Shimizu, 1995).

Here we present an analysis of 169 compact high-temperature objects (“hot X-ray points”, HXPs) observed between 20 February 2002 and 28 February 2002, using the spectroheliograph Mg xii as part of the CORONAS-F/SPRIT experiment.

2. Experimental Data

The Mg xii spectroheliograph is a part of the SPIRIT instrumentation complex, developed in the Lebedev Physical Institute of the Russian Academy of Sciences (Zhitnik et al., 2003b). The Mg xii spectroheliograph obtains monochromatic images of the solar corona in $\lambda = 8.42$ Å. A high degree of monochromaticity is achieved by using an optical scheme with a spherical crystal mirror (see Figure 1), for which Bragg’s law is satisfied for a narrow wavelength band (only the Mg xii 8.42 Å doublet line is detected). Reflection from the surface of the mirror occurs only from its small parts where Bragg’s law is satisfied:

$$2d \cos \theta = m\lambda$$

(1)

(interplanar distance $d$ ($2d = 8.501$ Å), angle between incident ray and normal to a mirror $\theta$, order of diffraction $m$, wavelength $\lambda$). For a working wavelength of $\lambda = 8.42$ Å, Bragg’s angle is close to 90°, and almost normal incidence occurs. Normal incidence allows us to obtain a high spatial resolution, $\approx 8''$ (effective size of the CCD’s pixel is $\approx 6''$).

Equation (1) shows that different wavelengths reflect at different angles, and therefore from different parts of the mirror. Due to spherical aberrations of the mirror, rays that have

Figure 1 Scheme of the Mg xii spectroheliograph: 1 – CCD matrix, 2 – spherical crystal mirror.