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Mechanism of Coronal Mass Ejections Triggered by Emerging Flux

P. F. Chen, C. Fang

Department of Astronomy, Nanjing University, Nanjing 210093, China

K. Shibata

Kwasan Observatory, Kyoto University, Kyoto 607-8471, Japan

The origin of coronal mass ejections (CMEs) is an interesting, while still mysterious, subject in solar physics. As well, the relationship between CMEs and solar flares is poorly understood. This paper attempts to provide answers to these questions on the base of the flux rope model, and put forward a trigger mechanism for CMEs. The work is motivated by an interesting discovery of the relation between reconnection-favored emerging flux and CMEs (Feynman and Martin 1995), i.e., such emerging flux, either within the filament channel or on the outer edge of the channel, can trigger CMEs.

In the consideration of Aly's constraint, a detached flux rope model was proposed for the pre-CME configuration. A quadrupolar magnetic field with a flux rope is introduced as the initial magnetic configuration in current research. Since our trigger mechanism is magnetic in nature, gravity is omitted. Emerging flux is simulated by changing the local magnetic flux at the bottom boundary.

Our MHD numerical simulations show that the response of the flux rope to the emerging flux presents two stages: the onset of CME and the following eruption process (see Chen and Shibata 2000 for details). The first stage is characterized by local heating owing to the reconnection driven by emerging flux, and the loss of equilibrium: when reconnection-favored emerging flux emerges within the filament channel, it cancels the magnetic field below the flux rope or reconnects with the two-sided field lines, leading to the local heating and the rise of the flux rope, as well as the formation of a current sheet below it; when such emerging flux appears on the outer edge of the channel, it rearranges the global magnetic configuration, leads to the loss of equilibrium of the flux rope and the formation of a current sheet similar to the former case. The ensuing magnetic reconnection of the current sheet, in the second stage, induces fast ejection of the flux rope (i.e., a CME) above the reconnection region and flaring loops below the reconnection region. It is also shown that generally the non-reconnection oriented emerging flux can not trigger the eruption of the flux rope.

References

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