Complex Eruptive Dynamics Leading to a Prominence Eruption and a Partial-Halo Coronal Mass Ejection

M. Dechev, K. Koleva and P. Duchlev
Institute of Astronomy with NAO, Bulgarian Academy of Sciences, Bulgaria

Background

The filament eruptions (FEs) are often closely associated with flares and a coronal mass ejections (CMEs). All these phenomena are different manifestations of the release of magnetic energy stored in the corona prior to the event. One of the mechanisms that can lead to the instability and trigger the energy release is the MHD ideal instability (kink or twist) of a twisted coronal flux rope (FR). Such instabilities may be caused by the evolution of the external magnetic fields (cancellation or emergence), shearing motion and the change of loops topology overlaying the filament. The interactions between two nearby filaments can also cause their eruptions and can lead to a flare and/or CME. Moreover, the threads of a filament can also interact and rapidly change the magnetic connectivity in the filament structure upon magnetic reconnection.

We present very rarely reported case of an eruptive prominence (EP) composed by both hot, bright flux rope (BFR) and cool massive flux ropes (MFR) that was involved in sympathetically linked chain of events on 2014 March 14, which finished with a partial-halo coronal mass ejection (CME) with a bi-components bright core.

Results: pre-eruptive activity (04:30-08:00 UT)

The filament was overlaid by a common arcade of the unipolar-bipolar-unipolar streamer belt (multic arcade streamer) that is a favorable magnetic configuration for producing sympathetic events.

The multipolar photospheric magnetic field around the filament, nearby young AR still in the emergence phase, and the gradual EUV emission under the slow rising filament as a precursor of slow magnetic reconnection suggest a complex, multi-step process that produced a chain of a casually related events. The continuous flux emergence in the young AR, as well as the associated flare suggest that the flux emergence could supply sufficient energy to trigger the surge appearance at 08:16 UT by generation of low-altitude reconnection, which was suggested by increasing of 195 Å brightening before surge onset (Fig. 7).

Results: prominence eruption (08:01-09:16 UT)

The surge is most reliable trigger of the EP BFR and its slow rising bellow the arch-like MFR. Moreover, the EUV brightening in all AIA channels responds at the same time and have similar decay times (Fig. 3 and 4), which is an observational signature supporting the dominant role of the plasma compression over reconnection.

The BFR slowly rose beneath the MFR that accompanied by an apparent plasma drainage observed in the threads of MFR and BFR. Just before the EP fast-rise onset, the BFR was already visible as bright loop. which was merged with the MFR inner edge forming in this way a single common EP FR in the AIA FOV (Fig. 3 and 4).

In the AIA FOV the EP slowly rose with an average speed of ~3 km s⁻¹-6 km s⁻¹ in the EUVI FOV (Fig. 6).

Results: prominence eruption (09:16-10:00 UT)

The EP fast rise is consisted of two specific stages: first one of coherent, rapid rising of a single EP FR between 09:16 UT and 09:32 UT, and second one of sharp EP rising and splitting of the single FR between 09:32 UT and 09:41 UT. Main feature of this stage is dynamic EUV brightening that spread from top to bottom covering whole EP FR at 09:30 UT.

The second stage started with brightening fragmentation due to EUV dimming in different part of EP FR, and at 09:34 UT only three regions of strong EUV emission remained in FR: at the top (B1), in the middle part of northern leg (B2), and at FR footpoints (B3) (Fig. 3 and 4).

Just after the strong acceleration onset of EP the upper part of the single FR began to split laterally and at 09:36 UT the massive and bright FRs were again visible, but well separated, with propagations in quite different directions (Fig. 5). During the EP fast rising the velocities exponentially increased from ~3.5 km s⁻¹ to ~280 km s⁻¹ in the AIA FOV, while in the EUVI FOV they increased from 12 km s⁻¹ to 470 km s⁻¹ (Fig. 6).

Results: partial halo CME and ribbon flare (10:00 UT - 20:49 UT)

The late EP evolution beneath the CME and multic arcade streamer surrounded it affect on the CME three-parts structure. The CME bright core presented a specific bi-component structure produced by the upper parts of cool MFR and hot BFR, which had quite different asymmetrical positions in the cavity (Fig. 8).

The impulsive flare started in this stage at 09:52 UT, just after the EP splitting and almost simultaneously with the CME appearance (10:02 UT) in the LASCO C2 FOV. It reached maximum at the time when extensive strong EUV brightening in the bipolar region containing BFR was observed (Fig 7).

Conclusions

The EP was part of a chain of physically linked sympathetic events appearing in a single region below the multic arcade streamer (Fig. 9). The EP evolution on 2014 March 14 composed by both hot BFR and cool MFR, which involved a rare feature of interaction between the BFR and MFR that subsequently appeared as bi-component bright core in the associated partial-halo CME.

The dominant role of the BFR below the MFR suggests the torus instability as a most reliable source of eruption.