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Large-Scale Shining Chains on the Solar Disk: Yohkoh/SXT, SOHO/EIT and TRACE Data

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Abstract

An analysis of the modified Yohkoh/SXT, SOHO/EIT, and TRACE heliograms shows that the large-scale shining chains discovered on the Nobeyama Radioheliograph maps at 17 GHz are also characteristic of soft X-ray, EUV and other ranges. It means that the presence of such chains and threads are general feature of the large-scale solar activity.

Key words: Sun: large-scale activity — Sun: soft X-ray emission — Sun: EUV emission

1. Introduction

The discovery of the large-scale microwave shining chains on the modified Nobeyama radio heliograms at 17 GHz (Chertok and Shibasaki 1998a,b) stimulated the similar analysis at first of the Yohkoh/SXT (Tsuneta et al. 1991) and SOHO/EIT (Delaboudinière et al. 1995) images and recently of the TRACE images as well. To make these relatively weak features visible and pronounced, the same approach (i.e. formation of the modified images with a restrict range of intensities) was used. The consideration of such renewed heliograms reveals that the large-scale chains and threads in the soft X-ray range and especially in the EUV range are still more typical and inherent than at microwaves. In this paper, some features of the soft X-ray and EUV chains and threads are briefly described and illustrated.

2. Features of Soft X-ray and EUV Chains

In Figures 1-3, a number of modified Yohkoh/SXT, SOHO/EIT and TRACE images are presented. All images are inverted, i.e. bright sources look as dark, and absorption features look as light ones. Some descriptions of the concrete events are given in the attached captions. Let us remind that the Yohkoh soft X-ray images correspond to the approximate coronal plasma temperature $T_e \geq 2.5$ MK, and the SOHO and TRACE EUV images in the Fe IX/X (171 $\AA$) and Fe XII (195 $\AA$) spectral lines are sensitive to the plasma of $T_e \approx 1.1$ and 1.5 MK.

It should be emphasized that in many cases the large-scale chains under consideration are relatively weak. Perhaps, it is one of reasons why these structures have not been discovered so far. To distinguish them on the background of other features, one should examine these solar images very attentively.

As the consideration of the presented and many other modified Yohkoh/SXT, SOHO/EIT, and TRACE images shows (see also Chertok 1997,1998a,b), rather often the soft X-ray and EUV bright points are not scattered chaotically through the solar disc, but are aligned at definite lines forming large-scale (i.e. comparable with the solar disk diameter) chains and threads of various (sometimes very puzzled) configurations. These chains consist as a rule of bright points of smaller sizes (a few tens of arcseconds) in comparison with the blobs forming the microwave chains (30–60″). Usually the spatial interval between the neighbor bright points is of several times larger than their sizes.

In many cases, one can see not only bright points, forming the chains, but also some shining "bridges" between the neighbor points.

There are examples, in which almost continuous thin shining threads rather than the bright point chains are observed. These large-scale threads appear to differ from the relatively small filament-associated soft X-ray threads described by Solberg and McAllister (1997) which appear to correspond to the arcade tops on the solar disk.

Usually the thin shining chains and threads are the most pronounced on the SOHO/EIT and TRACE images in the Fe IX/X (171 $\AA$) and Fe XII (195 $\AA$) lines.

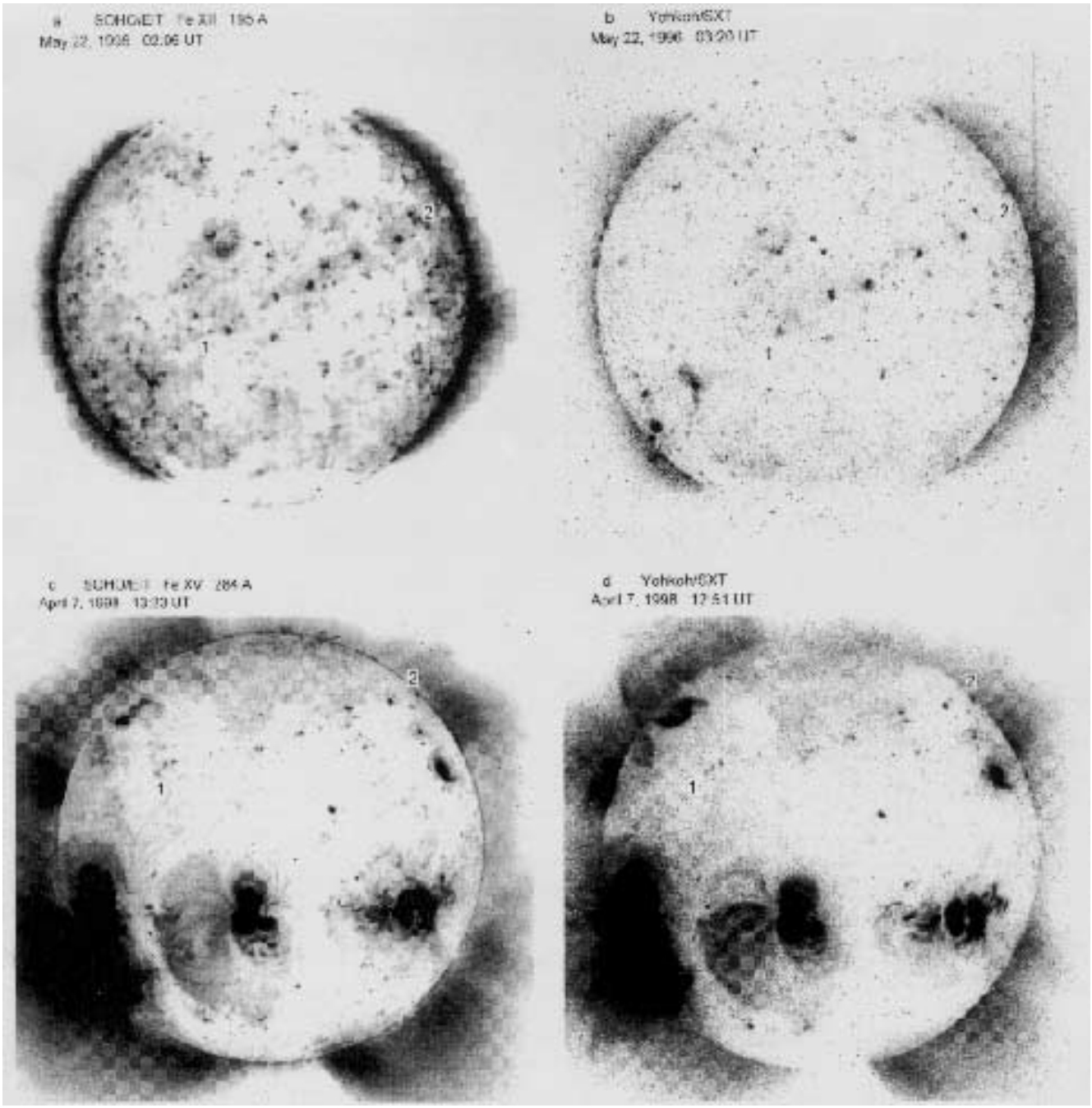

Fig. 1.. The coinciding EUV and soft X-ray large-scale chains of bright points on the modified SOHO/EIT and Yohkoh/SXT images of May 22, 1996 (a,b) and April 7, 1998 (c,d). In the both cases the almost straight-line chains extend between very distant points 1 and 2.

The reality of these chains and threads is confirmed by the fact that in many cases their form and location coincide on different images in several EUV lines as well as in the soft X-ray range. Sometimes the coinciding large-scale features are seen also on some ground-based images, for example, on the He I (10830 $\AA$) heliograms. Comparison with various magnetograms seems to be promising as well.

There are examples where similar (coinciding) large-scale chains are present on the soft X-ray, EUV images and on the Nobeyama microwave heliograms (see Figure 3 in the paper of Chertok and Shibasaki, 1998b), although, as

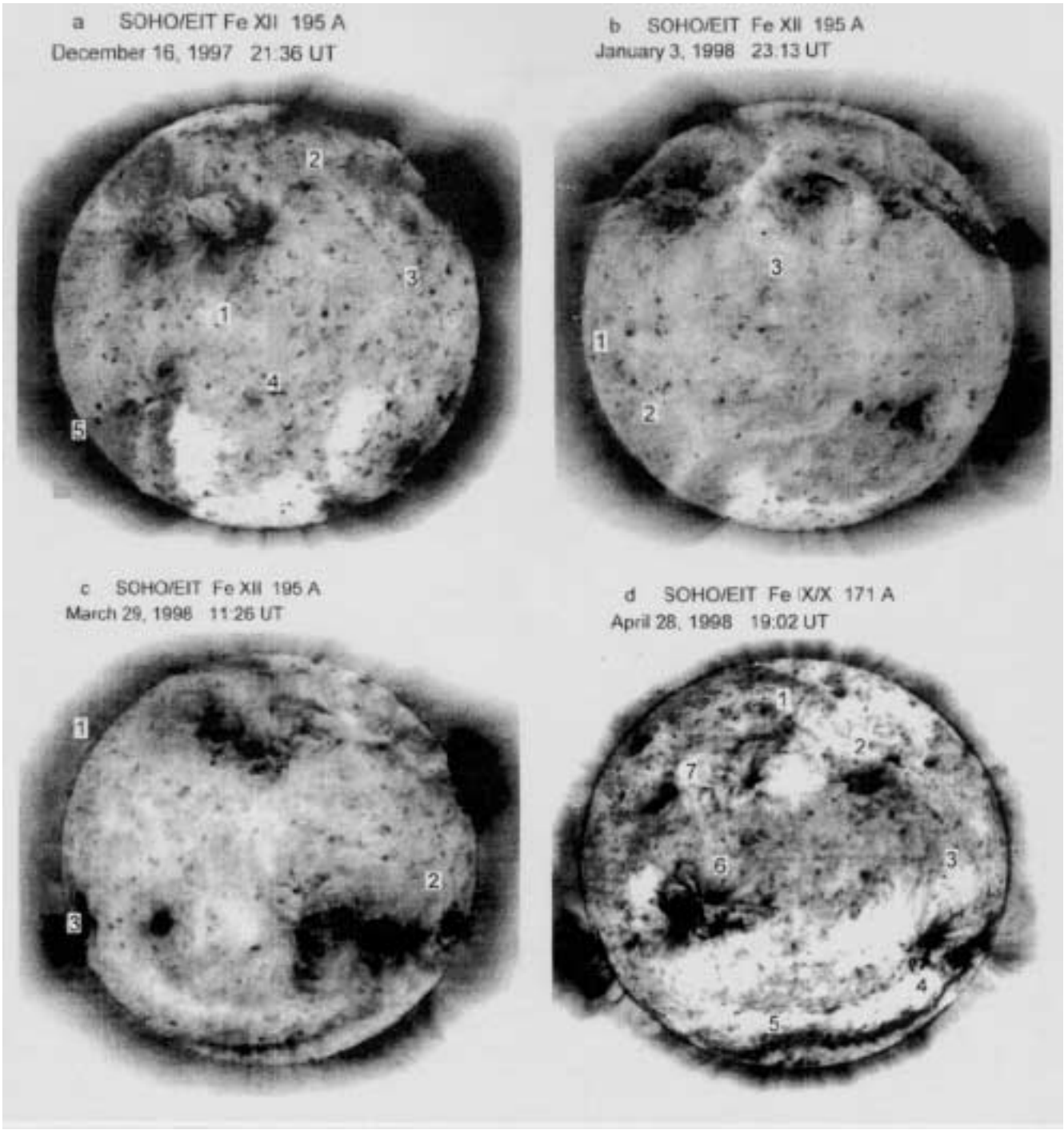

Fig. 2.. Several examples of various large-scale chains on the SOHO/EIT images at 171 $\AA$ and 195 $\AA$. (a) – The complex chain (thread) of December 16, 1997 consisting of several quasi-straight-line fragments between points 1-2-3-4-5 and covering a large part of the solar disk. (b) – The J-like chain 1-2-3 of January 3, 1998 in the equatorial part of the eastern hemisphere. (c) – The chain of March 29, 1998 going from the north-east limb (point 1) to the near-west limb (point 2) with a possible turning to the north direction. Perhaps this chain is crossed in the central region of the disk by two weaker chains outgoing from the east-limb (point 3). (d) – The image of April 28, 1998 with a complex system of the chains forming an extensive oval structure 1-2-3-4-5-6-7 on the visible disk. Two (maybe even three) straight chains, located quasi-parallel to the solar equator between points 3 and 6, seem to be present as well.

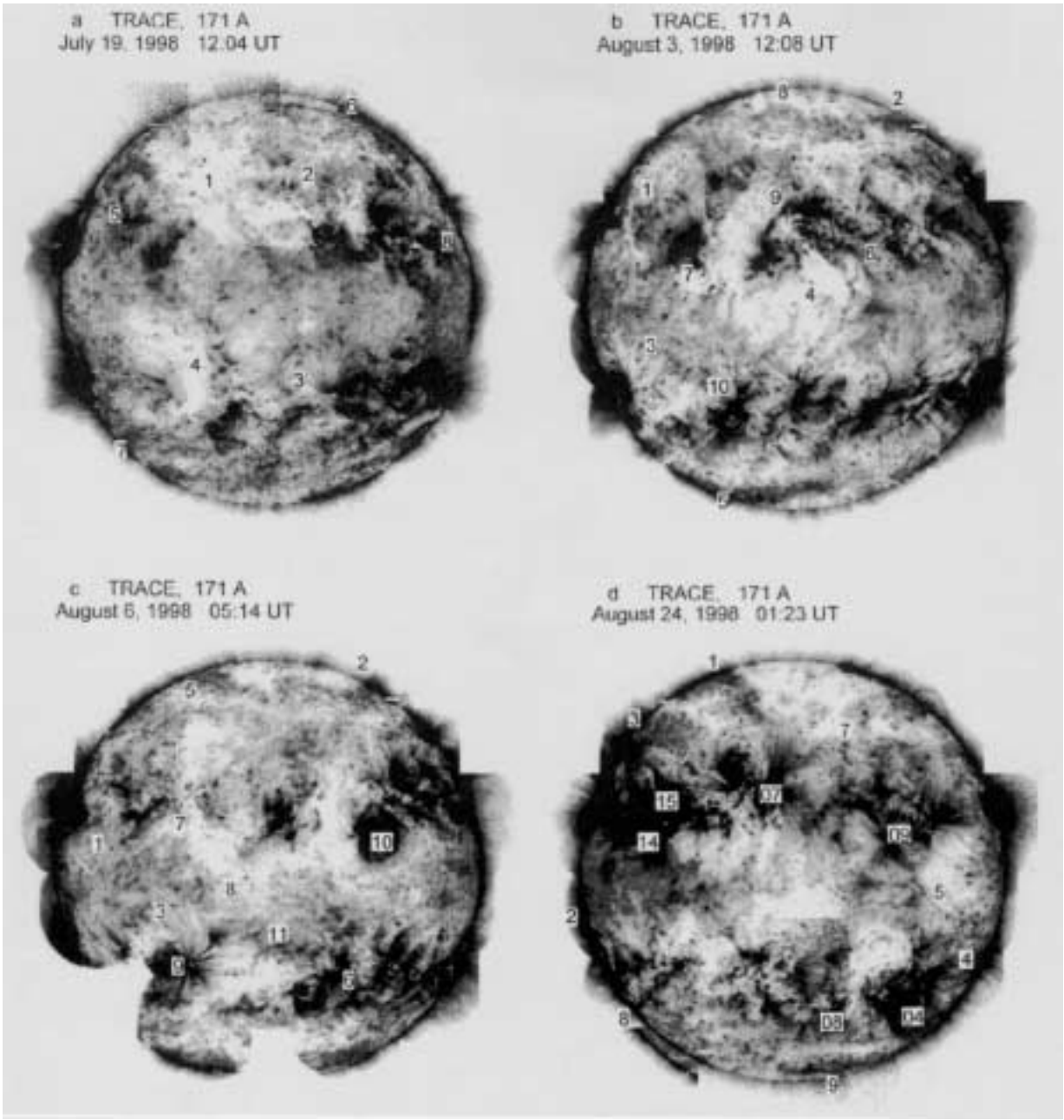

Fig. 3.. Some EUV chains revealed by the modified TRACE full-disk mosaic images at 171 *Å*. (a) – The July 19, 1998 image with an 8-like structure at the central area of the disc restricted by points 1-2-3-4. Some fragments of this structure consist of the two parallel threads. Several other chains can be seen inside and outside of the structure, in particular the arc-like chain 5-6 near the north polar zone and the long straight-line chain 7-8. (b) – A number of chains and threads of August 3, 1998: the high-latitude straight-line diffuse chain 1-2, the J-like chain 3-10-4 in the south-east sector, the long trans-equatorial chain 5-6 with a possible continuation to the north pole area, the loop-like chain 7-8-9 with a top stretched to the north pole zone, and others. (c) – The crossing chains of August 6, 1998: at least three almost straight-line thin chains 1-2, 3-4, and 9-10 go through the solar disk from the east (south-east) to north-west (west) directions. Another thin thread 5-6 stretches from the north-east to the south-west sectors and crosses the chains 1-2, 3-4, 9-10 in points 7, 8, and 11. (d) – The image of August 24, 1998, preceding the X1/3B/ LDE flare after 22 UT in AR 07 (it means AR 8307), with many chains: the diffuse in part, arc-like chain 1-AR07-2 in the north-east sector; the thin chains 3-4 going from the north-east limb to the south-west one; at least two chains 2-5 and 8-AR09 crossing the chain 3-4; the chains joining ARs 08-14 and ARs 04-09; the curved chain 7-5 surrounding AR09; the chain 2-9 located along the south-east limb, and others.

one could expect, there is not one-to-one correspondence between them due to different conditions (temperature, emission measure) of the emission origin in these ranges.

It should be noted also, that usually the blobs and bright points form many various complicated structures on the disc. Therefore it is not so easy to outline the concrete chains and threads unambiguously, although the fact of their presence is obvious. By this reason, only those chains and threads are described in the captions to Figures 1-3 which predominate and are distinguished clearly.

Some chains consist of two parallel and similar ribbons separated by a short distance, and small loops seem to go from the bright points of one ribbon to the bright points of another ribbon.

The chains in the analyzed ranges display very strong evolution at the time scale of hours. Similar to the microwave chains, the soft X-ray and EUV chains and threads seem to be related to CMEs. However, the question on the character of the relationship between the large-scale chains and CMEs (post-CME energy release) appears to be opened. In particular, a spectacular evolution of the chains and threads appears to occur not only after a CME, but also before that, when large-scale magnetic structures approach to their unstable state.

One more strange feature of the analyzed chains and threads is that they can cross each other, the solar equator and appear to cross such essential large-scale structures as the reverse polarity lines of the magnetic fields, filaments, coronal holes and so on.

According to the preliminary impression, sometimes the absorption (i.e. light on the negative images) thin large-scale threads are also observed on the disk. Perhaps some of them are transformed later into the shining threads or chains.

The chains and threads under consideration do not coincide with radio and optical filaments, i.e. they do not correspond to the neutral lines of the large-scale magnetic fields.

3. Concluding Remarks

It is obvious that the discovered chains and threads reflect some unknown peculiarities of the organization and evolution of the large-scale magnetic fields. Apparently, the prolonged energy release, occurring under such an evolution (including the process of CMEs and the post-eruption relaxation of the magnetic fields), initiates a plasma heating in the wide temperature range (from tens of thousands to millions of degrees), which takes place, on the one hand, in sufficiently compact local elements corresponding to the individual bright points, and, on the other hand, in some selected, globally organized magnetic structures corresponding to the observed large-scale chains and threads. As Klimchuk (1998) noted, the separatrix surfaces separating different magnetic flux systems can, in particular, play a role of such large-scale structures.

The presence of the large-scale chains and threads extended from one active region to another is an additional evidence that several very remote regions can be associated into an united global complex on the solar disk.

The overall analysis of these novel phenomena and especially detailed comparison with other images and magnetograms are in progress.

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