Destabilization and eruption of solar prominences

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Prominence eruptions are large-scale eruptive phenomena that occur in the low solar atmosphere. Observations show that prominences display a wide range of eruptive activity. There are three types of prominence (filament) eruptions according to the observational definitions of (Gilbert et al, 2007) based on the relation between the filament mass and corresponding supporting magnetic structure: full, partial, and failed (confined). A full eruption occurs when the entire magnetic structure and the pre-eruptive prominence material are expelled into the heliosphere. If neither the filament mass, nor the supporting magnetic structure escape the solar gravitational field, it is a failed eruption. One important observational consequence concerning partial and failed eruptions is the re-formation of the filament at the pre-eruptive location.

The study of solar prominence occurrence, stability, destabilization and eruption allows to solve a wide range of physical problems related to local magnetic fields behavior and evolution.

The results from investigations of different types of prominence eruptions are presented. We summarize the morphology, kinematic, and helicity evolution of the prominences during their eruptions.

The studies are based on observations of 8 eruptive prominences (EPs), obtained with ground-based observations and the tools of space observatories. They have been performed in the context of the magnetic flux rope model of the solar prominences and the results for different types of eruptions have been compared.

The main results from this study are:

1. The morphology as well as kinematic and helicity evolution of a loop-shaped helically twisted prominence with fixed feet was investigated using state-of-the-art observations from the Atmospheric Imaging Assembly (AIA) on board the Solar Dynamics Observatory (SDO) in the He II 304 Å EUV passband, EUVI/STEREO B and LASCO/SoHO. We have the unique opportunity to combine limb with on-disk observations, thanks to the different observational position of the instruments.

The same sign of the prominence body twist and writhe, as well as the amount of twisting above the critical value of 2π after the activation phase provide the conditions for kink instability to work. No signature of magnetic reconnection was observed anywhere in the prominence body and its surroundings. The filament/prominence descent following the eruption, its partial reformation at the same place two days later, and the asymmetric background magnetic field around the prominence are important arguments for a confined (failed) type of eruption (Koleva et al., 2012).

2. By ground-based observations of the helically twisted prominence at the limb, we determined the confined type of eruption, at which the conditions for the development of kink-instability are present. The degree of twisting loop

was qualitatively evaluated. We proposed a scenario of a confined eruption (Duchlev et al., 2010a; Koleva et al., 2009).

3. The kinematics and the evolution of five EPs observed with the Small H_α Coronagraph in Wroclaw, Poland were studied. Two of them are classical examples for the two basic different types of eruption (type I and type II, according to Rompolt, 1984).

The basic kinematic parameters of these EPs were compared and discussed from the point of view of their associations with topologically different parts of the erupting huge magnetic system (HMS). Some essential differences in their kinematics and evolution were established (Duchlev et al., 2010b).
A special attention was paid to the kinematic characteristics of the post-eruptive phase of EP of type II when the prominence plasma fell back to the chromosphere. The obtained results are indicative of the evolution of the magnetic field at the bottom of HMS.

4. An analysis of the evolution and the untwisting of the internal structure during the prominence eruption (II type) was performed on the base of a long series of H_α filtergrams of the eruptive prominence of 20 September 1980. The dynamic characteristics of the prominence eruption were determined (Duchlev et al., 2007).

5. The evolution of an EP with a reconnection of magnetic field is investigated. The main goal is to study the precursor eruption signatures, observed in H_α, as well as their relation to the prominence destabilization. A method, using the mean values of relative H_α brightness of the EP body, was developed. The observed H_α brightening was discussed with respect to the low atmosphere magnetic reconnection that might be responsible for the prominence destabilization and acceleration. Our results suggest that the pre-eruption H_α brightening can be used as an indirect signature of a magnetic reconnection process, considered as a trigger mechanism for a prominence eruption (Koleva, 2007; Koleva et al., 2009).

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