DYNAMIC CHARACTERISTICS OF THREE ERUPTIVE PROMINENCES

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Abstract:

The kinematics and dynamics of eruptions of three prominences was studied. The properties of their dependence of the height on time, as well as of horizontal expansion on time during the eruption was analyzed and compared.

1. Introduction

The eruption process of the prominences develops in two main phases. In the first pre-eruptive phase, the prominence slowly rises with approximately constant velocity of several km/s (Rompolt, 1990). At some critical height the prominence erupts and a large part of its material is lifted into the corona and into the planetary space. The velocity of the ejected prominence ranges from several km/s at the beginning phase of the eruption to several hundreds km/s at the late phase of the eruption (Rompolt, 1990).

Besides the eruption in the vertical direction, some eruptive prominences (EPs) exhibit expansion in the horizontal direction. Most of them show constant velocity (Rompolt, 1984; Rudawy et al., 1994). The velocities of the horizontal expansion are in the range from 15 to 80 km/s (Rompolt, 1998).

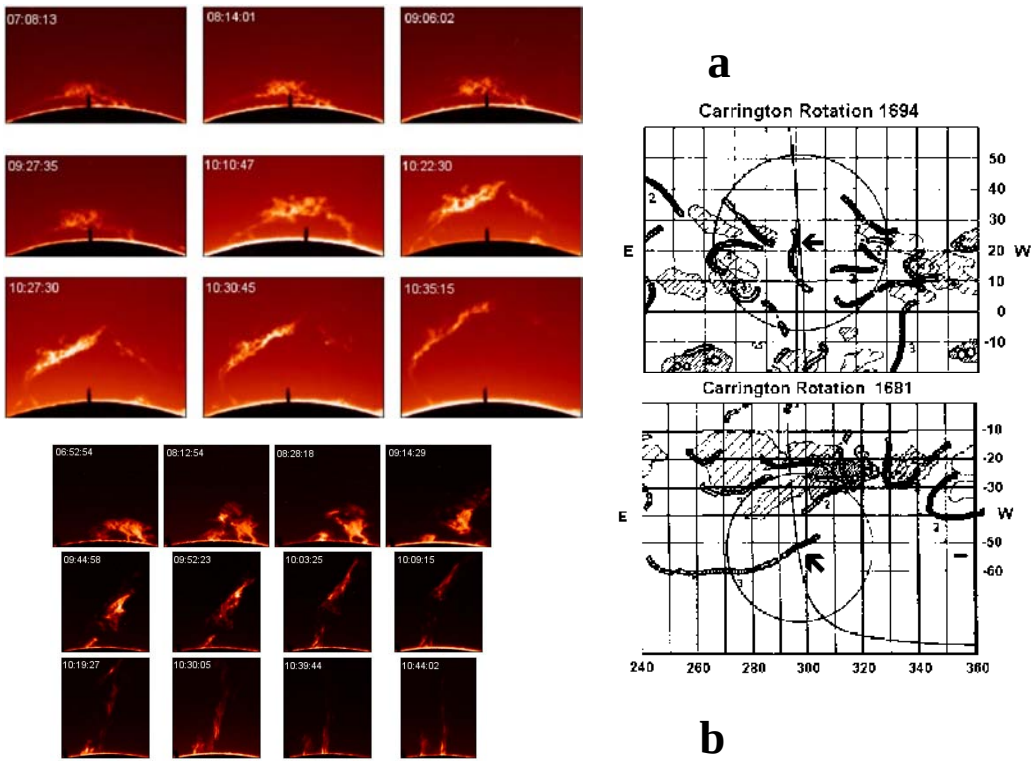
According to Vršnak's classification (Vršnak, 1998), there are three classes of EPs in dependence of the fine structure of the eruptive phase. Class **A** when the prominence material often remains constant after the initial acceleration. Class **B** when after the acceleration and the constant velocity follow deceleration of the EP material. Class **C** when the initial acceleration of the EP continues up to the prominence disappearing in H_α.

There are two basic types of EPs according to Rompolt's classification (Rompolt, 1990). Both types EPs are embedded in the lower part of huge magnetic system (HMS). The EPs of type I have shape of a large arch at the bottom of the HMS that rising up into the corona during the eruption. The EPs

of type II are located in one leg of the HMS loop. The inclination of the prominence body to the solar limb grows up to vertical position during the eruption.

2. Observational Data

The H_α filtergrams of three EPs observed with Small Coronagraph of Wroclaw Astronomical Institute were used. The EP of May 5, 1980 is classical example of type I EP (Figure 1a). The EP of May 8, 1979 EP is a classical example of an EP of type II (Figure 1b). The third EP of August 14, 1979 (Figure 1c) by morphology and eruption evolution is more similar to the EPs of type II. All H_α filtergrams were processed with the automatic Joyce-Loebl MDM6 microdensitometer at the National Astronomical Observatory – Rozhen, Bulgaria.



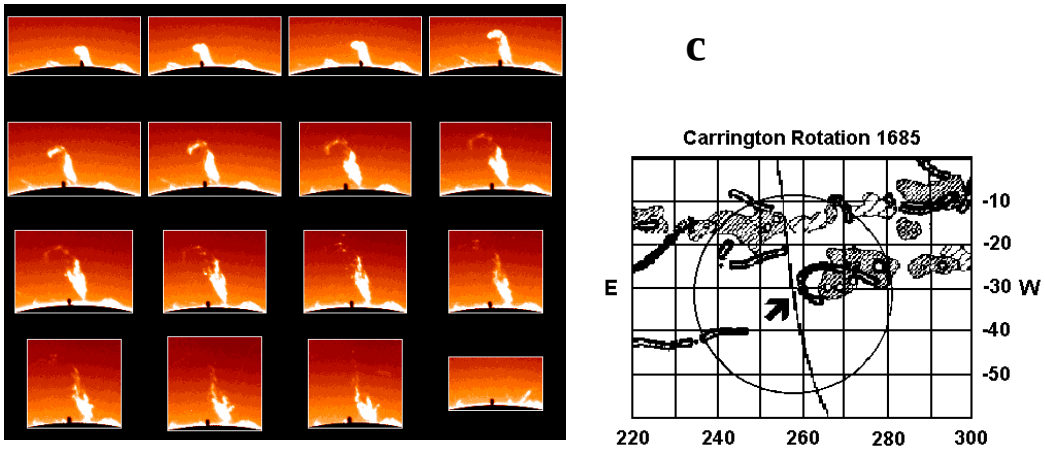


Fig. 1. A sequence of H_α filtergrams of the three EPs and the associated with them filaments in the synoptic maps - (a) I type EP of May 5, 1980; (б) II type EP of May 8, 1979; EP of August 14, 1979.

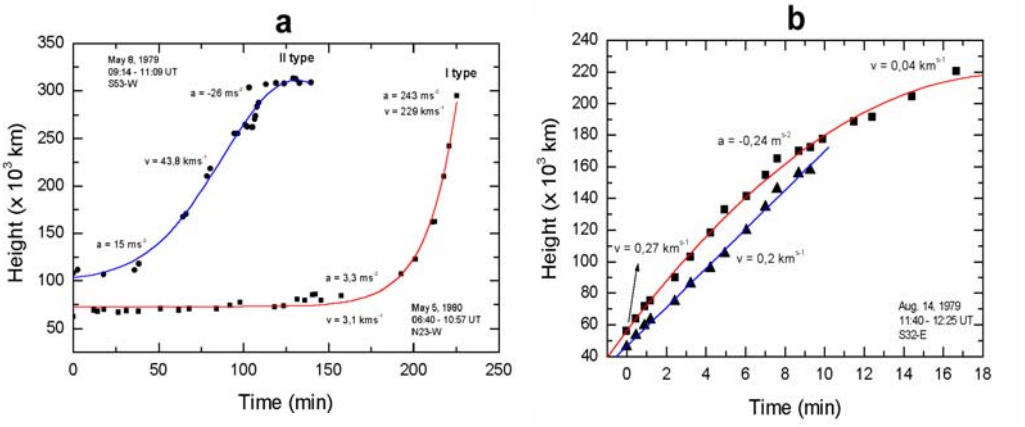


Fig 2. Height-time diagrams of the EP of I type (May5, 1980) and the EP of II type (May 8, 1979), as well as of the EP of August 14, 1979.

3. Height-Time Diagrams

Figure 2a represents height-time diagrams of the EPs of I and II type. The dependence of the height on time for these two EPs is essentially different. The curve of EP of I type shows two distinct phases during the eruption: pre-eruptive phase and eruptive phase. During the pre-eruptive phase, throughout the 146-min time interval, the EP slow rises from 65 000 km to 85 000 km with velocity of 1.8 km/s. After some critical height of about 90 000 km the prominence eruption enters on the acceleration phase. The height of the prominence arch grows very fast up to the prominence disappearing. In the frame of the acceleration phase the velocity of the EP increases from 3.1 km/s to 228.8 km/s, and the acceleration increases from 3.3 m/s^2 to 243.2 m/s^2.

The curve of the EP of II type shows three distinct phases during the eruption: acceleration, constant velocity and deceleration. During the acceleration phase this EP rises with acceleration of 15 m/s^2 and it reaches a maximal velocity at height of 170 000 km. After acceleration the EP raises with constant velocity of 43.8 km/s during 40-min time interval. At height of 106 550 km, the EP evolution enter in the deceleration phase. The negative acceleration of the EP material during this phase increases from –9.2 m/s^2 in the beginning to –35.5 m/s^2 just before the EP to reach a maximal height of 325 750 km.

Figure 2b represents the height-time diagram of the EP of August 14, 1979. The longer curve is more representatives for the prominence eruption. It clearly shows deceleration of prominence material during the eruption. The velocity of the EP rise decreases from 0.27 km/s in the beginning to 0.04 km/s to the end of the eruption. The negative acceleration during the eruption is – 0.24 m/s^2.

The eruption processes of the EPs of I and II type are pronouncedly different as regards their fine structure, as well as by their dynamic parameters. These differences most probably reveal the specific evolution of the different parts of the HMS where the EPs of I and II type are embedded. From the dynamic point of view the third EP has essentially different eruption process than those of the EPs of I and II type. To a certain degree it is more close to the EP of II type as far as its eruption is similar to the last, deceleration phase of to the EP of II type. On the other hand, as in the case of the EP of II type, the

prominence material of the third EP falls back into the chromosphere after the prominence eruption.

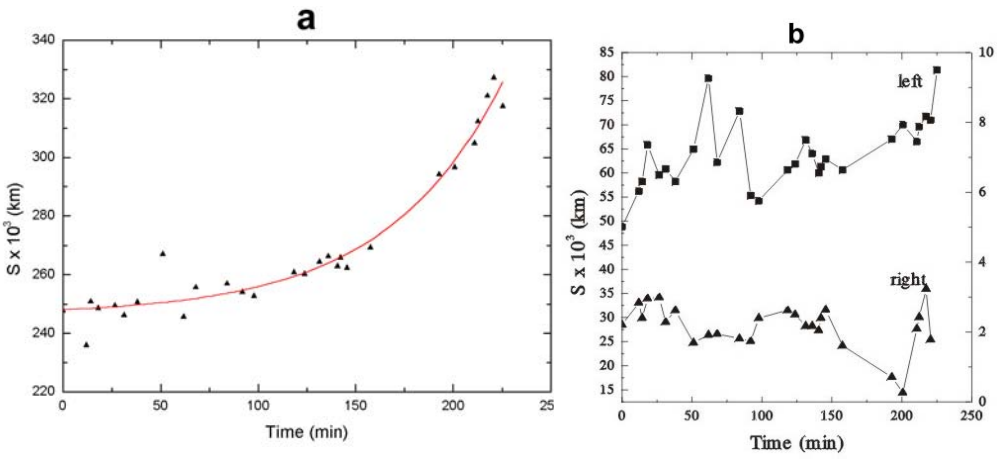


Fig.3 Horizontal expansion between the prominence arch feet (a) and between the feet of the magnetic tubes consisting left and right arch leg of type I EP (May 5, 1980).

4. Horizontal Expansion

During the eruption in vertical direction the EP of I type shows two kind of horizontal expansion. The first is between the prominence arch feet and the second is between feet of intertwisted magnetic tubes composing the left and right arch leg of the EP. Figure 3a represents the horizontal expansion between the EP leg feet as a function of time. During pre-eruptive phase the velocity slow increases from 0.6 km/s to 5.8 km/s and acceleration slow increases from 0.2 m/s^2 to 1.6 m/s^2. During eruptive phase the velocity quickly grows from 7.1 km/s to 22.3 km/s and the acceleration quickly grows from 2 m/s^2 to 6.3 m/s^2.

During the eruption of the EP of I type the magnetic tube feet in every prominence leg undergone horizontal displacement. Figure 3b represents the distance between magnetic tube feet in the left and right EP leg as a function of

time. In the process of the prominence eruption the magnetic tube feet in the left and right leg show alternative change of the direction of the horizontal expansion. While the horizontal expansion of the prominence legs is a result of prominence arch stretching, the specific horizontal expansion between the tube feet in the EP legs are most probably connected with the changes in the internal structure of EP arch during its stretching.

During the eruption of the EP of type II the prominence body consisted of two main intertwisted bundles untwists. Along with the growing of the prominence height the feet of main bundles move away each from other, showing horizontal expansion. Figure 4 shows the horizontal expansion of the bundle feet of EP body as a function of time. The mean velocity of horizontal expansion is estimated of 15.5 km/s. The onset of horizontal expansion is registered 100 min after the onset of the prominence eruption. During the 18-min time interval the bundle feet show uncertain horizontal expansion as a result of alternative change of the direction of horizontal displacement. When the two bundles of the EP body are completely untwisted, they show apparent horizontal expansion, moving away each from other. Hence, this special feature of the EP of II type horizontal expansion is close connected with the process of simplification of the prominence magnetic configuration that is a part of HMS.

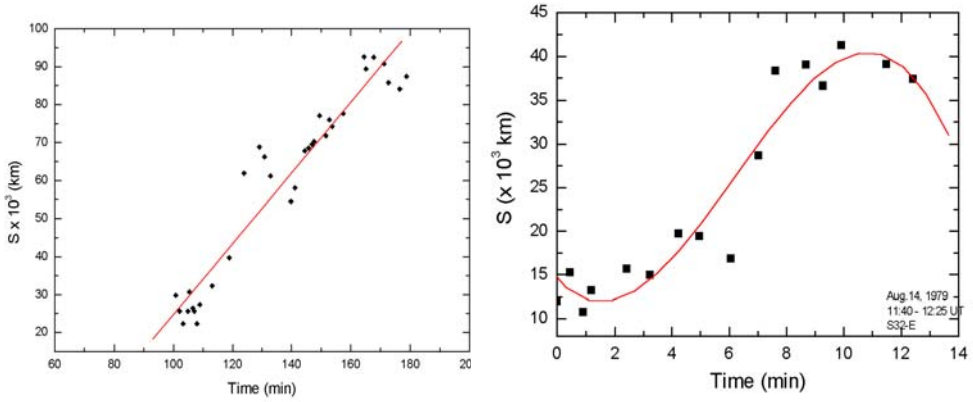


Figure 6 shows the horizontal expansion of the EP of August 14, 1979 as a function of time. The behaviour of the curve suggests that the horizontal expansion of this EP has periodical character, i.e. the EP foot probably oscillates about mean point at the solar surface. Hence, the pattern of the horizontal expansion of this EP is different than those of the horizontal expansion of the EPs of I and II type.

4. Conclusions

The eruption processes of the EPs of I and II type have different patterns as in respect to the fine structure of the eruption evolution, as well as in respect to the dynamic parameters. The eruption of the EP of II type is consisted of distinct phases of acceleration, constant velocity and deceleration and after the eruption the prominence material falls back into the chromosphere. The EP of I type shows only two distinct phases: pre-eruptive phase and acceleration.

The horizontal expansions of the EPs of I and II type have also different patterns. The EP of II type shows the horizontal expansion between two bundles consisting the prominence body whereas the EP of I type shows two kind of horizontal expansion: between the prominence arch legs and between magnetic tubes consisting left and right prominence leg.

The eruption process of the EP of August 14, 1979 is presented only of deceleration. Its horizontal expansion is characterized with specific oscillation of the prominence foot about mean point at the solar surface.

Reference

Rompolt, B.: 1984, *Adv. Space Res.* **4**, No. 4, 357.

Rompolt, B.: 1990, Hvar Obs. Bull. 14, 37

Rompolt, B.: 1998, in *New Perspectives on Solar Prominences*, D. Webb, D. Rust and B. Schmieder (eds.), IAU Colloq. 167, ASP Conference Series vol. 150, 330.

Rudawy, P., Rompolt, B., Kotrc, P., Heinzel, P. and Knizek, M.: 1994, in *Solar Magnetic Fields*, Proceedings of the international conference held in Freiburg, Germany, June 29-July 2, 1993. M. Schüssler and W. Schmidt (eds). Cambridge: Cambridge University Press, 372.

Vršnak, B.: 1998, in *New Perspectives on Solar Prominences*, D. Webb, D. Rust and B. Schmieder (eds.), IAU Colloq. 167, ASP Conference Series vol. 150, 302.