HELICAL INTERNAL STRUCTURES IN ERUPTIVE PROMINENCES

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Introduction

Helical structures have been observed in many active prominences on the Sun. These structures can be roughly divided in two classes: internal (or microscopic) and external (or macroscopic). In the case of internal twist two or more fine threads with different helix radii are observed within the body of the prominence tube. In the second case, the whole body of a prominence tube shows helical twist or two or more tubes are intertwined in a rope-like structure.

Observation of twisted prominences have been reported by Jockers and Engvold [1], Rompolt [2], Wang [3], Vrsnak et al. [4] and Vrsnak et al. [5].

Twisted, helical-like patterns are more frequent in active region prominences. All these configurations can be represented by an axial current and so are equivalent to a simple twisted magnetic flux tube.

In the eruption phase, the morphology of a prominence often changes dynamically. In the late phases of the eruption usually a rather simple arch remains, frequently exposing helical-like structure. Such a behavior is described in Tandberg-Hanssen [6] and Vrsnak et al. [7].

A more detailed classification of the prominences exposing helical-like structures is made in Vrasnak et al. [5]. The authors described four main classes (Figure 1):

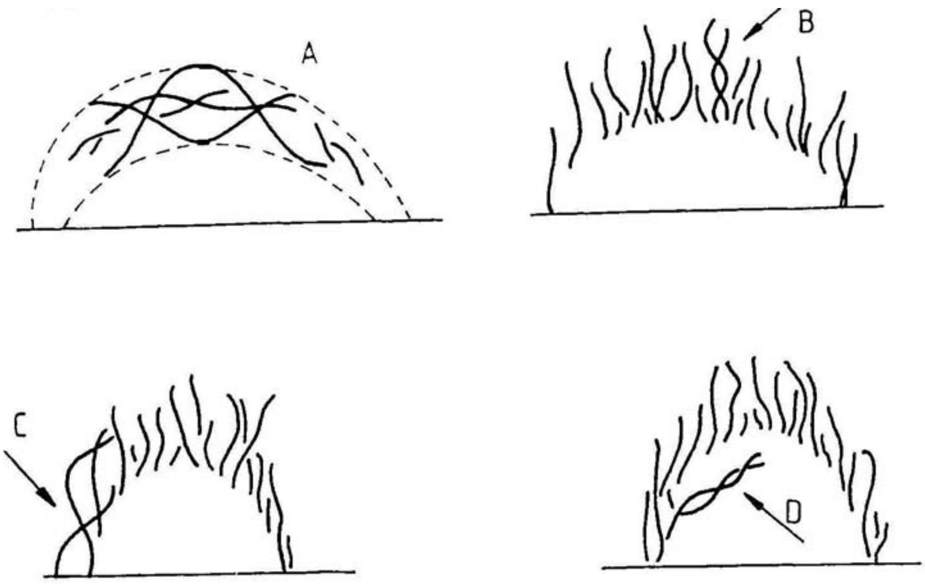

Figure 1. Classification of helical patterns in prominences

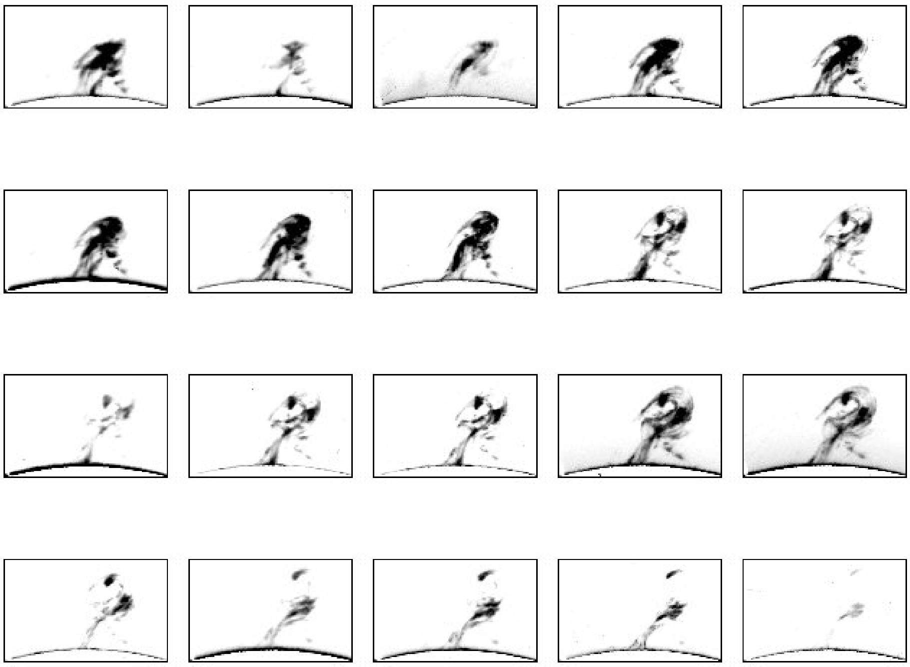

Figure 2. Eruptive prominence observed in H-alpha on May 7, 1979.

class A – pattern, where the threads are apparently twisted around the prominence cylinder axis;

class B – typical for huge QPs which have a sharp lower edge and a number of twisted threads extended upwards making the upper edge diffuse;

class C – “cross-like” structures in the legs of QPs or in the eruptive prominences;

class D – helical threads which are twisted around an axis parallel, but not coinciding whit the axis of the prominence.

There is theoretical support for the concept that the helical twisted structures are responsible for the eruption of prominences (Hood and Priest, [6]). The system becomes unstable and erupts when the twist increases to a critical value. Pneuman [7] gave adiabatic and isothermal models of a helical pinch rising in a low β atmosphere under influence of an ambient coronal magnetic field that decreases radially away from the center of the Sun.

Study of evolution of erupting helical prominences is important for a better understanding of structure, equilibrium and dynamics of prominences in general. This may also provide knowledge about stability of the other structures, which might be twisted, such as coronal loops, coronal arches and two ribbon flares.

In the following sections we discus the morphological details and evolution of the prominence eruption on May 7, 1979.

Observational material.

The eruptive prominence (Fig. 2) was observed in H-alpha on May 7, 1979 with a small coronograph at the Astronomical Institute of Wroclaw University, Poland. All H-alpha plates were digitalized with the automatic Joyce-Loebl MDM5 microdensitometer at National Observatory – Rozhen, Bulgaria.

The two-dimensional scans have a resolution of 20 μm per pixel and a step of 20 μm in both directions.

The prominence appeared on the western limb at a mean latitude of N38°. The prominence was observed between 13:38 UT and 14:26 UT. In this time interval prominence loop slowly rose and complicated its structure. After 14:24 UT it faded and disappeared.

Measurements and Results

Figure 3 represents a sketch of the measured prominence loop. With H1 is marked the maximal height point and H2 marks the height of the cross-point. Alpha is the angle between the legs of the loop.

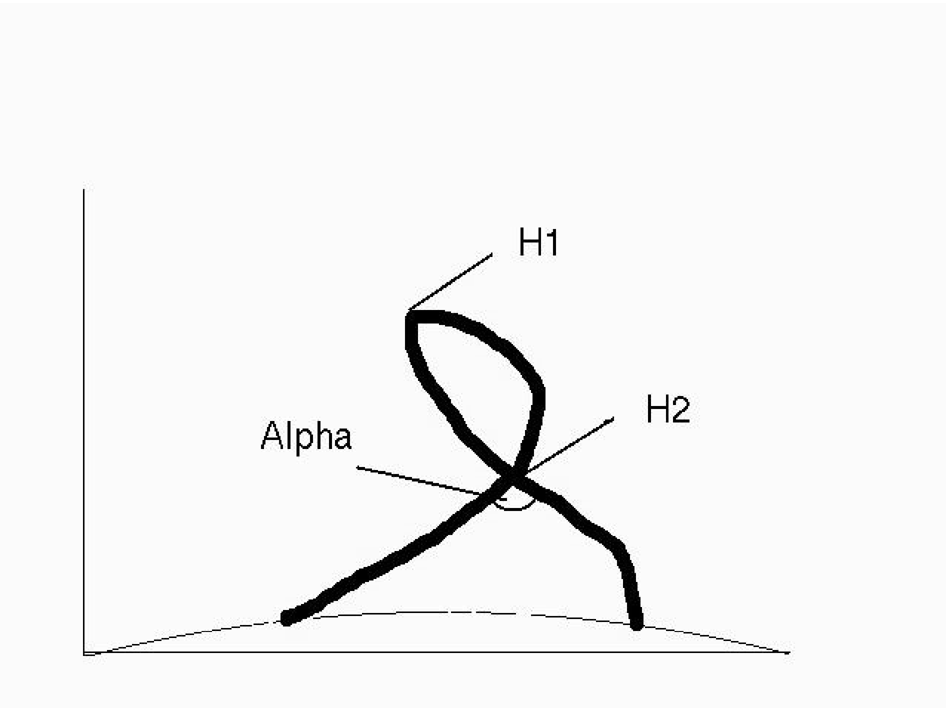

Figure 3. Sketch of the prominence loop.

On Figure 4 is presented height-time variation for these two points. Height is given in pixels (1 px is equal of 750 km). The time is given in seconds after 13:38 UT.

Figure 5 shows normalized differences between H1 and H2 as a function of time.

On Figure 6 is shown the angle variation as a function of time.

T – R periodogramme analyses of the angle variation gives two statistically significant periods of about 4 min and 14 min.

These angle variations can be result of three independent mechanisms: movements of the feet of the loop, propagation of some kind of wave mode along the loop or a shaking of the whole loop.

Our measurements showed that there are no observable movements in the legs, so the first mechanism can be excluded. If the angle variation is result of a pure wave mode propagating along the loop or a shaking of the whole loop, we should observe correlation between time variations of H1 and H2. As it is easily seen from Figure 5, there is no such a correlations.

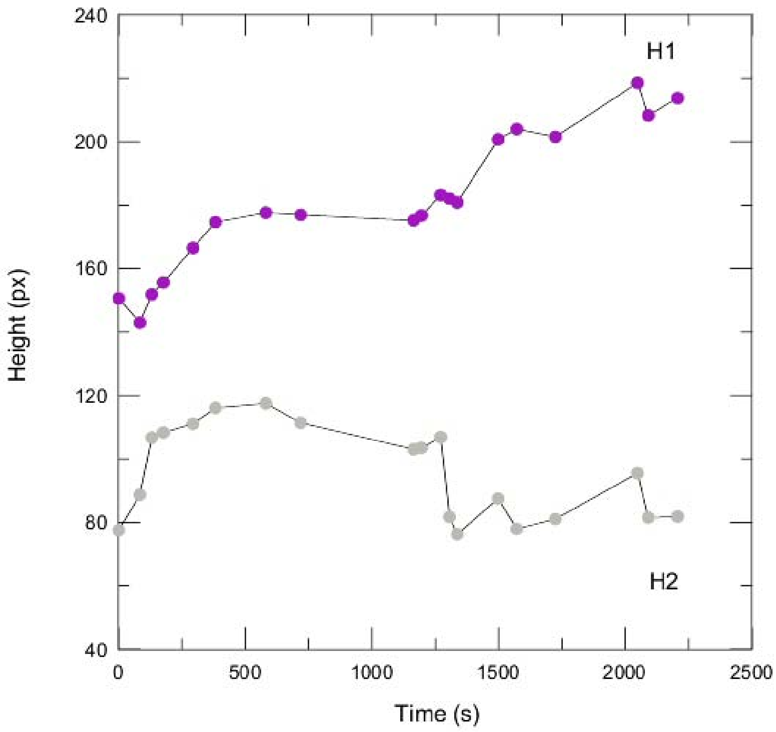

Figure 4. Variations of the measured H1 and H2 heights

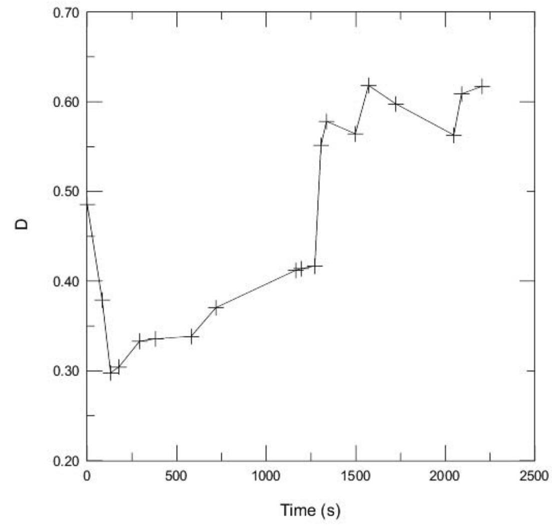

Figure 5. Normalized difference D between H1 and H2 as a function of time.

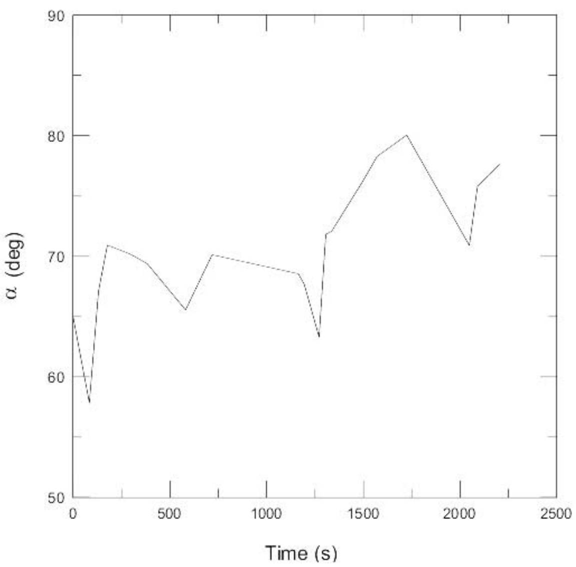

Figure 6. Angle variation as a function of time

So, the most probable explanation of the angle variation is a superpositionof propagating wave modes an a shaking of the whole prominence loop. Figure 6 demonstrates also an observable trend in the angle changes. This can be result of a mechanism of intensification of field-aligned currents, described in Nenovski et al. [8].

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