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KINEMATICS OF TWO ERUPTIVE PROMINENCES

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Abstract. In this paper we study the kinematics and evolution of two eruptive prominences (EPs), observed on May 8, 1979 and on May 5, 1980 in Astronomical Observatory of Wroclaw University, Poland. The EPs are typical representatives of two basic types of eruption (type I constant velocity and acceleration, type II acceleration, constant velocity and deceleration). Both velocity and acceleration are measured in all stages of the eruption. We show that there are essential differences between the final stages of these eruptive events. The kinematic differences between EPs are discussed in point of view of the temporal evolution of the topological by different parts in the erupting huge magnetic system. We suggest that the change of energy of twisting or untwisting of a helical magnetic structure may play important role in the observed eruptions.

1. INTRODUCTION

The quiescent prominences (QPs) as well as active region prominences (ARPs) some times undergo eruptions. A large part of the prominence material is usually lifted high into the corona during the prominence eruption and sometimes into the interplanetary space. In some eruptive events a part of the erupted matter falls back to the chromosphere (Rompolt, 1990). The time scale of the eruption is several hours and erupted matter reaches a height of several 10^5 km up to ten solar radii (Valnicek, 1968).

In the evolution of the prominence eruption the internal structure ot the prominence gradually transforms from intricate and chaotic to a simpler one, frequently characterized by helical-like patterns (Vršnak et al., 1991). These patterns indicate that the prominence could be described in cylindrical geometry as a twisted magnetic flux tube, whose footpoints are anchored in the photosphere (Vršnak, 1998). There is theoretical support for the concept that helically twisted structures are responsible for the eruption of the prominences (Hood and Priest, 1979).

In this paper we consider the evolution and kinematics of two EPs that are classical examples of two basic types of EPs (Rompolt, 1990). Here we present the results of a detailed analysis of their evolution and kinematics, as well as their comparison. We show the differences in their horizontal motions as a criterion for classification and discuss the possible importance of helical-like structures in the observed eruptions.

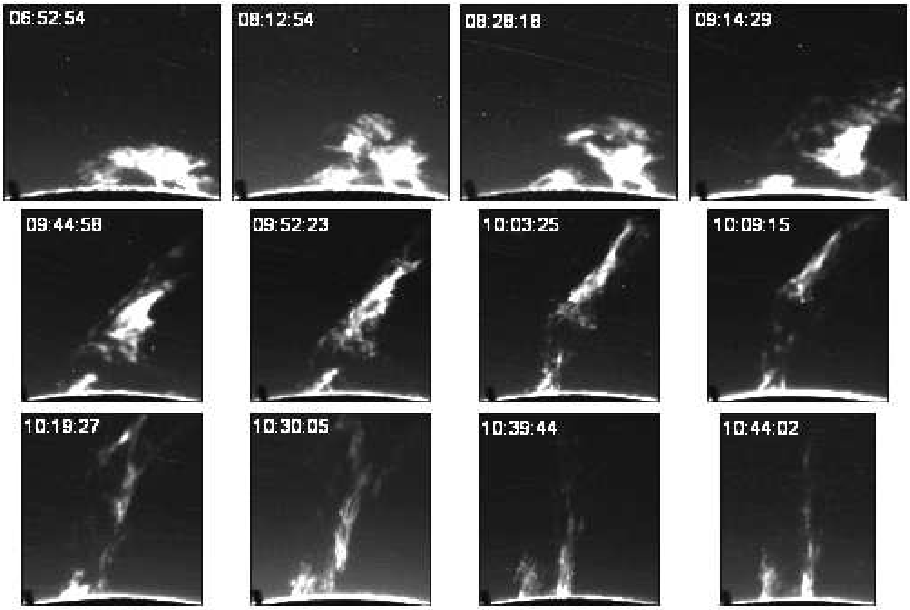

Figure 1: H_α filtergrams of EP on May 8, 1979.

2. OBSERVATIONAL MATERIAL

The eruptive prominences were observed in H_α on May 8, 1979 and on May 5, 1980, with a small coronograph at The Astronomical Observatory of Wroclaw University, Poland. All H_α plates were digitalized with the automatic Joyce-Loebl MDM6 microdensitometer at the National Astronomical Observatory Rozhen, Bulgaria.

The two-dimensional scans have a resolution of $20\mu m$ per pixel and a step of $20\mu m$ in both directions. The spatial resolution of the image (Fig. 1, Fig. 2) is a little more than 1 arcsec.

The first EP (May 8, 1979, CRN 1681) appeared on the western limb at a mean latitude of $S53°$. The prominence was observed between 06:53 UT and 11:09 UT. The prominence did not show eruption between 06:53 UT and 07:05 UT. Eruption started at 08:10 UT. In the first interval 08:10 $\div$ 08:49 UT the prominence slowly rose and its morphology changed slightly. At 08:49 UT fast ascension began and EP reached maximal height, measured from the center of the solar disk, at 10:21 UT. Part of the erupted material fell back to the chromosphere after reaching maximal height.

The prominence eruption event on May 5, 1980 (CRN 1694) was observed on the western limb at a mean latitude of $N23°$. The observation had duration of 3.5 hours between 06:50UT and 10:35 UT (Fig. 2). In the interval 06:50 $\div$ 09:27 UT the prominence arch slowly rose. The internal structure at that time also underwent slow variations. The start of the prominence eruption was at 10:02 UT. The prominence arch rose fist and after 10:35 UT it faded and disappeared.

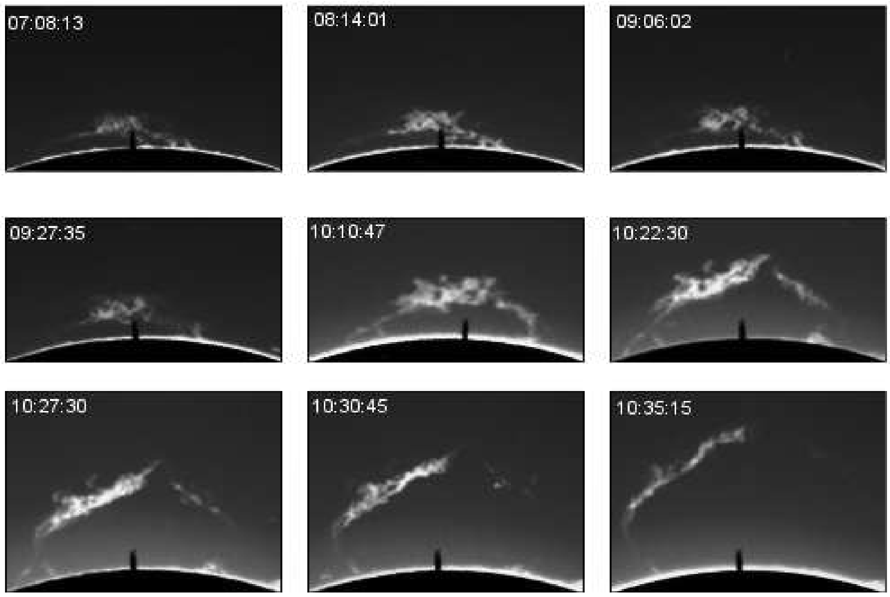

Figure 2: H_{α} filtergrams of EP on May 5, 1980.

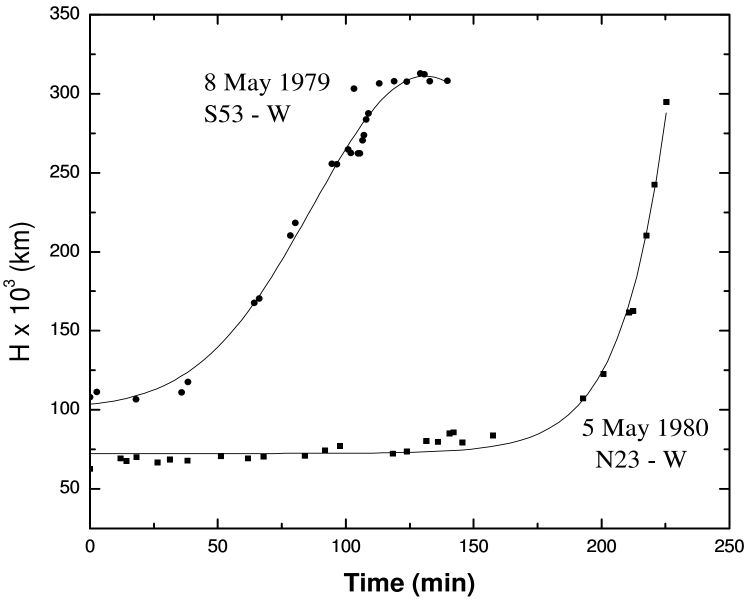

Figure 3: Prominence axis hight as a function of time for the two EPs.

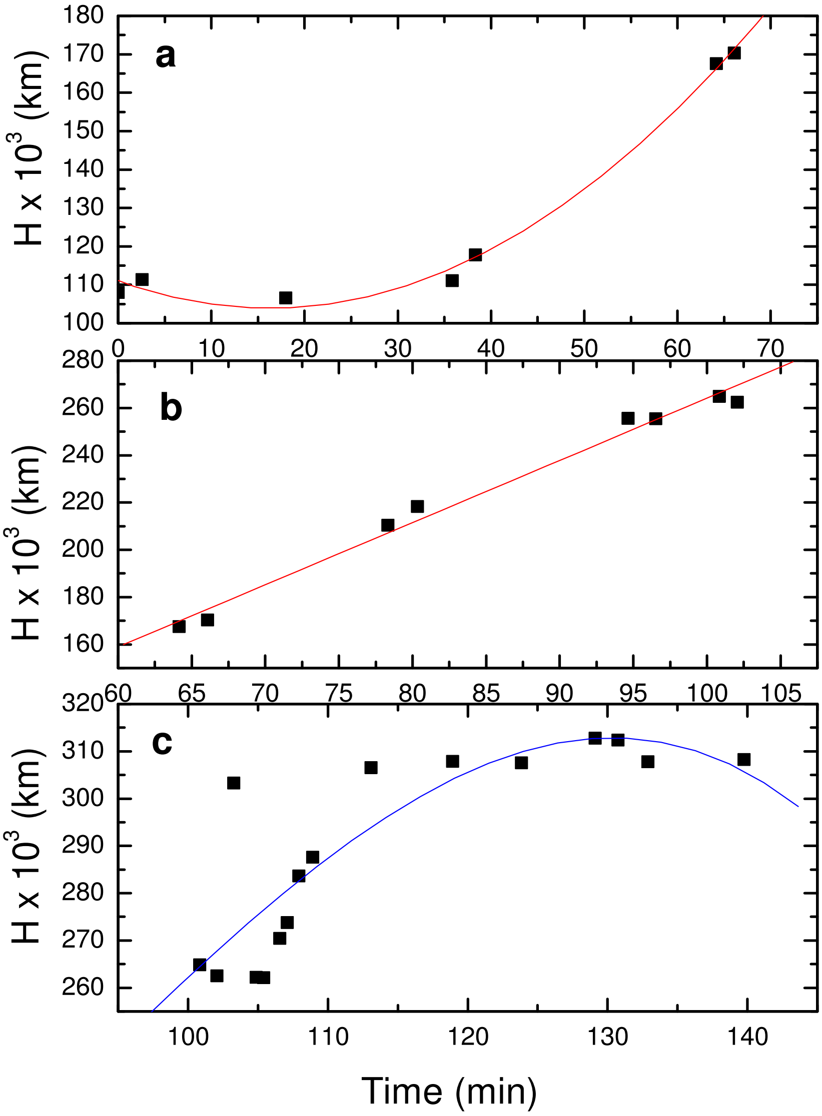

Figure 4: Height-time diagrams for three subphases of EP on May 8, 1979.

3. RESULTS AND DISCUSSION

In the Fig. 3 are presented "height-time" dependencies of the two EPs. One can see clearly the differences between the two types of EPs. EP (May 8, 1979) demonstrates three phases, which are shown in Fig. 4.

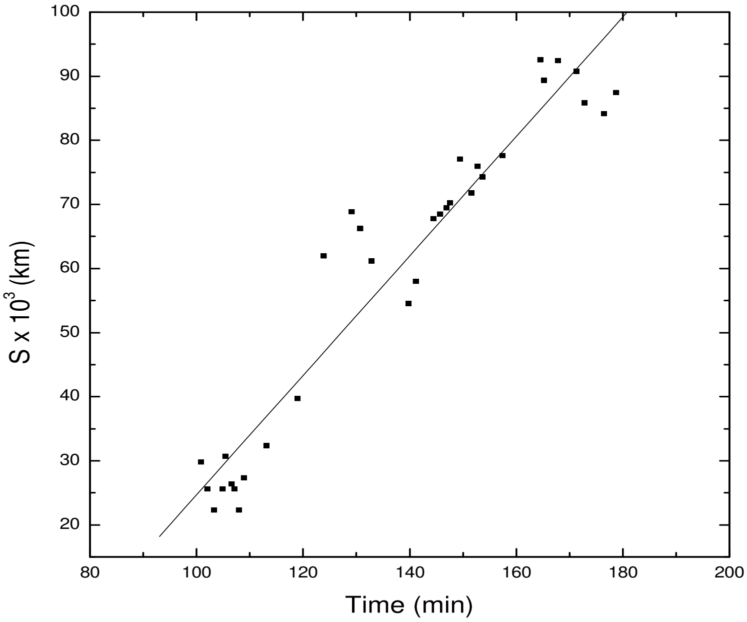

Figure 5: Horizontal expansion in EP on May 8, 1979.

The second-order polynomial fit (Fig. 4a) determines 15 m/s^2 acceleration in that phase of the eruption. In the interval 09:16 ÷ 09:56 UT EP rose with a constant velocity. To estimate the value of this velocity we use linear fit (Fig. 4b), which gives a value of 43.8 km/s. At 09:56 UT (height 106 550 km) one can observe the deceleration phase (Fig. 4c). The negative acceleration is determined by a third-order polynomial fit. The deceleration varies from -9.2 m/s^2 in the beginning of the phase to -35.5 m/s^2 just before the maximal height of 325750 km.

The H(t) of May 5, 1980 EP is shown in Fig. 3. One can see that time evolution of the eruptive event is composed of two distinctive characteristic phases: a pre-eruptive phase between 06:50 UT and 09:16 UT and an eruptive phase in the interval 09:27 ÷ 10:35 UT. The EP slowly increases its height from 65000 km to 85000 km with an average velocity of 1.8 m/s during the first phase. At 09:27 UT the prominence eruption entered in an acceleration phase. The prominence rose from 85000 km to approx. 300000 km in an interval of 70 min before disappearing and its velocity changed from 3.1 km/s to 228.8 km/s.

Beside the eruption in vertical direction the two EPs also exhibit expansion in a horizontal direction. Fig. 5 shows the horizontal expansion of the bundle feet of the EP body as a function of time. The expansion velocity, determined by a linear fit, is 15.5 km/s. It is clear that we cannot distinguish any eruption phases which are well seen in the vertical motion.

The horizontal expansion of eruptive event on May 5, 1980 is presented in the Fig. 6. The kinematic parameters are estimated by an exponential fit (95% confidential

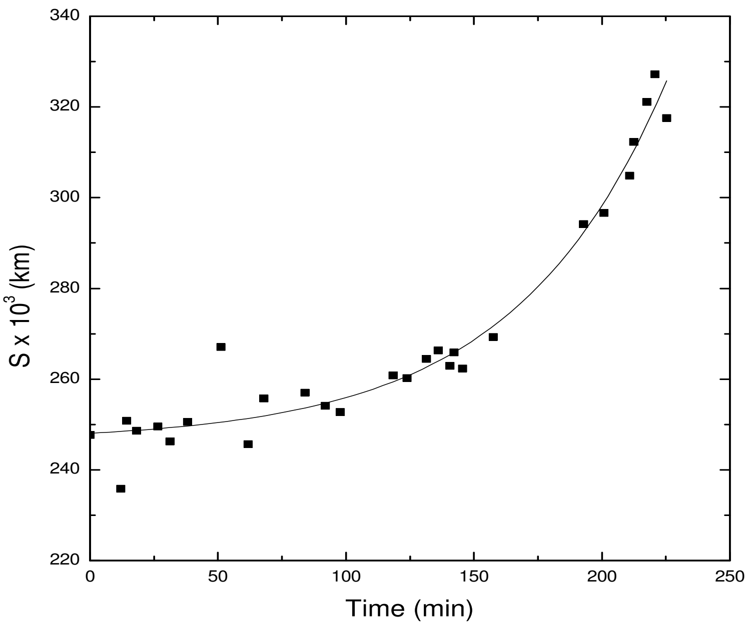

Figure 6: Horizontal expansion in EP on May 5, 1989.

probability). The results for the velocity and acceleration are presented in Fig. 7. Unlike EP type II (May 8, 1979) the eruption phases can be seen here clearly in the horizontal expansion behaviour. During the pre-eruptive phase the velocity slowly increased from 0.6 km/s to 5.8 km/s and acceleration changed from 0.2 m/s^2 to 1.6 m/s^2. In the eruptive phase velocity grew from 7.1 km/s to 22.3 km/s, respectively acceleration increased from 2 m/s^2 to 6.3 m/s^2.

We can measure dimension variations of the prominence legs during the eruption because EP type I does not undergo observable changes of inclination of the large magnetic tube. Fig. 8 represents that function. It is probable an anticorrelation between variations in the prominence legs to exist, but we cannot claim with a certitude because of the small number of points for correlation analysis.

Such changes in the dimensions of the prominence feet can be interpreted in terms of twisting and untwisting of the fine structure elements in the prominence body. Similar behaviour is discussed in Vršnak (1990) and Vršnak, Ruždjak and Rompolt (1991).

The two events show fundamentally different behaviour at the final stages of eruption. The matter of EP type I on May 5, 1980 disappeared while a part of the prominence material of May 8, 1979 event fell back. The estimated acceleration in that case is 66.1 m/s2 which is smaller than the solar free fall acceleration. Probably the changes in magnetic configuration do not allow such a free fall. Unfortunately we do not have enough time resolution to explore in details that last phase eruption.

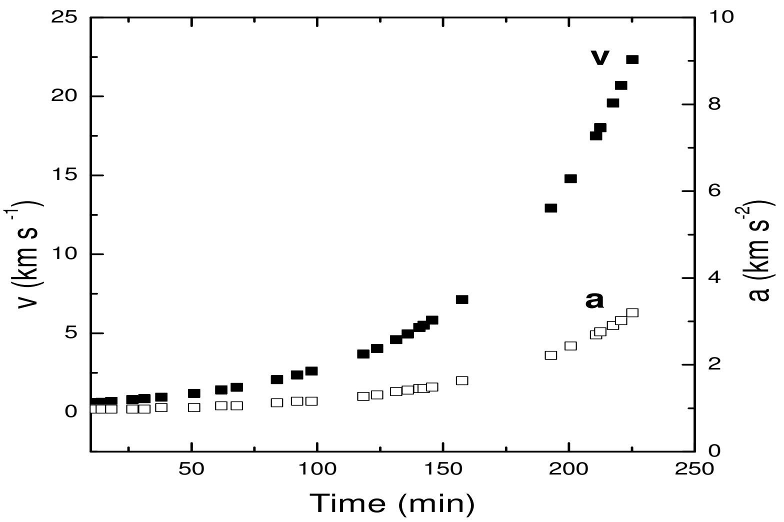

Figure 7: The velocity and acceleration of horizontal expansion for EP on May 5, 1980.

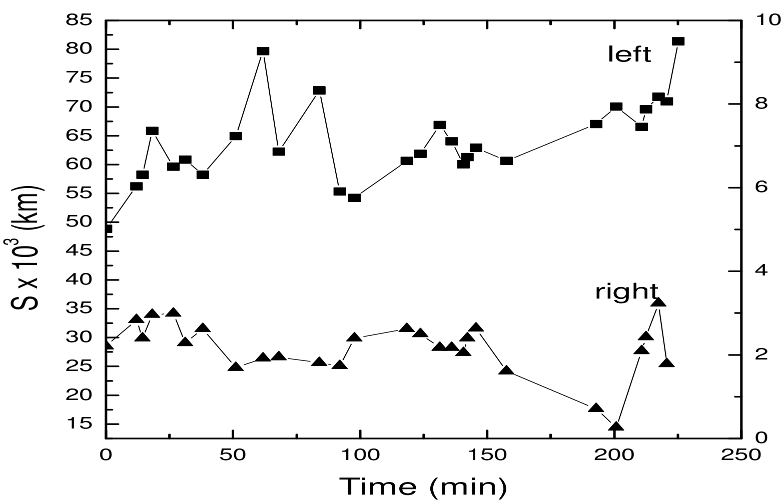

Figure 8: Dimension variations in the feet of EP on May 5, 1980.

4. CONCLUSION

The behaviour of both EPs during the pre-eruptive phase is similar, they rise slowly with a velocity of several km/s, but after the eruption onset their kinematics is radically different. The observed kinematics in vertical direction is as described in Rompolt (1990). One can see that there is a fundamental difference between the kinematics in horizontal direction, so we can classify these events by their horizontal motions.

The observations and measurements of the two events suggest presence of a helical fine structure with a specific twisting and untwisting motion during their eruption. More studies are needed on that point.

Acknowledgements

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