MULTI-WAVELENGTH STUDY OF A SOLAR TWO-RIBBON FLARE

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МНОГОВОЛНОВОЕ ИССЛЕДОВАНИЕ СОЛНЕЧНОЙ ВСПЫШКИ

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Представлено исследование вспышки с двумя лентами, которая предшествует эрупции волокна/протуберанца. Событие наблюдалось между 00:00 UT и 08:00 UT 18 февраля 2014 года в спокойной солнечной области.

Многоволновой анализ вспышки проводился с использованием данных, полученных от Солнечной Динамической Обсерватории (SDO). Кинематика и эволюция лент были оценены с использованием изображений в каналах EUV 131, 171, 195, 211 и 304 Å. Эволюция вышележащих магнитных полей была исследована по данным SDO/HMI.

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Introduction

Solar flares are large explosive phenomena in the low solar atmosphere. They are characterized by huge amount of energy release that produces radiation across the whole electromagnetic spectrum [Schrijver, 2009; Fletcher et al., 2011].

Solar flares are usually accompanied by often-observed flare ribbons. It is widely accepted that two-ribbon flares are caused by magnetic reconnection between coronal field lines [see a review by Svestka & Cliver, 1992].

Ribbon's behavior is important for probing the trigger mechanism of the eruption process.

Evolution of two-ribbon flares is morphologically characterized by a separation of the two ribbons in the chromosphere [Švestka, 1986; Maurya & Ambastha, 2010].

According to the standard flare model scenario, such separating motion is believed to provide a signature of the reconnection process occurring progressively higher up in the corona [Fletcher et al., 2011].

Observations

The studied event was observed on 18 Feb 2014 in quiet-Sun region, close to the Southwest limb. A large-scale quiescent filament erupted, producing two bright flare ribbons.

In the present study we analyzed the kinematics of flare ribbons by images taken with 12s cadence in 304 Å, 131 Å, 171 Å, 211 Å, 193 Å and 94 Å pass-

bands of the Atmospheric Imaging Assembly (AIA) on-board the Solar Dynamics Observatory [SDO; Lemen et al. 2012]. The AIA image field-of-view reaches 1.3 solar radii with a spatial resolution of $<1.5''$. We used level 1 reduced data, i.e. with the dark current removed and the flat-field correction applied. Sample SDO images, corresponding to different atmospheric heights and temperatures are shown in Figure 1.

Line-of-sight (LOS) magnetograms taken by the SDO/HMI [HMI; Schou et al. 2012] with a 45 s cadence were used to determine the topology and evolution of the magnetic field. The HMI magnetograms and AIA images were co-aligned by using the AIA 1600 Å channel.

Fig. 1. Collection of multi-wavelength images illustrating the ribbon evolution in various AIA channels corresponding to different atmospheric layers and the HMI LOS magnetogram with over plotted ribbon position (red dotted lines).

Kinematics

In Figure 2 the behavior of relative distance between the ribbons with time is shown. The distance was estimated using data in 131 Å AIA channel. The ribbon kinematics consisted two stages. The first one lasted 35 minutes. It represented a fast phase of rapid split at a decreasing velocity from 45 km/s to 0.5 km/s. The second stage, without a separation motion, lasted for about 2 hr.

Fig. 2. Time profiles of ribbon separation.
The start time $T(0)$ is 17-Feb-2014 23:59:56 UT.

Magnetic flux evolution

Analyzing the photospheric LOS magnetic field evolution, we looked for regions of flux emergence/ cancellation. The HMI magnetogram from the corresponding flaring region is presented in the left panel of Figure 3. We tested the two places, marked with white lines. In the right panel the time-slice showing the magnetic field evolution is shown. At about 02:38 UT, after the flare impulsive phase, a flux emergence could be observed close to the ribbon marked with R2 in Figure 1.

Fig. 3. *Left:* the HMI magnetogram in the flaring region.
Right: time-slice showing the magnetic field evolution.

In Figure 4 are shown the time profiles of positive and negative normalized fluxes.

One can clearly see that on the time preceding the flare onset the behavior of the two magnetic fluxes was similar. After 00:49 UT, just before the impulsive flare phase, the positive flux (solid line) increased, while the negative one

(dotted line) decreased. This suggests an indirect evidence of magnetic reconnection.

Fig. 4. Time profiles of positive and negative fluxes (normalized) within the region covering the entire flaring area.

Summary

The ribbon kinematics consisted of a fast stage of rapid split at a decreasing velocity from 45 km/s to 0.5 km/s in the first 35 minutes and a stage without a separation motion, lasting for about 2 hr.

A flux emergence could be observed close to the southward ribbon after the flare impulsive phase start.

Prior to the flare onset the behavior of the two magnetic fluxes was similar. Just before the impulsive flare phase, the positive flux (solid line) increased, while the negative one (dotted line) decreased.

Referances

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