Magnetic Induction in Footpoints of Coronal Loops

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ABSTRACT

The fact that the coronal loops occur in active regions, i.e. in the areas with an increased magnetic induction, is well known. However, less is known about a precise location of their footpoints. To fill in this gap, we have decided to use images from the instruments HMI and AIA onboard the SDO satellite. The acquired images have a resolution of 0.6″/px. We compared the AIA image at wavelength 17.1 nm (FeIX) with the image of magnetic field and photosphere from the SDO/HMI instrument. Images at wavelengths 30.4 nm (HeII), 21.1 nm (FeXIV) and 13.1 nm (FeXX) served to specify the morphological and physical conditions. The loops connect always areas of the opposite polarity of the magnetic field. According to the results of our investigation, it seems that the footpoints of loops are sometimes anchored outside the locations with maximum values of the magnetic induction.

1. INTRODUCTION

The most remarkable structures in monochromatic images of the corona in the EUV spectral region are ***loops***. These structures were observed sporadically also in the past in the optical region of the spectrum during total solar eclipses and later more often after the invention of a coronagraph and a narrow bandwidth filter (B. Lyot).

At present, these observations are transfered above the Earth's atmosphere and to the EUV spectral range (10-100 nm). They are in the observing program of all solar space observatories. Freely available are mainly the observations from SOHO and SDO.

The causes of formation of loops, physical conditions in them, their development and relations with other struture on the surface of the Sun are insufficiently explored. The vast majority of authors describe a loop as spiral coronal plasma fluxes around magnetic field lines. Many issues related to the physics of coronal loops are presented in the book of **Aschwanden (2004)**. Great attention to research in this area is addressed by classics of solar physics (**Kleczek (1975), Stepanov (1978)**). There have been formulated also many problems associated with loops during discussions with them. Among them dominated a question: "***Are the physical conditions in locations of footpoints of loops different from the conditions of the surrounding surface***?"

Observational material provided by the SDO satellite has sufficient spatial and temporal resolution for our attempt of intitial survey of the problem.

2. METHOD AND RESULTS

We used for that purpose the images from the **HMI** and the **AIA** instruments onboard the **SDO** satellite. They have a resolution of 0.6″/px, which is about 0.03° in heliographic coordinates if the area is near the central meridian. For this contribution we examined loop-like structures that occurred in the active region AR11861 on October 11, 2013 around 0^h0^m UT and the center of which was located around– 20° E and – 12° S. In **Figures 1a, 1b** and **1c** we see the selected area in the line of **FeIX, 17.1 nm**, the **photosphere** in the integral light and the **magnetic field**. Although loop structures are visible also in other lines, we can see them the most markedly in the line of FeIX. We used images in other wavelengths only to specify the situation.

In the **Fig. 2** are marked areas in loop beams where we compared some of their measurable parameters.

Numbers in quotation marks refers to a region which is marked in **Fig. 2**:

"**1**": Location 19.519° E; 7.751° S; the highest intensity 869 u (arbitrary intensity units) is further from the footpoint. Loop connects the leading spot (B = +1768 G) with the following one; the maximum optical density in the sunspot is D = 0.644 (– log(13650/60120)).

"**2**": Location 25.66° E; 9.97° S; intensity 2403 u; B = – 600 G, the loop is not anchored at the point of minimum induction (– 1418 G), but at the edge of the adjacent spot; the maximum optical density in the sunspot D = 0.594 (– log (15302/60120)).

"**3**": Location 18.58° E; 12.13° S; intensity 3901 u; B = + 465 G, the loop is anchored in the place where is not a high field strength; no sunspot was observed in the location of the footpoint.

"**4**": Location 29.89° E; 13.11° S; intensity 3952 u; B = – 650 G, the loop is anchored in the place where is not a high field strength; no sunspot was observed in the location of the footpoint.

"**5**": Location 29.34° E; 13.70° S; intensity 6458 u; B = – 483 G, the loop is anchored in the place where is not higher field strength; no sunspot was observed in the location of the footpoint.

"**6**": Location 27.52° E; 13.06° S; intensity 6274 u; B = – 1070 G; in the footpoint was observed a small sunspot, D = 0.30.

"**7**": Location 23.12° E; 17.80° S; intensity 4609 u; B = + 641 G, the loop is anchored in the place where is not a high field strength; no sunspot was observed in the location of the footpoint.

3. CONCLUSIONS

a) For all loops applies that they connect the points of the opposite polarity of the magnetic field.

b) The brightness of radiation of loops (in the radiation of the FeIX line) is not related to the intensity of the magnetic field at the footpoint of a loop.

c) According to a preliminary survey, the loops are the brightest in the footpoint in the radiation of all ions with higher degree of ionization (except of HeII). Intensity of radiation in loops decreases with a distance from the footpoint. The rate of the decrease is related obviously to the degree of ionization - the higher the degree of ionization, the faster the decrease of the radiation.

d) The question „Why are loops formed in some places of the field and in other ones not?", however, remains open.

FIGURES

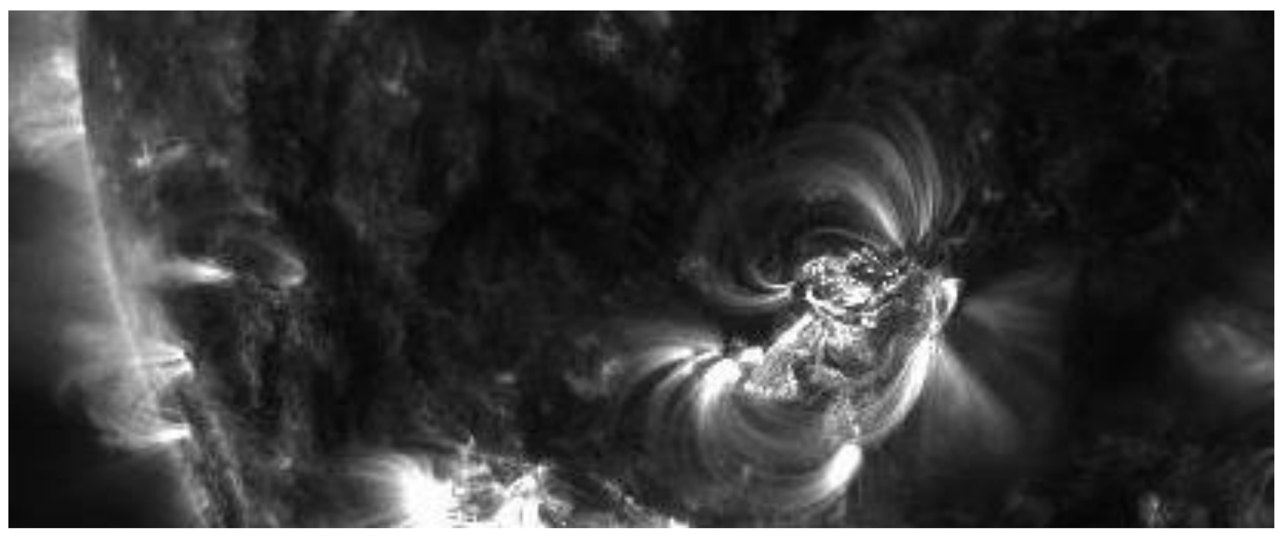

Figure 1a. Active region AR11861 with coronal loops at the wavelength 17.1 nm.

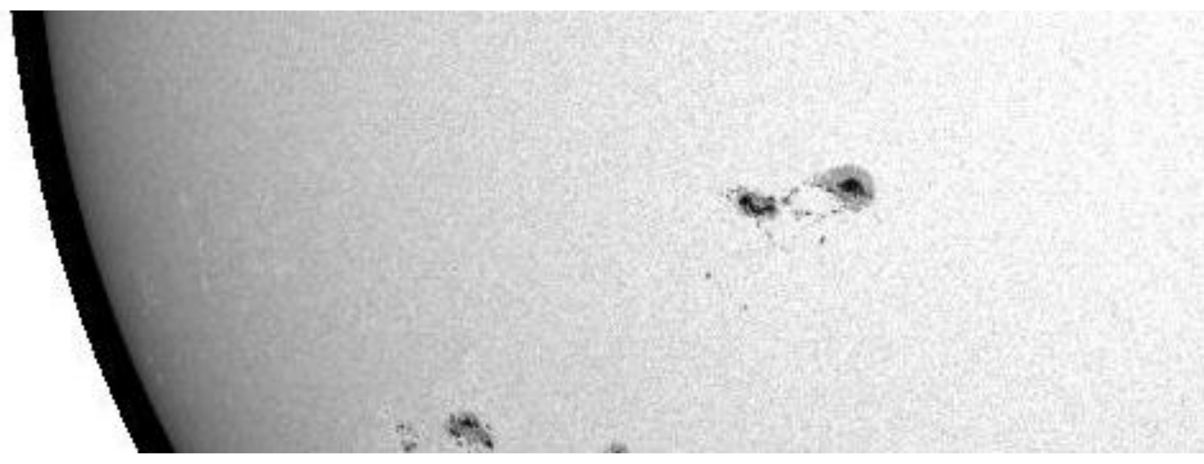

Figure 1b. The same region in the photosphere.

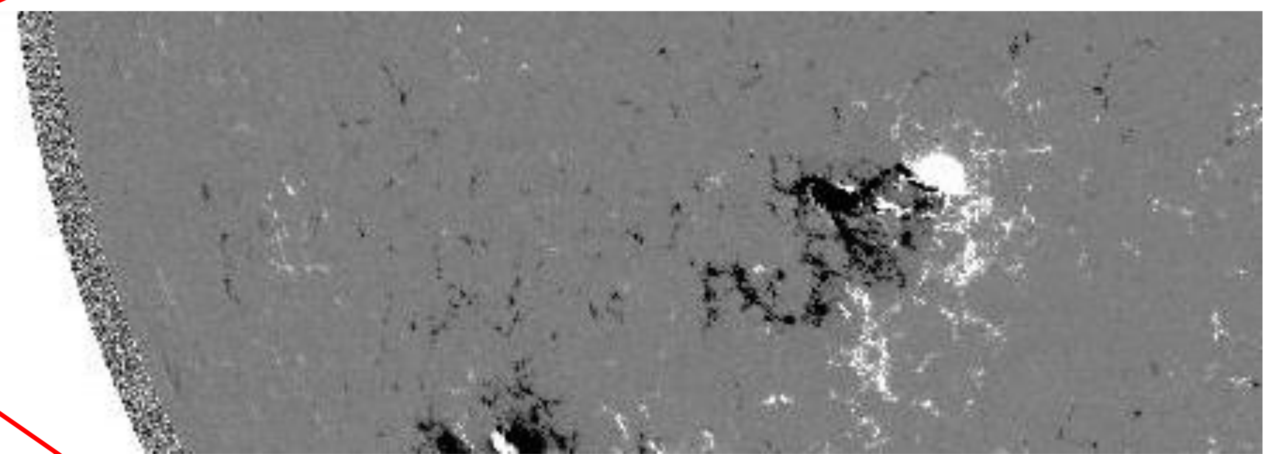

Figure 1c. Radial magnetic field in the same region.

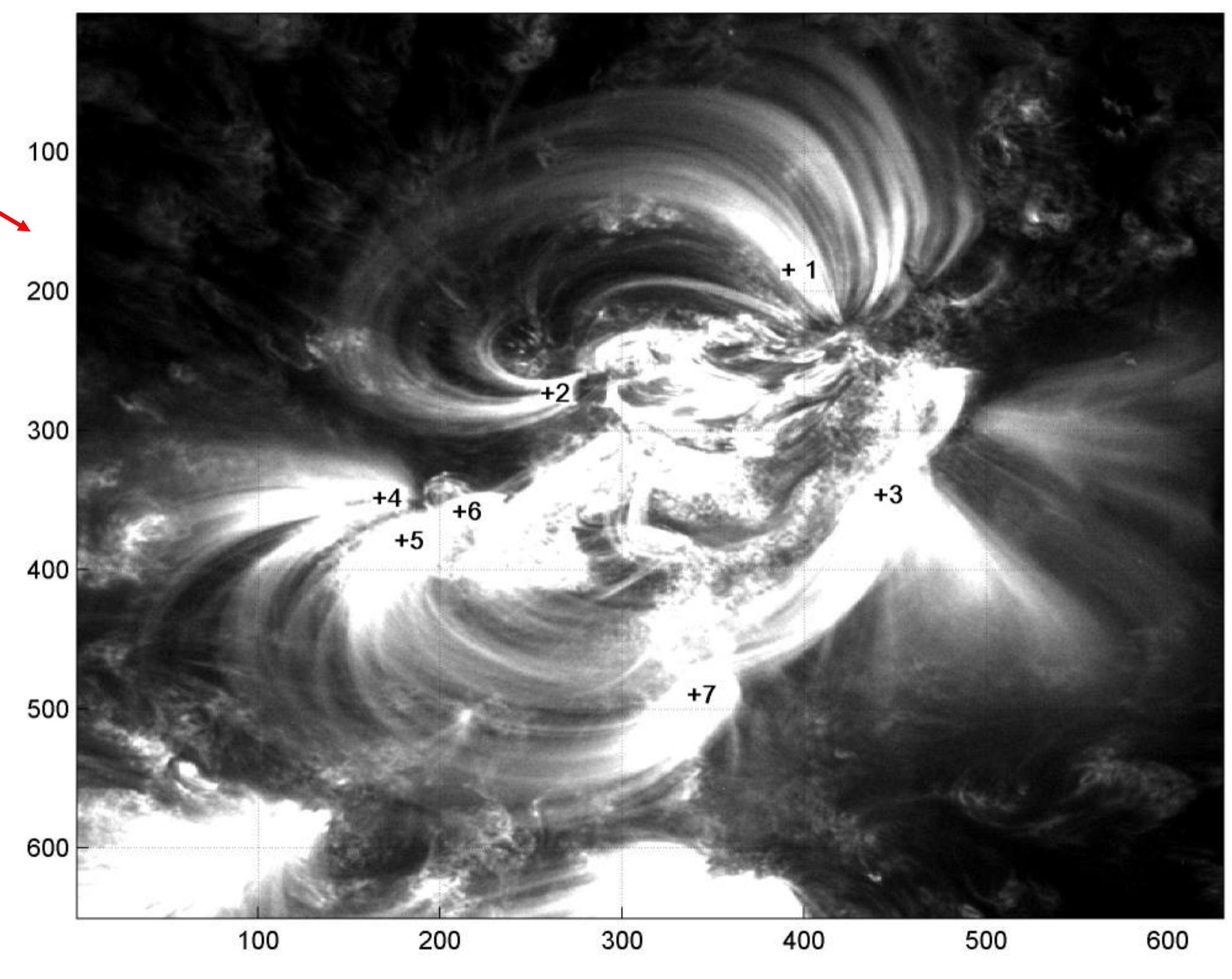

Figure 2. The studied region in the radiation of the FeIX (17.1 nm) with marking of locations where we investigated some physical parameters.

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